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Contents

Abstract

In our study we analysed the effect of the introduction of an instant payment system in Hungary, using a large number of transaction level data of an extended time period, simulating the operation of the payment system. We analysed the two main theoretical models of instant payments: instant settlement in central bank money, and instant clearing with prefunded cyclical settlement. For both models we estimated the effect of using low and high transaction limits. We differentiated three liquidity costs associated with the operation of such a system. First we estimated the impact on settlement queues in the real-time gross settlement system and calculated the costs of extra liquidity needed to dissolve the queues and support the continuous operation of the system. In the second step we estimated the liquidity needs of a prefunded instant payment system by different confidence levels and prudential requirements. Lastly, we analysed the effects of the different models on the stability of the payment system. The results clearly show that the costs associated with the dissolution of queues are marginal because retail payments comprise a very small percentage of the inter-bank payment flows, thus the instant payment system would not generate additional settlement queues. On the other hand, liquidity needs of a prefunded model can be significant, especially with high collateral confidence levels and high transaction value limits. However, these liquidity needs can be lowered by seasonal adjustments to the prefunded amounts and by using a robust but rational collateral confidence level. We also show that these costs are relatively higher for institutions with fewer customers as their payments turnover is more volatile, and so they have to make relatively larger prefunded deposits.

Key terms: instant payments, retail payments, liquidity management, RTGS
Journal of Economic Literature (JEL) codes: C53, G17, G29

1 Introduction

With the widening of the technical possibilities of payments, an increasing number of service providers – central banks or market participants – made the settlement of instant payment transactions possible in Europe. Realising the advantages of this type of development, the assessment and analysis of the tasks to be performed for the introduction of instant payments started in the Magyar Nemzeti Bank (the central bank of Hungary, MNB) as well. As part of this analytical work, in this study we examine the liquidity management aspects of an instant payment system to be introduced in Hungary, quantifying the liquidity needs of the potential implementation models and the theoretical costs of liquidity. The central elements of payments in Hungary are the Real-time Gross Settlement System (VIBER), in which the interbank settlement takes place among accounts kept by the Central Bank; the Interbank Clearing System (ICS), which is operated by GIRO Ltd., and functioning as a clearing house is responsible for the cyclical processing of low-value transactions and their forwarding into VIBER for settlement; as well as the securities clearing and settlement system run by KELER Group. All the three infrastructures play a role in the shaping of the liquidity model of the instant payment system, as stemming from their settlement, clearing and depository functions they serve as the fundamental locations of forint liquidity management.

The ICS, which is responsible for the intraday clearing of low-value transactions, is based on the logic of deferred clearing and settlement cycles. In spite of the fact that in 2015 the number of intraday clearing cycles increased to ten, under the current conditions, real-time transfer is possible only in the VIBER. However, the availability of the latter for households and companies is limited, and typically high commercial bank fees are charged for it. Therefore, with the involvement of market participants the MNB launched a project for the long-term development of the central infrastructure with the objective of introducing instant payments in Hungary. Our study analyses the question what impact the switch-over of low-value payments from the current intraday cyclical clearing system to an instant system that applies individual clearing would have on the liquidity management of direct system participants, typically commercial banks. Our study separately examines the operating principle and impact of two settlement models that would force direct system participants to change their liquidity management in different ways and to different extents. Our objective is to quantify the relevant cost elements, not necessarily by calculating the exact values, but by giving lower and upper estimates. We wish to make it clear that liquidity management is only one of the factors that influence the decisions related to the shaping of the instant payment system. Nevertheless, our study focuses only on this issue; other points to be considered, such as effects on banking processes and information technology, are not examined.

In our study we apply the simulational and computational methodology of the analysis of the liquidity needs of settlements, primarily created for the analysis of Large-Value Transfer Systems. Kimmo és Soramäki [1998] using interbank data from a 100-day period proved the connection between settlement delay and the liquidity needs of the system. In their study they confirmed that moving from end of day settlement towards real time gross settlement without queueing substantially increases the liquidity needs with an increasing margin. Leinonen and Soramäki [1999] and Hellqvist and Laine [2012] came to the same conclusions using Finnish data, Arjani [2006, 2007] by analysing the Canadian interbank transfers, and Oleschak and Nellen [2013] studying the operation of the Swiss SIC system. In our analysis we partially depart from this methodology (Denbee et al. [2015]) and concentrate primarily on the operational plausability of retail instant payments. To this day no study was completed to analyse the liquidity needs of instant payments and its effect on the RTGS systems. It is also worth mentioning that Christensen et al. [2013], Korsby et al. [2012] and Andersen and Gladov [2015] analysed the effects of the change to interday settlements and the first experiences of the Danish instant payment scheme, but not from a liquidity perspective.

In the second chapter we briefly present the examined settlement and liquidity management models of the instant payment system, and the third chapter follows by detailing the methodology and data sources used in our analyses. The following chapters describe three liquidity cost elements which were considered relevant in instant payment systems: the fourth chapter presents the interest cost of the additional liquidity necessary to dissolve those settlement queues of the real times gross settlement system that hinder the operation of the instant payment system; the fifth chapter describes the interest cost associated with the replacement of the prefunded amounts segregated for prefunded models; and the sixth chapter examines whether the overall liquidity of the Hungarian real times gross settlement system would have been enough during the analysed timeframe for the different models to function, and if not, what would have been the interest cost of the necessary liquidity raise. The seventh chapter contains the conclusions of our paper.

2 Theoretical models

There are various solutions in worldwide practice for operating instant payment systems. The two most relevant solutions are the prefunded instant clearing but deferred settlement model and the instant settlement model (Dutch Payments Association [2016]), (Bolt et al. [2014]) and (Gajo et al. [2015]). In the instant settlement model, the clearing, the settlement and the crediting of the amount of the transaction is done immediately, most often in central bank money and less often in commercial bank money. In contrast, in the deferred settlement model the direct system participants record their positions on a separate account, and although the amounts received for clients are made available immediately, settlement is carried out only later in central bank money. In the case of this model, different solutions exist in terms of the guarantee that ensures crediting prior to settlement. Below is a presentation of the sub-types of individual settlement models of an instant payment system and of the operating logic that could make them available within the existing infrastructural framework.

2.1 SECURED MODELS APPLYING DEFERRED SETTLEMENT

In the deferred settlement models, the receiving bank credits the amount of the transfer to the beneficiary's account immediately, prior to the settlement, and the collateral for this credit entry is provided by the guarantee system behind the payment method. In the case of a night transaction, for example, it would mean with regard to the domestic infrastructure that the amount immediately credited to the beneficiary's account at night would be received by the receiving bank only in the morning of the next working day through the VIBER, and the collateral for the amount credited at night would be provided by the collateral items placed with the clearing house or another central player. The two deferred settlement sub-types presented below are different in terms of the types of cash collateral; accordingly, scriptural money placed with a clearing house and scriptural money placed with the central bank are used as types of collateral.

2.1.1 Segregation of scriptural money on a dedicated clearing house account (clearing house scriptural money guarantee)

One of the simplest forms of collateral is cash collateral, which can be used in instant clearing as well. The application of cash collateral practically means the prefunding of transactions. The essence of the solution is that based on historical data and forecast shocks, each system participant estimates the size of collateral required for the performance of the transactions submitted in a cycle, and prior to the cycle places this collateral in scriptural money on a central account kept typically by the clearing house as system operator. As an alternative solution, the clearing house itself may perform these estimations instead of the system participants. The amount collected this way provides collateral for the given cycle, and allows instant crediting based on this money. Of course, the challenge is the preparation of a good estimate, because if a bank miscalculates the expected size of the transactions submitted by its clients, it may reach the upper limit determined by the collateral prior to the end of the cycle. It may also mean that temporarily it will not be able to use the instant system, which may undermine the credibility of not only the bank but also of the system. A solution for cases like this may be that the system notifies the bank when its collateral declines below a critical level and requests the bank to make up for the missing amount. Irrespective of the way of prefunding, the operational safety of the system applying this method depends on the sufficiency of the amount deposited in advance.

Another important factor in the case of the systems based on cash collateral is the opportunity cost of joining, which here means the interest loss resulting from setting aside the cash collateral. Market infrastructures typically do not pay any interest on the collateral amounts placed with them, as they do not realise significant interest income on this money. Accordingly, the banks that join the system are compelled to give up the interest income achievable on the amount tied up for the clearing house, which they may offset through the price of the service. This is a factor that has to be taken into account in any case when planning an instant infrastructure available for everyone, as in this case the minimising of end-user fees is of primary importance. It is also to be noted that in the case of segregation on the clearing house account, banks may face higher capital requirements than in the case of prefunding on central bank account.

2.1.2 Segregation of scriptural money on central bank accounts (central bank scriptural money guarantee)

The second option is only a little different from the previous one, as it is also based on scriptural money segregation, but instead of a central account, cash collateral would remain on joining banks' central bank accounts, i.e. on the VIBER accounts in our case. Within the framework of this solution, a portion of system participants' account balance would be dedicated and pledged for the instant clearing, and the VIBER would continuously inform the system performing the instant clearing about the size of the pledged amount. The most important advantage of this solution is that the pledged amounts could be parts of the minimum reserves, and thus banks would not realise any interest loss. It may be advantageous firstly in terms of keeping the price of the service low and secondly in terms of increasing banks' willingness to join.

2.2 MODELS APPLYING INSTANT SETTLEMENT

Within the models applying instant settlement we also determined sub-types according to the form of the available collateral. Somewhat similarly to the previous group, the types of collateral are scriptural money and securities placed with the central bank as well as scriptural money at commercial banks.

2.2.1 Settlement in central bank money (use of real-time gross settlement infrastructure)

In Hungary, real-time settlement in central bank money would mean directing the turnover of the instant payment service into the VIBER without netting as well as the implementation of a 24 business hour scheme for VIBER. Accordingly, selecting a technical solution like this requires the modification of the operating model of the ICS as well as the increasing of the processing capacity and business hours of the VIBER. In this case, participants could continue to manage their liquidity in the current manner, and their total liquidity available in the VIBER, consisting of their account balance kept due to the reserve requirement and their intraday credit line provided against securities collateral, would be at their disposal for the settlement of the instant payment service. In the case of the continuous operation of the VIBER the question arises whether the system should be continuously available with full functionality or only the settlement of the transactions of the instant payment service should be possible outside the current business hours, which are between 7:00 and 18:00. This could also be affected by the changes in the business hours of KELER Central Depository Ltd., which is acting as the Central Bank's custodian. Namely, if the VIBER worked at night and on holidays, when the central securities depository is closed, participants' liquidity would practically start from the level valid upon the closing of KELER Ltd., which could only be changed by interbank payments, i.e. primarily by the instant payments. This follows from the fact that banks can raise their respective central bank credit limits only during the business hours of KELER Ltd. through the pledging of securities in favour of the MNB. Accordingly, outside the business hours of the central securities depository, participants would be able to obtain additional liquidity only through interbank lending, i.e. without a partner bank open for this, it may happen that they will not be able to carry out all payment transactions. However, if KELER Ltd. was open, they would be able to involve additional liquidity through securities transactions and pledging as well, thus ensuring the settlement of transactions. At the same time it is important to note that in parallel with the settlement of instant payments, the probability of high-value, unforeseeable turnover in the period outside the VIBER's current business hours is low, stemming from the general operation of the interbank market and the corporate sector.

2.2.2 Settlement in central bank money to the debit of securities holdings pledged in favour of the MNB (secured central bank loan)

A securities-based solution is the connecting of central bank collateral management with instant payment and its preparation for 24-hour operation. From a practical point of view, this model is very similar to the one presented in the previous point; the only difference is the sequence of using the liquid elements. While the previous model would first deplete the account balance and then the credit limit, the version presented here would first reduce the credit limit, and then would block the account balance. The difference may play a role in terms of complying with the reserve requirement, as banks can meet it with the end-of-day account balance.

In addition to the account holdings held with the MNB, many banks have large unutilised central bank credit limits, which in itself may constitute the collateral for an instant payment system. The essence of the MNB's collateral management system is that the individual bank liquidity available at the Central Bank is determined taking into account the bank's liabilities vis-à-vis the MNB. It means that a bank is allowed to use only that part of its total liquidity, i.e. of its account balance and credit limit, which is determined by the MNB to be of unrestricted use. Accordingly, if the bank's liabilities vis-à-vis the Central Bank increase, the MNB first reduces the bank's credit limit, and when that is over, it blocks the appropriate part of the account balance. Therefore, theoretically the collateral for the instant payment system could also be ensured if the instant payments effected in the VIBER would work as central bank receivables type items, and thus until the depletion of the credit limit they would result in its decline, and then would entail the blocking of the appropriate part of the account balance. Accordingly, banks' VIBER transfers related to instant payments would not entail a change in the account balance, but in the recorded value of central bank receivables vis-à-vis the bank, which can be interpreted in a way that the MNB extends secured central bank credit to the originator bank, and then carries over the amount to the account of the beneficiary bank.

2.2.3 Instant settlement in commercial bank money (commercial bank loan)

Instant settlement of transactions is possible not only in central bank money. If there was a forint account providing market participant that undertakes 24-hour availability, this institution could also perform the instant settlement. Within this solution, each participant of the instant payment system would open an account with this institution, and the transfers should immediately be forwarded to the account provider, which would perform the transactions instantly. However, in connection with the model working with commercial bank lending it is important to emphasise that in this model, in addition to the risks arising in the above liquidity management models, the participants would also take the settlement and credit risks related to the commercial bank that functions as a central actor.

3 Methodology and data sources

Below is a presentation of the theoretical methodology and data sources that serve as basis for our liquidity analysis of the July 2012 –August 2015 period.

3.1 THE VIBER AND THE ICS IN EUROPEAN COMPARISON

The two main pillars of the payment system in Hungary are the VIBER, which settles high-value interbank items, and the ICS, which clears high volumes of low-value items. The settlement of ICS cycles hardly accounts for 5 per cent of the daily turnover value in VIBER, and in the case of the major banking market participants it does not have a significant impact on the daily developments in VIBER balances. However, in the case of direct VIBER participants with a low amount of central bank account balance, the ICS turnover may account for a significant portion of the VIBER turnover.

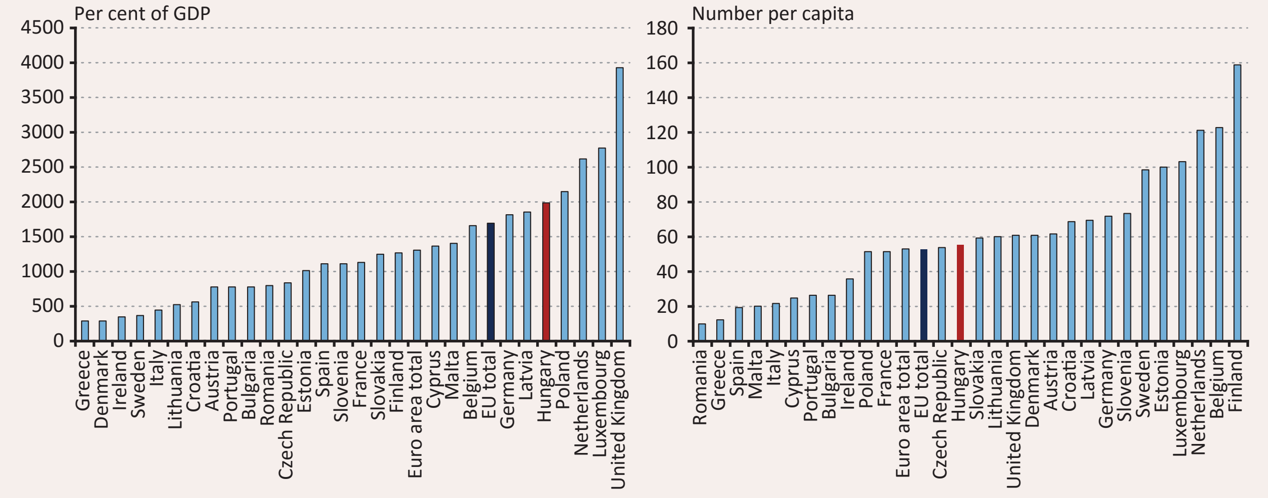
The daily number of transactions settled in the VIBER is low; therefore, direct VIBER settlement of ICS transactions according to the instant settlement model would considerably increase the average daily turnover of the system.

Table 1
Main turnover statistics of the VIBER and the ICS

		VIBER	ICS
Daily average turnover (July 2015 – Aug. 2015)	ea	5,822	629,870
	HUF billion	5,483	296
Total turnover (July 2015 – Aug. 2015)	ea	4,523,815	489,408,990
	HUF billion	4,260,000	229,883

The volume of Hungarian payment transactions can be considered average in a European comparison. The value of transactions as a proportion of GDP is only slightly higher than the European average; moreover, significant dispersion across European countries is observed in this respect. As a result of interbank items and

Chart 1
Value of credit transfers as a proportion of GDP and the number of credit transfers per capita in 2014



Source: ECB Statistical Data Warehouse, Blue Book intra-company transactions, this indicator is not necessarily a good one for showing the intensity of a country's electronic payment transactions, which is more precisely indicated by the number of transfers. According to the latter indicator, in spite of the fact that Hungarian payment transactions are significantly cash-oriented, Hungary can be regarded as having an average number of payment transactions in the European Union.

Based on all the above, it can be concluded that there is no Hungarian specialty that would render the use of usual methodologies or the generalisation of the findings of our analysis difficult.

3.2 INFORMATION BASE OF THE ANALYSIS

The main sources of the model and simulator built by us are the statistics collected by the Magyar Nemzeti Bank. The MNB has detailed, highly reliable data on the operation of the VIBER dating back to several years. However, the simulation of the VIBER in itself is not enough, as the transactions cleared by the ICS appear only in cyclically aggregated net settlements. Therefore, in our calculations we used the statistical data provided by GIRO Ltd. as the only Hungarian clearing house, which operates the ICS. The statistics provided are basically anonymous, aggregate data, which can be broken down according to various aspects. In the case of the backcasting of individual transactions, we used the aggregate data for each cycle according to value limits.

The data are available for more than 10 years retroactively, but in order to be able to make statements that are relevant and robust for the current situation, we limited the analysis to the period between July 2012 and August 2015, which covers the five-cycle phase of operation of the intraday clearing system.

3.3 THE METHODOLOGY OF THE SIMULATOR AND SCENARIOS

In our analysis we modelled the operation of the VIBER, and simulated the various clearing and settlement models of instant payment. The simulator individually clears the transfers arriving in the VIBER in the order of receipt. If a lack of funds evolves, the transaction is put in a queue, then cleared after adequate collateral has been provided. In the simulator, participants' account balances, pledged securities holdings (i.e. central bank credit limits) as well as their items standing in a queue and being settled are continuously kept on record detailed by seconds.

As we have mentioned, the analysis presented below is based on the examination of the transactions settled in the VIBER between July 2012 and August 2015. As a first step, we mapped the historical developments in the system, the queues evolving due to lack of funds, the liquidity management tools used by system participants as well as the various parameters of the transactions cleared by the intraday module of the ICS. Setting up the baseline scenario, we simulated various settlement methods, which are abbreviated as follows in the charts below:

1. BASE:
Shows the baseline scenario, i.e. the real parameters and results from the historical operation of the VIBER.

2. INSTANT_NL:
A model assuming transaction-level instant settlement, displaying each ICS transaction as individual VIBER transaction in the system.

3. INSTANT_500:
A model assuming transaction-level instant settlement, complemented with a HUF 500 million transaction limit, equalling the upper bound of the transfer amount of the payment transaction that can be performed in the system.

4. INSTANT_10:
A model assuming transaction-level instant settlement, complemented with a HUF 10 million transaction limit.

5. PRE10M_NL:
A deferred settlement secured model assuming ten-minute prefunded cycles and operation without value limit.

6. PRE10M_500:
A model assuming ten-minute prefunded cycles, complemented with a HUF 500 million transaction limit.

7. PRE10M_10:
A model assuming ten-minute prefunded cycles, complemented with a HUF 10 million transaction limit.

8. PRE2H_NL:
A deferred settlement secured model assuming two-hour prefunded cycles and operation without value limit.

9. PRE2H_500:
A model assuming two-hour prefunded cycles, complemented with a HUF 500 million transaction limit.

10. PRE2H_10:
A model assuming two-hour prefunded cycles, complemented with a HUF 10 million transaction limit.

In the simulations we recalculated each direct VIBER participant's respective account balances and credit limits related to each transaction, and, in line with the operating principle of the model, cleared the transactions performed in the intraday clearing of the ICS and in the VIBER one by one. This way we were able to determine when the various solutions result in a lack of funds, when it happens that an instant item stands in a settlement queue and what other transactions are deprived of liquidity as a result of the settlement of instant payments. We also calculated the possible liquidity need for the individual models. VIBER priority 4 applied currently for the settlement items of the ICS was used as the priority of prefunding in the prefunded models and as the priority of individual transactions in the instant model. This plays a role in the case of lack of funds, as in that case the items waiting for liquidity stand in the evolving settlement queue according to their priority. The VIBER uses priority values between 0 and 98, where the lower number means higher priority. Priorities from 0 to 3 are reserved for system operator's, central bank and authorities' items, and thus the use of priority 4 means a special role among the items other than the ones listed above.

The essence of the simulation principle of the **two-hour prefunded models** is that the moments of paying in and paying out of the ICS cycles included in the historical data series were removed from one another in time. In the period under review, the intraday module of the ICS worked with five cycles, and thus for some minutes every two hours during the business hours of the VIBER a portion of bank liquidity was transferred to the account of GIRO Ltd., which operates the ICS, and then, following clearing, this amount was distributed among the receiving banks. Almost all ICS participant institutions applied gross collateralization parameters; accordingly, at the end of the two-hour cycle the gross amount of the transfers initiated by their clients during the given cycle was carried over in one sum to the VIBER account of GIRO Ltd., and then, some minutes later they received the amounts sent for their clients during the two hours by the clients of other payment service providers. Upon carrying out the simulations, the moment of inpayment was brought two hours earlier, while the disbursement was left at the original point in time, so the bank account balances were modified as if inpayments had taken place earlier than in reality. As the cycles follow one another without a break, with this method we simulated as if the collateral of ICS transfers left the institution permanently, i.e. as if it funded the transfers in advance. Upon applying the various value limits, banks' inpayments were divided, and only the part below the value limit was timed for an earlier moment, while the remaining amounts were left at the original point in time, i.e. at the end of the two-hour cycles. By this we assumed that the items above the value limit remained in the ICS operating according to the current arrangement, i.e. the system worked in parallel with the instant system. Night shift in this model was simulated in a way that the first ICS inpayment of the day was timed to be before the first VIBER transaction of the day in every case, so we assumed that all the items settled in the first ICS cycle were submitted to the originator bank during the night operation, i.e. prior to the opening of the VIBER. As the end-of-day closing balances are carried over in an unchanged state by the VIBER to the beginning of the next day, then the balance changes that took place at night are carried over through central bank transactions upon the opening, by timing the ICS inpayments to be before the opening, we simulated prefunding taking place at the end of the previous day.

The simulation of the **ten-minute prefunded models** was carried out because we also wanted to present a cyclical mode that is as close to instant settlement as possible, and because less than ten-minute cycles are unlikely to be feasible without a major development of the VIBER. For this, we had to convert the data of the two-hour ICS cycles into ten-minute data, which we did by proportionately distributing the in- and outpayments due at the end of the two-hour cycles to the previous two hours, thus forming ten-minute periods. The operation of shorter periods is completely identical with those of longer ones: at the beginning of the cycle the bank segregates the collateral of the ICS transactions calculated for the given ten minutes, then, at the end of the cycle it receives the amounts sent to it in the given ten minutes, and deposits the collateral for the next cycle. The value limits were applied as described above, and night operation is also similar to the previous one, with the exception that upon the division of the first ICS cycle not the whole amount is allocated to the beginning of the day, but only 70 per cent of it. The underlying reason is that only this portion of the inpayment due at 8:30 falls to the time period preceding the opening of the VIBER.

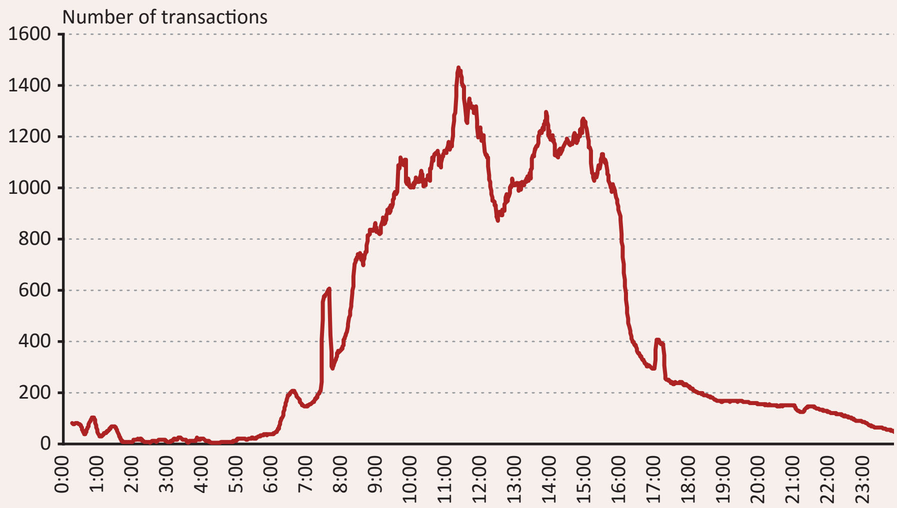
Upon the simulation of the **instant settlement model**, the two-hour cycles were decomposed into individual items by applying the intraday historical distribution of ICS transactions.

3.4 ANALYSIS OF THE DISTRIBUTION OF INDIVIDUAL TRANSACTIONS OVER TIME IN ORDER TO SUPPORT THE MODELLING

The time for sending in the transactions had to be determined for the whole period for the estimation of the ten-minute prefunded model and the calculation of the instant settlement model. The currently available statistics do not contain such a detailed breakdown, thus we had to rely on estimates when decomposing the individual cycles. Clearing house statistics contain the quantity and value of the main transaction modes with breakdown according to value limit, which allows a detailed decomposition of the transactions received from individual participants within the value limits under review to the various intraday cycles of the ICS.

In our analysis we combined the value limit statistics with the distribution of individual transactions over time to be able to prepare an estimation for individual transactions for conducting the simulation. We estimated the time of submitting low-value transactions on the basis of payment service providers' booking timestamps, and assumed that settlement is done by transactions at the moment of submittal by clients. Based on short periodic samples taken from the ten largest Hungarian banks' operation between 2012 and 2015, the examination of nearly eight million transactions allows a robust estimation of Hungarian clients' habits.

Chart 2
Intraday distribution of ICS transactions on the basis of the habits of the customers of ten large banks



The average daily distribution of households' and non-financial corporations' credit transfer turnover is well visible from the above chart. The values seen in individual parts of the day correspond to the intraday low-value activity. Night operation is simulated in the instant settlement model similarly to the prefunded models: the items that fall before the business hours upon the redistribution of the first ICS inpayment represent the night transfers. This methodological simplification is allowed here as well because only the instant transactions are settled at night in the model, and thus in terms of examining the liquidity it is also suitable if the night position is calculated for one point of time while keeping the order of settlement. In the instant settlement model, the value-limit cycle data were decomposed into individual items on the basis of the relevant percentiles of the distribution, and thus the distribution of the estimate over time is as close to the assumed chronology of transactions as possible. In the case of the ten-minute prefunded model these transactions were aggregated into ten-minute cycles.

3.5 QUANTIFICATION OF ADJUSTMENT COSTS

The simulator allows the analysis of 'what would have happened if?' scenarios, which show to what extent the developments in daily balances and settlement queues would have changed as a result of the application of the various models. In the course of the calculations we identified three cost elements that determine the cost of adjustment. In spite of the fact that in the case of most cost elements we prepared estimates on the basis of detailed data covering three years, as regards exact bank behaviour, significant uncertainty remains in connection with the data. Therefore, our analysis contains lower and upper estimates, which allow the identification of the adjustment costs.

Table 2
Cost elements taken into account in the calculations by operating models

Cost element	Operating model	Mode of estimation	Methodology
1. Interest cost of dissolving the queues jeopardising the operation	Prefunded and instant settlement models	Lower and upper estimates on the basis of the speed of adjustment	Time cost of supplying the liquidity necessary for dissolving the queues
2. Replacement cost of the liquidity leaving the interbank space	Prefunded model	Lower estimate	Liquidity cost of past cycles
		Upper estimate	Cost of liquidity demand conceivable on the basis of past behaviour according to confidence levels
	Instant settlement model	*Does not arise at system level as the liquidity needed for the operation of the model moves among the accounts of system participants, i.e. it does not leave the interbank space*	
3. Cost of restoring system stability	Prefunded and instant settlement models	Maintaining the level of system stability	Examination of the maximum utilisation of credit lines

3.5.1 Cost of dissolving the queues jeopardising the operation

The banking system has to provide additional collateral in any case for the amounts queuing with a priority number between 0 and 4 for the instant transfers with priority 4 to be performed at any time. It means that for completely smooth operation, at priorities 0, 1, 2, 3 and 4 no settlement queues may evolve upon initiating individual transfers necessary for the performance of instant payments or upon initiating prefunding. This statement is based on the already mentioned condition that individual transactions in the instant settlement model and transfers implementing prefunding in the prefunded model enter the VIBER with priority 4. We intended to estimate what size of cost the dissolving of the amounts queuing with a maximum priority 4 would entail in the case of the individual models, which we did by calculating the interest cost of additional liquidity. In the calculations, the cost of dissolving a queue is the interest cost of the additional liquidity required for the dissolving of the queue, i.e. the fee that a bank would pay for the interbank loan with which it can terminate the liquidity shortage. In practice it would mean that if a bank had a settlement queue that blocked the settlement of priority 0, 1, 2, 3 and 4 items, it would immediately take out an interbank loan in order to avoid the formation of the queue. The 0.9 per cent central bank base rate prevailing at the time of compiling this material was used in the calculations presented below.

Three methods were applied in calculating the total cost of the loan necessary for dissolving the queue. The cost of the first approach was determined according to the following formula:

$$Interest_1 = \frac{\sum_{queues} \left(queue\_amount_{individual}^{priority\,4} \times queue\_length_{second} \times rate_{seconds} \right)}{3}$$

In the case of interest cost type 1 we assumed that the banks concerned borrow an amount corresponding to the given queue only for the period when priority 0, 1, 2, 3 and 4 queue amounts subsist, and pay the relevant second-based interest rate. As the time series under review covers three years, the total value was divided by three in order to calculate the annual cost. This approach assumes that banks react to the evolving queues at once, and following the dissolving of the queue they immediately repay the temporarily borrowed forint liquidity to the lender. As in the interbank market there is no lending with such short-term, second-based interest calculation at present, this indicator primarily presents the theoretical lower bound of the cost of dissolving the queue.

The second approach is described by the formula below:

$$Interest_2 = \frac{\sum_{days} \sum_{banks} \left(queue\_amount_{daily\,max}^{priority\,4} \times rate_{daily} \right)}{3}$$

In this case we used the assumption that each bank increases its daily liquidity in line with its highest liquidity shortage on the given day. On various days banks face different liquidity situations, and this approach assumes that each day they obtain the highest additional liquidity need relevant for the given day in the interbank market. Therefore, compared to the previous version, this one assumes less active liquidity management, as the bank reacts to days and not to seconds by the involvement of additional collateral. Accordingly, the cost level is higher, as the banks concerned create reserves for those seconds as well when queues otherwise would not have evolved. For conversion into an annual basis, the amount was divided by three here as well.

The third approach is described as follows:

$$Interest_3 = \sum_{banks} \left(queue\_amount_{threeyears\,max}^{priority\,4} \times rate_{yearly} \right)$$

This approach assumes that the banks concerned permanently increase their liquidity by their highest liquidity shortage that occurs during the three years, i.e. they choose a liquidity management method that is even less active than the previous approach. Accordingly, the given bank's annual interest expenditure equals the annual interest cost of its historically highest, maximum priority 4 queue sum. As annual interest is used here, there is no need for annualising the resulting values.

3.5.2 Replacement cost of the liquidity leaving the interbank space

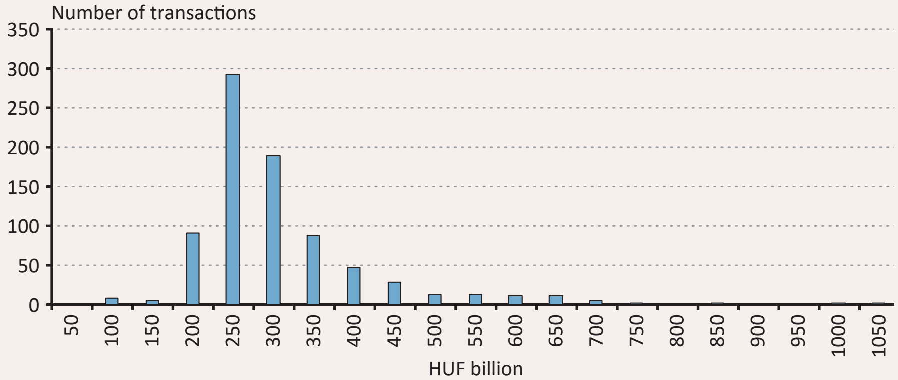
In the case of the prefunded operating logic, of the adjustment costs of the change-over to the instant payment system the cost of making up for the missing liquidity is one of the most significant costs. In the calculation we assume that the liquidity currently available in the system is an equilibrium value, and there is no regulatory constraint that would hinder liquidity management, and the participants set the value that is optimal for them.

Accordingly, each participant has an amount of liquidity that is necessary for its banking operations, taking account of its clients' habits and its own internal rules.

As a result, if the available liquidity declines due to changes in the system, the participants will make up for this liquidity, and they have to bear the relevant costs. In the simulation, this cost is the cost of making up for the segregated balance on the special clearing house account. For quantifying this cost we used the 0.9 per cent annual central bank base rate. The exact interest burden may be different from this depending on the actual operation, but we consider this simplification sufficient for a comparison in terms of magnitude. This approach determines the cost of the minimum capital necessary for the adjustment, and assumes that a liquid interbank market is available for the system participants, and they use this market for obtaining additional liquidity before using their other reserves.

Of course, the estimate prepared by past data assumes perfect foresight on the part of banks, but as the transfers into the ICS are initiated by clients, participants are unable to precisely determine the liquidity cost of a cycle in advance. Therefore, in our calculations we also examined how big amount the direct participants would segregate if they estimated the expected liquidity needs of the cycles on the basis of the three-year analysis period. The requirement of the greatest cycle occurring during the three years can be used as absolute upper bound. If, based on its experiences, an institution creates reserves for the greatest cycle, it acts in the most prudent manner possible. However, it is observed that this maximum is determined by outliers, which indicate one-off, infrequent events. Consequently, it is rational to use a high percentile, which excludes these outliers.

Chart 3
Distribution of the daily ICS turnover by value



Source: MNB statistics for the period between 05.2012 and 09.2015.

3.5.3 Cost of restoring system stability

The interest cost of obtaining the liquidity necessary for the restoration of the overall stability of the payment system was determined as the third cost element, and the maximum utilisation of credit lines was applied as stability indicator. This indicator shows the maximum utilisation of the intraday central bank loan granted with securities collateral broken down by system particpants and days. Taking the average of individual data, we calculated the sector-level credit limit utilisation for the whole analysis period, and examined whether the credit limit utilisation comes near to its theoretical maximum, i.e. 100 per cent, as a result of the liquidity stress caused by the individual models.

4 Queuing and the cost of dissolving the queues in the various models

When setting up the instant payment system and formulating the liquidity management solution, special attention must be paid to making the service continuously available at every participating institution. Therefore, the liquidity management solution has to be designed in a way to be able to maintain the low probability that the liquidity available for the system will not be sufficient and that the otherwise sufficient liquidity will not be usable for the settlement of instant payments because of the items queuing with a low priority number (between 0 and 4). The impacts of queuing on the conducting of instant payment transactions are different in the case of the two liquidity management solutions: due to the segregated liquidity, the prefunded system is less sensitive to queues than the system that applies instant settlement.

4.1 THE IMPACT OF QUEUING ON THE SERVICE LEVEL OF THE INSTANT PAYMENT SYSTEM

In the case of the **model based on instant settlement**, the participant's total VIBER liquidity is available for the settlement of the instant payment transactions, and this liquidity is typically much greater than the expected turnover. It is important, however, that in this operating model the processing of the instant payment transactions takes place together with the other transactions conducted in the VIBER. Accordingly, if an item whose priority number is identical with or lower than that of the instant payment transactions queues up in the VIBER, it would not be possible to settle the instant payment transactions received after the formation of the queue, even if the participant otherwise may have sufficient liquidity for the settlement of the instant transactions, as it does not have sufficient liquidity for the settlement of a higher-value item waiting in the front of the queue. Therefore, it needs to be examined what impact the queues with low priority number have on the availability of the instant payment service.

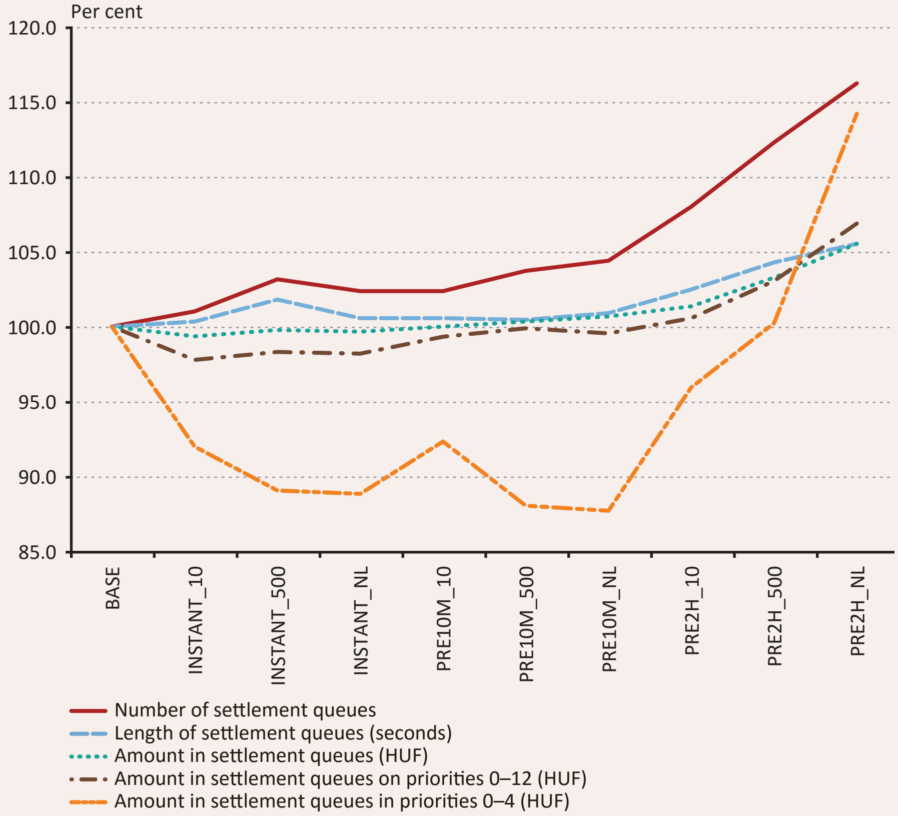
In connection with that, of the queues that occur at individual participants, those ones have to be taken into account where items with priority number 4 or lower are queuing up, i.e. the ones wherein there are transactions that may block the settlement of priority 4 instant transactions. It can be established that in the three-year period under review, on average, there were 23 hours per month when items with low priority number were queuing at a participant, thus creating the opportunity that it would not have been possible to settle instant payment transactions. It is important, however, that queues affect the individual participants to different degrees, and thus queues mainly occur at participants that have a lower weight in low-value payments. 87.5 per cent of the queuing time is related to eight institutions that submitted a total 5 per cent of the transactions into the settlement system. Accordingly, for the proper interpretability of the results it is necessary to weight the queuing occurring at the individual participants with their role played in low-value transactions. According to the queuing values weighted on the basis of the number of the transactions sent by the participants, settlement queues resulting from shortage of liquidity would cause 25.2 minutes of interruption per month on average in instant payments. At system level it corresponds to a 99.94 per cent availability. In connection with that, however, it has to be taken into account that by ensuring additional liquidity, these queues could be avoided at low costs.

In contrast with the previous model, the **prefunded model** is less sensitive to queuing, as the segregated liquidity can only be used for the instant payment system, and thus following the settlement of the prefunding transaction, the queues in the VIBER become irrelevant. Accordingly, in the prefunded model the settlement queues may primarily have a perceptible effect in those moments when the given participant would increase the degree of liquidity segregated for prefunding. As the degree of prefunding can continuously be changed during the business hours of the VIBER, and participants would probably fund the estimated turnover of several settlement cycles in advance, it is relatively unlikely that the participant queues up at the time of liquidity segregation for the instant system, and in the meantime its funds segregated earlier also run out. However, with the prefunding of a longer period, the liquidity needs of the instant payment system may multiply, which may add to the number of queuing in the VIBER due to the missing liquidity.

4.2 QUEUING INDICATORS

The chart below depicts the most important **queuing indicators** of the individual models, and everywhere the corresponding values of the baseline scenario were considered as 100 per cent. Accordingly, the chart shows to what extent the queuing indicators of the individual models deviate from the historical baseline scenario as an average of the three years under review.

Chart 4
Queuing indicators in individual settlement models of instant payment



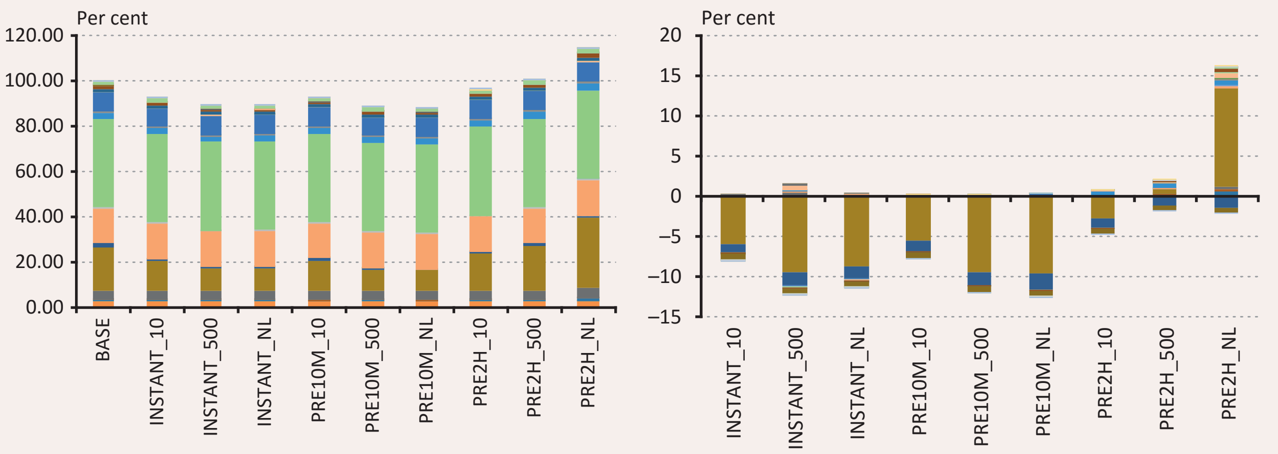
Based on the **number of settlement queues**, a clear order can be drawn starting from the model with the lowest liquidity need to the one with the highest liquidity requirement. It is clearly visible that while in the instant settlement model there are only 2 per cent more settlement queues, the limitless two-hour prefunding results in 16 per cent more queues than the baseline scenario. Numerically it means that during the three years under review 3729 queues would have evolved in the version that requires the highest liquidity instead of the 3208 queues of the baseline scenario. At the same time it is to be noted that liquidity issues are primarily affected by the length of the queues and the total value of the queuing transactions and not by the number of queues. The number of queues is not suitable for the comparison of the two basic models either, as the instant settlement one contains far more transactions.

The **total length of settlement queues** shows how many seconds were in the three years under review when a bank participant was temporarily unable to settle payments in the VIBER due to lack of liquidity. A rise is observed here as well in the direction of the models that determine an increasingly high collateral requirement, which has a correlation with the fact that the number of queues increases as the cycle number of prefunding is reduced and the transaction value limit is raised. The comparison of the length and number of queues also reveals that the average length of new queues is shorter than that of the original ones.

The indicators shown as **amount in settlement queues** (queue sums) present how big amounts in total weighted with the length of the queues queued up at the individual priority levels during the three years. Of the priority values appearing in the queue sum total, i.e. of the values between 0 and 98, 12 is the smallest commercial bank priority number that can be chosen, whereas 4 is the priority level of the ICS transactions. The queue sums were determined by weighting, i.e. the sums of individual queues were multiplied by the length of the given queue, then the products of multiplication were added up, and thus the shorter but higher-sum queues and the longer but lower-sum queues became comparable. The queue sum total means the maximum of the settlement queues, i.e. the size of the total forint amount that could not be settled immediately in the VIBER. The queue sum determined according to priority 12 shows the sum of the items queuing up with priority number 12 at most, i.e. the value of the transactions queuing with priorities between 13 and 98 was deducted from the queue sum total. Similarly, the queue sum determined according to priority 4 does not contain the items with priorities between 5 and 98. A rise in the queue sum total means that the queuing forint amount increases with the models' increasing liquidity needs, which is correlated with the increase in the number and length of queues. The change in the amounts queuing at a priority not exceeding 12 implies that the queues evolving at priority numbers below 12 have an impact on the transactions queuing at priority number 12, which is corroborated by the developments in the values evolving at priorities between 0 and 4.

It is worth emphasising that with instant settlement the total value of the queuing transactions slightly declines compared to the baseline scenario, i.e. existing queues become dissolved as a result of the instant payments, instead of new queues coming into being. The main underlying reason is that service providers' having to transfer the amounts earlier is not the only consequence of instant settlement; the amounts transferred to service providers are also received earlier by them. In addition, the above chart shows that with instant settlement the queue sum total slightly declines if no value limit is applied instead of a HUF 500 million value limit. This feature, which is significantly different from the other models, stems from the fact that the positive impact of instant settlement (beneficiaries receive money sooner) and its negative impact (originators have to transfer the amount sooner) are realised to different extents. Based on individual data, service providers can be divided into two groups: system participants with ample and tight liquidity. Earlier receipt of transactions does not result in a positive effect for participants with high liquidity levels, and the negative impact of earlier settlement is not perceived either. In contrast, for participants that are short of liquidity, several hours earlier settlements may cause serious problems, and significant relief if they receive the amounts addressed to them earlier. As a result of these contrasting effects, in the case of instant settlement the liquidity impact may be more favourable if no value limit is applied. This, however, significantly depends on market participants' practices and on the structure of the market, because in our case – as we will see below – the behaviour of only a few banks determines the developments in queuing indicators.

Chart 5
The total amount queuing at priorities between 0 and 4, and difference decomposition compared to the baseline scenario according to the banks affected by the queuing

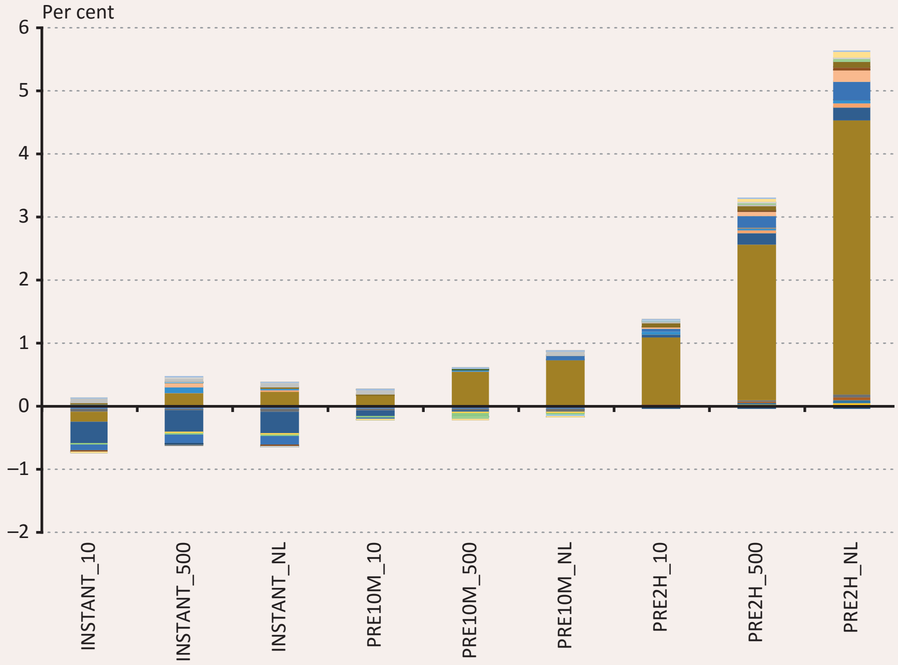


Based on Chart 5 it can clearly be concluded that the majority of queues with priorities between 0 and 4 belong to 4–5 institutions; moreover, without exception, they are banks that have corporate portfolios. The difference decomposition shows that the downturn seen at aggregate level is practically related to one institution. In the case of this participant, in terms of the queues, significant improvement would be achieved with all the operating models that allow earlier crediting, and only significant prefunding would impair the current state. However, this behaviour can be linked only to this one institution, in spite of the fact that the considerable portion of high-priority queues is realised by others. The various models cause much smaller changes for the other corporate banks that have major amounts queuing up. The underlying reason is that the majority of high-priority items are monetary transactions, with significantly higher amounts. Therefore, this feature cannot be considered as a characteristic of the system as a whole. In terms of the number of institutions, Chart 7 reveals that the models with higher funding requirements result in an unfavourable effect, i.e. an increase in the queuing amounts for an increasing number of institutions, but at the same time the magnitude of the changes in value can in fact be measured in tenths of a per cent. Consequently, contrary to theoretical expectations, no substantial adjustment at all can be expected of the majority of system participants.

The queues containing items with priorities between 0 and 4 are important in terms of the operation of the system, because if they exist, the transfers are not settled; nevertheless, the total queuing amount is also an important indicator for the participants. Based on Chart 6 it can clearly be established that considering all the queues only the instant settlement model is able to reduce the queued amount. The ten-minute one can reduce the queues only to a negligible degree at some participants, while the two-hour one cannot do it at all, in line with the theory. In the instant settlement and ten-minute cycle operating models the participants receive the amounts transferred to them a little bit sooner, but in the two-hour model they receive the transfers exactly at the same time as originally, although they have to pay earlier. Accordingly, regarding the queue sum total even theoretically they cannot get into a better position.

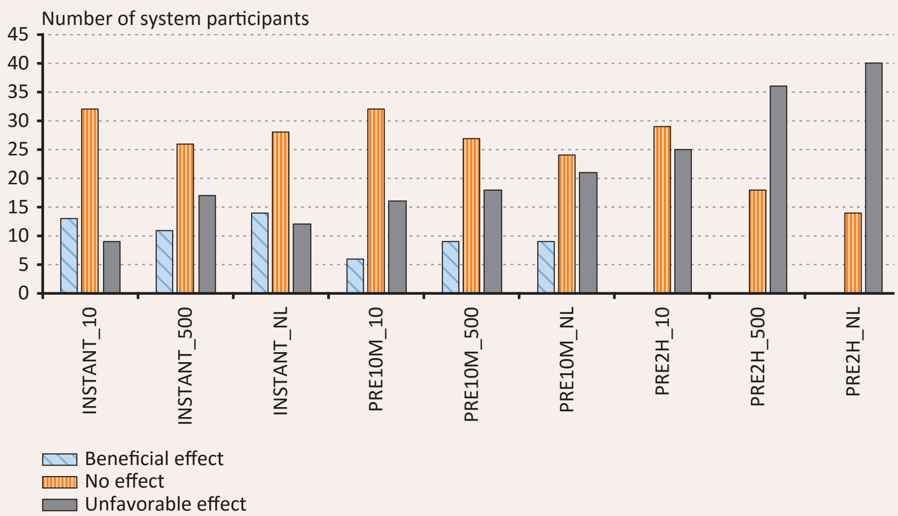
Based on the above, our findings concerning the queues with priorities between 0 and 4 can be made more precise, as there is no major decline in the queues for most of the participants, but the queues become rearranged among the priorities. As a result of bringing the inpayment time forward, the ones with high priority can be settled, but they take away the liquidity from the items that have originally been settled successfully. This impact can be seen especially clearly in the case of the institution already referred to above, but based on Chart 7 it can be concluded that similar developments take place at most of the institutions, although to a smaller degree. Nevertheless, it is still true that excluding the unique behaviour, at the majority of the institutions the queue sum total increases by only a few tenths of a per cent in the various models; therefore, no major adjustment is necessary.

Chart 6
The difference decomposition of the total queuing amount compared to the baseline scenario, according to the banks affected by the queuing



The queue sum total also reveals that there is a significant difference in the number of the institutions affected across the various models. Although in the case of the majority of the institutions the impact is negligible at the aggregate level (the average continues to be influenced by the unique behaviour of one institution), it does not mean that marginally they are not affected negatively by a long prefunded cycle. However, short-term prefunding, and the ensuing frequent adjustment, as well as instant settlement already have a more differentiated impact. For some institutions it is favourable, for others it is unfavourable. This impact correlates with the breakdowns by net payers and beneficiaries as well as participants with ample and tight liquidity.

Chart 7
The impact of operating models on the direct VIBER participants



An operating model has a favourable effect on an institution if the sum of its queuing items declines compared to the baseline scenario, and the effect is unfavourable if the sum increases.

Instant settlement is advantageous for net beneficiary participants with tight liquidity, because the amounts that arrive earlier dissolve their queuing items. In contrast, the change is unfavourable for net payer participants with tight liquidity, because the earlier withdrawal of funds results in further liquidity shortage. Change in the clearing model does not have an impact on participants that have ample liquidity; they do not perceive its negative impact, while the positive one cannot be realised.

When applying **ten-minute cycles**, the aforementioned positive effect appears only to a lower degree because in a prefunded system the settlement is delayed. System participants make the collateral available for the clearing house sooner, but the incoming transactions are not immediately credited to their central bank accounts. In this case, an increase of the value limit clearly impairs the queuing indicators, adding to the queue amounts.

In the case of the **two-hour prefunded models** it is clearly seen that switching over to a longer period of prefunding increases the probability that a transaction will have to queue up, although the total impact may be reduced by applying a value limit. The queue sum total is the highest in the models working with the two-hour cycles, but with a HUF 10 million value limit the sum of the amounts with priority numbers up to 4 is not more than in the baseline scenario. It is observed that with low value limits the two-hour cyclical model is worse than the unlimited ten-minute cyclical model. It shows that the prefunded time period – or the adjustment time of the amount on the participants' clearing house accounts – has a greater impact on liquidity than the exclusion of high-value transactions from the system.

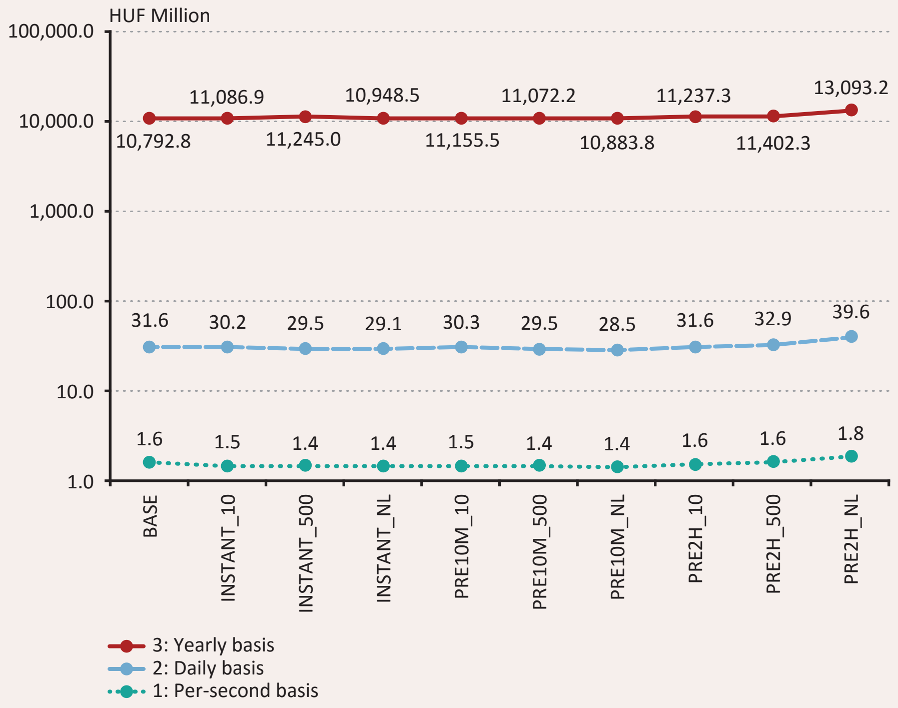
In the next point we present at what additional cost at banking sector level the termination of queues with priority numbers between 0 and 4 would be possible.

4.3 ADDITIONAL LIQUIDITY COST OF DISSOLVING THE QUEUES WITH LOW PRIORITY NUMBERS

The results of the three interest cost approaches presented in the methodological part are shown in the chart below in respect of the individual instant payment models. Depicted on a logarithmic scale, it is well visible that there are significant differences between the individual approaches. Assuming the most active liquidity management possible, annual interest costs amount to around HUF 1.6 million. In a less active case, annual costs are around HUF 30 million, and the interest cost of permanent liquidity increase exceeds HUF 10 billion in every case. As the activity of liquidity management depends on the given bank's discretion, individual bank costs depend on the mode chosen. The costs shown in the chart relate to the sector as a whole. However, as mentioned before as well, they concern a narrow group of banks. Nearly 80 per cent of the settlement queues are related to six institutions, i.e. the cost of dissolving the low priority number queues has to be primarily borne by these banks. Taking also into account that these institutions are less active in the retail market, it can be established that for the large retail banks the additional liquidity need of the settlement queues related to instant payments probably would not represent a significant interest cost.

In the methodological part it was mentioned that the assumption applied upon the calculation of the interest costs had been that instead of using their other liquidity reserves, for example their eligible securities for credit limit increasing, banks always satisfy their liquidity needs for dissolving the settlement queues from the interbank market. This can be considered a strict condition, as by using the eligible securities in the balance sheet of local banks, the banking sector's liquidity could have been more than doubled within a short period of time in November 2015. Accordingly, prior to interbank borrowing, raising the central bank credit limit as a liquidity increasing tool is available for the majority of banks. Moreover, it does not entail any costs, and it is still possible to realise a yield on the securities holdings pledged for raising the credit limit. Therefore, the values presented here presumably exceed the actual costs. According to our related estimations, in the case of pledging the total available eligible securities holdings, the interest cost of the additional liquidity necessary for the avoidance of high priority queues would be halved.

Chart 8
Yearly interest cost of the additional liquidity necessary for the avoidance of queues with priorities 0-4



5 Cost of the prefunded amount

In the first chapter we saw that the cost of dissolving the queues is not really high. It does not cause any serious problem at system level in the instant settlement model either, while in the prefunded model only the dissolving of the queues existing in the moment of the prefund have to be funded, which can be considered a negligible cost. However, in the prefunded operating models the segregation of the collateral on a clearing house account may entail significant costs at system level as well.

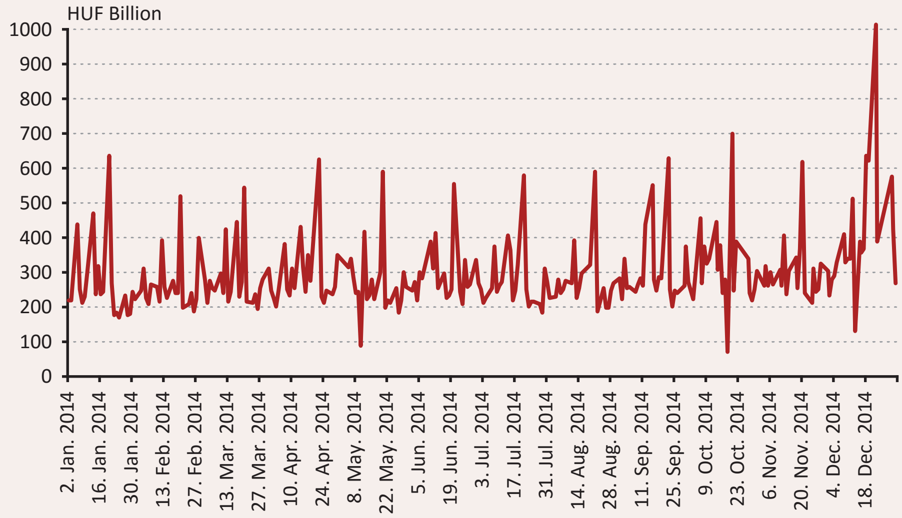
In this chapter we examine the cost of capital necessary for the operation of the prefunded models. Estimating the segregated collateral is not a simple task, and it entails significant uncertainties as well. Therefore, only lower and upper bounds were given for it, as described in the methodological part. Based on the data for the period between July 2012 and September 2015, we calculated the approximate size of the amount that service providers would have segregated if they had acted in a prudent manner, and had tried to determine the level of collateral with a high (99 per cent) level of confidence.

5.1 LIQUIDITY DEMAND AND THE FACTORS THAT AFFECT IT

Estimating the collateral mainly requires a knowledge of the bank's clientele. Higher-value transactions, which account for a major part of the total ICS turnover, are typically related to corporate clients, and in many cases the transactions are known by the service providers days in advance. Exclusion of these transactions would provide a more precise picture of the amount that is actually a random, external shock faced by banks. This unforeseeable turnover is what they have to keep provisions for.

The simplest solution to the problem is the maximum of the turnover values of the past period, as service providers may make their liquidity safe by getting prepared for the highest turnover observed to date. However, this solution would entail significant costs. Moreover, a major part of them can be considered unnecessary. Chart 3 showed that the distribution of turnover values is strongly extending to the right, i.e. extremely high values occur with low frequency. At the same time, general provisioning corresponding to the extreme values cannot be the objective of the system; therefore, it is justified to use the high percentiles in the calculations.

Chart 9
Fluctuation of intraday retail payments in 2014



Nevertheless, the collateralization parameter can be made even more precise, thus reducing the cost of liquidity. It can be observed in Chart 9 that a considerable portion of the turnover is seasonal fluctuation, recurring in a monthly breakdown. Outliers are observed on the twelfth and twentieth day of each month and at the end of the year. The twelfth and twentieth can clearly be identified as the dates of paying the personal income tax (PIT) and the value added tax (VAT), respectively, to the State Treasury. Examining the time series more precisely results in the following items that are easy to exclude:

Table 3
Seasonal turnover factors

Period	Type
12th of each month	Payment of PIT advance
20th of each month	VAT payment
Around the 5th of each month	Wage payments and household payments early in the month
15 March and 15 September	Payment of local taxes

For more precise calculation, the impact of these days have to be excluded during the calculation of the percentile, as these days can be planned. It is not justified for the service providers to segregate a large amount of collateral because of them for the whole month, as it would be used only on the relevant days.

As it was mentioned several times in the first chapter, prefunded models result in the exclusion of a portion of the sector's total liquidity from interbank payments, and depending on the deposit method used, they may result in various degrees of interest loss for credit institutions. Therefore, theoretically, the cash collateral may be placed on a clearing house account or central bank subaccount as well, but there may be differences between these two solutions in terms of the interest paid on the balance.

Chart 10
Average amounts permanently segregated for prefunding as a proportion of the average sectoral liquidity

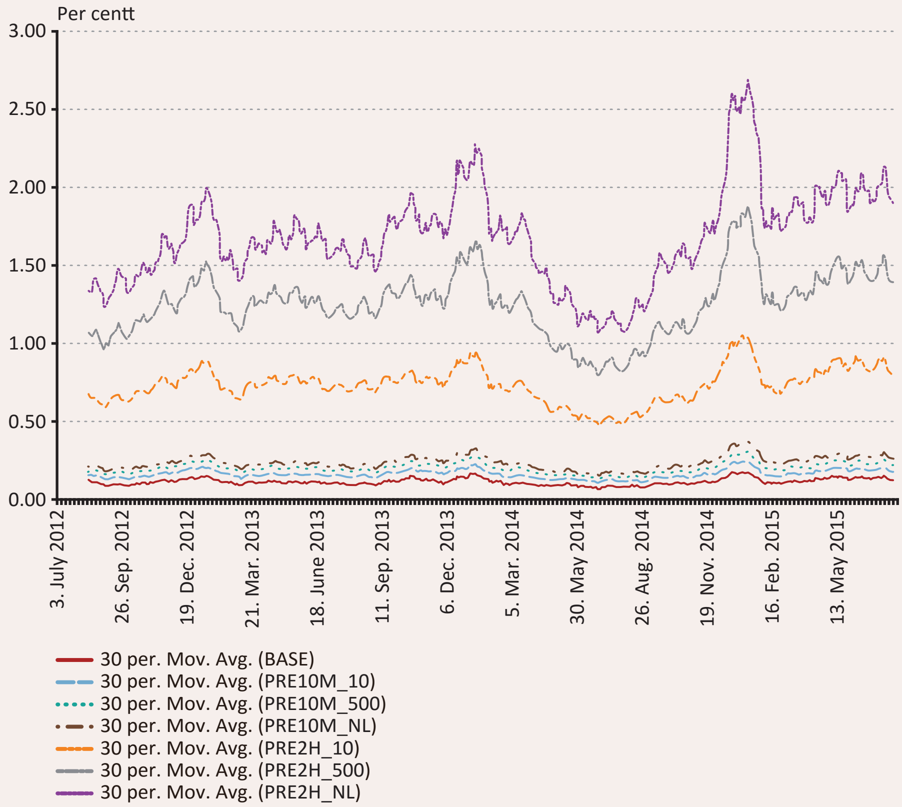
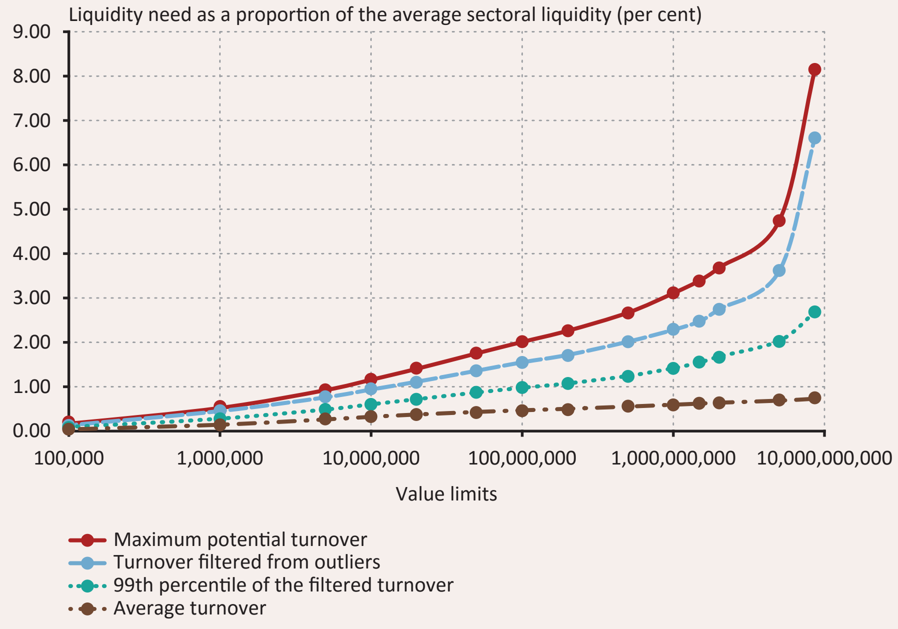


Chart 10 shows the 30-day moving average of the prefunded amounts for the individual models, as the average of the average bank liquidity on the given day, i.e. as the average of the sum of the account balances and intraday credit limits. The lowest level line represents the baseline scenario, i.e. it shows that in the period under review there was an average amount of HUF 3 billion on the account of the clearing house because of the intraday settlement of the ICS, and it corresponded to 0.1 per cent of bank liquidity. The blue level lines show the impact of the 10-minute prefund complemented with the value limits chosen, while the green level lines depict the impact achieved with the two-hour cycles. It is clear that longer prefunded cycles significantly increase the value of the interbank liquidity taken away, but the application of value limits may reduce the need for liquidity.

It is seen from the chart that the limitless two-hour prefund deprived the banking sector of approximately 1.6 per cent of its liquidity in the period under review, while the ten-minute model that applies a limit of HUF 10 million took 0.2 per cent, i.e. only 0.1 percentage point more than in the baseline scenario. All this is closely correlated with the fact that prefunded models with increasing liquidity demand result in a rise in the number of settlement queues in the VIBER.

The impact of applying turnover and value limits is worth mentioning here, namely in order to corroborate our statement that the highest turnovers are related to one-off events and tax payment days. The ICS turnover in the chart below was adjusted for the impact of outlier days, and is depicted with value limits.

Chart 11
Liquidity demand of a one-hour cycle with various value limits and collateralization parameters



Two impacts are shown in the above chart: it can be seen that both the exclusion of the days with extreme turnover and the application of value limits reduce the liquidity demand of the instant payment system. The latter impact will be analysed in detail later; here attention is called to the role of the days with outlier turnovers. If the collateral requirement of a prefunded system takes into account that it is necessary to apply a high collateralization parameter only on certain days, it may as well determine a lower liquidity requirement for average days. Accordingly, in the case of prefunded deferred settlement systems it is worth determining the collateralization parameter for each day, as it is necessary to deposit high amounts in advance only on high-turnover days. High-turnover days are mainly tax days, which can be known from the tax schedule in advance, so it is relatively easy to take account of this aspect.

5.2 REASON FOR AND IMPACT OF USING VALUE LIMITS

Although theoretically the ICS is the system of clearing low-value customer items, some banks use it for the settlement of high-amount transfers as well. It means that from time to time transactions amounting to more than HUF 5 billion occur in the system, although these transactions considerably increase the liquidity demand of the settlement. As the number of high-value transactions is minimal, using adequate value limits and excluding some hundred items a day, it is already possible to significantly reduce the liquidity need of the instant payment system. This has no material impact on the primary objective of setting up the system, as low-amount household and corporate transactions remain processable. Based on the ICS data of the period between July 2012 and August 2015, we determined the debit values of the greatest and the average one-hour ICS cycles, and compared them to the banking sector's average liquidity in November 2015, i.e. to the sum of banks' average account balance and credit limit. By indicating various value limits we present how the liquidity demand of the two types of ICS cycles change compared to the individual liquidity holdings, and we also present the number of transactions that exceed the value limit.

Table 4
The impact of using value limits on the liquidity demand of the instant payment system

Transaction value limits	Ratio of the greatest potential one-hour ICS cycle to the average liquidity	Ratio of the average one-hour ICS cycle to the average liquidity	Average daily number of transactions above the value limit
HUF 100,000	0.15%	0.03%	147,163
HUF 1,000,000	0.52%	0.14%	25,057
HUF 5,000,000	0.92%	0.26%	5,541
HUF 10,000,000	**1.15%**	**0.32%**	**2,553**
HUF 20,000,000	1.40%	0.37%	1,182
HUF 50,000,000	1.75%	0.43%	431
HUF 100,000,000	2.01%	0.46%	212
HUF 200,000,000	2.26%	0.50%	107
HUF 500,000,000	**2.67%**	**0.55%**	**42**
HUF 1,000,000,000	3.11%	0.59%	20
HUF 1,500,000,000	3.40%	0.62%	12
HUF 2,000,000,000	3.68%	0.64%	8
HUF 5,000,000,000	4.74%	0.68%	2
Without value limit	**8.14%**	**0.73%**	**629,870**

It is well visible that the application of a transaction value limit allows the reduction of the bank liquidity demand of the instant payment system, and this tool can be applied in the case of both the deferred and instant settlement systems.

5.3 COST CALCULATION

In parallel with the costs of dissolving the queues, the system's adjustment cost can be calculated for the prefunded operating model as well. It is assumed that no interest is paid on the segregated amount serving as collateral, and its replacement cost for the participants is the interest cost of an interbank loan of identical amount. The central bank base rate prevailing at the time of writing this study (0.9 per cent) was used for determining the interest cost. We present the liquidity demand and annual cost of a model operating with one-hour prefunded cycles in the table below. We apply one-hour cycles in this case due to this being the most suitable for the current operation of the ICS.

Table 5
Liquidity demand and annual cost of a model operating with one-hour prefunded cycles
(HUF billion)

	Maximum	Maximum of average days	99th percentile of average days	Average turnover
Liquidity demand				
HUF 10 million value limit	33.48	27.09	17.39	9.22
HUF 500 million value limit	77.43	58.42	36.01	15.92
Without value limit	236.32	191.73	77.62	21.07
Annual interest cost				
HUF 10 million value limit	0.30	0.24	0.16	0.08
HUF 500 million value limit	0.70	0.53	0.32	0.14
Without value limit	2.13	1.73	0.70	0.19

The values shown in the ‘maximum’ column are the results of an extremely risk-averse upper estimate. Reserving a higher amount than that as collateral is senseless from an economic point of view, as in most cases it is necessary to set aside such an amount only for the tax days, for a short time. The choice between the maximum and a percentile of the average days adjusted for the seasonal effects indicated in Table 3 already depends on the level at which the participants are able to forecast their turnover. If the extreme values are connected to expected items, such as high-value corporate transactions, the use of high percentiles is a reasonable assumption. In our analysis, this level is considered as reasonable upper bound, which allows adequately reliable operation. The values shown in the ‘average turnover’ column are the results of a lower estimate, which assumes that participants foresee their clients’ turnover exactly, and are able to determine the reserves precisely.

The above analysis also reveals that the collateral required for the prefunding of the ICS turnover does not account for a significant part of banks’ average liquidity of HUF 2,000 billion and potential liquidity of HUF 5,400 billion, measured in November 2015. Accordingly, even the most extreme estimates do not result in excessive costs, while more realistic assumptions require an amount of liquidity that can completely be handled at sector level. Projected to the 350 million transactions a year, depending on value limits, the costs amount to HUF 1–2 per transaction.

5.4 BANK-LEVEL DIFFERENCES

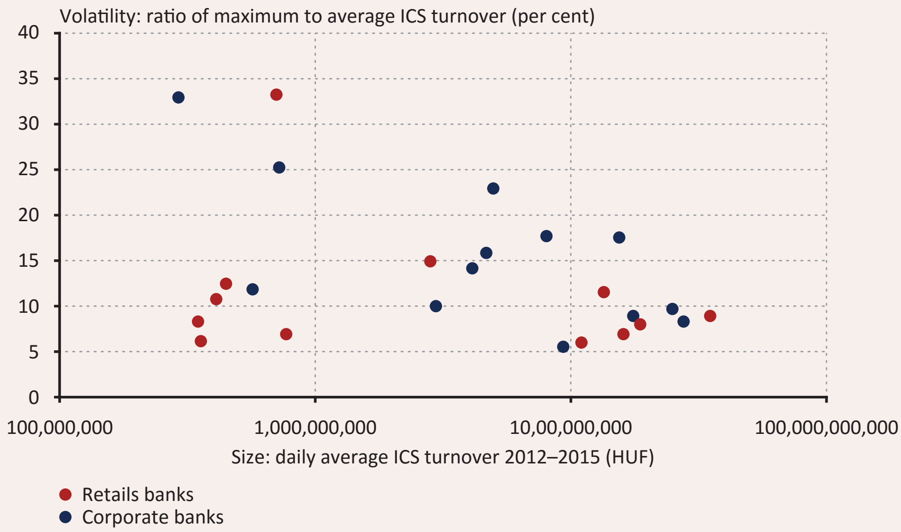
To date, the results of our analysis concerning the prefunded cash collateral are completely aggregated, i.e. we only examined the sector-level indicators. However, as we have emphasised in the case of the queuing indicators as well, broken down by individual actors, significant deviations from the average are conceivable.

Payments fundamentally constitute a complex process, which may be considered a completely random process at aggregate level. However, in view of the extremely high number of transactions, the observed distributions can be well approximated by mathematical distributions. It can be established that both the VIBER and ICS turnovers as well as households’ purchases by cash and card follow a Pareto distribution. The Pareto distribution is a combination of the power of a number and lognormal distribution. Due to its lognormality, the probability of the occurrence of high values is relatively high, which justifies the percentile calculation used above. As a result of this characteristic, the shape of the distribution influences the collateralization parameter significantly.

Based on preliminary expectations, the main difference is between corporate and retail banks. In the case of retail banks, low-value transactions account for a major part of the turnover. Although extremely high values may occur, it is coupled with a relatively low variance. In contrast, corporate banks have few clients, which initiate high-value transactions. As a result, the volatility of the turnover increases considerably, and according to our assumptions the account-holding bank is compelled to choose a higher collateralization parameter.

The various types of banks were separated on the basis of their empirical turnover figures. For our calculations, we used the ICS turnover data collected with the MNB's regular data requests. The index used for separation shows to what extent the service provider's weight calculated on the basis of the turnover deviates from its weight calculated according to the number of clients. If the value of the indicator is lower than one, the bank is mostly a retail bank. If it is greater than one, the bank can be considered as one with a mainly corporate portfolio. Using this grouping, the next chart shows the volatility of the ICS turnover performed by the VIBER participants.

Chart 12
Distribution of twenty-five VIBER participants on the basis of the daily average ICS turnover (HUF) as well as on the basis of the ratio of the maximum to the average ICS turnover (per cent)



The vertical axis of Chart 12 shows the ratio of individual VIBER participants' highest historical turnover to their average turnover, and the horizontal axis shows the size of the participants according to their daily average ICS turnover. It can clearly be established that volatility declines on average with an increase in the service provider's size; larger players have more stable turnover. Moreover, it is also seen that corporate banks may expect significantly greater outliers compared to retail banks. This observation is in line with our preliminary expectations, and the analysis of the relative dispersion also confirms this conclusion. Retail banks' relative dispersion is typically between 0.5 and 1, while in the case of low-turnover participants and corporate banks it may exceed 1 significantly, even many times over.

The results may well be explained with the number of clients, in spite of the fact that no clear-cut comparison of the various types of clients can be made. As it was mentioned above, the dispersion of the transactions basically follows a Pareto distribution, and the institution's turnover in one cycle is the sum of probability variables of such distribution. According to the central limit distribution theorem, the sum of independent variables is close to normal distribution – and customer transactions can be considered independent of one another –, and thus the relative dispersion, i.e. the probability of extreme values declines continuously until a certain level is reached. This process can clearly be detected in their payment transactions. If a large retail bank is examined, the behaviour of individual clients has only negligible impact on the sum total; therefore, the turnover amount of an average ICS cycle will be relatively stable and predictable. In contrast, extremely high-value transfers of a client of a small retail bank or of a corporate bank significantly move the sum of its ICS cycles, and the above stabilisation effect will be smaller. However, the quantification of the exact impact is unclear, as although in the retail business the number of accounts is a good approximation of this process, there are significant differences among corporate banks in terms of the sizes of their clients.

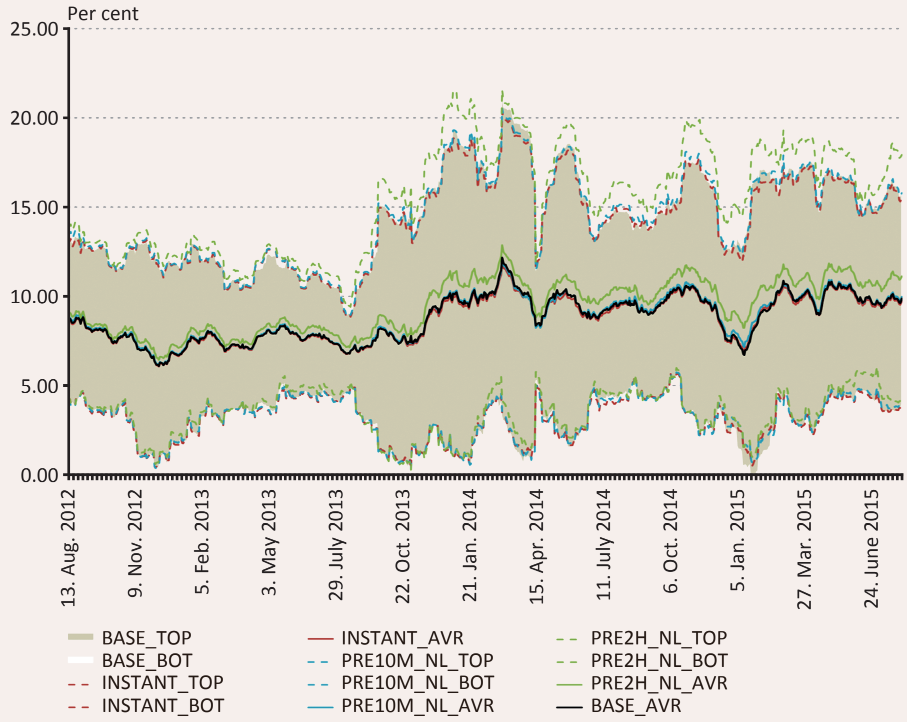
Accordingly, in terms of ratios, the prefunded operating model represents a greater burden on corporate banks and low-turnover participants. Smaller players have few clients; therefore, their turnover is volatile, and the behaviour of one client can significantly move the average. And as their turnover is less predictable, they have to provide relatively more collateral for the settlement, which they can do by undertaking additional costs. In contrast, retail banks face relatively lower collateral needs.

6 Credit limit utilisation and the stability of the system

The liquidity demand of the individual basic models and the stability of the system are presented below with the help of a special liquidity indicator, the maximum utilisation of intraday credit lines (MICL). For a given settlement day, the MICL shows the maximum percentage of the utilisation by an institution of the intraday credit line provided to it by the central bank. VIBER participants can use their respective intraday credit lines after depleting their central bank account balance. Accordingly, the 0 per cent MICL means that the bank was able to conduct its daily VIBER turnover without using its intraday credit line, whereas the 100 per cent value shows that there was a moment within the settlement day when the bank used all the liquidity available, i.e. both its account balance and its credit line. It is to be noted that the MICL may vary significantly across market participants, as the ones with a high balance sheet total typically hold a high VIBER balance, and thus in their case the utilisation of the credit line is less frequent. Upon the simulation of the individual settlement models of the instant payment system, the MICL values were also determined in every case, and our basic finding is that there would have been hardly any change in the baseline scenario of the MICL when applying the individual instant payment models. The sectoral average indicator historically fluctuated around 10 per cent, and the liquidity stress represented by the instant payment would have resulted in a perceptible increase only in the case of the scenario that requires the highest liquidity.

The chart below depicts baseline scenarios without value limits, i.e. the instant settlement, the ten-minute deferred and the two-hour deferred models as a function of the MICL, noting that applying a value limit would also result in similar MICL paths. The chart shows the thirty-day moving average of the average MICL over

Chart 13
Maximum utilisation of intraday credit lines in the basic models of the instant payment system



the analysis period, with a 97.5 per cent confidence interval. It is shown that the baseline scenario fluctuated around 10 per cent, while the lower and upper confidence levels moved between 0 and 5 per cent, and 10 and 20 per cent, respectively.

Based on the simulations it can be concluded that the basic models of instant payment only slightly change the maximum utilisation of credit lines. Of the three models, only the two-hour deferred settlement model results in a perceptible, one percentage point increase in the average value of the maximum credit line utilisation; the instant settlement and the ten-minute deferred models would not have had a major influence on the changes in the indicator. As the 100 per cent MICL means the complete utilisation of the sector's short-term liquidity reserves, it can be established that over the analysis period, at sector level, none of the basic implementation modes of the instant payment system would have caused any liquidity stress. Even in the most extreme point of time of the three years the upper bound of the 97.5 per cent confidence interval increases only up to 21.5 per cent, while the average MICL rises to 13 per cent at most. Accordingly, the impact on credit line utilisation is not significant in any of the basic models. At the same time, it needs to be stressed that the sectoral indicator averages the individual bank indicators, i.e. it does not depict the stresses manifested in them, while at individual banks' level, MICL values that significantly deviate from the average may occur. Nevertheless, it can be concluded that the sector's liquidity supply between July 2012 and August 2015 would have been sufficient for operating an instant payment system, while the dissolving of the liquidity stresses appearing at individual banks' level could have been solved through interbank lending, as the sectoral value of the MICL would never have reached 100 per cent. Accordingly, with adequate interbank cooperation, the instant payment system could have functioned in a stable manner over the analysis period.

As the cost of restoring system stability, the cost of reducing the maximum utilisation of credit lines was mentioned. We used this term because the sectoral MICL provides quantifiable information on the liquidity situation of the system as a whole. As our analysis revealed, instant payment models do not have a material impact on the trend of the MICL, i.e. in this respect the system remains stable even in the case of the introduction of the model that requires the highest amount of liquidity. As the stressed MICL paths do not even come close to 100 per cent, it can be stated that at system level it would not be necessary to raise additional liquidity; therefore, it is not worth taking account of its interest cost either. At the same time, all this is based on the assumption that a liquid interbank market is available for market participants, and using this market, the liquidity, which is sufficient at system level, can efficiently be redistributed in order to manage the liquidity stresses that occur at individual levels.

7 Summary

Our study was seeking an answer for the question what impact the various operating models of instant payment systems would have on the liquidity management of direct VIBER participants. At theoretical level, two main operating models can be distinguished: the system that implements instant settlement in central bank money and the system that applies prefunding-based instant clearing with cyclical settlement. In our analysis we examined the liquidity demand of these two systems, with special focus on the liquidity demand reducing effect of the use of value limits.

Firstly we presented that the VIBER and the ICS as payment systems can be considered as ones having average turnovers in European comparison, i.e. they are not much different from the infrastructures of similar countries. Accordingly, although to a limited extent, our findings may be generalised for other countries as well. For our analysis we set up a simulator in which we were able to process all the transactions that the VIBER and the ICS settled between July 2012 and August 2015, modelling the operation of the two main systems in detail. Based on the period processed and the size of the transactions concerned, our findings may be considered robust. In addition, we determined in detail how it is possible to quantify and express in forints the three main cost elements identified by us.

The additional liquidity requirement of dissolving the settlement queues that jeopardise the operation were taken into account as the first cost element. In connection with the queuing indicators it can clearly be established that the instant settlement models and the models that apply a short prefunded cycle have different impacts on system participants. In contrast, the models working with a long prefunded cycle have an unfavourable impact on all participants. However, at the level of individual institutions it can be concluded that the majority of the current queues belong to 4–5 corporate banks, and the impact of the various operating models is practically related to one institution. The introduction of the various instant models practically has no effect on the settlement queues of most institutions, which stems from the favourable general liquidity situation of the sector. Finally, based on various calculation methods, we presented that the cost of dissolving the settlement queues that jeopardise the operation is negligible in annual terms even at sector level.

As the second cost element, the cost of replacing the segregated collateral was quantified, which appears only in the prefunded operating models. Based on empirical data, we calculated for various confidence levels the size of liquidity demand that would arise upon operating the cyclical prefunding. On this basis we came to the conclusion that the liquidity that becomes lost at system level reaches 8 per cent of the liquidity of the system only in the case of the strictest prudential measures and the widest transaction circle. However, with frequent settlement cycles and by applying value limits, i.e. by active collateral management, this demand can be reduced to a degree that does not cause any problem for the system as a whole. The exclusion of seasonal fluctuations is also able to significantly reduce the liquidity demand, as the collateral for high turnover has to be provided only for a day or two. We also presented that at institution level the main difference is between the corporate and retail banks that have few clients and the large retail banks that have a wide clientele. With an increase in the number of clients, the relative liquidity demand required for conducting the turnover clearly declines, and the turnover becomes more stable and predictable.

In the last chapter we examined the developments in system participants' maximum utilisation of credit lines and came to the conclusion that the system-level MICL, still remaining at an acceptable level, increases by 1 percentage point only in the case of the two-hour prefunded model without a value limit. Consequently, we deemed the third cost element identified as the cost of the restoration of system stability as negligible.

We wish to summarize our findings about the theoretical liquidity costs of the two basic settlement models for instant payment systems in the table below:

Table 6
Liquidity management costs of the basic settlement models for an instant payment system based on data from the July 2012 – August 2015 period

	Prefunded models	**Instant settlement models**
1. Annual interest cost of dissolving disruptive settlement queues on a daily basis	HUF 28-40 million	HUF 29-31 million
2. Annual interest cost of replacing the liquidity leaving the interbank space	HUF 80-2200 million	*Not applicable.*
3. Cost of restoring system stability, i.e. the cost of managing systemic liquidity deficiency	*Not applicable due to abundant systemic liquidity.*	

Finally, we would like to emphasize that our analysis wishes to support the implementation of instant payments in Hungary by quantifying to stakeholders the liquidity effect of the various possible settlement models. As such an infrastructure development project considers further aspects that are not covered here, we do not wish to commit to one model in this paper.

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