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Managing Intraday Liquidity: The Mexican Experience*

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Abstract: The present study calculates the proportional liquidity usage of the Mexican Real Time Settlement Payment System, SPEI, during a one month period. In particular, our interest is to get insights on how different is the liquidity level at the settlement in real time of low and large value payment transactions. To that end, we create an artificial environment, in which we use historical data from April 7 to May 7, 2010 and reproduce the operational conditions of SPEI. For each of these days, we arrange the transactions in four sets, delimited according to their value: all payments, payment orders with value higher than 100,000 MXN; transactions with value higher than 1,000,000 MXN and payments with value higher than 10,000,000 MXN. We measure the liquidity usage in different settings of settlement speed requirements. We find that among participants settlement strategies are heterogeneous. In particular, according to the size of the payment order, on weekly basis participants follow different patterns for settlement. Even further, payments within the same set are not homogeneously treated by banks.
Keywords: Payment systems, intraday liquidity management, simulation.
JEL Classification: C63, G20, G28.

Resumen: El presente estudio calcula el uso proporcional de la liquidez del Sistema Mexicano de Pagos Liquidados en Tiempo Real, SPEI, durante el período de un mes. En particular, nuestro interés es conocer qué tan diferente es el nivel de liquidez en la liquidación en tiempo real de las transacciones de pagos de bajo y alto valor. Para ello, creamos un ambiente artificial, en el cual utilizamos datos históricos de 7 de abril a 7 de mayo de 2010 y reproducimos las condiciones operativas del SPEI. Para cada uno de estos días, organizamos las transacciones en cuatro sets, de acuerdo con su valor: todos los pagos, órdenes de pago con valor superior a 100,000 MXN; transacciones con valor superior a 1,000,000 MXN y pagos con valor superior a 10,000,000 MXN. Medimos el uso de liquidez en escenarios con diferentes requisitos de velocidad de liquidación. Encontramos que entre los participantes las estrategias de liquidación son heterogéneas. En particular, de acuerdo con el tamaño de la orden de pago, semanalmente los participantes siguen diferentes patrones de liquidación. Aún más, los pagos en el mismo conjunto no son tratados homogéneamente por los bancos.
Palabras Clave: Sistemas de pago, gestión de liquidez intradía, simulación.

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1. Introduction

In the last three decades, payment systems have been subject to an extensive transformation process in modern economies, as the services they provide are becoming part of everyday life. Historically, their key role was to settle large payment obligations between banks. Today, this role is growing into an important intermediary trade platform among individuals, as stated in Kokkola (2010). Like many other service industries, the main driver for creating new payment methods, as well as refining processes and payment settlement methods is technological innovation. In the last decade, we have been witnessing new payment types competing on the consumer service level alongside prominent growth in the volume of electronic retail payments. The possibility of real time telecommunication-based services has changed our everyday life activities and has shaken the payment industry (Bolt & Chakravorti, 2010). Consequently, there is an increasing demand for more processing and settlement of low value payments in real time. For instance, Faster Payments in the United Kingdom is now offering low value payments settlement services in near real time.

Alternatively, as taken into consideration by the Australian Payment Clearing Association (2008), integrating the settlement of high value and low value payments in real time could also be feasible. To achieve this, settlement engines need to ensure that retail payments do not use available liquidity in a way that could delay time sensitive payment orders, which settle important financial market obligations. To this end, payment systems may incorporate a Liquidity Saving Mechanism and establish timely and liquidity efficient operational rules.

The best known example of a Large Value Payment System (LVPS) that settles both high value financial market payments and retail payments in real time is the SIX, Interbank Clearing SIC, the Swiss interbank clearing system. This system settled 394.7 million payments in 2010, many more annual transactions than those settled in Real Time Gross Settlement (RTGS) systems of other developed countries like Germany (43.80 million) and France (8.22 million) (BIS, 2011). Moreover, other countries like the Czech Republic, Serbia, Slovakia, Turkey, Ukraine and Mexico also settle large value payments together with retail payments in real time (Allsopp, Summers & Veale, 2009). In Mexico, most low value payments between banks' clients go straight through a Real Time Settlement Payment System, SPEI, and are settled with large value payments in real time.

The Mexican Central Bank operates SPEI, charging participants less than a 0.05 USD per transaction. SPEI processes, on average, around 500,000 interbank operations daily[1]. More than 80% of these transactions have a value lower than 100,000 MXN[2], and only around 1.3% of the transactions have a value above 10,000,000 MXN. These characteristics allow us to study the effects of settling a large number of low-value payment transactions on the liquidity used for large value payments in real time.

In this context, in the analysis of how low value payments could affect the speed of settlement for wholesale payments, we need to take in consideration that, in the near future, the volume of electronic retail payments could rise significantly. In 2002, there were in Mexico 884 million non-cash transactions, which include checks, card payments (credit and debit cards) and electronic transactions (direct credit and direct debit), while in 2010 this number rose to

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[1] These operations do not include transactions received from ancillary systems scheduled for a particular time of the day.

[2] As a reference 1MXN = 0.079USD or 1MXN = 0.060EUR according to http://www.xe.com on 20 of March 2012.

2,300 million transactions[3], a 160% increase. To be prepared to settle a larger number of low value electronic transactions in real time, RTGS operators require a deeper understanding to maintain or, better yet, improve settlement efficiency in terms of liquidity needs.

In order to get further insights on the way participants manage their intraday liquidity under normal operational conditions, in the present study we analyze payment instructions sent during a period of one month. We calculate the average liquidity usage per day and per participant. We use transactions from April 7 to May 7, 2010 sent to SPEI from 9:00 to 17:00. The data for each payment transaction includes the identification numbers of the payer and the payee, the amount of the transaction, the time of reception and the time of settlement. For each day, we arrange the transactions in four sets, delimited according to their value. The idea is to evaluate the impact on liquidity usage of the low value payments by removing them from the whole set of transactions. Given that there is no convention regarding the specific size of payments considered as low value, the structures of the transaction sets are determined as follows: all payments, payments with value higher than 100[4]; transactions with value higher than 1,000 and payments with value higher than 10,000.

The study consists of simulating two different scenarios, performed in an artificially created environment that reproduces the current operational conditions of SPEI[5]. The objective is to measure how the settlement of low value payments modifies the pressure on liquidity (either positively or negatively). To that end, we calculate the amount that each participant needs to have available in its account in order to cover its payment obligations. Using the settlement algorithms of SPEI, the calculation is made first in one scenario, let it be named (a), in which payments are settled immediately at the time of reception and then in a second scenario (b), in which we repeat the exercise, but this time the payments are settled according to their original time of settlement. Based on the obtained amount of liquidity we establish a measure of a proportional liquidity usage[6] and we calculate it for the four sets previously defined. In addition, with these measures we obtain the difference in liquidity usage in the settlement of payments lower than 100 MXN, between 100 and 1,000 MXN and between 1,000 and 10,000 MXN. This exercise allows us to gain further insights on how intraday liquidity management strategies are related to the size of the payments.

The rest of the paper is organized as follows. In the next section we briefly present an overview of the literature. In section 3 we present the notation used. In section 4 we analyze the intraday liquidity management from the perspective of the participants and in section 5 we present our findings regarding the liquidity usage of the system as a whole. Finally we make comparisons between the two case studies and draw some conclusions in section 6.

2. Literature review

In this section we make a brief overview of the literature, in order to put our paper in the context of similar studies previously made at other central banks.

One of the most important reasons to use real-time gross settlement (RTGS) systems is the elimination of settlement and credit risk that could arise between participants in deferred net settlement (DNS) systems (Armantier, Arnold & McAndrews, 2008). Nevertheless, in

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[3] Statistics reported by Banco de México.
[4] From now on all references to payment values are expressed in thousands of MXN, unless other units are stated.
[5] Both scenarios.
[6] For detailed notation and explanation of this measure, please see section 3.

comparison with DNS payment systems, RTGS require more intraday liquidity to fulfill payment obligations (Johnson, McAndrews & Soramaki, 2004). This liquidity can be obtained from intraday overdrafts on the participants' current accounts at the central bank[7], or from incoming payments from other participants, which allows banks to recycle liquidity. In other words, participants reduce liquidity cost by reusing incoming payments and if the settlement engine includes Liquidity Saving Mechanism (LSM), they can also offset outgoing payment instructions (Norman, 2010). The amount of liquidity used in the form of costly overdrafts consequently is primary determined by the time urgent payments are sent.

McAndrews and Potter (2002) are among the first to study the rules participants in payment systems apply under conditions of stress. The authors look at the empirical data presented on September 11, 2011 and find the rules financial institutions in the USA followed to cover urgent payments. Liquidity flow in the system was considerably reduced during that day. Nevertheless it is commonly acknowledged that authorities need to understand the participants' behavior regarding intraday liquidity usage not only when the system is under unusual circumstances, but also under normal operational conditions. To that end, in order to go further in our understanding of the complex game participants in the payment systems face, Bech and Garratt (2003) model the banks' behavior through a game theoretical framework. They find that one of the motivations behind financial institutions´ strategies is the liquidity provision policy of the central bank as well as the incentives of the participants to delay payment orders. This study was extended by Bech (2008), who found that participants in payment systems, in which the liquidity arrangement is by collateral credit, delay payment obligations, even though sending transactions earlier in the day would imply less of their own fund liquidity usage. Further, Denbee and Norman (2010) analyze the impact of payment splitting on the level of liquidity required throughout the day. This study is similar to ours, as the authors analyze different sizes of payment orders in order to evaluate how those sizes impact the liquidity requirements. In the study presented here we do not split payments, but we attempt to evaluate to what extent low value payments reduce or increase the level of participants' funds used during the day.

Nevertheless, the usage of liquidity not only depends on the careful management of available funds, but also is a consequence of the rules the settlement engine applies. Under this line of research, the study of Leinonen and Soramaki (2005) is among the first to use simulation techniques in order to analyze the impact of offsetting algorithms in RTGS systems. Previously McAndrews and Trundle (2001) reviewed various payment system designs in order to find a solution, a hybrid system, in which the cost of liquidity is reduced together with the risk of settlement. In the same research area, Galbiati and Soramaki (2011) presented an agent-based model to study under a game theoretical framework the motivation of participants to submit payments either through RTGS or LSM queues.

This growing literature is a signal that the interest of authorities in how participants manage their intraday liquidity is increasing. For instance, McAndrews and Rajan (2001) and later Becher, Galbiati and Tudela (2008) study the process of liquidity recycling in Fedwire and CHAPS funds transfers respectively. They find that there is a high level of reuse of incoming payments in both systems. Furthermore, Norman (2010) makes an analysis of the factors that help banks to economize liquidity usage. Moreover Ball, Denbee, Manning and Wetherilt (2011) analyze the factors involved in the management of the intraday liquidity risk and its relevance from the perspective of the system as a whole, whereas Manning, Nier and Schanz

[7] Those overdrafts in most jurisdictions are obtained by pledging or transferring intraday collateral or alternatively maintaining high quality liquid assets (referred as government debt) for repos.

(2009) present a thorough study of the economics involved in large-value and settlement systems.

In the present study, continuing with this line of research, our aim is to elaborate on the participants' motivations in the submission of different sizes of payment orders throughout the day and evaluate the level of the recycling and the offsetting of payments in the Mexican Large Value Payment System, SPEI.

3. Motivation of the study and notation

In this section we describe the variables used to measure daily liquidity usage. In order to do that, we start the exposition with brief descriptions of the operational conditions of SPEI.

This system receives payment instructions continuously during the day, which are placed in a queue. It starts operations at 19:00 and closes next day at 17:35. During operation time, a settlement process (SP) is executed at the latest 20 seconds after receiving a new payment. Payment instructions, which are not settled in a certain SP are kept in the queue and are considered for settlement in the subsequent processes. After execution of the latest SP before the operation is closed, payments in the queue are cancelled.

All commercial banks in the Mexican financial sector have direct access to SPEI and throughout the day they send payment orders received form customers and the banks' own proprietary transactions. The intraday liquidity management consists of scheduling the settlement of those payments carefully in order to use the different sources of liquidity efficiently as presented in Bech (2008). For that reason it can be that not all payment orders are sent directly to SPEI, but instead are left for some period of time in the participants' own queues. Nevertheless, the transactional data we use does not reveal the periods of time payment transactions have been in the banks' queues. We can only observe from the historical data that there are occasionally some differences between the times payments have been received and the times payments have been settled. There can be two reasons why a transaction is not settled in the next SP after reception. First funds might not be available in the sender's account to cover the payment, or second, the amount received from incoming payments is not enough to offset the payment request.

In the present study our aim is to evaluate to what extent the delay observed in the SPEI's queue reduces the liquidity usage of commercial banks. In order to do that, we measure participants' liquidity requirements in two scenarios. First, we simulate the case in which all transactions are settled at the moment of reception; then we repeat the simulation for a second time, but in this occasion all transactions are settled according to their original settlement time. Based on the obtained amount of liquidity, we compare these two cases under the perspective of different payment sizes. More specifically, according to their value we arrange the transactions in four sets: all payments, payment orders with value higher than 100 MXN; a subset of transactions with value higher than 1,000 MXN and a subset of payment requests with value higher than 10,000 MXN. In addition we obtain the difference in liquidity usage in order to settle payments lower than 100 MXN, between 100 and 1,000 MXN and between 1,000 and 10,000 MXN.

In LVPS, the term intraday liquidity is used to define the funds that the participants have to cover their payment obligations during one day. Those funds come primarily from two sources: the participants' resources from previous balances or electronic transactions from other payment systems, or alternatively from payments received during the day from the rest of the participants. For our study, we measure the liquidity usage in terms of participants' resources. To that end, we have developed notation for the measures used for the present study. First, $\mathcal{P}$ is the set of payments received and processed by SPEI in one day and I is the set of participants in SPEI such that $p_{i,j}$ is a payment in $\mathcal{P}$ from participant $i \in I$ to participant $j \in I$; $\varphi_{p_{i,j}}$ is the amount in MXN of $p_{i,j}$. For each $i \in I$ the intraday payment orders sent are presented as:

$$p_i^{snt} = \sum_{j \in I} \varphi_{p_{i,j}} \tag{1}$$

whereas the received payments are denoted as:

$$p_i^{rcv} = \sum_{j \in I} \varphi_{p_{j,i}} \tag{2}$$

Let ℓ_i^{max} denote the required calculated level in order to have all transaction settled at the time of their reception. In addition, ℓ_i^{real} is the required level of liquidity in order to have all payments settled according to their original time of reception, which in other words means that ℓ_i^{real} is the actual usage of liquidity calculated ex post using our simulated environment. Thus, we define the maximum proportional liquidity usage per participant $r\ell_i^{max}$ and the real proportional liquidity usage per participant $r\ell_i^{real}$ in the following way:

$$r\ell_i^{max} = \frac{\ell_i^{max}}{p_i^{snt}} \tag{3}$$

$$r\ell_i^{real} = \frac{\ell_i^{real}}{p_i^{snt}} \tag{4}$$

Furthermore, we denote $\mathcal{P}_{snt}$ as the sum of p_i^{snt} for each $i \in I$ and $\mathcal{L}_{max}$ and $\mathcal{L}_{real}$ are the variables representing the macro level of liquidity usage (consumption) and are obtained by the sum of ℓ_i^{max} and ℓ_i^{real} for each $i \in I$ respectively. Finally we define proportional liquidity usage at the macro level as:

$$r\mathcal{L}_{max} = \frac{\mathcal{L}_{max}}{\mathcal{P}_{snt}} \tag{5}$$

$$r\mathcal{L}_{real} = \frac{\mathcal{L}_{real}}{\mathcal{P}_{snt}} \tag{6}$$

4. Intraday liquidity management from the perspective of the participants

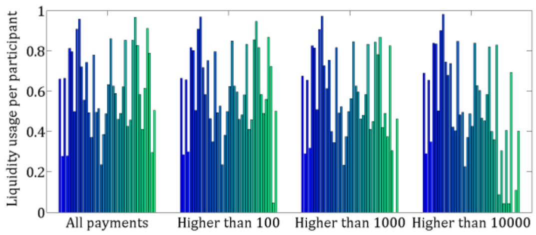
In this section we look at the empirical evidence in order to study the motivations for the participants' behavior in the management of intraday liquidity. In particular we analyze the effect on liquidity usage of the difference in the time of receiving and the time of settling payments. In Alexandrova-Kabadjova and Solís-Robleda (2012), the authors analyze the patterns observed in the structure of the delayed payments. They observed that proportionally the number of delayed payments is small as well as that the time those orders are delayed is in general below 20 minutes. Nevertheless, they found that in relative terms the majority of payments delayed are with value higher than 10,000 MXN and those are also the transactions with the longest time spent in the queue. In order to continue with the line of research focused on understanding the banks' intraday liquidity management, in the present paper we evaluate to what degree the liquidity usage would be affected if all payments were settled at the moment of their reception. In order to do that, we calculate liquidity usage in a simulated environment based on two scenarios, first at the time the payments are received, and then at the time of their original settlement. We present the results according to the value of the transaction in terms of average liquidity usage per participant and average liquidity usage per day. The payment orders are divided in four sets in the following way: all payments, transactions higher than 100 MXN, payment requests higher than 1,000 MXN and finally payment orders higher than 10,000 MXN.

In table 1 we list the number of transactions per day and per set, whereas in figure 1 the average liquidity usage per participant is presented. In this figure we use different colors to represent different banks. The same color is used for the same institution throughout the rest of the paper in the figures related to average per participant. In Figure 1(a) we present the average proportional liquidity usage per bank $r\ell_i^{max}$, calculated if all payments were settled at the moment of reception; in Figure 1(b) the proportional average $r\ell_i^{real}$ is again calculated, but in this figure the settlement time is the original time. Finally in Figure 1(c) we present the difference between those two cases, i.e. $\left(r\ell_i^{max} - r\ell_i^{real}\right)$. The intention behind the way we present the data is to observe patterns in the differences of liquidity usage per bank.

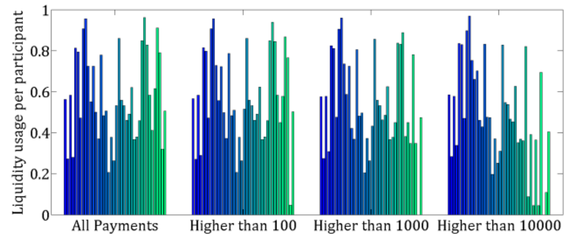
Day	All Payments	Payments >= 100	Payments >= 1000	Payments >= 10000
07.04.2010	195,637	31,280	7,116	2,136
08.04.2010	195,578	33,211	7,563	2,318
09.04.2010	277,326	41,367	8,559	2,608
12.04.2010	202,695	33,616	8,556	2,758
13.04.2010	179,899	31,728	8,140	2,577
14.04.2010	229,436	36,093	8,219	2,322
15.04.2010	279,731	38,203	8,481	2,526
16.04.2010	305,347	43,045	8,876	2,621
19.04.2010	205,322	36,703	9,363	2,981
20.04.2010	181,098	30,611	7,804	2,999
21.04.2010	174,978	30,525	7,464	2,633
22.04.2010	193,068	35,190	9,041	3,215
23.04.2010	274,774	42,249	8,861	2,792
26.04.2010	198,330	34,711	8,760	3,061
27.04.2010	182,009	32,532	8,020	2,645
28.04.2010	196,682	35,879	8,562	2,692
29.04.2010	269,387	44,756	10,374	3,572
30.04.2010	416,860	59,374	12,853	4,023
03.05.2010	195,294	31,954	8,601	2,807
04.05.2010	184,136	30,388	7,952	2,823
05.05.2010	217,316	39,758	9,845	2,836
06.05.2010	208,648	34,747	8,706	3,047
07.05.2010	290,832	43,507	10,082	3,665

Table 1. Number of transactions per set

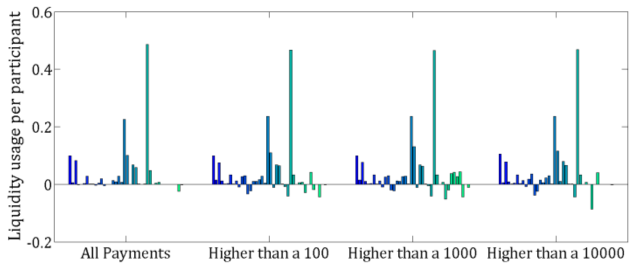
There are three issues regarding the proportional liquidity usage per participant, which we would like to examine. First, in subsection 4.1 we analyze the heterogeneity of participants' intraday liquidity management. To that end, we focus on the different patterns among participants observed in Figure 1 and we complement the analysis with four histograms presented in Figure 2, in which each subfigure represents one of the four sets of transactions studied. Next, in subsection 4.2 we make observations regarding the patterns presented in the four sets of transactions, which are shown in Figures 1(a) and 1(b), and the analysis is strengthend with the data presented in Figure 3. Finally, in subsection 4.3 we refer to the differences presented in Figure 1(c), which allow us to measure per participant the difference in liquidity usage between settling payments at the moment of reception and at their original time of settlement.



(a) Settlement at reception, $r\ell_i^{max}$



(b) Settlement at the original time, $r\ell_i^{real}$

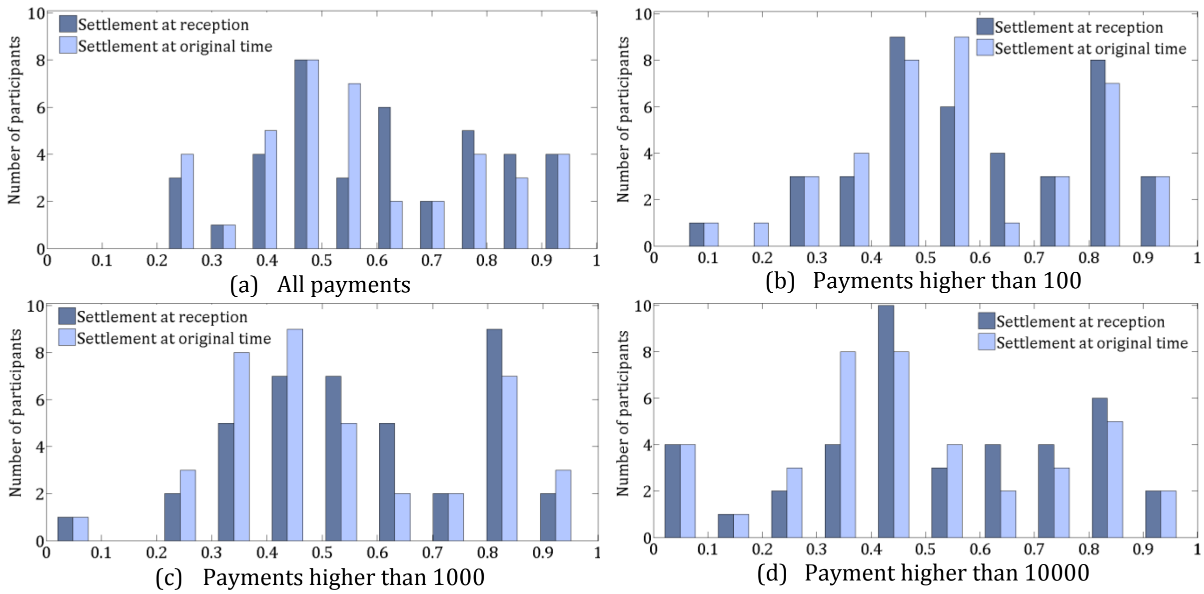


(c) The difference $\left(r\ell_i^{max} - r\ell_i^{real}\right)$

Figure 1. The average proportional liquidity usage per participant

4.1. Heterogeneity in the participants' liquidity management strategies

In this subsection we make general observations regarding the intraday liquidity management strategies of the participants. We notice in figures 1 and 2 that financial institutions are highly heterogeneous in the way they use incoming payments to fund their payment obligations. This observation is true for $r\ell_i^{max}$ and for $r\ell_i^{real}$, regardless of the set of payments we are referring to. Furthermore, in the case of the original time of settlement of all payments presented in subfigure 2(a), we observe that there are ten participants that reuse incoming payments to cover daily obligations averaging 60% or more of the total value of transactions. This number is the sum of the participants represented by the deciles lower than or equal to a ratio of 0.4 of the average liquidity usage in subfigure 2(a). On the other hand, in the same histogram we notice that there are 11 banks that cover with their own funds obligations averaging 80% or more of the total value of transactions paid per day. This observation shows that the management of intraday liquidity varies across participants significantly.



(a) All payments (b) Payments higher than 100 (c) Payments higher than 1000 (d) Payment higher than 10000

Figure 2. The histogram of the average proportional liquidity usage per participant

4.2. Managing different sets of transactions delimited by value

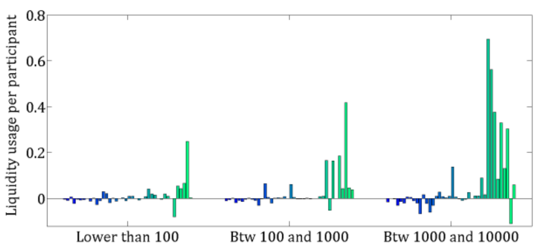
In this subsection, in order to analyze the differences in liquidity management among participants from the perspective of the different sets of transactions, let us first focus on the pattern presented in Figure 1(b). We can see in this figure that the usage of a participant's own funds is driven by the payments with value higher than 10,000 MXN. For that reason, we focus on two figures – first the histogram presented in 2(d) and then Figure 3, in which we have included the average additional usage of funds provided by participants for the following subsets: transactions with value lower than 100, payment orders with value between 100 and 1,000 and transactions with value between 1,000 and 10,000 MXN. In subfigure 3(a) we present the case of settlement at reception and in subfigure 3(b) the case of settlement at the original time. In this section we make our remarks analyzing Figures 1(b), 2(d) and Figure 3(b), whereas in the next subsection we focus on the patterns observed in Figure 3(a) among other data.

First in Figure 2(d), we observe that there are 4 banks that pay less than 10% to cover the transactions with value higher than 10,000 MXN. In addition, we note that there are 24 banks that cover with their own funds less than 50% of their obligations, whereas 16 banks need to cover more than 50% of their obligations with their own funds. There are seven banks that need to provide funds for more than 80% of their payments.

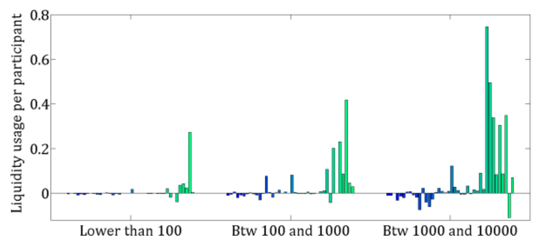
Next, we observe in Figure 1(b) and Figure 3(b) that for the majority of banks the usage of their own funds is not affected significantly from the settlement of transactions with values lower than 100 MXN. Nevertheless, according to the data reported in Figure 3(b) there is one institution that on average provides more than 20% of the proportional liquidity usage to cover its payment obligation for transactions with value lower than 100 MXN and another three banks that pay obligations with value lower than 100 using more than 5% of their daily available funds.

In addition we note that there are 11 institutions that have small negative additional liquidity usage; i.e., they use payments with values lower than 100 to fund obligations with higher values. Further, regarding the transactions with values between 100 and 1,000 MXN, we observe in Figure 3(b) that there are 9 institutions that provide their own funds for more than 5% of the average liquidity usage to cover those transactions, from which three banks give near 20% of the funds and one participant provide more than 40% to cover its obligation with value between 100 and 1,000 MXN. For this subset of transactions, we also note that there are seven banks that on average present negative additional liquidity usage.

The third bar in Figure 3(b) presents the payment orders with value between 1,000 and 10,000. Regarding the management of intraday liquidity for this subset of transactions, we observe that there are 10 participants, using their own funding to pay on average at least 10% or more of their payment obligations. Among those banks, two banks reuse incoming payments for less than 50% of the transactions and three institutions provide their own funding for about 30–40% of the transactions. Those proportions are significantly higher than the proportions observed for the subset of transactions with value between 100 and 1,000 MXN. Furthermore, there are ten participants with negative additional liquidity usage for this subset of payments.



(a) Settlement at reception



(b) Settlement at the original time

Figure 3. Average additional liquidity usage per participant

Finally, we note in subfigure 3(b) that some institutions present negative additional liquidity usage, whereas other banks provide at least 5% or more of their own funds to cover payment obligations regardless of the subsets of transactions presented. Therefore, we can say that liquidity management among participants from the perspective of the three subsets of transactions delimited by value, also significantly varies across participants, in particular for the subset of transactions with value between 1,000 and 10,000 MXN, in which the higher proportion of additional usage of participants' own funds is observed.

4.3. Settlement at reception vs. original time

In this subsection we analyze the different levels of liquidity usage obtained in two cases. First is the case in which all transactions are settled at the moment of reception. Second is the case in which all transactions are settled at their original time. These cases are calculated in an artificially created environment, using simulation techniques.

Let us first focus in the first bar of Figure 1(c), which presented the difference between $\left(r\ell_i^{max} - r\ell_i^{real}\right)$ for the set of all payments. This data reveals that on average all participants except one are able to reduce the proportion of their own funds used to cover their

obligations in SPEI. Furthermore, eight banks reduce the proportional usage of funds by at least 5% and the highest among them on average has reached an almost 50% reduction. Furthermore, looking at the bar of the set of transactions with value higher than 10,000 MXN, we also observe that the reduction is driven primary by this set of transactions.
Next, from the histograms presented in figure 2, we obtain even more detailed insights on how much the original time of settlement allows banks to save liquidity. More specifically, we observe that in the four sets of transactions studied the change in the time of settlement has reduced the number of participants that provide less than or equal to 50% of funds to cover their payment obligations and has increased the number of banks that need to cover more than 50% of the value of their payments with their own funds.

These observations allow us to conclude that the settlement at the time of reception and the settlement at the original time impact the intraday liquidity usage of the participants, so that we believe that the careful selection of the time in which payments are sent to the system and afterwards settled forms part of the participants' strategic behavior related to the management of intraday liquidity.

5. Intraday liquidity management from the perspective of the system as a whole

In this section we present our analysis of the results obtained by the simulation exercise, but this time we present them from the perspective of the system as a whole; i.e., we present the proportional average liquidity usage per day, which we previously defined as $r\mathcal{L}_{max}$ and $r\mathcal{L}_{real}$ for each case respectively.

In the figures included in this section the colors used allow us to distinguish the different days in the studied period. More specifically in all of them we apply the same color representing the same day. We start our exposition by showing in Figure 4 the proportional average liquidity usage per day. Subfigure 4(a) presents the case of settlement at reception, subfigure 4(b) the case of settlement at the original time, and Figure 4(c) the difference ($r\mathcal{L}_{max} - r\mathcal{L}_{real}$).

First, let us focus on the bar presented in Figure 4(b) that represents the set of all payments settled at their original time. We observe that the average liquidity usage per day is more homogeneous that the average liquidity usage per participant previously presented in section 4. This is confirmed by looking at the difference between the maximum and the minimum presented in Figure 1(b) and Figure 4(b). For instance, in Figure 1(b) the minimum level of liquidity average per participant is 20% and the maximum is higher than 90%, whereas the minimum level of liquidity average per day shown in Figure 4(b) is 45% and the maximum level is 70%.

In addition we notice that in Figure 4(b), the day with the lowest average, 45%, is Friday April 30[8] (strong orange), which according to table 1 is the day with the highest number of transactions. Another observation is that in the studied period the two days with the highest level of average liquidity usage (70%) are Wednesdays. This is also true for the subset of transactions with value higher than 10 000 MXN, but when the additional liquidity usage per day presented in figure 5 and in particular the case of the original time of settlement shown in Figure 5(b) are considered, this observation is no longer true.

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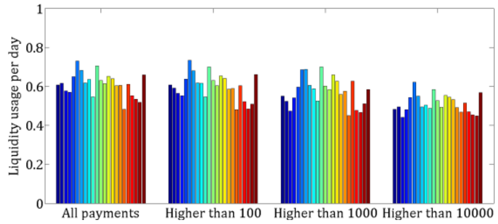
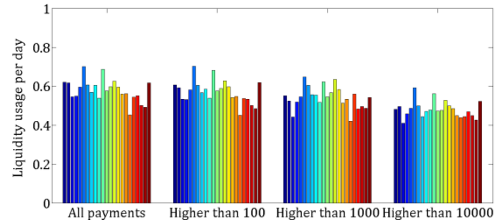
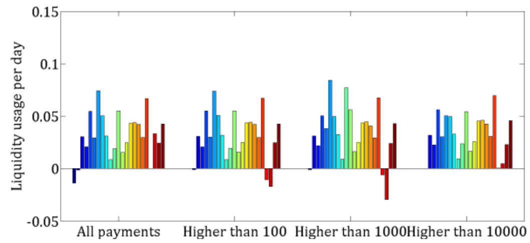
[8] The correspondence between days and colors is not reported in the figure, but given that the studied period begins on Wednesday April 7 and ends on Friday May 7, 2010, we have checked the data in order to obtain the date with the lowest level of liquidity usage.



(a) Settlement at reception, $r\mathcal{L}_{max}$



(b) Settlement at the original time, $r\mathcal{L}_{real}$



(c) The difference, $(r\mathcal{L}_{max} - r\mathcal{L}_{real})$

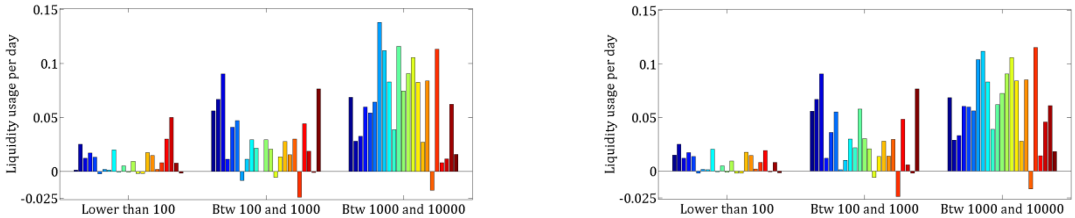
Figure 4. Proportional average liquidity usage per day

Further in our analysis, let us look at the difference $(r\mathcal{L}_{max} - r\mathcal{L}_{real})$ presented in Figure 4(c). First, we observe that at the macro level the proportional difference of the average liquidity usage between the two case studies – settlement at reception and settlement at the original time – is less than 8% for each day of the whole period. Further, regarding the set of all payments, there are two days in the studied period in which the difference is even negative. This is an indication that the strategic decision making process that participants face is complex; i.e., on certain occasions if delayed payments are processed a few settlement cycles earlier, the overall use of liquidity could be reduced, even though on most days proportional liquidity usage is reduced by the lag in the payment settlement.

Next, let us analyze the data presented in figure 5, in which we present the average additional liquidity usage for the following subsets – transactions with value lower than 100, payment obligations with value between 100 and 1000 and orders with value between 1000 and 10000. In Figure 5(a) the case of settlement at the time of reception is shown, whereas in Figure 5(b) the case of original time of settlement is presented. We observe in Figure 5(b) that for transactions with value lower than 100 MXN, at the macro level the additional proportional liquidity is not higher than 2.5% daily. Furthermore, the calculated average[9] for the period for this subset of transactions is 0.8%.

Regarding the average additional liquidity for payment orders with value between 100 and 1000 MXN presented in Figure 5(b), we note that the highest proportional level in a single day is 10.3%, whereas on different days we observe that participants use this size of transactions to cover other obligations, so that occasionally the additional liquidity is negative. On average the additional liquidity usage for this subset of payments is calculated for the studied period at 2.94%. Further, in the third bar presented in Figure 5(b) we observe that the highest level of the additional liquidity usage for the subset of transactions with value between 1,000 and 10,000 MXN, is 11.5%, though the calculated average for the studied period is 6.14%.

[9] This data is not shown in figure 5, but is available on request.



(a) Settlement at reception (b) Settlement at the original time

Figure 5. Average additional liquidity usage per day

Finally, let us make the comparison between the cases presented in Figure 5(a) and Figure 5(b). Among the three analyzed subsets of transactions, we observe that the most important difference is presented between the payment orders with value between 1000 and 10000 MXN, followed by the set of transactions with value lower than 100 MXN. For the subset of payments with value between 100 and 1,000 MXN almost no changes are observed. For the case of settlement at reception (subfigure 5(b)), the maximum additional liquidity usage per day is 13.8% and is observed for the subset of transactions with value between 1,000 and 10,000 MXN, for which the calculated average is 6.30%. With respect to the calculated average of additional liquidity usage for the subset of transactions between 100 and 1,000 MXN, we notice that for this case instead of increasing it decreases from 2.94% to 2.65%. Even though this difference might not be significant, it is worth underlining that there was one day that the additional liquidity usage dropped from 5.78% calculated for the case of settlement at the original time to 0% calculated for the simulated scenario of settlement at the moment of reception.

From those observations we can conclude that the difference on the macro level of liquidity usage if settlement is at reception is less noticeable than in the case of observations made at the participant level. Nevertheless, the four sizes of payments studied, exhibit different levels of sensibility to changes in settlement time, with the most sensitive being payments with value between 1,000 and 10,000 MXN.

6. Conclusions

This paper is dedicated to analyzing some aspects of the intraday liquidity management of the Mexican Large Value Payment System, SPEI. In particular, in order to get further insights regarding the behavior of the participants in SPEI, the study consists of the simulation of two scenarios with different times of settlement. In the first case all transactions are settled at reception, whereas in the second the payment orders are settled at their original times. The aim is to observe if there is any evidence that the level of real liquidity usage is affected by the number of payments delayed. We present our data from two perspectives – the average liquidity usage per participant (i.e., the micro view of the system) and the average liquidity usage per day (i.e., the macro perspective). This allows us to compare the levels of heterogeneity between the two and obtain some insights on the complex game that participants in the payment system face.

To that end we use thirty days of transactional data taken from SPEI between April 7, and May 7, 2010 corresponding to the payment orders performed from 9:00 to 17:00 each working day. The two case studies are performed in an artificially created environment that reproduces the operational conditions of SPEI. Furthermore, given that the value of more than 80% of the transactions settled in SPEI are payments lower than 100,000 MXN and only 1.3% of the payment orders are above 10,000,000 MXN, we perform the study using four sets of transactions delimited according to their value: all payments, payment orders with value higher than 100,000 MXN, a subset of transactions with value higher than 1,000,000 MXN, and a subset of payment requests with value higher than 10,000,000 MXN[10]. We calculate the proportional liquidity usage for each of the sets and furthermore we use these measures to obtain in relative terms the level of liquidity used to cover the remaining sets of payments.

From the perspective of the participants, the division of the transactions in four sets allows us to study the aspect of intraday liquidity management related to the size of the payment orders. In particular we observe that these strategies are highly heterogeneous. For instance, there are around 12 banks that use payments with value lower than 10,000,000 to offset obligations with higher value, whereas 5 participants use 30% or more of their own funds to settle payments with value between 1,000,000 and 10,000,000 and 4 financial institutions used on average 5% or more of their intraday liquidity to pay obligations with value lower than 100,000 MXN. These observations allow us to conclude first that according to the size of the payment order participants follow different strategies for settlement and second there is no homogeneous treatment of payments with the same size by all financial institutions.

Continuing with the analysis of the disaggregated level of liquidity usage, we note that individual liquidity consumption in SPEI is also highly heterogeneous. We notice that some participants are very efficient in reusing liquidity from incoming payments, in a way that these banks cover their obligations with a relatively low proportion of their own funds. More specifically, we observe that there are 10 participants that reuse incoming payments to cover on average 60% or more of the total value of transactions. On the other hand, we notice that there are 11 banks that cover on average 80% or more of the total value of transactions paid per day with their own funds. Nevertheless a more detailed study is required in order to understand to what extent those differences in reusing incoming payments could raise concerns for competition or matters related to risk. In particular we would like to find out if there is a correlation between the size of the bank and intraday liquidity management strategies.

In addition we perform our analysis also from the perspective of the system as a whole. From this perspective we note that the differences present among the days are weaker than the differences observed among participants. This observation could imply that intraday liquidity management from the macro perspective does not show significant changes from one day to another but does vary for sets of transactions with different values. Nevertheless we need to look at a larger window of time in order to make a more conclusive statement.

As a final remark, the present study has allowed us to observe a very complex dynamic in the way intraday liquidity management is performed. For instance, the time of settlement and the size of the payment order are among the instruments that participants use in order to recycle or offset their payment obligations. Furthermore, proportional liquidity usage is highly heterogenous among financial institutions; whereas overall proportional liquidity usage does not show important changes across days. For that reason, we believe that more studies related to the issues of intraday liquidity are required in order to gain further insights into participants' behavior. To that end one possible extension to the present work could be to apply the empirical analysis to a more extensive time window, which statistically would be more accurate. Additionally, looking at the bilateral relationships among institutions could give us further insights into the relationships among participants and the reasons for

[10] In the core of the paper we refer to these amounts as 100, 1,000 and 10,000 MXN.

heterogeneity. It could also improve our understanding of the way liquidity flows throughout the system.

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