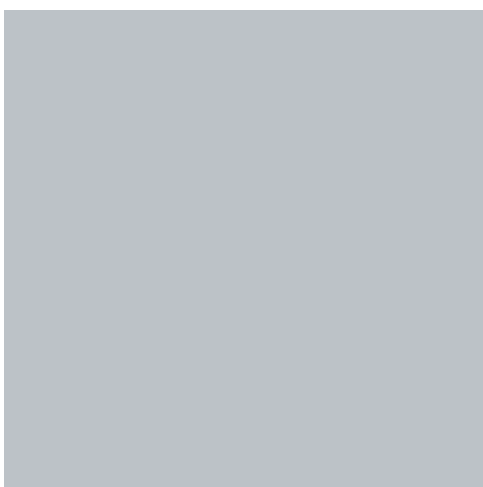


The Use of Liquidity in CHIPS®

**By James McAndrews
and Dean Vartin
April 2022**



The Use of Liquidity in CHIPS®

James McAndrews is an economic consultant, and he is the CEO of TNBUSA Inc. Dean Vartin is a former Vice President and Head of Systemic & Liquidity Risk Management at The Clearing House. Joe Alexander, Robert Cotton, Joel Feazell, Maddy Fiorillo, Arjuna Lal, and Jim McDade, all current or former employees of The Clearing House, also contributed to the research and the data analysis in this paper.

1. Introduction

The Clearing House Interbank Payment System (CHIPS®) is a large-value U.S. dollar payment system operated by The Clearing House Payments Company L.L.C. (TCH). It has a long history of providing financial institutions with the capability to execute large-value payments safely and efficiently. Throughout its history, CHIPS has provided liquidity-efficient methods of settling payments for its participants. In 2000 CHIPS began settling payments with intraday finality, using novel techniques both to conserve on the use of liquidity and to reduce delays in payment.

In this report we describe and examine the performance of CHIPS, focusing on its role in the U.S. payment system. As we describe in greater detail below, this framework leads us to analyze the use of liquidity by CHIPS' participants and the timing of payment settlement on CHIPS. We find that CHIPS is highly efficient in its use of liquidity when compared to other major payment systems around the world.¹ We also find that CHIPS' payments settle much earlier in the day than the payments made on the Fedwire® Funds Service ("Fedwire", operated by the Federal Reserve Banks), another efficiency-enhancing characteristic of CHIPS.

Further, CHIPS' liquidity efficiency tends to rise on days of

higher payment throughput in CHIPS. Other indicators also point to an economy of liquidity use related to payment throughput on CHIPS.

We also formulate and describe a new measure of the amount of liquidity used in CHIPS for the purpose of settling payments intraday. Based upon the application of this measure, we find that the liquidity used to settle payments during the day on CHIPS is extremely modest in amount. Secondly, we measure the average dollar of CHIPS settlement to occur at around 8:00 a.m., around five hours earlier than the average dollar on Fedwire.

These findings support the changes made by TCH to change CHIPS settlement from an end-of-day, deferred net settlement (DNS) system, to the current system of intraday settlement in 2000. Those changes greatly attenuated the settlement risk of delaying settlement until the end of the day while imposing a very low cost in terms of liquidity expended. In retrospect, this change can be seen as a significant gain in overall efficiency of the U.S. payment system.

CHIPS' payment and funding activity were significantly affected by the Federal Reserve's Large-Scale Asset Purchases and its other policies to expand the availability of reserves.

As reserves quickly became abundant in October 2008, CHIPS participants acted to submit an increased quantity of supplemental funding, quickening payment settlement. The provision by the Federal Reserve of ample funding liquidity yielded significant benefits in the operations of CHIPS.

¹ For the most part, we will use "liquidity" and "funding" interchangeably to refer to the funds sent by or on behalf of CHIPS participants to the CHIPS Prefunded Balance Account at the Federal Reserve Bank of New York in support of CHIPS operations. [NOTE: the account does not belong to CHIPS and it is provided by funding participants.]

In the following section we will lay out the framework for this report. We will follow that with a background section on CHIPS in Section 3. Section 4 will present two measures of liquidity efficiency. Section 5 will measure the timing of payments on CHIPS; Section 6 examines liquidity economies of scale within CHIPS. Section 7 provides an illustration of the concepts and measures introduced in this report by considering the changes in payment timing and the use of liquidity of a hypothetical bank that becomes a new CHIPS participant, and Section 8 concludes.

2. Framework

The large-value U.S. dollar payment system can be characterized as consisting of Fedwire, the Federal Reserve Banks' real-time gross settlement (RTGS) system, CHIPS, and several ancillary systems, including DTCC, CLS, the Fedwire Securities Service, and the National Settlement Service (NSS). This taxonomy was suggested by the 2005 BIS Report "Large-Value Payment Systems."² Most of the ancillary systems are in place to settle specific streams of payments. For example, DTCC settles payments associated with trading in commercial paper, bonds, stocks and other financial instruments housed at the depository, DTC; CLS settles cross border payments that consist of both a payment in a foreign currency, and one in dollars; the Fedwire Securities Service settles trades in U.S. Treasury and Agency Debt; and the NSS settles private-sector arrangements that clear payments, such as those for check clearing houses. CHIPS offers a general-purpose payment system, used to settle customer payments or bank-to-bank payments throughout the day.³

At first glance, then, one might conclude that CHIPS serves as a competitor to Fedwire, in that a general-purpose payment could be transferred by common participants either over Fedwire or over CHIPS. In this view a participant could tote up the costs of sending the payment on one system or the other and make the choice of the least expensive option. Of course, the two systems differ in their settlement characteristics, with Fedwire utilizing an RTGS design, and CHIPS utilizing a continuous netting design in which payments are offset so that only the net difference needs to be transferred via credits

and debits to participant positions. Consequently, there are differences in qualitative characteristics between the experiences of settlement on the one system or the other.

CHIPS offers less certainty that the payment will be settled immediately, for example, without additional considerations.⁴ Nonetheless, one might conclude that because the systems both offer settlement for general-purpose payments, they compete, and therefore one system might come to dominate the field. This viewpoint would not necessarily predict that both systems have seen growing volumes over time.

A deeper understanding of Fedwire and CHIPS is to view them as complementary. Indeed, the differences in the systems make this clear, with CHIPS effectively performing as a liquidity *savings mechanism* for the U.S. large dollar value payment system. In that regard, it is highly complementary to Fedwire, conserving liquidity for use in the more liquidity-demanding RTGS system of Fedwire. The growth of both systems in tandem is not a surprise, but a likely outcome when using this framework.

Liquidity savings mechanisms (LSMs) have been studied extensively. The benefits of an LSM, used in conjunction with an RTGS, was put this way by Martin and McAndrews (2008)⁵: "*liquidity-savings mechanism* refers to a mechanism intended to economize on the use of central bank reserves. ... An LSM can indeed economize on the use of central bank balances as well as lead banks to submit payments earlier to the payments system. In general, this outcome can be defined as making the payments system more 'liquid.'"

In this report we will examine the extent to which CHIPS economizes on the use of central bank balances in settling payments, and, similarly, the timing of payment submission and settlement on CHIPS. These are the key indicators of liquidity of the payments system generally. We will conclude that CHIPS economizes on the use of central bank balances, and that payments are settled on CHIPS much earlier than in Fedwire.

It is important to note that these findings not only suggest that CHIPS is performing the role of LSM successfully, but they also suggest that the liquidity on *Fedwire* is likely improved

² Bank for International Settlements, Committee on Payments and Settlement Systems, "New Developments in Large-Value Payment Systems," May 2005.

³ It should be noted that many CHIPS participants are US affiliates, branches or agencies of European and Asian based banks, likely as a reflection of the use of CHIPS to settle dollar legs of FX trades in the period before the creation and growth of CLS; because of that some payments within CHIPS are made in the U.S. overnight. So while CHIPS is general-purpose, the profile of payments submitted to CHIPS is more skewed to early payment submission, all else being equal, than is the case for payments made on Fedwire.

⁴ A CHIPS participant has the option to designate a payment as urgent and to provide supplemental funding in an amount sufficient to settle the payment immediately. In that case, a CHIPS payment is as predictable in its settlement as a similar payment made on Fedwire. Absent the use of supplemental funding, a payment made on CHIPS may remain in the queue of unsettled payments.

⁵ Martin, A. and McAndrews, J. "An Economic Analysis of Liquidity-Savings Mechanisms," Economic Policy Review, Federal Reserve Bank of New York, September 2008, pp. 25-39.

by virtue of the operation of CHIPS. Absent CHIPS, there would be more contention for central bank reserves from the additional payments routed over Fedwire, which, in turn, would likely lead to *additional* delays of payment on Fedwire.

In other words, it is likely that payments settle more quickly on Fedwire as a result of the presence of CHIPS. These effects of CHIPS significantly improve the operation and value of the U.S. large-value payment system.

3. Background

CHIPS cleared and settled approximately \$1.68 trillion per day on behalf of 43 bank participants, handing about 452,000 individual payments per day on average in the first half of 2020.⁶ It accomplishes these tasks using its “balanced release engine,” a set of procedures, algorithms, and policies it introduced in 2000, along with improvements to those procedures implemented since 2000.

Briefly, prior to 2000, payments sent to CHIPS were finally settled at the end of the processing day in a “deferred net settlement” procedure. In that procedure, payments were processed throughout the day, and, if they passed various bilateral and multilateral risk controls, those payments were released and the resulting multilateral net positions were finally settled at the end of the day. End of day settlement required participants in a net debit position to make pay-ins to a special account at the Federal Reserve Bank of New York used to support CHIPS end of day settlement, and those in a credit position to receive a pay-out from the account. The payments were finally settled once all the pay-ins and pay-outs were completed.

Since 2000, CHIPS finally settles payments throughout the day with its continuous netting design. Very roughly, every participant is required to send funds to a special deposit account at the Federal Reserve Bank of New York (the CHIPS Prefunded Balance Account). Each dollar of funding results in a dollar position on the CHIPS ledger; they then submit payments to CHIPS. If a payment submitted by a participant passes various risk controls, including the presence of sufficient position on the CHIPS’ ledger, and the payment would not result in an excessive concentration of liquidity for the receiving participant (i.e., its CHIPS ledger position cannot be too large), then the payment is released and immediately settled with finality. In addition to payments being immediately settled when participants have sufficient position on the ledger and receiving participants are eligible

to receive payments at that moment, CHIPS employs two algorithms to search the set of queued payments awaiting settlement to find pairs or batches of payments whose simultaneous release facilitates meeting the risk controls. At the close of the CHIPS business day, for payments that remain unreleased, settlement is achieved by CHIPS calculating what the ledger positions of all participants would be if the payments were released and notifying those participants that would be in a net debit position on the ledger that they must provide end of day funding to the CHIPS Prefunded Balance Account. If all participants with a final funding requirement send in the required funds (thereby increasing their positions on the CHIPS ledger), CHIPS will release and settle all remaining payments.

When all payments are settled, TCH initiates end of day payouts from the CHIPS Prefunded Balance Account to each participant that has a position on CHIPS for the amount of the participant’s position.

In 2008, after consultation with the Federal Reserve and after experimentation, a significant improvement was implemented in CHIPS, namely the allowance for supplemental funding during the day. Concern had previously been growing over the concentration of payments made in the final net settlement procedure in the 5:00 hour. Supplemental funding allows participants to settle payments that otherwise would be delayed owing to the inadequacy of the position on the CHIPS ledger at the moment of the supplemental funding. By sending-in the supplemental funds, a participant can immediately effect the settlement of these payments, resulting in more payment value being settled earlier in the day, before the final settlement procedure.

Those descriptions are summaries of highly detailed procedures, but they provide us the key ingredients to understand the liquidity usage aimed at the settlement of payments on CHIPS. CHIPS’ funding liquidity consists of i. initial funding; ii. supplemental funding; and iii. final funding. These sources of funding and the procedure used by CHIPS can be contrasted with the similar features of Fedwire, the large-value payment system of the Federal Reserve Banks. Participants in Fedwire submit payments to Fedwire and those payments are immediately settled so long as there are adequate balances in the account of the sending participant or access to Federal Reserve intraday credit.⁷

⁶ See The Clearing House, [theclearinghouse.org/-/media/new/tch/documents/payment-systems/chips-volume-ytd-through-june-2020.pdf](https://www.clearinghouse.org/-/media/new/tch/documents/payment-systems/chips-volume-ytd-through-june-2020.pdf)

⁷ Most Fedwire participants have access to intraday credit provided by Federal Reserve Banks, called “daylight overdrafts” on which they draw to settle payments if the balances that are already in their account are insufficient to settle the payment.

The corresponding elements of funding liquidity for a Fedwire participant are i. balances in one's account; and ii. daylight overdrafts.⁸

4. Measures of Efficiency

CHIPS is highly efficient in its use of liquidity. Efficiency of liquidity use in payments systems is generally defined as the ratio of the value of payments settled in a day to the amount of liquidity used to effect settlement. Here we examine two particular measures of the efficiency of CHIPS.

CHIPS derives its efficiency from its rapid recycling of liquidity, and from the netting and batching algorithms that are able to handle and clear a large volume of payments between its participant banks using less liquidity than other competing payments systems.

The CHIPS intraday settlement algorithm relies on a number of rules based on a number of principles and targeted goals, as well as guidance from CHIPS participants. The system will release payments immediately as they come in under certain conditions or batch and net them together in order to facilitate the processing of large payments while striking a balance between liquidity requirements in the form of initial funding and efficient payment processing.

may be less reliable. The operation of CHIPS in this mode, without the use of supplemental funding, is conducive to the settlement of payments even in the event of an operational outage of Fedwire. Similarly, supplemental funding can be used to settle urgent payment within CHIPS at the cost of supplying more funds into the system. The final funding is necessary to clear the queue of any unsettled payments that remain at the close of normal processing.

To gauge the efficiency of the performance of the CHIPS settlement system, we review two measures of efficiency of the liquidity use on CHIPS. The Liquidity Efficiency Ratio (LER) is one of the key performance metrics to measure CHIPS efficiency and effectiveness. The Real-Time Efficiency (RTE) is a new statistic that measures the liquidity efficiency of liquidity used solely to support the real-time, intraday, settlement of payments on CHIPS.

a. Liquidity Efficiency Ratio

The Liquidity Efficiency Ratio (LER) measures the value of transactions that CHIPS settled per dollar of total funding provided by CHIPS participants. It is an efficiency ratio of the total value of payments settled to the funds used for the settlement. For CHIPS, we use the sum of the initial,

LER is defined as:

$$LER = \frac{(Total\ Payments\ (dollar\ value))}{Total\ Funding\ (Initial + Supplemental + Final)}$$

Below are the key statistics for the Liquidity Efficiency Ratio.

Mean Value	Standard Deviation	Maximum Value	Minimum Value	Median Value
21.51	3.17	35.46	9.04	21.59

Source, TCH, May 13, 2019 – May 12, 2020, Number of Observations: 252.

An optimal prefunding of CHIPS would have enough deposits to meet a large portion of payment requests before cutoff even in stressed scenarios when supplemental funding

supplemental, and final funding as our measure of funds supplied for settlement.⁹

The LER reveals that, on average, participants settle \$21.50 dollars of payments for every dollar of total funding provided to CHIPS.

⁸ All of the funding sources listed consist of central bank balances or draw on central bank balances. All CHIPS payment settle without direct use of central bank balances – CHIPS payment settle on the CHIPS ledger with finality. The balance at the Federal Reserve Bank of New York is not used to settle any CHIPS payments during the day – it provides assurance to the participants in support of the ledger. In CHIPS, its algorithm and procedures search and settle pairs and batches of payments that are offsetting, which do not require the transfer of balances supplied by CHIPS participants and maintained on its ledger. J. McAndrews and S. Rajan, "The Timing and Funding of Fedwire Funds Transfers," *The Economic Policy Review*, Federal Reserve Bank of New York, July 2000, pp. 17-32.

⁹ Supplemental funding is sent to the CHIPS Prefunded Balance Account by participants to release payments; supplemental funding can later be withdrawn from the CHIPS Prefunded Balance Account by any participant with a supplemental position on the CHIPS ledger up to the amount of that position. Only Supplemental funding is included in our measure of efficiency; withdrawals are not considered.

The measure of 21.5 for the CHIPS efficiency measure reveals that CHIPS is a highly efficient system. This measure compares with an efficiency ratio of 4.55 for Fedwire, 4.13 for Target 2, and 12.55 for CHAPS.¹⁰

The measure of liquidity used in the study that derived the efficiency ratios for Fedwire, Target 2, CHAPS, and other systems is necessarily different from the one used in CHIPS.

Fedwire and the other systems are the central RTGS for their nations, and participants draw directly on balances in central bank accounts to fund the payments on those systems. It would be incorrect to imagine that all of a bank's balances on account at the central bank are necessarily used as "liquidity" to settle payments. Instead, the measure of liquidity used to settle payments in RTGS systems is the largest cumulative amount of net outgoing payments experienced by a participant at any time during the day. That measure of liquidity use is summed over all participants to obtain the aggregate liquidity used in the system.

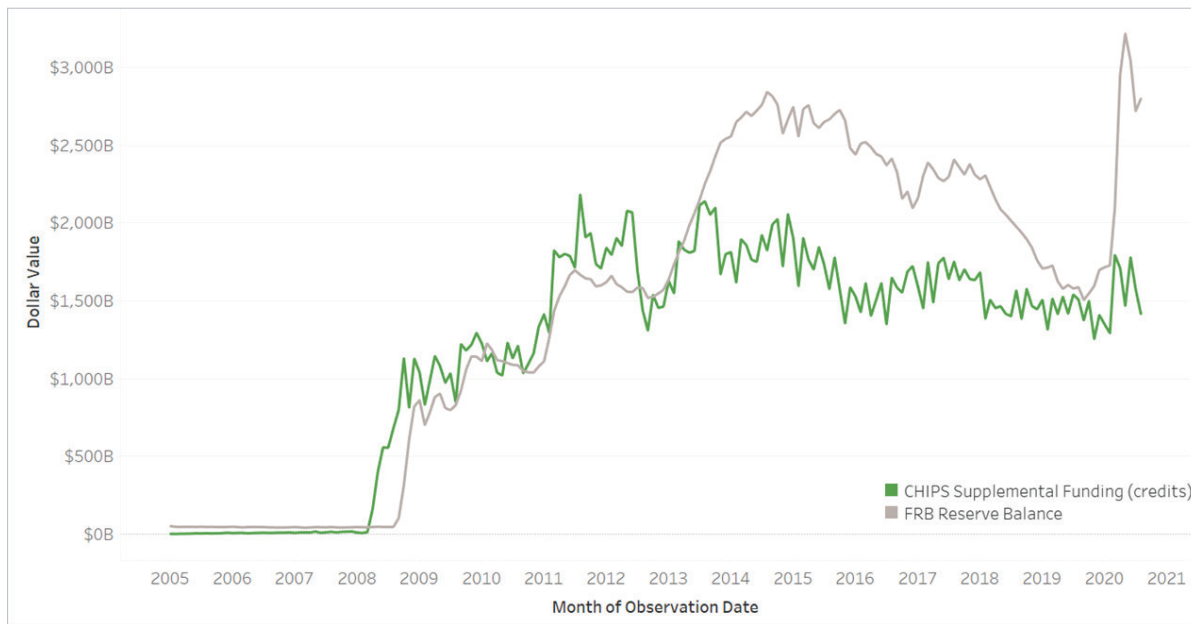
CHIPS liquidity must be prepositioned. In addition, the level of the initial funding is determined in a fashion so that participants often utilize all of that amount to settle (both to outgoing and incoming) payments. So all of the initial funding should be considered liquidity used to settle payments, as should all supplemental funding and final funding (which

are more akin to measures of net debits at the time of their submission). While this definition of funding is conservative, since supplemental funds may be withdrawn from the system, it is a close approximation to the definition used in the Experts Group study.

The LER has been affected by Federal Reserve balance sheet policies. CHIPS' participants payment behavior and efficiency on CHIPS was influenced by the provision of ample reserves by the Federal Reserve. Recall that the option to provide supplemental funding to CHIPS was introduced in mid-2008. That additional functionality allowed participants to provide funds in support of CHIPS intraday to the CHIPS' Prefunded Balance Account from their accounts at Federal Reserve Banks. In October 2008, as a result of the Federal Reserve's efforts to combat financial instability and to provide financial and economic support to the economy, the Federal Reserve expanded the quantity of reserves significantly.

The abundance of reserves seemed to reduce the costs of their use in payments. For example, payments on Fedwire moved earlier in the day, consistent with the hypothesis that reserve abundance reduced the marginal cost of using reserves.¹¹ We see in Chart 1 below that supplemental funding provided in support of CHIPS increased largely coincidentally with the surge and subsequent increases in reserves.

Chart 1: CHIPS Supplemental Funding (Credits) & FRB Reserve Balance Over Time



Source: TCH, Federal Reserve

¹⁰ The Expert Group on Payment System Liquidity Analysis, "Intraday Liquidity Around the World, September 4, 2020, Bank for International Settlements.

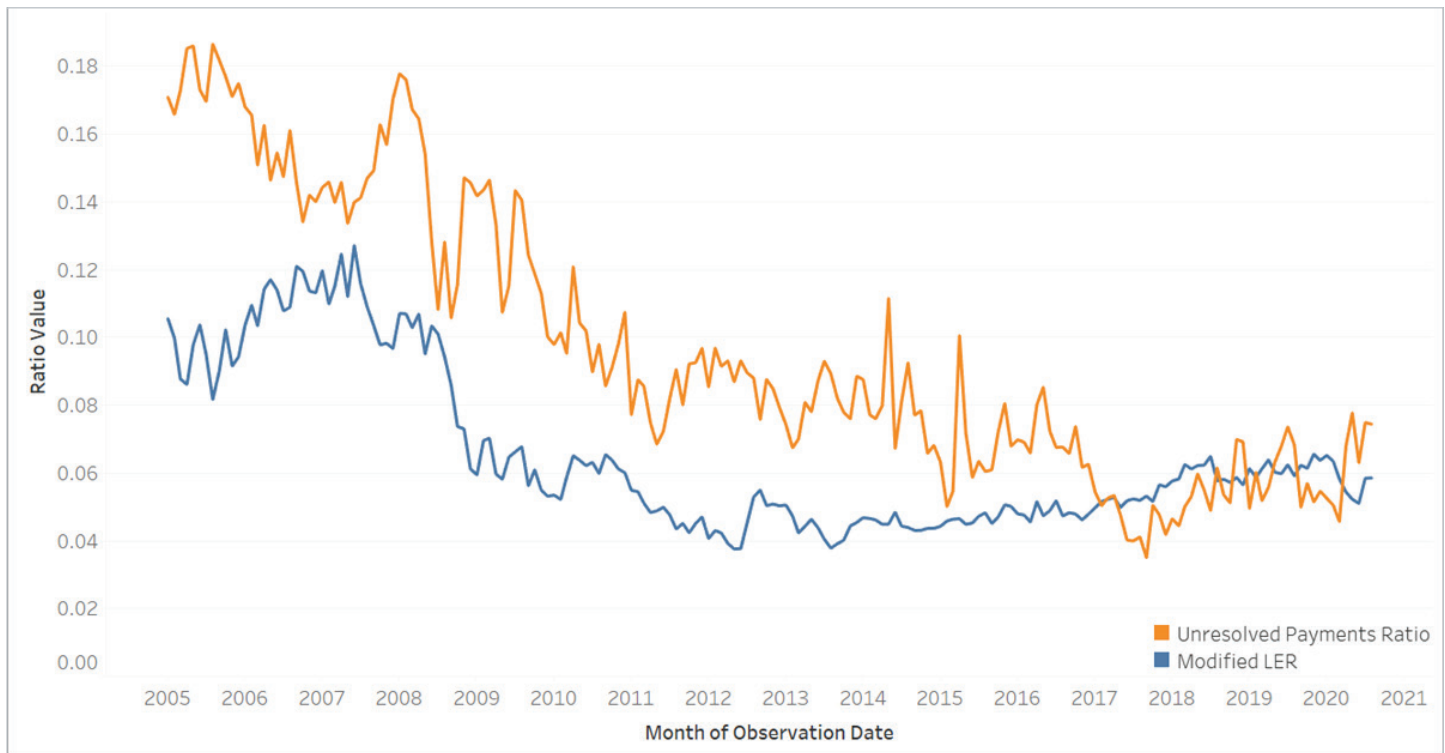
¹¹ See James McAndrews and Alexander Kroeger, "The Payment System Benefits of High Reserve Balances," *Journal of Payments Strategy and Systems*, Volume 10, Number 1, Spring 2016, pp. 72-83.

By settling some queued payments earlier in the day, the additional supplemental funding reduced the value of payments that remained unsettled at 5:00 PM. In addition, the LER fell, as more liquidity was employed to settle payments on CHIPS.¹² Unresolved payments at cutoff continued to decrease as supplemental funding remained elevated throughout the time series.

b. Real-Time Efficiency

The Real-Time Efficiency (RTE) ratio measures the value of transactions that CHIPS settles prior to the settlement of unreleased payments at the end of the day per dollar of funding provided by CHIPS participants in excess of the amount necessary to settle payments in a deferred net settlement system.

Chart 2: CHIPS: Unresolved Payments Ratio & Liquidity Efficiency Ratio Have Fallen as Reserves Expanded



The left axis represents the ratio values for the Unresolved Payment Ratio (Unresolved Payments/Total Payments Processed). The Modified LER values were adjusted (divided by 350) in order to fit on the Y axis. *Source: TCH*

Looking at both graphs, we can see that the supplemental funding series and the LER series are nearly identical reflections of one another. In part, this is because supplemental funding is in the denominator of the LER ratio. Essentially, participants chose to use more liquidity on CHIPS to settle payments more quickly as reserves became more abundant.

To carefully define the RTE, we will first calculate the liquidity intensity, or the multilateral net debit (MND), of CHIPS' payments. The MND is the smallest amount of money that must be transferred among participants to effect the settlement of all payments within a deferred net settlement payment arrangement.¹³

The liquidity intensity of a set of payments is the same as the theoretical amount that would need to change hands to

¹² This fact alone should remind us that while "liquidity efficiency" is a widely used measure in payment systems, "efficiency" is a broader concept that takes into account how urgent payment are. In this episode, for example, CHIPS participants willingly provided supplemental funding to make payments earlier than they otherwise would have. That is a perfectly efficient use of their resources, even if it results in a lowered "liquidity efficiency" ratio.

¹³ The multilateral net debit is formally defined as

$$MND = \frac{1}{2} \left\{ \sum_{i=1}^n \left| \sum_{j=1}^n p_{ij} - \sum_{j=1}^n p_{ji} \right| \right\}$$

Where p_{ij} is a sum of all the payments submitted on a particular day from bank i to bank j . There are n banks in total.

settle all the payments if they were settled in a DNS system. Another way of defining the liquidity intensity of a set of payments is to say that it is the value of the non-offsetting payments in a group of payments. To illustrate, suppose that Adam wishes to pay Barbara \$10; Barbara wishes to pay Cathy \$5, and Cathy wishes to pay Adam \$5. First we see which payments are offset on a multilateral basis. For example, Adam owes \$10, but is to receive \$5. After offsetting all the payments, we see that all of them can be settled with a single transfer: if Adam pays \$5 to Barbara, all the payments can be settled at the same time. The liquidity intensity is a characteristic of a set of payments. Suppose, for example, that, rather than the payments just described, Adam wishes to pay Cathy \$10, and no other payments are involved. It is clear that there are no offsetting payments, so the liquidity intensity for that set of payments is \$10. Even though there are fewer payments involved, the last set of payments requires more liquidity to settle, so that set has a higher liquidity intensity.

The MND can be measured using all payments submitted to CHIPS during a day. That number can then be compared with the sum of the total funding in support of CHIPS.¹⁴ The difference (Total Funding – MND) is equal to the funds supplied by CHIPS participants to the algorithm, which, together with the algorithm, allows settlement of the payments prior to the final settlement. One then measures (All payments settled *prior to the final settlement*). The ratio is a measure of the “efficiency of intraday settlement” of the algorithm.

The RTE is a measure of how much additional funding was required for CHIPS to transition from a net settlement system that settled payments at the end of the day to a system that settles payments throughout the day. It shows an astonishing efficiency of CHIPS intraday settlement. For every dollar of funding in excess of the minimum amount necessary to settle payments (in a deferred net settlement procedure, which, by definition would have to occur at the end of the day) CHIPS is able to settle \$61.8 on average during the day.

To put this measure in perspective, consider the policy options confronting TCH in 1999 when CHIPS adopted the new real-time intraday payment system. Prior to that decision, TCH operated a DNS system, so all payment settlement was deferred until the end of the day. By possibly introducing the new balanced release engine with intraday final settlement, TCH would greatly attenuate settlement risk. But as stated by BIS (2005): “the risk-reducing effects of introducing intraday finality are not free of cost. In particular, new approaches to ensuring continuous intraday finality are often characterized as imposing intermediate liquidity costs on large-value payment system participants — higher than in unprotected DNS systems, but lower than in RTGS systems. Assuming that the (marginal) cost of liquidity is strictly positive, a standard trade-off between conditions for settlement and liquidity costs therefore emerges.”¹⁵

TCH faced this trade-off: introduce the new system and reduce settlement risk a great deal, but increase the liquidity usage on CHIPS. What the real-time efficiency statistic tells us is what a favorable trade-off this turned out to be. Settlement

$$\text{Real - Time Efficiency} = \left(\frac{\text{All payments settled prior to the final settlement}}{\text{SUM of FUNDING} - \text{MND}} \right)$$

That leads us to the measures of the Real-Time Efficiency (RTE) ratio, which is a ratio of the payments completed prior to the end of day settlement of CHIPS to the amount of funding in excess of the MND.

risk was decreased by settling payments throughout the day, and the liquidity cost is extremely modest: for every \$61.8 of settlement within the day before closing, only \$1 of balances is used by the system. This statistic now makes clear how

Chart 3: Below Are the Key Statistics for the Real-Time Efficiency Ratio.

Mean Value	Standard Deviation	Maximum Value	Minimum Value	Median Value
61.87	12.64	147.66	18.04	61.88

Source, TCH, May 13, 2019 – May 12, 2020, Number of Observations: 252

¹⁴ Once again, withdrawals of supplemental funding are not deducted from funding paid into CHIPS for use in the RTE measure.

¹⁵ BIS op cit. pp. 37.

low were the liquidity costs of reducing settlement risks by a significant amount.

5. Timing of payment submission

The timing of payment settlement on CHIPS is an important facet of how liquidity is deployed in the system. Specifically, by entering and queuing payments, CHIPS' release engine can settle payments earlier and allow the liquidity within CHIPS to be available for later settlements, a form of recycling of liquidity. Furthermore, participants face no penalties, and may experience faster receipt of payments, by submitting payments early to CHIPS. In that way, payments can be placed in a queue to await the arrival of bilaterally offsetting payment, or a group of payments offset one another in a multilateral way.

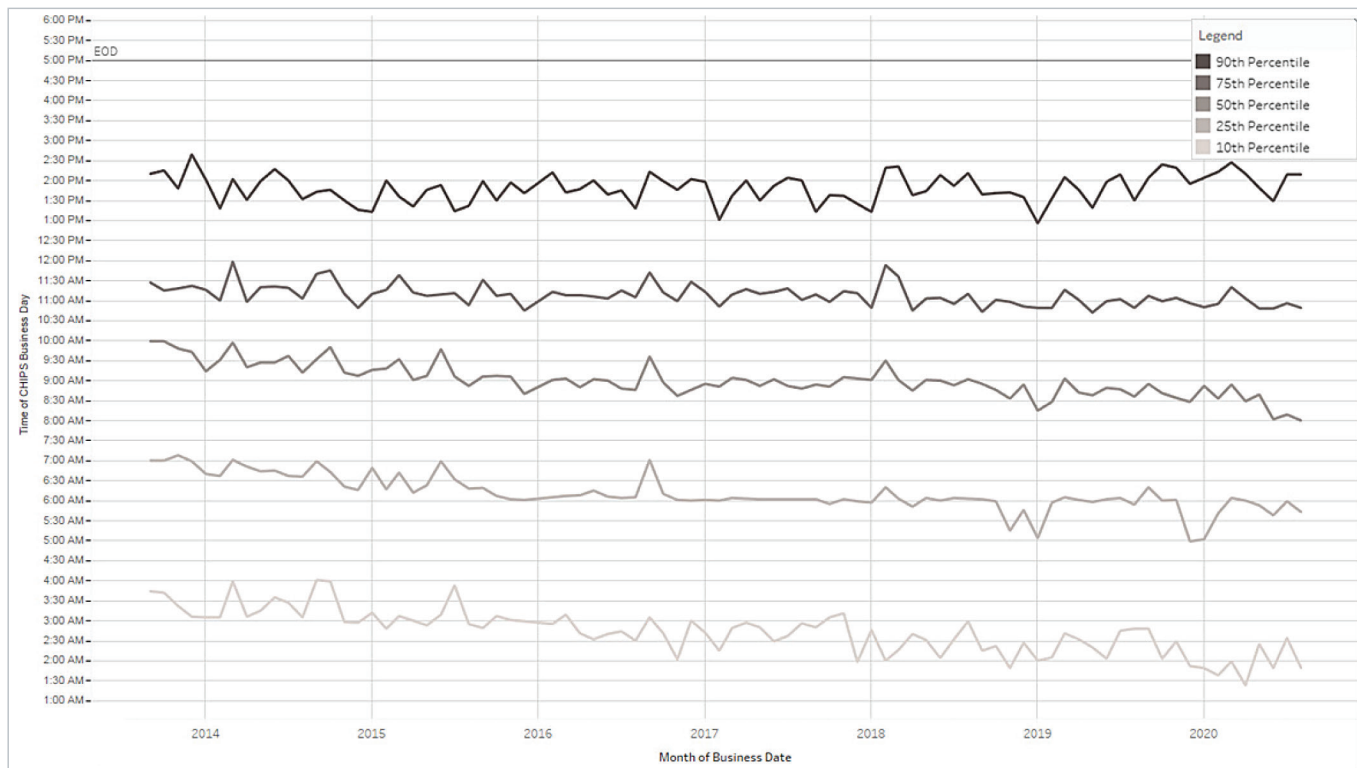
The CHIPS Value Time Percentiles over Time was created using data from 2013 – 2020. We calculated the time of day at which the 10th, 25th, 50th, 75th, and 90th percentiles of value settled on

CHIPS for one business day per month between September 2013 and August 2020. With the exception of the 90th percentile, which stayed flat, we can observe a broad trend in earlier payment release times.

Here we see that in 2020 the median dollar is settled on CHIPS at about 8:00 a.m. In contrast, as of 2019, the median dollar in Fedwire was settled about 1:30 p.m., more than 6 hours later than CHIPS.¹⁶ In general, it appears that for the 25th through 75th percentiles of payment value are settled between 6 and 4 hours earlier, respectively, on CHIPS than the same percentiles of value are settled on Fedwire.

There are three likely explanations for the relatively early settlement on CHIPS. First, as described in Martin and McAndrews (2008), the incentives for early submission to CHIPS, which is a liquidity savings mechanism, are enhanced relative to submission to Fedwire, and its RTGS system. It is expected that participants on CHIPS would submit payments to CHIPS early, as they have precommitted the initial funding

Chart 4: CHIPS Value Time Percentiles over Time



Source, TCH

¹⁶ See Copeland, A., Molloy, L., and Tarascina, A. "What Can We Learn From the Timing of Interbank Payments," Liberty Street Economics, Federal Reserve Bank of New York, February 25, 2019.

on CHIPS, and suffer no immediate expected marginal cost of liquidity use on CHIPS. Therefore they have a decreased incentive to delay payment submission. On Fedwire, in contrast, each payment requires expected marginal use of liquidity, and so a participant tends to delay payments and await funds to be paid to it. Those incentives result in overall delay of payments, as explained by Bech and Garratt (1998).¹⁷ Another explanation that may contribute to relatively early settlement on CHIPS is that payments on CHIPS may differ from those submitted to Fedwire. For example, payments related to Asian and European bank customers might be more prevalent among CHIPS participants, and might be more time-sensitive to settle during the operating hours of Asian and European banking systems. Finally, CHIPS' administrative procedures provide guidance that participants should submit at least 60 percent of payment value by noon. It is likely that all of these explanations for earlier settlement on CHIPS play a role in leading to its early pattern of settlement.

The pattern of earlier payment submission and settlement on CHIPS, relative to Fedwire, provides an important advantage in mitigating operational risks in the overall U.S. payment system and for individual CHIPS participants. Operational outages in large-value payment systems may occur late in the day. For example the recent April 1, 2019 outage on Fedwire began at approximately 3:30 p.m.¹⁸ The propensity for CHIPS to settle payments early in the day therefore contributes to an overall reduction in risk, as the likelihood of an operational outage threatens a lower proportion of the day's settlements than it would if settlement occurred later in the day.

6. Sensitivity analysis of liquidity demands relative to volume in CHIPS

CHIPS' participants vary the number of payments and their values that are submitted to CHIPS from day to day. The submitted payments can require more or less liquidity to settle. In this section we measure how the overall liquidity required and used on CHIPS varies with the values of payments submitted to CHIPS. We'll first consider how the liquidity *intensity* of the payments submitted to CHIPS varies with the value of those payments. The liquidity intensity of the set of payments, introduced in Section 4, only depends on the payments submitted to CHIPS, and is not dependent on their timing or how much liquidity is actually used to settle the payments.

After examining the liquidity intensity of CHIPS' payments and how it varies with the total value of payments submitted the

¹⁷ Bech, M. and Garratt, R. (2003). "The Intraday Liquidity Management Game," *Journal of Economic Theory*, 109, no.2 (April), pp. 198-219.

¹⁸ See the [TPMG Meeting Minutes](#), April 16, 2019, Federal Reserve Bank of New York.

CHIPS, we'll then examine how much funding CHIPS participants actually used to settle payments on CHIPS, and how that amount varies with the liquidity intensity of the payments.

Here we measure the liquidity intensity for CHIPS daily for the 252 business day period of May 13, 2019-May 12, 2020.

We also measure the total value of payments submitted to and settled by CHIPS each day. We then investigate how the liquidity intensity varies with respect to the total value submitted to CHIPS on a daily basis. Our hypothesis is that with a higher value of payments submitted to CHIPS, there will be more opportunities provided for the payments submitted to offset one another, and therefore the liquidity intensity will rise **less than** the increase in total value, indicating an unexploited liquidity economy of scale in the payments submitted to CHIPS.

In particular we can model the daily liquidity intensity (which we'll call the MND) as in the following equation, where a and β are parameters to be estimated, TV_t is the total value of payments made on CHIPS on day t , and MND_t is the multilateral net debit of the payments in CHIPS on day t .

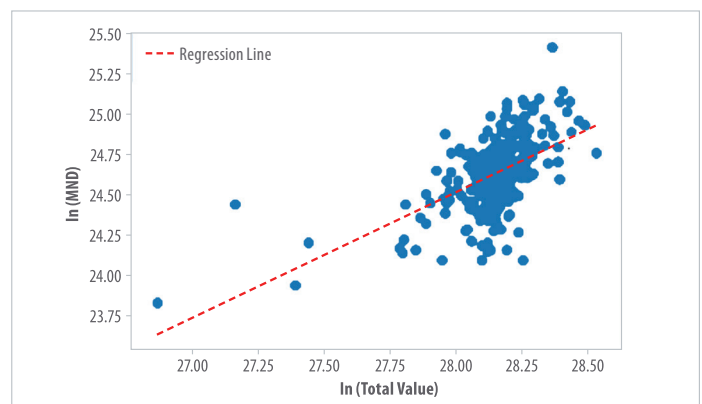
$$MND_t = aTV_t^\beta u_t$$

Taking logarithms of both sides, we have

$$\ln MND_t = \ln a + \beta \ln TV_t + \ln u_t$$

Conveniently, the parameter β is a measure of the elasticity of the MND with respect to TV . It measures the percentage point increase in the liquidity intensity for every one percentage point increase in total value of payments submitted to CHIPS. Below is a figure showing the scatterplot of pairs of log of the total value of payments along with the corresponding log of the MND for each of 252 days of the sample.

Chart 5: Log-log Regression



Source: TCH, authors' calculations

The estimated coefficients used to draw the red regression line in the diagram is below.

$$\ln(MND) = 0.7812 * \ln(TV) + 2.6350$$

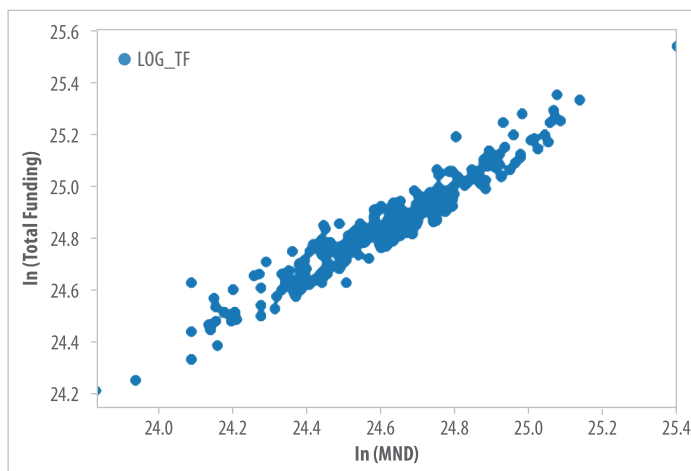
What this exercise tells us is that the elasticity of the liquidity intensity with respect to TV is 0.78. This reveals a significant economy of scale with respect to the minimum amount of liquidity needed to settle a group of payment, and the value contained in that group of payments. As CHIPS participants send payments with higher total values to CHIPS, the per-dollar minimum amount of liquidity needed to settle those payments rises more slowly than the value of payments. Specifically, when the value of payments rises by 10 percent, the liquidity intensity of those payments rises by only 7.8 percent.

c. Total funding usage

While the relationship between the total value of payments and the liquidity intensity of those payments displays an economy of scale in the payments submitted to CHIPS, how well does CHIPS' balanced release engine and participants' funding behavior capture that economy? Here we examine the relationship between the liquidity intensity and the total funding provided to CHIPS. How closely does the total funding provided to CHIPS by participants, that is, the sum of the initial funding, supplementary funding, and final funding, correspond to the MND.

Below is a scatterplot of the two variables in logarithmic scale.

Chart 6: $\ln(MND)$ vs $\ln(\text{Total Funding})$



Source, TCH

There appears to be a close, positive correlation between Total Funding and MND. Further, the variance between the variables is quite low as well. We next turn to regression analysis to describe the best fit line through the plot above.

We examine the regression equation shown below.¹⁹

$$\ln TF_t = \ln a + \beta \ln MND_t + \ln u_t$$

Where $\ln TF$ is the total funding provided on day t , $\ln a$ are parameters to be estimated, $\beta \ln MND$ is the natural logarithm, and $\ln u$ is the multilateral net debit on day t . The estimated equation is:

$$\ln(\text{Total Funding}) = 4.881 + 0.811 \times \ln(MND)$$

The coefficient is estimated to be 0.811.²⁰ Once again, this coefficient provides an estimate of the elasticity of Total Funding with respect to the liquidity intensity (or the Multilateral Net Debit). Specifically, were the MND of the day's payments to rise by 1 percent, we'd expect participants would submit about 0.8 percent additional funding during the day.

We conclude that there are economies in funding on CHIPS, in that, as the set of payments requires additional funding to settle, participants react in ways to moderate the effects on the funding they submit to CHIPS. Regression analysis reveals that the CHIPS balanced release engine, together with the behavior of the participants, captures the economies of scale in funding that exists in the payment submissions to CHIPS, and that the Total Funding provided to CHIPS hews closely to the minimum theoretical amount needed to settle the payments submitted to CHIPS.

7. Illustration

In this section, we illustrate our measures by considering a hypothetical bank that utilizes only Fedwire for its large-value payments, and has a payment profile that fits the averages of Fedwire payments that we've described. We then imagine that the bank becomes a CHIPS participant, and submits (and receives) payments to (and from) other CHIPS participants in an amount equal to half of those participants market-share of payments. We assume that the payments submitted to CHIPS are settled to equal the CHIPS averages of payments. We then consider the liquidity savings and earlier timing of payments, and their effects on others.

¹⁹ We don't consider the direct relationship between total value sent and total funding, as the supplementary payments are directly collinear with payment value, and so the independence of the regressor is not assured.

²⁰ Both regressions equations are well specified; statistics are available upon request from the authors.

In the most recent data, the Fedwire Funds Service settled \$3.5 trillion of payments daily in the second quarter of 2020, and CHIPS settled \$1.7 trillion daily on average in the first half of 2020. Consequently, in recent quarters CHIPS settled about one-third of large-value payments submitted to the two systems.

Consider a participant that settles all of its payments on Fedwire, and conforms to the averages of payment timing for Fedwire, and for its use of liquidity on Fedwire. Suppose, furthermore, that it makes \$10 billion in large-value payments daily on Fedwire. It settles its median dollar of payment at around 1:30 p.m. and it would devote about $(1/\text{liquidity efficiency}) (\$10) = (1/4.55)(\$10) = (.2197) (\$10) = \$2.20$ billion in funding for its payments.

Now suppose that the bank becomes a CHIPS participant, and shifts *one-sixth*, or \$1.65 billion, of its daily payments to CHIPS. Its median dollar of CHIPS settlement would occur at 8:00 a.m., and its liquidity efficiency ratio of 21.5 would suggest that it would devote about $(\$1.65/21.5)$ billion = \$67.3 million to funding on CHIPS.

On Fedwire, the bank, after joining CHIPS, would need to devote only \$1.83 billion to funding its \$8.35 billion of payments on Fedwire. So its overall liquidity use would fall from \$2.2 billion to $(\$1.83 \text{ billion} + \$67.3 \text{ million}) = \1.90 billion. If its payment timing on Fedwire were to remain at the Fedwire averages, its overall timing of payment moves earlier, so that the bank's median dollar of payment occurs at 12:25, about one hour earlier than before its joining CHIPS.

The combined effects on timing of its Fedwire payments may reflect two forces. First, it may be that the payments it moved to CHIPS were made early in the day on Fedwire. In that case, its average payment time on Fedwire might occur later in the day. A countervailing incentive is that the bank, by moving payments to CHIPS, conserves liquidity for the payments that remain on Fedwire. That freed-up liquidity might then be used by the bank to make its remaining Fedwire payments earlier than it previously had done.

In sum, by moving payments to CHIPS the bank will likely make and receive payments earlier — almost certainly for payments made and received on CHIPS. That will result in customers receiving earlier settlement from their bank, an important customer service interest, and reduce operational and credit risks broadly. Further, depending how the bank deploys the liquidity that was freed-up by virtue of its participation on CHIPS, it may decide to make payments earlier than it otherwise would on Fedwire, improving the liquidity positions of other banks, and providing better customer service to both senders and receivers of payments.

8. Conclusion

A liquidity savings mechanism, if successful, achieves two objectives: conservation in use of central bank balances, and earlier settlement. CHIPS accomplishes both objectives: on average CHIPS settles payments hours earlier than Fedwire, and CHIPS is more than four times more economical with liquidity than is Fedwire. CHIPS acts as liquidity savings mechanism for the U.S. large-value payments system. This makes clear that the performance of CHIPS is complementary to that of Fedwire and is a highly valuable part of the nation's payments infrastructure.

Our analysis also reveals that the adoption, in 2000, of CHIPS' balanced release engine provided significant settlement risk reductions with only small increases in liquidity use. Prior to 2000, all CHIPS' payments were finally settled at the end of the day. After the introduction of the balance release engine, payments are settled throughout the day, reducing risks associated with deferred settlement. We've estimated that the settlement during the day, which provides a direct decrease in settlement risk exposure and uses only \$1 of liquidity for every \$61.8 of intraday settlements — represents an extremely favorable trade-off for the U.S. payment system.

The complementarity of CHIPS operation to Fedwire can be understood in the following thought experiment: suppose that CHIPS' payment traffic were all shifted onto Fedwire. What effects would we expect? First, would we expect payments to occur in line with Fedwire's current timing of settlement? We suggest that, no, the timing of payments on Fedwire would occur *later* than they do currently. Were CHIPS' payments, totaling approximately \$2 trillion, moved to Fedwire, banks would face more contention in allocating liquidity to payments. Banks would find it necessary to use more reserves to make the payments than they had on CHIPS — they would need to use about (\$2 trillion) $(\{1/[\text{Liquidity efficiency of Fedwire}]\} - \{1/[\text{Liquidity efficiency of CHIPS}]\}) = \346 billion of additional reserves to make the former-CHIPS payments on Fedwire, an increase of about 4.7 times the amount of reserves used to settle on CHIPS.²¹ All else equal, that would tend to make reserves more costly and therefore to slow payments, and lead to additional delays. This is central to CHIPS being complementary to Fedwire: the payments on CHIPS improve the flow of payments on Fedwire (as well as directly serving the interests of the participants on CHIPS).

²¹ This reflects the efficiency ratios of 4.55 for Fedwire and 21.5 for CHIPS. This quantitative exercise is not intended to be precise, but instead to illustrate the order of magnitude of the qualitative effects of shifting payments from CHIPS to Fedwire.

That CHIPS provides important social benefits to the U.S. payment system is clear. It acts to settle payments earlier in the day than would otherwise be the case, and conserves on Federal Reserve Bank balances for CHIPS participants. Arguably this assists even non-participant banks as they likely receive payments from CHIPS participant banks earlier than would be the case if all those payments had to be made on Fedwire. That, in turn, endows non-participant banks with more liquidity during the day. These effects reduce operational risks throughout the payments system, on CHIPS and Fedwire, but also on other ancillary systems that utilize reserve balances to settle payments as well, such as DTCC and CLS.

Our findings show that there are unexploited economies of scale in CHIPS use of liquidity. In other words, were additional payments added by participants to CHIPS, it would yield even more savings of liquidity for every dollar of payment value transferred. Consequently, the role played by CHIPS can be further expanded to serve the U.S. payments system in future, and, in so doing, would confer additional benefits on participants and non-participants alike.



For more information about CHIPS, contact:

Richard Dzina

Senior Vice President, Product Development
The Clearing House
richard.dzina@theclearinghouse.org

Media Contact:

Greg MacSweeney

Vice President & Head of Communications
The Clearing House
gregory.macsweeney@theclearinghouse.org