Liquidity risk in securities settlement

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Introduction

A viable capital market requires a well functioning transactions infrastructure. Securities settlement, which effects the legal transfer of the securities that are traded, is a critical element of this infrastructure. Settlement failures can increase the trading costs and risks for market participants, as well as hampering the efficient allocation of capital.

Disruptions in the settlement infrastructure, if serious enough, can also lead to an erosion of market liquidity, which may undermine financial stability. An extreme example of the potential severity of settlement failures was provided by the September–11 attacks. Settlement failures in the U.S. Treasury market jumped from 1.7 billion USD per day in the week ending September 5 to 190 billion USD per day in the week ending September 19 (see Flemming and Garbade, 2002). Failures rose initially because of the destruction of communication facilities, but remained high because the securities lending and borrowing program was ill-suited to absorb the massive shock.

This article considers the effect of a shock to securities settlement that is less extreme than that of September–11 but nevertheless serious; namely, the default of the largest participant in the system. Although a number of previous studies have analysed the impacts of major disruptions to payment systems and the extent of resulting contagion, very little investigation of disruptions in securities settlement systems (SSSs) has been undertaken. Such analysis may yield new insights, due to a number of differences between securities settlement and payment systems which could potentially lead to important differences in the impact of disruptions in the two types of systems.

A first key difference between payment systems and SSSs is that unlike payments, securities transactions involve a securities leg as well as a cash leg. This gives rise in securities settlement to principal risk, which is the risk that the seller of a security delivers the security but does not receive cash in return or that the buyer of a security makes the payment but does not receive delivery of the security. Although the response to this risk has been to implement delivery-versus-payment (DVP) systems − by which settlement finality of the securities and cash leg are at the same time, and thus principal risk is eliminated − default by a major participant can still have an impact on liquidity in the SSS, if unsettled trades of the defaulted participant are deleted from the system, leaving nondefaulting participants with unanticipated cash or securities positions.

Yet, contrary to payment systems, a disruption in securities settlement cannot be fully accommodated by providing liquidity. This is because after the initial default, participants may not only be short in cash, but also short in securities. In order to further eliminate the effects of a settlement disruption, it would also be necessary to have a broad, well functioning program of securities borrowing and lending.

A second difference between SSSs and payment systems is the presence of a settlement lag in SSSs. For example, settlement at time \( t+0 \) implies that the settlement of trades takes place two days after the trades have occurred.
The existence of a settlement lag suggests that a disruption in the settlement system may have impacts lasting longer than a single day. Indeed, the direct effect of a default by a major participant will continue to be observed for the number of days corresponding to the lag in settlement. In addition, the total disruption – which includes the indirect, or contagion, effects of default – may last even longer than the period of the lag. The reason is that although participants are assumed to know their counterparties and, thus, can calculate the direct effect of default, participants do not know the counterparties of their counterparties and cannot know which of the nondefaulting counterparties traded with the defaulting participant and thus will be unable to settle another trade as a consequence. Participants must thus form expectations about the indirect effects of default. The expected quantities of securities and cash upon which they base their trades after the default will reflect their expectations. If, ex post, actual settlement failures due to the default turn out to be higher than participants had expected, then additional post-default settlement failures may occur.

We report in this article results from simulations with a multi-period, multi-security model of securities settlement, designed to examine the direct and contagion effects of a disruption in settlement, where the disruption is triggered by the default of the largest participant.\(^{(1)}\) The analysis addresses the following questions. What are the dynamic effects on settlement, both direct and contagion effects, of a major disruption in the market? Are the impacts different if the defaulting participant is a net buyer versus a net seller? Is the first-day impact larger or smaller than the impact in subsequent days? How many days does it take for settlement efficiency (the percentage of trades settled) to return to its normal level? Could central bank support of the SSS through credit provision prevent contagion?

The results show that the settlement lag causes the impact of a default to last for more than one day. This implies that in assessing the potential severity of a settlement disruption, policy makers need to look beyond the first-day impact. Indeed, the simulations illustrate that the impact on trade settlement may last even longer than the length of the settlement lag. A second result, deriving from the presence of a cash and a securities leg, is that when very little or no credit is provided by the SSS during the settlement process, the impact of a default and the degree of contagion are greater if the defaulting participant is a net buyer than if it is a net seller. This is due to the fact that cash is needed for every transaction, whereas securities are needed only in transactions involving those particular securities. When significant liquidity is available, the differential between net buyer and net seller disappears. However, even generous liquidity provision is not sufficient to completely eliminate settlement contagion. Finally, the results suggest a policy trade-off between liquidity provision by the SSS and conservative reactions (i.e. reduction of the volume of trades) by participants in response to a disruption. Whereas reduction of the average volume of trades by non-defaulting participants in response to the default of a participant will limit settlement failures, and therefore the need for liquidity, it can also significantly reduce market liquidity, with potentially negative repercussions for financial stability.

The remainder of the article is organised as follows. Section 1 briefly discusses the risks arising in SSSs. Section 2 provides a description of the model used in the simulations and the key assumptions. Section 3 presents the simulation results. The last section concludes.

### 1. Risks in SSSs

Three main financial risks in SSSs are principal risk, replacement cost risk, and liquidity risk. Principal risk has been defined above. Replacement cost risk is the risk that a counterparty may default prior to settlement, denying the non-defaulting party an unrealised gain on the trade. The reasoning is that if market prices have changed in the meantime, the new terms for a similar trade may be significantly less favourable. Liquidity risk is the risk that the seller of a security who does not receive payment when due (or a buyer of a security who does not receive the security) may have to borrow or liquidate assets in order to satisfy other trades.

As noted earlier, DVP systems largely eliminate principal risk. They do not, however, eliminate liquidity and replacement cost risk. Whereas replacement cost risk depends in part on the lag in settlement, the nature of liquidity risk will depend on whether the settlement system uses gross (trade by trade) settlement or net settlement.\(^{(2)}\)

Gross settlement. In this type of system, delivery and payment occurs on a per-transaction basis during the settlement process. This implies that if participants are unable to adjust their money balances during the processing cycle, they will need to hold enough cash balances to cover the largest debit position arising during processing. This may require substantial intraday liquidity. If sufficient money balances are not available, high “fail” rates may result, implying substantial liquidity risk and replacement cost risk.

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\(^{(1)}\) Additional details and results may be found in Devriese and Mitchell (2005).

\(^{(2)}\) Note that, apart from net and gross settlement, some systems settle the securities leg on a gross basis and the cash leg on a net basis.
**Net settlement.** In this type of system all deliveries and payments occur on a net basis at the end of the settlement process. Net settlement economies on the amount of intraday liquidity needed, thereby lowering liquidity risk; however, it increases replacement cost risk, as the settlement of any trade is only final at the end of the settlement process. In addition, default by a participant raises the possibility of costly trade unwinds, through which the settlement system deletes (or unwinds) some or all of the transfers involving the defaulting participant and then has to recalculate the settlement obligations of the other participants.

**2. Description of model used in settlement simulations**

Much of the empirical literature on contagion in payments systems and interbank markets makes use of simulations with relatively strong underlying assumptions, which are necessary, for example, due to the inability to obtain data on participants’ bilateral positions. This is all the more true for simulations of SSSs, for which it is generally impossible to obtain any real data. Data relating to individual trades in SSSs are highly confidential. In addition, the amount of data required for an empirical study would be massive, due to the need for data not only on participants’ trades but also their cash and securities holdings. Only the SSSs themselves are able to use real data in simulations or stress tests. Such exercises are for internal use only and often suffer from the shortcomings, when viewed from a financial stability perspective, that they estimate only the direct effects of default or only the first-day impact of a shock. The simulations reported here suggest that an extension of such an analysis may be desirable.

We model a SSS with DVP and gross settlement, where settlement occurs with a two-day lag. This implies that trades that are undertaken during day \( t \) will not be settled until day \( t+2 \). All securities prices are assumed to be fixed and normalized to one; hence, there is no replacement cost risk arising from changes in asset prices.\(^{(1)}\) Liquidity risk is thus the major risk in the model. The disruption in settlement is caused by the default of the largest participant.

This section presents a nontechnical description of the model. Box 1 provides more detail on a number of important technical assumptions.\(^{(2)}\)

**Starting point: initial endowments of securities and cash**

Simulations are run for several scenarios, which differ according to values of parameters such as the number of participants, the number of securities, the limit on intraday credit and the reactions of participants (in terms of expectations regarding the magnitude of indirect effects) following the default. One hundred simulations are run for each scenario. For each simulation involving a given scenario, participants are randomly allocated initial quantities of cash and all securities according to a truncated joint normal distribution.

**Timing of events during a given day**

Three “events” occur during each day \( t \) in the following order: (1) participants’ determination of their expected holdings of cash and securities, which will form the budget constraints used for trading on day \( t \); (2) trading; and (3) settlement at the end of day \( t \) of trades undertaken on day \( t-2 \) (which effects the legal transfer of cash and securities from day \( t-2 \) trades into participants’ accounts).\(^{(3)}\)

The two-day lag in settlement implies that at the beginning of day \( t \) participants do not know with certainty what their legal holdings of securities and cash from all past trades are, as trades from days \( t-2 \) and \( t-1 \) have not yet settled. (Trades from day \( t-1 \) will only be settled at the end of day \( t+1 \)). However, if participants want to trade on day \( t \), they need to have an idea of the amounts of cash and securities they will have to back these trades. Thus, the budget constraints that participants use for determining their trades during day \( t \) will be their “expected” budget constraints, or the amounts of securities and cash that participants expect to be deposited in their accounts after settlement of the trades from the previous two days.

Note that at the point when trades for day \( t \) are settled (i.e. at the end of day \( t+2 \)), the holdings of securities and cash that participants have in their accounts will reflect the settlement of all trades undertaken up to day \( t \) (i.e. through day \( t-1 \)). Therefore, whereas day-\( t \) trades are undertaken on the basis of expected holdings of cash and securities resulting from all trades undertaken through day \( t-1 \), settlement of day-\( t \) trades will use the actual (legal) holdings resulting from these trades.

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\(^{(1)}\) Cifuentes et al (2004) argue that market risk due to changing asset prices may be an important source of contagion in payments systems. The same argument could be made for securities settlement systems.

\(^{(2)}\) Devriese and Mitchell (2005) provide a more technical discussion, as well as results of additional simulations not reported here.

\(^{(3)}\) In practice, settlement of day-\( t \) trades will typically begin during day \( t+2 \); however, all trades will not usually be settled until the end of the day. For modeling purposes, we assume that settlement of all day-\( t \) trades occurs at the end of day \( t+2 \).
Determination of “expected” budget constraints

As mentioned above, if participants want to trade on day $t$, they must form expectations about the amount of cash and securities they have to back these trades.\(^1\) We make the distinction between participants’ expectations in “normal” times; i.e., before any default has occurred, and in “crisis” times, following default by a participant.

**Expectations in normal times.** We assume that as long as no defaults have occurred, participants expect that all of their previously committed trades will settle (which will actually turn out to be the case). Thus, participants’ “expected” budget constraints at the beginning of day $t$ (reflecting the expected results of settlement of all trades undertaken prior to day $t$) will be identical to the amounts of securities and cash that will actually be deposited in their accounts once settlement of all trades undertaken up to day $t$ has occurred. This means, further, that the amounts of securities and cash actually in participants’ accounts on day $t+2$ and used for settlement of day-$t$ trades will be identical to the amounts that were reflected in the “expected” budget constraints used for determining day-$t$ trades. Thus, no settlement failures will occur.

**Expectations in crisis times.** When a participant defaults, all of its unsettled trades are deleted from the system.\(^2\) Thus, occurrence of a default implies that some of the non-defaulting participants’ actual holdings of securities and cash after settlement of trades which are not yet settled at the time of default will differ from the expected budget constraints that were used to determine these trades. For example, if a participant defaults on day $t$, then all participants who were counterparties of the defaulting participant on day $t-2$ will find themselves with trades from day $t-2$ which do not settle (since these trades are now deleted) and, consequently, with amounts of securities and cash in their accounts available to settle day $t-1$ trades (and even other day $t-2$ trades) that will differ from the amounts that were in the expected budget constraint used for determining day $t-1$ trades. This effect is the direct effect of the default.

There may also be indirect, or contagion, effects of the default, whereby a counterparty of the defaulting participant is now unable to fulfill some of its previously committed trades with other, non-defaulting counterparties as a result of the unsettled trades with the defaulting participant. As noted in the Introduction, we assume that participants do not know the counterparties of their counterparties and, thus, cannot accurately estimate the indirect effects of default. Participants must form some expectations about these effects.

The simulations reported below use a mechanical rule for determining participants’ expectations regarding indirect effects (see Box 1 for more detail): participants’ expected holdings of all securities and cash are assumed to be some percentage of what they would have been if all trades conducted with non-defaulting counterparties had settled. This assumption allows for comparison of simulations with differing expected percentages of settled trades.

**Trades**

Trades on any given day are assumed to occur randomly, and trades are considered between all possible combinations of counterparties and securities. Once a pair of participants and a security have been randomly selected, the range of feasible trades between the two participants in that security is determined via the two participants’ expected budget constraints. A trade is then randomly chosen from the set of feasible trades, and the expected budget constraints of the participants involved in the transaction are updated to reflect the trade. Selection of the trade is determined via a Beta distribution, which has the advantage that different parameter values can lead to more or less “extreme” trades (i.e., how close the trade is to the boundaries of participants’ budget constraints).

Simulations with conservative and “extreme” trading behavior can thus be compared.

The assumption of random trade behavior is more realistic than might appear to be the case at first glance. Large securities firms are often dealers who trade on behalf of their clients. Trades are executed according to the demands of the clients; therefore, the trades may look random from the point of view of the security firm.

**Settlement**

A trade between two participants is considered to be settled when it is confirmed during the settlement process that the implied transfers of securities and cash are feasible given the amounts of securities and cash in the accounts of the two participants involved in the transaction. Settlement of trades is assumed to occur in the same order as the order in which the trades were undertaken. This maximises settlement efficiency (the percentage of trades that actually settle).\(^3\)

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\(^1\) We assume that use of credit in settlement is costly; therefore, participants base their trading only on the cash and securities they expect to have available for settlement.

\(^2\) This reflects real practice in many SSSs where the administrator or liquidator may block unsettled trades to protect the interests of creditors.

\(^3\) In practice, SSSs do not know the actual order of trades; however, they use other algorithms to maximise settlement efficiency and minimise the amount of liquidity that must be provided.
A further aid to settlement is the assumption of a queue of unsettled trades, which also reflects practice in SSSs. Trades that are still unsettled at the end of settlement process are placed in a queue for settlement the following day.\(^{(1)}\) Allowing for a queue of unsettled trades increases the amount of settled trades which otherwise would have been deleted. This reduces replacement cost risk for the participants.

Another feature of the model that can reduce settlement failures is the provision of intraday credit, which may be drawn upon during the settlement process in order to avoid settlement failure. The credit limit is set as a percentage of the total value of the participant’s initial endowment of assets.

**The initial shock**

The initial shock in settlement is assumed to stem from an exogenous default of the largest participant.\(^{(2)}\) All unsettled trades of the failed participant are then deleted from the system. We assume, further, that the default is anticipated. In other words, we assume that if the largest participant defaults on day \(t\), all other participants learn of the impending default just before trading begins on day \(t\), and they avoid trading with the defaulting participant during that day. The direct effects of the default, therefore, will be confined to the trades undertaken on days \(t-2\) and \(t-1\), before the impending default became known. Making such an assumption adds to the realism of the model, as in reality defaults are often anticipated.\(^{(3)}\)

Furthermore, it allows us to show that even an anticipated shock can cause large scale settlement failures.

**Settlement efficiency**

Settlement efficiency, or the percentage of trades actually settled on a given day, is used as an aggregate measure of liquidity risk. Settlement efficiency is calculated by dividing the aggregate value of settled trades by the aggregate value of trades needing to be settled. We distinguish between two measures: total settlement efficiency and indirect settlement efficiency. Total settlement efficiency includes in the denominator all trades committed two days earlier, including those involving the defaulting participant.\(^{(4)}\) Indirect settlement efficiency, on the other hand, includes in the denominator only the trades that did not involve the defaulting participant. Hence, indirect settlement efficiency is a measure of contagion in the settlement system.

(1) In practice, the settlement process in any given day will involve several iterations, or batches. Trades that are unsettled in the first batch are tried again in the second, etc. The running of multiple batches reduces the number of trades left in the queue at the end of the day. Three batches are used in the settlement simulations reported here.

(2) Although the initial shock in settlement is assumed to arise from the default of the largest participant, this does not imply that solvency risk is playing a role in the model. The simulation takes into account liquidity risk only, gauged in terms of the trades that fail to settle because of insufficient cash or securities holdings by the transaction participants. Unlike the interbank contagion literature, participants’ losses due to failed trades are not compared with a solvency constraint.

(3) The assumption of anticipated default is also equivalent to an assumption of an unanticipated default where the largest participant defaults just before trading begins on day \(t\). Other assumptions are also possible; for example, the default on day \(t\) is anticipated on day \(t-1\), in which case trading with the defaulting participant would cease on day \(t-1\). Employing such an assumption would not change the qualitative results or the conclusions deriving from the simulations.

(4) Any unsettled trades in the queue from previous days are also included in the denominator.

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**Box 1 – Some technical assumptions of the model**

**Determination of trades**

Suppose there are \(K\) securities. On day \(t\), participant \(i\)’s expected budget constraint, representing the expected amounts of securities and cash that the participant will have to settle trades undertaken on day \(t\), can be expressed by a vector \(B_i\) of dimension \(K+I\), where the first \(K\) rows represent the expected quantities of each of the \(K\) securities, and the \(K+1\)st row represents cash.

Trades are determined as follows. First, a security \(k\) and two participants \(i\) and \(j\) are randomly chosen. Then, all feasible trades of the security between the two participants are determined from their expected budget constraints.

The maximum amount of security \(k\) that participant \(i\) can purchase from \(j\) is given by: minimum \([B_i,(K+1) ; B_j(k)]\), that is, by the minimum of the amount of cash of player \(i\) and the amount of security \(k\) held by player \(j\). Call this amount \(P\). The maximum amount of security \(k\) that player \(i\) can sell to player \(j\) is determined analogously: minimum \([B_i,(k) ; B_j,(K+1)]\). Call this amount \(S\). All feasible trades can be represented by the interval \([-S, P]\).
where negative values represent a sale of the security by $i$ to $j$ and positive values represent a purchase of the security by $i$ from $j$.

The actual trade is then randomly chosen from the interval $[-S, P]$ according to a symmetrical beta probability density function (pdf) with parameter $\beta$. The parameter $\beta$ determines the shape of the distribution and, therefore, the probability that a trade will occur in the middle of the interval versus the endpoints. Variations in the pdf as a function of $\beta$ are illustrated by the graph below. For example, the constant pdf (the flat line) shows that the standard uniform distribution is a special case of the beta distribution. On the other hand, values $0 < \beta < 1$ represent more extreme trading behaviour, as trades occur more frequently near the endpoints. Different choices of $\beta$ thus allow for simulations with differing degrees of moderation in trading behaviour.

Participants' expectations following a default

The default of a participant $j$ during day $t$ can have both direct and indirect effects on a participant $i$, and hence, on $i$'s expected budget constraint for day $t+1$, $B_{i,t+1}$. The direct effects are linked to trades that were committed between $i$ and $j$ prior to the default but that are not yet settled at the time of default. These trades will be deleted by the settlement system (due to our assumption that $j$'s default reflects insolvency of that institution). Since we assume that each participant knows its counterparties for all trades, it is possible for participant $i$ to modify the expected budget vector $B_{i,t+1}$ to adjust for the deleted trades with $j$. Call this modified vector $\overline{B}_{i,t+1}$.

Whereas the direct effects of default can be calculated, the indirect effects of default are not known by participant $i$ with certainty, since participants do not know the counterparties of their counterparties. Thus, participant $i$ has to form some expectations about how the indirect effects of default will further alter the vector $\overline{B}_{i,t+1}$. We assume that participants use a mechanical rule to modify $\overline{B}_{i,t+1}$ to account for the indirect effects of default. Namely, we assume that participants diminish the expected quantities of each security and cash by some constant $\epsilon \leq 1$. Thus, the new expected budget vector will be given by $(1-\epsilon)\overline{B}_{i,t+1}$, and feasible trades will be chosen from this new vector. While the rule for incorporating indirect effects in participants' expected budget constraints is admittedly mechanical, there are few obvious choices of rules that would clearly be more "rational". In addition, the rule has the advantage of allowing comparison of results where participants react very conservatively to default (high values of $\epsilon$) with results where participants do not react conservatively (low values of $\epsilon$). This is one of the differences underlying the "high" and "low" scenarios depicted in Chart 2.
3. Simulation results

The tables and charts below present results from several scenarios, where 100 simulations have been run for each scenario. All scenarios reported below involved 15 participants and 30 securities. The simulation begins five days prior to default by the largest participant and runs up to ten days following default. In the charts below, day \( D \) represents the day of default. Given that the default on day \( D \) is anticipated on that day, no trading with the defaulting participant occurs on day \( D \); therefore, the direct impact of default will be due only to the trades conducted on days \( D-2 \) and \( D-1 \), which are not yet settled at the time of default.

The market shares of the largest participant (i.e. the share of total turnover value accounted for by this participant) averaged 20 p.c. in the simulations, with standard deviation equal to 2 p.c., and minimum and maximum values at 16 p.c. and 26 p.c., respectively.

Table 1 illustrates the first-day impact of default and presents the two measures of settlement efficiency on day \( D \) (for trades on day \( D-2 \)) for differing amounts of liquidity provision. Simulations with three different credit limits are presented: (1) no credit; (2) a limit equal to 15 p.c. of the value of initial assets; (3) a limit equal to 30 p.c. of initial assets.

This table shows that settlement efficiency improves dramatically with liquidity provision, reflecting the positive role that liquidity can play in mitigating contagion. Interestingly, however, an increase in the credit limit from 0.15 to 0.30 does not seem to have a large effect. This suggests that although generous liquidity provision can significantly reduce contagion, it can not completely eliminate it.

A question of interest is whether the magnitude of the first-day impact of the default depends upon the net trade position of the defaulting participant. If the defaulter is a net buyer, then the default will cause cash to be extracted from the system. As cash is used in every transaction, this may lead to significant contagion and hence low settlement efficiency. On the other hand, if the defaulter is a net seller, counterparties will become constrained on the securities side. However, as each security is only used in transactions of that particular security, contagion may be weaker and settlement efficiency higher.

Charts 1A–1D, illustrate the effects on day-\( D \) settlement efficiency of the defaulting participant’s net trade position (as measured from the trades on day \( D-2 \)) for scenarios where the credit limits are zero and 15 p.c. of assets, respectively. The net trade position is defined as the sum of the values of all trades undertaken by the defaulting participant (where negative values represent sells and positive values represent buys) as a proportion of the total volume traded by that participant. The more positive is the measure of net trade position, the larger a net buyer the defaulting participant was on day \( D-2 \). A negative net trade position represents a net sell position.

Charts 1A and 1B show that when no liquidity is provided by the SSS, the first-day impact of the default is greater if the defaulting participant is a net buyer than a net seller. As might be expected, the net trade position of the defaulting participant is more important in determining the extent of contagion (indirect settlement efficiency) than total settlement efficiency. When the credit limit is increased to 0.15 (Charts 1C and 1D), the differential impact on settlement efficiency of net buy and net sell positions disappears. Nevertheless, as suggested above, settlement efficiency does not return to 100 p.c. This is because even generous liquidity provision cannot completely compensate for shortages on the securities side of transactions.

The discussion above suggested that because of the settlement lag, settlement failures can continue for more than a single day following a default. This is illustrated by Chart 2, which compares two scenarios: a “high” and a

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1. The smaller the number of participants and the larger the number of securities, the more severe will be the effects of the default. See Devereux and Mitchell (2005). Although the number of participants and securities might appear rather low, this is not necessarily the case. For SSSs within the EU, for example, the number of participants varies from a dozen to a few thousand. Even when the SSS involves over a thousand participants, it is not uncommon that the ten largest participants account for over fifty percent of the trading volume. The number of securities that are actively traded may also represent only a small proportion of the total number of securities in the system (see ECB, 2004).

2. It is possible to use the measures of indirect and total settlement efficiency to compute the percentage of total trades involving the defaulting participant. Using the mean values of the settlement efficiency measures, the trades involving the defaulting participant averaged around 20-31 percent of total trades across the different scenarios. This implies that in the absence of any indirect effects of default, total settlement efficiency would have averaged around 80 percent on the day of default.
"low" settlement scenario. The "high" scenario assumes a high credit limit (equal to 30 p.c. of a participant’s initial assets) and very conservative expectations concerning the indirect effects of default (participants assume that 80 p.c. of previous trades will not settle as a result of the indirect effects of the default). The "low" scenario involves no credit and only slightly conservative expectations concerning the indirect effects of default (participants assume that 20 p.c. of previous trades will not settle as a result of the indirect effects of the default).

Chart 2 presents the values of settlement efficiency over a period of several days, from $D–1$ up to $D+10$. The thick lines represent the average value of total settlement efficiency across simulations, and the thin lines represent two standard-deviations around the average. (1)

Several observations can be made. First, even in an SSS with DVP and gross settlement, there is still a possibility of a significant, multi-period disruption of settlement activity when a large participant fails. (2) Second, the rapid return of settlement efficiency to high levels in the high scenario occurs as a result of two factors: generous liquidity provision by the SSS and participants’ very conservative expectations about the magnitude of indirect effects (which causes them to severely limit volumes in trades undertaken following default, thereby lowering the risk of settlement failures). (3) Third, even with generous liquidity provision, settlement efficiency may not return to its "pre-stress event" levels by day $D+3$. In the low scenario,

(1) The measure of total, rather than indirect, settlement efficiency is used in this figure, since from day $D+2$ onwards there are no trades involving the defaulter; therefore, total settlement efficiency and indirect settlement efficiency are the same.

(2) Note that because the settlement efficiency measure is based on the value, rather than the number, of trades, the failure to settle a single large trade can result in a value of settlement efficiency well below 100 p.c.

(3) In each of these scenarios trades are selected according to a beta distribution with a value of $\beta$ which generates trades nearer the endpoints of the participants’ budget constraints (see Box 1). If a higher value of $\beta$ were used, trades would be farther from the endpoints, and settlement efficiency would be higher.
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settlement efficiency declines over time due to the fact that inflows into the queue exceed outflows. Part of the new inflows are generated by participants’ expectations not being “conservative” enough. The assumption underlying the low scenario is that participants expect that only 20 percent of their previously committed trades will not settle as a result of the indirect effects of the default. These expectations turn out, ex post, to be insufficiently conservative. In addition, part of the new inflows into the queue result from the unpredictable impact of the actual settlement of some of the trades that are in the queue, but for which settlement of that trade then affects the ability to settle a subsequent trade. (1)

Conclusion

This article has used a multi-period, multi-security model of gross settlement to simulate the impact on settlement efficiency of default of the largest participant in a SSS. The simulation results illustrate that differences between payment and securities settlement systems have important implications for the effects of disruptions to the system.

The presence of a settlement log in SSSs leads to situations where settlement disruptions may persist over several days. This suggests that in order to evaluate the full effect of a settlement disruption, policy makers must look beyond the first-day impact. The securities settlement simulations also suggest that, as for payments systems, liquidity provision can be an important tool for limiting contagion. However, due to the presence of a securities as well as a cash leg in securities transactions, generous liquidity provision by an SSS cannot completely eliminate settlement failures. This suggests the need for a well functioning securities lending and borrowing programme in order to completely eliminate contagion; however, it is precisely during crisis periods that participants will be the least willing to lend securities.

In practice, SSSs may decide not to provide large amounts of liquidity, due to the costs or risks involved. For instance, in the high scenario illustrated in Chart 2 – where the SSS provides each participant an emergency credit line equal to 30 p.c. of the participant’s total assets – aggregate end-of-day credit reaches a peak on day $D+1$ of 4 p.c. of outstanding securities in the SSS.

One remark following from the simulation results is that liquidity provision by the SSS and participants’ conservative reactions to default – via reductions of the volume of trades – may serve as partial substitutes in response to a settlement disruption. That is, either very conservative reactions by participants to the crisis or ample liquidity can dampen the impact of a disruption and lead to a relatively rapid restoration of settlement efficiency. However, these two alternatives create a tradeoff from a financial stability perspective. Whereas generous liquidity provision places a potentially heavy burden on the liquidity provider but does not reduce trading activity, conservative reactions by market participants avoid the burden on the liquidity provider but entail a potentially severe fall in trading volume. Thus, on the one hand, conservative reactions by market participants to a default will result in a more rapid return of the SSS to a normal level of efficiency, and an end to the crisis. On the other hand, severe limitation of trading volume by market participants may sharply reduce market liquidity, which may have a significant, negative impact on financial stability.

Finally, the policy trade-off also suggests that the settlement efficiency measure used here, while a gauge of the extent of disruption in settlement, may not be an accurate measure of the total welfare loss due to the disruption. To the extent that trade volumes are lower than would have been the case in the absence of the disruption, welfare will be reduced beyond the loss due to the unsettled trades. Settlement efficiency may be very high, although trading volume is very low.

(1) Participants are implicitly assumed to ignore the specific trades that are in the queue when making current trades. Although this assumption might seem unrealistic, it would actually be quite difficult to have participants take account of these trades, as it is impossible to know which of the trades in the queue are likely to remain unsettled and which are likely to be settled in the next day’s settlement process.
References


Flemming M. and K. Garbade, 2002, “When the back office moved to the front burner: Settlement fails in the treasury market after 9/11”, FRBNY policy review, November