POLICY PAPER

CHIPS Supplemental Funding and Its Effects on CHIPS, Overdrafts, and Fedwire

Dennis Kuo
James McAndrews
Clara Sheets

August 25, 2009

Introduction

In 2008, the Clearing House Interbank Payments System (CHIPS) Funds Transfer Committee, which consists of major participants of CHIPS, was given responsibility for looking into various methods that would continue to improve payment throughput and address payments system risk concerns. On May 9, 2008, the committee agreed to begin a coordinated initiative of adding supplemental funds to CHIPS as one possible way to achieve these goals.

Supplemental funding allows for the release of payment messages from the CHIPS queue that otherwise could be held back by optimization algorithm constraints. The participants expected to begin adding funds late in the day and to make subsequent adjustments as they became better able to incorporate the process into their funds management. The intent was to utilize funds more efficiently and to settle CHIPS payments more quickly and at earlier times, with the hope of creating positive spillover effects in Fedwire as well. (For a description of supplemental funding, see Appendix 1.)

This report examines patterns of supplemental funding and also analyzes the new initiative's effect on CHIPS, participants' overdrafts, and aggregate Fedwire activity. We focus on changes that occurred between the first and third quarters of 2008, the period prior to the Federal Reserve's action to pay interest on reserve balances.

We find that supplemental funding did increase markedly as a result of the initiative and that it had pronounced, positive effects on CHIPS flows. These effects included an increase in CHIPS payments value settled prior to 17:00 and a corresponding decrease in residual payments value settled after 17:00. There was also a decrease in withdrawn payments value in CHIPS. Increased overdrafts in reserve balance accounts emerged as a statistically, but not economically, significant side effect when participants transferred Fedwire funds into their CHIPS supplemental funds accounts. The improvements in CHIPS flows had positive effects on Fedwire, causing the latter's value to accumulate earlier during the late afternoon and to decrease during the 17:00 hour.

Dennis Kuo is an economist, James McAndrews a senior vice president, and Clara Sheets an associate business support analyst at the Federal Reserve Bank of New York. The views expressed in this report are those of the authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

Correspondence: <jamie.mcandrews@ny.frb.org>

Supplemental Funding

Supplemental funding has been a feature of CHIPS since 2003, but it did not occur in significant amounts until April 2008. On the dates of April 24, 25, 28, and 29, CHIPS conducted a preliminary experiment with a couple of participants, each contributing a large amount of supplemental funding in the late afternoon. On May 9, members of the CHIPS Funds Transfer Committee agreed to coordinate efforts to fund their positions beginning in the late afternoon, an initiative that began in earnest on or about May 19. The dramatic difference before and after the initiative began can be seen in Chart 1, which measures aggregate supplemental funding during the time of day between 15:00 and 17:00. (In this section, any before-and-after comparisons exclude data from April 21 to May 16, the period of the preliminary experiment.)

Aggregate supplemental funding was negligible before and during the first quarter of 2008, but during the third quarter it had reached a daily average of $28.9 billion. (Quarterly summary statistics for supplemental funding are available in Appendix 2.)

In the period between May 19 and September 30, 2008, twelve banks participated in the initiative. From the behavior of individual CHIPS funding participants, it is clear that a majority of them—about two-thirds—significantly expanded their amounts of daily supplemental funding in the first twenty weeks of the initiative.

The supplemental funding patterns varied widely from bank to bank. The least active participant funded its supplemental position on only two business days, whereas the most active funded its supplemental position on eighty-seven out of the ninety-four business days in that period. Only five out of the twelve banks funded their positions on more than half the business days in the period. The average positive daily funding amount also varied widely, from a low of $11 million to a high of $14.6 billion.

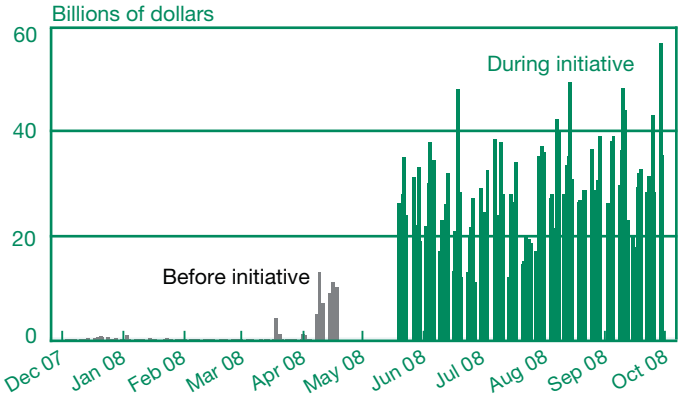
Effect on CHIPS

Even though levels of participation varied widely among the twelve banks, it is evident that the aggregate effect of increased supplemental funding did have an effect on CHIPS payment flows. Late-afternoon queued payments, late-afternoon deleted payments, residual value, and final funding all decreased after the initiative took effect, while CHIPS payments settled in the late afternoon prior to 17:00 increased in value terms.

Supplemental funding was expected to increase the value of payments released from the queue relative to those submitted. In the twenty weeks before the preliminary experiment, supplemental funding between 15:00 and 17:00 was infrequent, and the weighted average time of funding varied greatly from day to day. For the period of time tracked after the initiative began, supplemental funding clustered around 16:30, as shown in Chart 2.

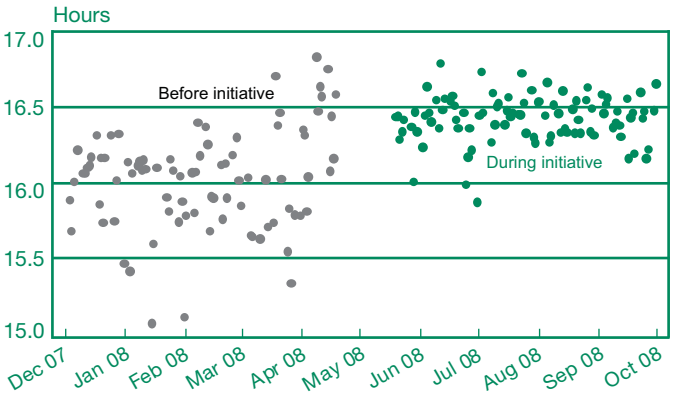
Chart 3 shows the differences in the patterns of transactions queued and released between the first and third quarters of

Chart 1
CHIPS Supplemental Funding



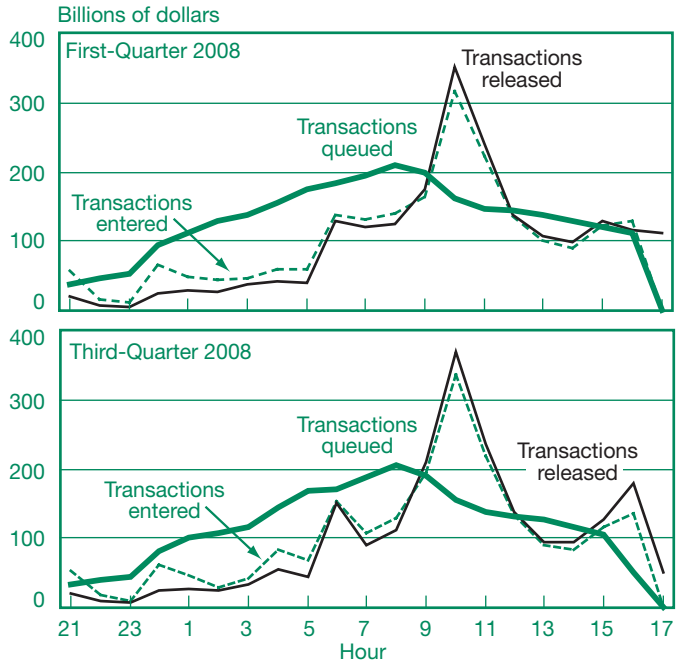
Sources: Federal Reserve Bank of New York; authors' calculations.

Chart 2
Weighted Average Time of Aggregate Supplemental Funding



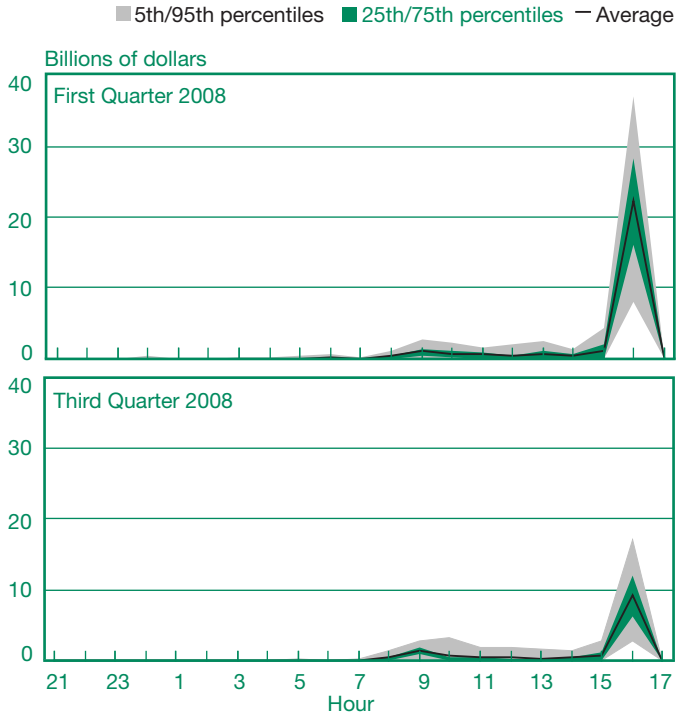
Sources: Federal Reserve Bank of New York; authors' calculations.

Chart 3
Value of Transactions Entered, Queued, and Settled, by Hour



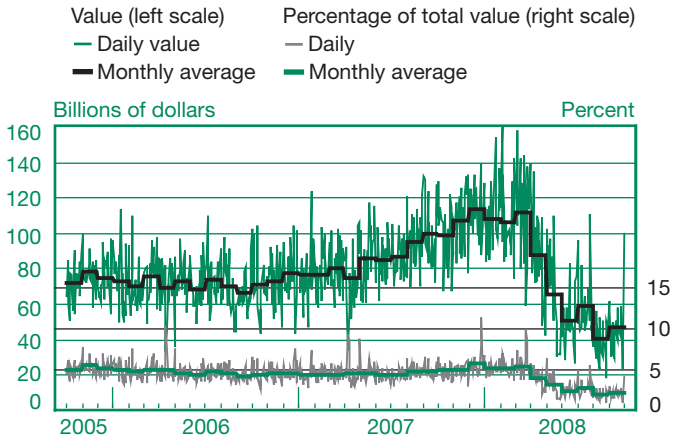
Sources: CHIPS; Federal Reserve Bank of New York.

Chart 4
Value of Deleted Transactions, by Hour



Sources: CHIPS; Federal Reserve Bank of New York.

Chart 5
Daily Residual Value



Sources: CHIPS; Federal Reserve Bank of New York.

2008. The afternoon peak of released payment value (the black line) shifted from the 15:00 hour to the 16:00 hour. This shift appears to have been a direct result of the large amount of supplemental funds flowing into CHIPS around 16:30 each day. Between these two periods, payments released from the queue during the 16:00 hour increased by more than $50 billion, while payments released from the queue after 17:00 decreased by more than $50 billion. As a consequence, fewer payments were held in the queue (the solid green line) during the 16:00 hour. The late-afternoon pattern of submitted payments (the dashed green line) did not change significantly.

Part of the increase in released payments during the 16:00 hour came from a decrease in the value of deleted payments, which usually peak in the 16:00 hour as participants try to clear the queue in advance of end-of-day closing procedures. Reasons for deleting payments include being able to settle them immediately outside of CHIPS (in Fedwire) and avoiding a violation of CHIPS' soft cap on the gross residual position. Supplemental funding provides the funds to settle payments that otherwise would be deleted. Chart 4 illustrates the decrease of more than $10 billion in average daily value of deleted payments from the first quarter to the third quarter of 2008.

Supplemental funding lowered the average daily value of payments in the queue during the 16:00 hour by more than $50 billion (the solid green line in Chart 3). With fewer dollars in the queue by the 17:00 close of CHIPS, the end-of-day residual value decreased.

Chart 5 shows that residual value began to increase in October 2006, leveling off in late 2007 and fluctuating around a monthly average of $110 billion through early 2008. Then,

in April, residual value began a precipitous decline, falling to a monthly average of less than $50 billion in September. Over the same period, residual value as a share of total CHIPS value settled also fell, from about 5 cents per dollar of total value to roughly 2.5 cents. Both the absolute and relative declines in residual value can be seen in Chart 5.

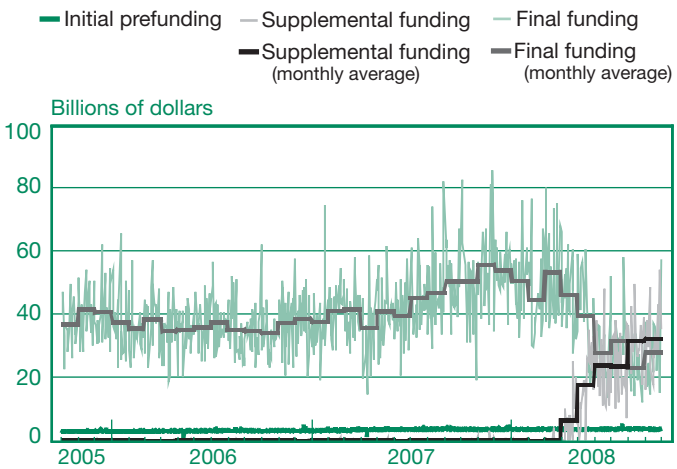
If residual value drops by roughly 50 percent, then final funding should fall proportionately. And that, in fact, is what happened. Aggregate final funding fell from a daily average of $49.5 billion in the first quarter to $27.6 billion in the third quarter. Furthermore, Chart 6 shows that, on a monthly average basis, moves in supplemental funding were matched by opposing moves in final funding for the months of April, May, June, and August. As daily average final funding dropped by $21.9 billion from the first quarter to the third quarter, supplemental funding rose from essentially zero to $28.9 billion. This pattern suggests that, when added late in the day, supplemental funding may be close to a dollar-for-dollar substitute for final funding—at least at an aggregate level. However, as supplemental funding moves to earlier in the day, the changes in payment flows may cause that comparison to diverge.

One measure of the effect of opposing moves in supplemental and final funding is the total funding ratio, calculated as the total of all funding—initial, supplemental, and final—as a percentage of total value settled. This ratio captures the liquidity savings that occur from the bilateral and multilateral netting of offsetting payments on CHIPS. The total funding ratio drifted upward from 2.6 percent in the first quarter of 2008 to 2.9 percent in the third quarter, as illustrated in Chart 7.

Supplemental funding is used to settle payments that remain in the queue because they are not netting to a sufficient degree against other payments. Therefore, it would not be surprising if the use of supplemental funds increased the total funding ratio. However, when the entirety of the total funding ratio time series is examined (Chart 7), it is not clear whether the ratio's increase from 2.6 to 2.9 between the first and third quarters represents a departure from either a consistent time trend or normal historical ranges. For instance, the ratio was 2.8 in the fourth quarter of 2007 and 3.0 in the fourth quarter of 2005. By contrast, the aforementioned changes in deleted value, residual value, and value released from the queue prior to 17:00 were clear, dramatic, and positive.

Overall, the CHIPS supplemental funding initiative appears to have had an unambiguously positive effect on CHIPS payment flows. Because late-afternoon supplemental funding acts, in many cases, as a substitute for final funding, total funding ratios have not increased noticeably. Meanwhile, deleted payments have decreased, payments released from the queue prior to 17:00 have increased relative to those submitted, and residual value has dropped by more than half since March 2008, both in absolute terms and as a share of total CHIPS value.

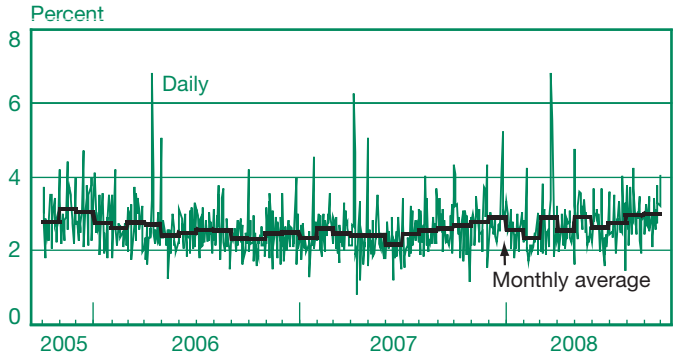
Chart 6
Initial Prefunding, Supplemental Funding, and Final Funding



Source: Federal Reserve Bank of New York.

Note: Calculations of supplemental funding begin in March 2008.

Chart 7
Total Funding Ratio (Includes Supplemental Funding)



Sources: CHIPS; Federal Reserve Bank of New York.

Note: The total funding ratio is the ratio of the sum of initial prefunding, supplemental funding, and final funding to the total value settled.

Table 1
CHIPS Deleted and Residual Value (Regression)

	Log of Deleted Value		Log of Residual Value	
December 3, 2007, to September 30, 2008	Coefficient	Standard Error	Coefficient	Standard Error
Log of supplemental funding value	-0.044	(0.005)***	-0.049	(0.005)***
Log of CHIPS total value	0.889	(0.188)***	0.570	(0.176)***
First day of quarter	0.039	(0.143)	0.224	(0.134)*
Last day of quarter	0.303	(0.225)	0.385	(0.210)*
Day after holiday	0.132	(0.175)	0.062	(0.163)
Day before holiday	-0.243	(0.175)	-0.058	(0.163)
MBS P&I day	0.188	(0.104)*	0.027	(0.098)
Friday	0.071	(0.132)	0.028	(0.124)
Monday	-0.090	(0.135)	0.027	(0.126)
Tuesday	-0.111	(0.134)	0.019	(0.125)
Wednesday	0.043	(0.130)	0.113	(0.121)
Maintenance day 6	0.046	(0.129)	0.098	(0.121)
Maintenance day 7	-0.150	(0.137)	0.039	(0.128)
Maintenance day 8	-0.074	(0.136)	0.054	(0.127)
Maintenance day 9	-0.112	(0.135)	-0.074	(0.126)
Maintenance day 10	-0.154	(0.129)	-0.202	(0.121)*
Constant	-0.590	(5.333)	9.766	(4.979)*
N	210		210	
R^2	0.3339		0.3738	
R^2_a	0.2786		0.3219	

Sources: CHIPS; Federal Reserve Bank of New York; authors' calculations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

However, to test the effects of supplemental funding more rigorously, we need to conduct regressions with the log of the deleted value and the log of the residual value as the dependent variables, against the log of aggregate supplemental funding as the explanatory variable of interest. The log of CHIPS total value and various calendar effects are included as explanatory variables. The log-log relationship between some of the explanatory variables and the dependent variable is meant to measure the elasticity of the dependent variable with respect to these explanatory variables. In other words, because of the properties of the log function, the resulting coefficient on the explanatory variable is a close approximation of the percent change in the dependent variable that results from a percent change in said explanatory variable.

The results, shown in Table 1 for in both regressions, are highly significant, predicting that a 1 percent increase in supplemental funding results in declines of 0.04 percent in deleted value and 0.05 percent in residual value.

Effect on the Use of Reserve Balances

Supplemental funding can be represented as a trade-off between improved end-of-day payment flows over CHIPS and increased use of balances in Federal Reserve accounts. This use of balances may manifest itself in some degree as larger daylight overdrafts. For instance, supplemental funding draws down reserve balances earlier, at an average time of 16:30, to settle payments that would otherwise be funded after 17:00 (or deleted and then rerouted onto Fedwire after 17:00, which would have the same effect on Fedwire liquidity). All else being equal, an overdraft caused by supplemental funding will last longer and cost more than one caused by final funding.

In order to measure the actual impact on overdrafts, we organize time series data from banks that funded their supplemental positions into a Tobit panel regression with random effects for each individual bank.

Table 2
Average Overdraft (Regression)

	Log of Average Overdraft	
May 19 to July 31	Coefficient	Standard Error
Log of Fedwire total value sent	0.918	(0.234)***
Log of CHIPS total value sent	-0.339	(0.121)***
Log of supplemental funding	0.072	(0.018)***
Log of other banks' supplemental funding	0.015	(0.282)
First day of month	0.396	(0.696)
Last day of quarter	0.743	(0.992)
Day after a holiday	0.765	(0.781)
Day before a holiday	-2.747	(0.696)***
MBS P&I day	0.180	(0.467)
Friday	0.970	(0.574)*
Monday	0.208	(0.645)
Tuesday	0.203	(0.577)
Wednesday	0.124	(0.572)
Maintenance day 6	-0.384	(0.542)
Maintenance day 7	-1.354	(0.623)**
Maintenance day 8	0.115	(0.656)
Maintenance day 9	0.485	(0.571)
Maintenance day 10	0.223	(0.554)
Constant	4.687	(8.815)
Observations	520	
Number of banks	10	

Sources: CHIPS; Federal Reserve Bank of New York; authors' calculations.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

The Tobit model is ideal for performing a regression on a dependent variable that can take on only nonnegative values. In this regression, the dependent variable is defined as the log of each bank's average overdraft per minute from 15:00 until 17:30. The 15:00 to 17:30 window covers the time period of supplemental funding and lasts until the close of CHIPS, when final payouts are made. The average overdraft is nonnegative by definition, but the log of the average overdraft is not similarly constrained and goes to negative infinity as the average overdraft approaches zero. To remedy this, we made an adjustment to the average overdraft, such that any value below 1 is set equal to 1 and the log of the average overdraft is therefore nonnegative.

The explanatory variable of interest is the log of the sum of each bank's supplemental funding in the timeframe from 15:00 to 17:00. Other explanatory variables include the log of the sum of supplemental funding made by all other banks in the sample on that day, the log of total Fedwire value sent by each bank between 15:00 and 17:30 on that day,[1] the log of total CHIPS value sent by each bank between 15:00 and 17:30 on that day, plus various calendar effects including maintenance days. The panel regression model assumes that these explanatory variables affect the dependent variable of all the panel's banks to the same degree.[2]

The period covered is from May 19 to July 31, 2008, and ten banks are in the panel. One bank that funds its supplemental position but does not run overdrafts is excluded, because it is assumed to be operating under a different reserves management regime.

The results, shown in Table 2, represent the partial effects of each explanatory variable on the dependent variable.[3] There is a small but statistically significant relationship between the log of overdrafts and the log of supplemental funding. Specifically, because of the elasticity effect that a log-log regression approximates, for every 1 percent increase in supplemental funding, there is a 0.07 percent increase in average overdrafts per minute between 15:00 and 17:30. The small elasticity probably results because supplemental funding is by no means the only factor contributing to overdrafts in the afternoon, and banks can be assumed to actively manage their overdrafts.

In addition, the results show that the partial effects of both the Fedwire value sent and the CHIPS value sent are highly significant. For every 1 percent increase in Fedwire value sent, there is a 0.92 percent increase in the average overdraft. For every 1 percent increase in CHIPS value sent and settled, there is a 0.34 percent decrease in the average overdraft.

[1] From total Fedwire value sent by each bank between 15:00 and 17:30, we exclude payments made to CHIPS.

[2] The random-effects feature of the regression allows each bank to have its own time-invariant effect of random origin that contributes to the log of its overdrafts, before the partial effects of any explanatory variables are factored in. The model assumes that these random, time-invariant bank-level effects on the log of the average overdraft are part of the unobserved residual and ideally are uncorrelated with any of the other explanatory variables. We believe that the Fedwire value sent by each bank will, over the time period of the regression, capture any slow-moving bank-level characteristics that would affect the average overdraft dependent variable and be correlated with the other explanatory variables. Including this Fedwire value sent should remove most, if not all, of any bank-level, time-invariant, omitted-variables bias that would otherwise have been present, and therefore the random effects should be largely uncorrelated with any of the explanatory variables.

[3] The coefficients from the regression were exactly equal to the adjusted partial effects. Usually, the coefficients and adjusted partial effects are different in a Tobit regression because the range of the dependent variable has been censored. The results from this Tobit log-log regression were very close in magnitude and direction to those of a similar ordinary least squares log-log regression, although the Tobit results were much more significant.

The partial effect of a variable describes the impact of a change in that variable when the values of all other variables are held constant. However, in the section on CHIPS payment flows, we saw how participants use a portion of supplemental funds to settle payments on CHIPS that they otherwise would have deleted and rerouted over Fedwire. If reductions in deleted payments occur, then the full impact of an increase in supplemental funding includes the indirect effects of the resulting increase in CHIPS value and the corresponding decrease in Fedwire value.

An increase in CHIPS value and a decrease in Fedwire value both decrease overdrafts, whereas the partial effect of supplemental funding is to increase overdrafts. For the majority of participants in this initiative, the movement of payments settlement from Fedwire back onto CHIPS is insufficiently large, when compared with the base values of CHIPS and Fedwire, to make an economically significant reduction in the overdrafts caused by supplemental funding. Therefore, the partial effect of supplemental funding is a good approximation of the full impact.

The banks in the panel had a total of $25.19 billion in average overdrafts per minute between 15:00 and 17:30, on a daily average basis, during the period of the regression. Together, they funded their supplemental positions by $24.43 billion, on a daily average basis, during the same period. The results of the regression suggest that if these banks increased their supplemental funding in aggregate by $5 billion on a given day, then that 20.5 percent increase in funding would translate into a 1.47 percent increase in average overdrafts, or an additional $0.37 billion, for all the banks combined, per minute, over the two-and-a-half-hour period.

To put this $0.37 billion into context, we can examine a plausible but hypothetical scenario in which the extra aggregate supplemental funding of $5 billion makes a direct contribution to existing aggregate overdrafts by the same amount ($5 billion) beginning at 16:30. This overdraft condition persists through 17:00 (past which point the overdraft contribution would simply be the same as that caused by an alternative final funding activity), which would mean an extra $5 billion times a duration of thirty minutes. Averaging this level of increased overdrafts over the entire period from 15:00 to 17:30, we find that it would equal $1 billion in extra average overdrafts per minute over the two-and-a-half-hour period. This amount is almost three times the regression measurement increase of $0.37 billion. The difference suggests either that participants conduct supplemental funding when they have some measure of liquidity available, or that overdrafts tend not to persist for an extended period of time.

EFFECTS ON FEDWIRE TIMING

The overdraft results in the previous section should be weighed against the improvements in late-afternoon CHIPS payment flows. The effect of supplemental funding on Fedwire flows should also be investigated and factored into the overall picture.

There are two possible ways through which CHIPS supplemental funding in the late afternoon can affect Fedwire payments. The first is by replicating some, if not all, of the conditions of final settlement at an earlier time. Final settlement in CHIPS is likely to be associated with 1) the release of Fedwire payments that are conditional upon specific CHIPS payments, 2) the general reduction of payments uncertainty, and 3) the formation of a temporal coordination point around which banks can concentrate offsetting Fedwire payments to each other. To the extent that any of these associations holds true, replication of CHIPS final settlement conditions at an earlier time will also move Fedwire value earlier. The second possible way in which supplemental funding can affect Fedwire payments is by reducing deleted payments from CHIPS that would otherwise be rerouted onto Fedwire during the 17:00 hour. Both the first and second ways would lead to a shift to earlier settlement of late-day Fedwire value.

To evaluate the changes in Fedwire timing associated with aggregate CHIPS supplemental funding, we conducted two regression tests. Both tests use a measure of Fedwire value that excludes payments to and from settlement institutions, in order to avoid measuring the direct effects of CHIPS prefunding, funding, and payouts on Fedwire value transferred.

The first test regresses the time of settlement of the 50th, 60th, 70th, 80th, and 90th percentiles of Fedwire value on aggregate supplemental funding from 15:00 to 17:00, expressed as a percentage of total CHIPS value sent on that day. We will call this *normalized supplemental funding*, the square of which we also regress on. Other explanatory variables include measures of financial stress, other payments system variables, and calendar-effect variables. The second test regresses the percentage of total Fedwire value settled both in the 16:00 hour and the 17:00 hour on the same set of explanatory variables as the first test. The date range for both tests is January 3, 2005, to September 30, 2008. A detailed explication of the results can be found in Appendix 3.

Overall, these two Fedwire timing regressions show that the average level of normalized supplemental funding during the third quarter of 2008 is associated with a shift in the time of settlement of the 60th, 70th, and 80th percentiles of Fedwire value earlier in the day by 1.47, 2.58, and 1.66 minutes, respectively, and reduced value settled in Fedwire in the 17:00

hour by roughly $37.5 billion on average. By contrast, the absolute level of supplemental funding had no significant effects on any measures of Fedwire timing in an alternate regression model.

The statistically significant results obtained with normalized, rather than absolute, levels of funding suggest that what matters for Fedwire is the earlier and more predictable settlement of payments on CHIPS, regardless of how much total supplemental funding or total CHIPS payments value is involved. That view supports either the hypothesis of reduction of uncertainty, or the coordination point for de facto netting—or both. A reduction of deleted CHIPS payments would be one component of earlier and more predictable settlement of CHIPS payments. Such a reduction would promote both the lowering of uncertainty and the formation of an earlier coordination point, in addition to directly lessening late-day Fedwire payments in a manner consistent with the positive timing results obtained. Lastly, the lack of significant results for Fedwire value in the 16:00 hour, and the lack of significant results for absolute levels of funding on Fedwire timing in general, suggests that the main channels through which supplemental funding affects Fedwire are not likely to include an increased release of Fedwire payments whose release depends on the release of specific CHIPS payments.

The two regressions do not provide evidence that continued increases in normalized supplemental funding would result in ever-increasing improvements to Fedwire payment flows. However, the regressions do suggest that almost all of the daily aggregate normalized supplemental funding amounts in the second and third quarters of 2008 had strictly positive effects on Fedwire.

Summary

As our review has shown, the CHIPS supplemental funding initiative appears to have had an unambiguously positive effect on CHIPS payment flows. The results have been an increase in settlement of payments prior to 17:00, a significant reduction in withdrawn payments, and less reliance on final funding to settle the remaining residual share of payments in the queue at the close of business.

The effects on Fedwire appear to be positive as well. Despite statistical evidence of marginally higher overdrafts associated with the increase in supplemental funding at around 16:30, participants either tend to fund when they have some liquidity available to begin with, or they are able to avoid extended overdrafts through account management. (These measurements were conducted for a period prior to the significant increase in excess reserve balances that began in the fall of 2008.)

Of significance is that the CHIPS initiative has tended, on average, to quicken settlement of payments on Fedwire and to reduce the percentage of Fedwire payments that occur after 17:00. Both results are positive from the standpoint of operational and systemic risk management. However, the results on possible diminishing returns suggest that further increases in supplemental funding may not lead to additional improvements in Fedwire payment flows.

In the period prior to payment of interest on reserves, the CHIPS initiative significantly changed the timing of late-day payments on CHIPS and Fedwire. These gains in operational and economic efficiency seem quite inexpensive relative to the costs of higher daylight overdrafts. Although overdrafts are higher in a statistical sense, they are not significantly higher in an economic sense, because the effects of the change in CHIPS' supplemental funding policies on overdrafts are swamped by first-order factors, such as Fedwire value sent, that drive overdraft levels. Consequently, this initiative appears to have conveyed a net positive economic benefit as payments settle more quickly and more surely, while the costs of earlier funding are not particularly large or certain.

Appendix 1: The Mechanics of CHIPS Supplemental Funding

Under the CHIPS settlement design, participants transfer funds, using Fedwire, to the CHIPS account at the beginning of each day, an activity called *initial prefunding*. Throughout the day, payment orders submitted to CHIPS settle against the current account balance of a CHIPS participant according to two constraints: 1) the account balance cannot fall below zero, and 2) the account balance can never exceed twice its initial prefunding. The latter constraint was developed to prevent a "liquidity trap," where the majority of funds are located in only a few accounts, preventing the flow of payments. At the end of each day, payments that cannot be settled because of the constraints—that is, those that remain in the payment queue—are settled by final funding. Participants transfer final funding payments via Fedwire into the CHIPS account after 17:00. After the remaining queued payments are settled, CHIPS pays out to participants any positive account balances, called *final payouts.*

Supplemental funding was designed (and first implemented in 2003) to allow participants more control over settlement of payments from the queue. Participants can fund their supplemental positions intraday, instead of only prior to 9:00 and after 17:00. By funding their accounts intraday, participants can expedite their payment orders from the queue. Supplemental funding also allows for a *reserved portion*; any portion of supplemental funds can be reserved for a "priority" payment. CHIPS allows payments to be flagged as "urgent," those receiving the highest priority, and "preferred," those receiving second-highest priority. Additionally, participants can withdraw funds from their supplemental funds account intraday. The withdrawal of funds must be the lesser of their total supplemental funding or their current supplemental position.

To account for funds eligible for withdrawal, CHIPS records two positions for each participant: a primary position and a supplemental position. Initial prefunding is directed to a participant's primary position, and supplemental funding is directed to a participant's supplemental position. The two positions are segregated across all participants at all times prior to end-of-day settlement. For example, if a payment is made from a participant's primary account, the receiving participant's primary account is credited. Likewise, if a payment is made from a participant's supplemental account, the receiving participant's supplemental account is credited. Single payments and groups of payments can be settled using a portion of money from both positions simultaneously, determined by the CHIPS settlement algorithm.

Appendix 2: CHIPS Prefunding and Funding Summary Statistics

Table A1

Value of Funding

Billions of Dollars

	2007:Q2	2007:Q3	2007:Q4	2008:Q1	2008:Q2	2008:Q3	Percentage Change from Year Ago
Initial prefunding							
Average	3.5	3.7	3.6	3.6	3.6	3.8	0.6
Median	3.5	3.7	3.6	3.6	3.6	3.8	1.3
Minimum	1.7	3.5	3.4	3.5	3.5	3.5	-0.1
Maximum	4.1	4.2	4.5	4.0	3.9	4.7	10.9
Standard deviation	0.3	0.2	0.2	0.1	0.1	0.2	1.1
Supplemental funding							
Average	—	—	—	—	15.7	28.9	N/A
Median	—	—	—	—	14.6	28.6	N/A
Minimum	—	—	—	—	0.0	7.1	N/A
Maximum	—	—	—	—	48.1	53.9	N/A
Standard deviation	—	—	—	—	11.5	9.6	N/A
Final funding							
Average	38.7	47.1	53.1	49.5	37.8	27.6	-41.5
Median	38.9	44.9	53.5	48.3	36.3	26.2	-41.5
Minimum	14.4	29.2	19.2	29.7	13.8	12.2	-58.3
Maximum	61.3	82.0	85.2	79.7	65.8	58.1	-29.1
Standard deviation	10.1	10.5	12.7	12.4	12.9	9.5	-9.4

Source: Federal Reserve Bank of New York.

Notes: Initial prefunding is the funding by participants to their CHIPS accounts at the beginning of the day to meet their initial position requirements. Supplemental funding is the afternoon funding by selected participants to allow for the release of queued payments. Final funding occurs at the end of the day by participants with a negative final position.

Table A2

Funding Ratios

Percent

	2007:Q2	2007:Q3	2007:Q4	2008:Q1	2008:Q2	2008:Q3	Change from Year Ago
Total funding ratio							
Average	2.3	2.5	2.8	2.6	2.7	2.9	0.4
Median	2.2	2.4	2.8	2.4	2.7	2.8	0.4
Minimum	0.8	1.5	1.2	1.7	1.6	1.4	-0.1
Maximum	6.3	4.0	5.2	6.8	4.8	4.2	0.2
Standard deviation	0.8	0.5	0.7	0.8	0.5	0.6	0.1
Intraday funding ratio							
Average	0.2	0.2	0.2	0.2	0.9	1.6	1.4
Median	0.2	0.2	0.2	0.2	0.9	1.6	1.4
Minimum	0.1	0.2	0.1	0.1	0.2	0.6	0.4
Maximum	1.0	0.2	0.6	0.7	2.3	2.7	2.4
Standard deviation	0.1	0.0	0.1	0.1	0.6	0.5	0.5
Residual funding ratio							
Average	47.2	50.2	49.6	45.7	57.4	57.2	6.9
Median	48.2	49.6	49.8	45.9	56.1	57.2	7.6
Minimum	22.7	38.8	28.5	27.7	35.8	34.8	-4.0
Maximum	61.7	67.6	70.2	62.8	79.9	80.8	13.1
Standard deviation	8.2	6.7	8.0	7.4	9.7	8.7	2.0

Sources: CHIPS; Federal Reserve Bank of New York.

Notes: The total funding ratio is the ratio of the sum of the initial prefunding, supplemental funding, and final funding to the value settled. The intraday funding ratio is the ratio of the sum of initial prefunding and supplemental funding to the nonresidual value. The residual funding ratio is the ratio of the final funding to the residual value.

Table A3

Daily Averages of the Distribution of Participant Funding Values

Millions of Dollars

	2007:Q2	2007:Q3	2007:Q4	2008:Q1	2008:Q2	2008:Q3	Percentage Change from Year Ago
Initial prefunding							
Average	78.8	84.1	81.7	81.3	80.2	82.7	-1.6
Median	37.6	41.8	44.0	43.3	39.1	44.6	6.6
Minimum	1.0	1.0	1.0	1.0	1.0	1.0	-1.6
Maximum	363.8	391.3	348.2	316.6	322.2	354.2	-9.5
Standard deviation	93.3	98.8	93.4	91.6	90.0	93.7	-5.2
Supplemental funding							
Average	—	—	—	—	1,858.0	3,433.0	N/A
Median	—	—	—	—	1,603.0	2,816.0	N/A
Minimum	—	—	—	—	127.5	193.1	N/A
Maximum	—	—	—	—	5,498.0	8,117.0	N/A
Standard deviation	—	—	—	—	1,849.0	2,985.0	N/A
Final funding							
Average	1,746.0	1,788.0	2,039.0	2,115.0	1,976.0	1,683.0	-5.9
Median	672.4	669.9	802.3	842.1	874.0	847.1	26.5
Minimum	11.8	13.3	11.8	13.7	14.9	15.6	17.7
Maximum	9,058.0	8,648.0	9,450.0	9,641.0	9,750.0	8,332.0	-3.7
Standard deviation	2,575.0	2,527.0	2,789.0	2,941.0	2,731.0	2,267.0	-10.3

Source: Federal Reserve Bank of New York.

Notes: All values are the unweighted averages of daily values of the indicated statistics. Banks that do not participate in the given round of funding or prefunding are excluded from the calculations.

Appendix 3: Fedwire Timing Regressions

The following two tests use a measure of Fedwire value that excludes payments to and from settlement institutions in order to avoid measuring the direct effects of CHIPS prefunding, funding, and payouts on Fedwire value transferred.

To test the null hypothesis that there was no shift in the timing of settlement over Fedwire, we regress the time of settlement of the 50th, 60th, 70th, 80th, and 90th percentiles of Fedwire value on aggregate supplemental funding in the time period from 15:00 to 17:00, expressed as a percentage of total CHIPS value sent on that day. We call this *normalized supplemental funding,* whose square is also regressed on. Other explanatory variables include measures of financial stress, other payments system variables, and calendar-effect variables.[4] The range of dates is January 3, 2005, to September 30, 2008.

The results of the regression show that supplemental funding has a significant linear effect at the 5 percent level on moving the 70th and 80th percentiles in question to an earlier time and an effect at the 10 percent level on moving the 60th percentile earlier. However, there is also a significant, opposing quadratic effect at the 5 percent level on moving the 60th percentile later and effects at the 10 percent level on moving the 70th and 80th percentiles later. In 2006, the 50th percentile settled at 16:15, the 60th at 16:37, the 70th at 16:58, the 80th at 17:14, and the 90th at 17:26. An abridged version of the regression results is shown in Table A4 and a full version can be found in Table A6.

If we choose to accept the results at the 10 percent significance level and those at the 5 percent level, then normalized supplemental funding shows a degree of diminishing returns, which applies differently to the 60th, 70th, and 80th percentiles. For the average level of normalized supplemental funding in the third quarter of 2008 (which came out to 1.409 percent), the regression predicts that the 80th percentile moved earlier by 1.66 minutes, the 70th by 2.58 minutes, and the 60th by 1.47 minutes.

However, for the second-largest level of normalized supplemental funding in the third quarter of 2008 (which was 2.422 percent), the regression predicts that the 80th percentile moved earlier by 0.05 minutes, the 70th moved earlier by 0.29 minutes, and the 60th moved later by 3.48 minutes. The maximum level of normalized supplemental funding during the third quarter was 2.517 percent, and the regression predicts that it moved the 80th percentile later by 0.22 minutes, the 70th later by 0.10 minutes, and the 60th later by 3.48 minutes.

To further investigate the causes of this shift in Fedwire timing, we examine what happens to Fedwire value both in the 16:00 and 17:00 hours. If Fedwire payments conditional on CHIPS payments being released are settled earlier because of supplemental funding, then one would expect to see an increase in the proportion of Fedwire payments made during the 16:00 hour followed by a decrease in the proportion of Fedwire payments made during the 17:00 hour. If deleted CHIPS payments are decreasing, then one would expect to see a decrease in the proportion of Fedwire payments made during the 17:00 hour, with no effect on the 16:00 hour.

To test the null hypothesis that there was no effect on the proportion of Fedwire payments settled during the 16:00 or 17:00 hour, we regress the percentage of total Fedwire value settled during the 16:00 hour and the 17:00 hour on the same set of explanatory variables as the first test, over the same range of dates. The effect of normalized supplemental funding on the percentage settled during the 16:00 hour was not significantly different from zero. However, for the 17:00 hour there was once again both a linear effect and a quadratic effect. The linear effect was significant at the 5 percent level and reduced the percentage of Fedwire value settled in the 17:00 hour. The quadratic effect was significant at the 10 percent level and increased the percentage of Fedwire value settled in the 17:00 hour. An abridged version of the regression results is shown in Table A5 and the full version can be found in Table A7.

If we accept the quadratic effect, with its 10 percent significance level, then there are diminishing returns to the effect of supplemental funding. The regression predicts that the average level of normalized supplemental funding during the third quarter of 2008 (1.409 percent) would reduce Fedwire value settled during the 17:00 hour by 1.39 percent, which translates roughly into $37.5 billion.

The fourth-largest value of normalized funding during the third quarter of 2008, at 2.227 percent, reduces Fedwire value settled in the 17:00 hour by 0.210 percent. The three largest values of normalized funding during the third quarter are all predicted to increase Fedwire value, with the largest funding percentage, 2.517, raising Fedwire value by 0.558 percent.

[4]For details on the payments system and the calendar-effect explanatory variables chosen, see Olivier Armantier, Jeffrey Arnold, and James McAndrews, "Changes in the Timing Distribution of Fedwire Funds Transfers," Federal Reserve Bank of New York *Economic Policy Review* 14, no. 2 (September): 83-112 (available at <http://www.newyorkfed.org/research/epr/08v14n2/0809arma.html>).

Table A4

Abridged Results of Fedwire Value Time Percentiles (Regressions)

January 3, 2005, to September 30, 2008

	Time at Which Percentiles of Fedwire Value Are Settled				
Explanatory Variables	50	60	70	80	90
Normalized aggregate CHIPS supplemental funding (percent)	-3.93214	-4.49586	-4.20607	-2.78537	-0.24016
	(3.20781)	(2.52793)*	(2.11213)**	(1.34052)**	(1.50243)
Square of normalized CHIPS supplemental funding	2.04960	2.44935	1.68701	1.14069	0.45825
	(1.49147)	(1.17536)**	(0.98203)*	(0.62328)*	(0.69856)
Observations	888	888	888	888	888
R^2	0.38	0.49	0.49	0.58	0.55

Sources: Bloomberg; Markit; CHIPS; Federal Reserve Bank of New York; DORPS; authors' calculations.
Note: Standard errors are in parentheses.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

Table A5

Abridged Results of Fedwire Value during 16:00 and 17:00 Hours (Regressions)

January 3, 2005, to September 30, 2008

	Percentage of Total Fedwire Value	
Explanatory Variables	16:00 Hour	17:00 Hour
Normalized aggregate CHIPS supplemental funding (percent)	0.92114	-2.52407
	(1.08572)	(1.21894)**
Square of normalized CHIPS supplemental funding	-0.44996	1.09070
	(0.50481)	(0.56675)*
Observations	888	888
R^2	0.38	0.40

Sources: Bloomberg; Markit; CHIPS; Federal Reserve Bank of New York; DORPS; authors' calculations.
Note: Standard errors are in parentheses.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

Table A6

Fedwire Value Time Percentiles (Regressions)

January 3, 2005, to September 30, 2008

	Time at Which Percentiles of Fedwire Value Are Settled				
Explanatory Variables	50	60	70	80	90
Normalized aggregate CHIPS supplemental funding (percent)	-3.93214	-4.49586	-4.20607	-2.78537	-0.24016
	(3.20781)	(2.52793)*	(2.11213)**	(1.34052)**	(1.50243)
Square of normalized CHIPS supplemental funding	2.04960	2.44935	1.68701	1.14069	0.45825
	(1.49147)	(1.17536)**	(0.98203)*	(0.62328)*	(0.69856)
DORPS opening balances	0.15602	0.15507	0.10783	0.08440	0.07612
	(0.05236)***	(0.04126)***	(0.03447)***	(0.02188)***	(0.02452)***
Square of opening balances	-0.00038	-0.00029	-0.00025	-0.00023	-0.00044
	(0.00023)	(0.00018)	(0.00015)	(0.00010)**	(0.00011)***
Two days after major bank failure	-7.29281	-6.05672	-7.63305	-6.71991	-9.35998
	(5.57338)	(4.39213)	(3.66969)**	(2.32908)***	(2.61039)***
Four days after major bank failure	-4.82723	-3.69118	-0.43706	-0.10838	4.29636
	(4.90670)	(3.86675)	(3.23073)	(2.05047)	(2.29814)*
LIBOR - OIS spread	8.53342	5.07071	1.50227	1.64267	-0.93802
	(4.42933)*	(3.49056)	(2.91641)	(1.85099)	(2.07456)
Square of LIBOR - OIS spread	-14.49157	-10.97281	-3.58665	-1.33575	2.13826
	(3.00674)***	(2.36948)***	(1.97974)*	(1.25650)	(1.40826)
VIX	-1.72761	-1.09283	-0.47830	-0.18740	0.02912
	(0.40999)***	(0.32309)***	(0.26995)*	(0.17133)	(0.19202)
Square of VIX	0.04681	0.03033	0.01288	0.00633	0.00123
	(0.01012)***	(0.00797)***	(0.00666)*	(0.00423)	(0.00474)
CDX financial subsector	-0.02926	-0.00397	0.00863	0.00681	0.00756
	(0.02535)	(0.01998)	(0.01669)	(0.01059)	(0.01187)
Square of CDX	0.00005	0.00002	-0.00002	-0.00001	-0.00001
	(0.00004)	(0.00003)	(0.00003)	(0.00002)	(0.00002)
NYSE composite volume	0.00050	-0.00139	-0.00128	-0.00053	-0.00030
	(0.00120)	(0.00095)	(0.00079)	(0.00050)	(0.00056)
Payments greater than or equal to $10 million	840.40316	623.75481	309.98509	110.64774	113.83993
	(149.54450)***	(117.84937)***	(98.46499)***	(62.49361)*	(70.04186)
GSE credit policy	2.12235	4.48677	5.14270	3.37197	2.70608
	(1.46113)	(1.15145)***	(0.96205)***	(0.61059)***	(0.68435)***
MBS P&I day * new GSE credit policy	6.53187	3.13438	0.82865	0.22336	-0.25756
	(1.86282)***	(1.46801)**	(1.22654)	(0.77846)	(0.87249)
MBS P&I day	-7.47560	-3.66772	-2.10998	-1.39535	-1.60816
	(1.60889)***	(1.26789)***	(1.05934)**	(0.67234)**	(0.75355)**
Fedwire opens at 21:00 the night before	2.36808	1.53761	-0.82360	-1.12115	-1.73178
	(1.40779)*	(1.10942)	(0.92694)	(0.58831)*	(0.65937)***
Fedwire operating hour extension	0.00881	0.01136	0.02100	0.04465	0.09557
	(0.01745)	(0.01375)	(0.01149)*	(0.00729)***	(0.00817)***
Interbank payment value	0.00082	0.00890	0.01420	0.00583	0.00226
	(0.00755)	(0.00595)	(0.00497)***	(0.00316)*	(0.00354)
Customer payment value	-0.01506	-0.01021	-0.00161	0.00319	0.00518
	(0.00553)***	(0.00436)**	(0.00364)	(0.00231)	(0.00259)**
Fed funds deliveries	0.00706	0.01352	0.00835	0.00697	0.01113
	(0.01246)	(0.00982)	(0.00820)	(0.00521)	(0.00584)*
Fed funds returns	-0.00611	-0.00089	0.00183	0.00073	-0.00818
	(0.01268)	(0.00999)	(0.00835)	(0.00530)	(0.00594)
Fedwire number of payments	0.06934	0.05165	0.02563	0.01309	0.01214
	(0.01570)***	(0.01237)***	(0.01034)**	(0.00656)**	(0.00735)*
CHIPS extension	0.41873	0.57117	0.65404	2.48763	1.09852
	(0.64153)	(0.50556)	(0.42240)	(0.26809)***	(0.30047)***

Table A6 (continued)

Fedwire Value Time Percentiles (Regressions)

January 3, 2005, to September 30, 2008

	Time at Which Percentiles of Fedwire Value Are Settled				
Explanatory Variables	50	60	70	80	90
DTC settlement time	0.04042	0.13625	0.06362	0.03569	0.01867
	(0.02321)*	(0.01829)***	(0.01528)***	(0.00970)***	(0.01087)*
DTC net-net credits	0.05041	-0.03795	-0.04349	-0.01356	0.00000
	(0.02021)**	(0.01592)**	(0.01331)***	(0.00844)	(0.00946)
CLS bank U.S. dollar value	0.00534	0.02154	-0.04018	-0.03661	-0.00957
	(0.06855)	(0.05402)	(0.04514)	(0.02865)	(0.03211)
NYSE closed early	-16.78507	-16.92002	-15.96344	-6.98902	-6.32347
	(3.46162)***	(2.72795)***	(2.27925)***	(1.44659)***	(1.62131)***
Friday	-0.74546	0.96266	0.74313	0.36553	-0.63086
	(1.23696)	(0.97479)	(0.81445)	(0.51692)	(0.57935)
Monday	0.05669	2.36324	2.04558	1.59539	2.59536
	(1.29213)	(1.01827)**	(0.85078)**	(0.53997)***	(0.60519)***
Tuesday	1.40260	3.37611	1.75550	1.04421	0.62646
	(1.18572)	(0.93441)***	(0.78071)**	(0.49550)**	(0.55535)
Wednesday	1.77708	2.22426	1.17152	0.78693	0.64242
	(1.16982)	(0.92189)**	(0.77025)	(0.48886)	(0.54791)
Maintenance day 6	-0.02825	1.38811	0.34383	0.60446	0.36325
	(1.17110)	(0.92289)	(0.77109)	(0.48939)	(0.54851)
Maintenance day 7	-0.25331	-0.58076	-0.24358	0.01547	0.03280
	(1.15424)	(0.90961)	(0.75999)	(0.48235)	(0.54061)
Maintenance day 8	-0.38418	-0.07452	-0.02295	0.37152	-0.61286
	(1.20820)	(0.95213)	(0.79552)	(0.50490)	(0.56588)
Maintenance day 9	0.20679	-1.07726	-0.37714	-0.06005	0.23171
	(1.14618)	(0.90325)	(0.75468)	(0.47898)	(0.53683)
Maintenance day 10	-3.16031	-2.21898	-1.77080	-0.77742	-0.51131
	(1.12774)***	(0.88872)**	(0.74254)**	(0.47127)*	(0.52820)
Fed funds deviation	3.75040	5.93624	2.31752	0.92495	0.08349
	(2.61188)	(2.05831)***	(1.71975)	(1.09149)	(1.22332)
Fed funds target rate	0.73741	0.15579	0.22994	0.61525	1.02938
	(0.65041)	(0.51256)	(0.42825)	(0.27180)**	(0.30463)***
HHI of Fedwire value	0.00101	0.01895	0.02516	0.01311	0.00531
	(0.00858)	(0.00676)***	(0.00565)***	(0.00358)***	(0.00402)
Day before a holiday	-12.27122	-9.05264	-7.78639	-4.95372	-6.00395
	(1.54764)***	(1.21963)***	(1.01902)***	(0.64675)***	(0.72486)***
Day after a holiday	-3.62276	-1.66857	-0.28389	0.62687	0.05418
	(1.76559)**	(1.39138)	(1.16252)	(0.73783)	(0.82695)
Time trend	-0.01368	-0.02771	-0.02246	-0.01320	-0.01246
	(0.00597)**	(0.00470)***	(0.00393)***	(0.00249)***	(0.00280)***
First day of month	-0.54563	-1.07598	-1.01765	-1.02551	-0.28005
	(1.67462)	(1.31969)	(1.10262)	(0.69981)	(0.78434)
Last day of quarter	-5.71133	-5.08052	-3.83477	-1.87539	-0.89017
	(2.87010)**	(2.26179)**	(1.88976)**	(1.19939)	(1.34426)
Last five days of year	-5.12611	-4.66846	-3.22750	-2.07659	-1.35409
	(2.60560)**	(2.05336)**	(1.71561)*	(1.08886)*	(1.22038)
Constant	142.55813	261.68185	641.35104	874.66997	908.68633
	(136.65813)	(107.69419)**	(89.98018)***	(57.10848)***	(64.00630)***
Observations	888	888	888	888	888
R^2	0.38	0.49	0.49	0.58	0.55

Sources: Bloomberg; Markit; CHIPS; Federal Reserve Bank of New York; DORPS; authors' calculations.
Note: Standard errors are in parentheses.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.

Table A7

Fedwire Value during 16:00 and 17:00 Hours (Regressions)

January 3, 2005, to September 30, 2008

	Percentage of Total Fedwire Value			Percentage of Total Fedwire Value	
Explanatory Variables	16:00 Hour	17:00 Hour	Explanatory Variables	16:00 Hour	17:00 Hour
Normalized aggregate CHIPS supplemental funding (percent)	0.92114	-2.52407	Payments greater than or equal to $10 million	10.87392	251.29126
	(1.08572)	(1.21894)**		(50.61531)	(56.82556)***
Square of normalized CHIPS supplemental funding	-0.44996	1.09070	GSE credit policy	-2.23975	2.60273
	(0.50481)	(0.56675)*		(0.49454)***	(0.55522)***
DORPS opening balances	-0.03654	0.05656	MBS P&I day * new GSE credit policy	0.89007	0.44955
	(0.01772)**	(0.01990)***		(0.63050)	(0.70786)
Square of opening balances	0.00012	-0.00008	MBS P&I day	-0.75145	-0.94797
	(0.00008)	(0.00009)		(0.54455)	(0.61136)
Two days after major bank failure	-0.41453	0.60634	Fedwire opens at 21:00 the night before	1.06756	-0.49343
	(1.88638)	(2.11783)		(0.47649)**	(0.53495)
Four days after major bank failure	0.60379	-2.54169	Fedwire operating hour extension	-0.00566	-0.02557
	(1.66074)	(1.86450)		(0.00591)	(0.00663)***
LIBOR - OIS spread	0.18861	1.86555	Interbank payment value	-0.00799	0.00608
	(1.49916)	(1.68310)		(0.00256)***	(0.00287)**
Square of LIBOR - OIS spread	-0.13328	-4.19343	Customer payment value	-0.00299	-0.00254
	(1.01767)	(1.14253)***		(0.00187)	(0.00210)
VIX	-0.08513	-0.33132	Fed funds deliveries	0.00148	0.00123
	(0.13877)	(0.15579)**		(0.00422)	(0.00473)
Square of VIX	0.00290	0.00873	Fed funds returns	-0.00061	-0.00101
	(0.00343)	(0.00385)**		(0.00429)	(0.00482)
CDX financial subsector	-0.00803	0.00058	Fedwire number of payments	0.00367	0.01895
	(0.00858)	(0.00963)		(0.00531)	(0.00596)***
Square of CDX	0.00001	0.00000	CHIPS extension	-0.17330	0.21046
	(0.00001)	(0.00002)		(0.21713)	(0.24378)
NYSE composite volume	0.00070	-0.00035			
	(0.00041)*	(0.00046)			

Table A7 (continued)

Fedwire Value during 16:00 and 17:00 Hours (Regressions)

January 3, 2005, to September 30, 2008

	Percentage of Total Fedwire Value			Percentage of Total Fedwire Value	
Explanatory Variables	16:00 Hour	17:00 Hour	Explanatory Variables	16:00 Hour	17:00 Hour
DTC settlement time	-0.03990	0.03571	Maintenance day 10	-0.21862	-0.93114
	(0.00786)***	(0.00882)***		(0.38170)	(0.42853)**
DTC net-net credits	0.03299	-0.01942	Fed funds deviation	-0.47395	1.30339
	(0.00684)***	(0.00768)**		(0.88403)	(0.99249)
CLS bank U.S. dollar value	0.01144	-0.01112	Fed funds target rate	0.29747	-0.01389
	(0.02320)	(0.02605)		(0.22014)	(0.24715)
NYSE closed early	2.93618	-7.10481	HHI of Fedwire value	-0.01165	0.01273
	(1.17163)**	(1.31539)***		(0.00290)***	(0.00326)***
Friday	-0.74538	0.60029	Day before a holiday	0.38941	-3.85277
	(0.41866)*	(0.47003)		(0.52382)	(0.58809)***
Monday	-1.44906	0.99547	Day after a holiday	-1.48055	-0.10099
	(0.43734)***	(0.49100)**		(0.59759)**	(0.67091)
Tuesday	-0.61730	0.96154	Time trend	0.00961	-0.01143
	(0.40132)	(0.45056)**		(0.00202)***	(0.00227)***
Wednesday	0.12662	0.63941	First day of month	0.61751	-0.73385
	(0.39594)	(0.44452)		(0.56680)	(0.63634)
Maintenance day 6	-0.47171	0.53497	Last day of quarter	-0.42393	-2.37469
	(0.39637)	(0.44501)		(0.97142)	(1.09061)**
Maintenance day 7	0.00341	-0.21123	Last five days of year	-1.38369	-0.48478
	(0.39067)	(0.43860)		(0.88190)	(0.99011)
Maintenance day 8	-0.07835	0.12072	Constant	60.75901	-251.72520
	(0.40893)	(0.45910)		(46.25374)	(51.92885)***
Maintenance day 9	0.29171	-0.27794	Observations	888	888
	(0.38794)	(0.43554)	R^2	0.38	0.40

Sources: Bloomberg; Markit; CHIPS; Federal Reserve Bank of New York; DORPS; authors' calculations.
Note: Standard errors are in parentheses.
*Statistically significant at the 10 percent level.
**Statistically significant at the 5 percent level.
***Statistically significant at the 1 percent level.