Liquidity effects of a participant-level operational disruption in SIC *

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Abstract

This paper examines the liquidity impact of an operational disruption preventing a major participant in the Swiss large-value payment system Swiss Interbank Clearing (SIC) from inputting any payments from a certain time onward until the end of the settlement day. We use simulation methods – employing the BoF-PSS2 simulator developed by the Bank of Finland – to analyse the size and determining factors of the systemic effect. Our simulations show significant systemic effects in SIC. In terms of payment values, a daily average of 22% – or 36 billion Swiss francs – would not be settled due to liquidity being trapped on the account of the disrupted participant. However, in terms of the number of payments, the systemic effect is much smaller. As SIC is linked to a variety of other payment and securities settlement systems, these systemic effects might spread and liquidity interdependencies can arise. The size of the systemic effect is driven – amongst others – by the input behaviour of participants and the liquidity levels in the system. The SIC fee structure encourages early input of payment orders, which, in combination with centrally operated queues, can act as a shock absorber limiting potential liquidity sinks. Our work also demonstrates the importance of other measures taken to prevent operational disruptions and to limit the negative effect on other participants if disruptions should occur.

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1 Introduction

Safe and efficient payment and securities settlement systems are a key prerequisite for the smooth functioning of an economy and an integral component of a stable financial system. One of the key features of today's large-value payment systems is that participants' liquidity management relies on the constant recycling of liquidity from incoming payments. This allows participants to effect their payments with liquidity levels equivalent to only a small fraction of the total values settled. The operational disruption of a participant during the day can however interrupt this recycling mechanism. Liquidity accumulates on the account of a disrupted participant and a so-called liquidity sink develops. This can lead to systemic effects, as other participants lack liquidity to settle their payments. Through interdependencies, these systemic effects can spread to other connected systems.

Research efforts in payment and securities settlement systems are typically hampered by the complexity of these systems, the dynamic behaviour of the participants and the large amount of data, which make traditional econometric models difficult to apply. As a result, simulation methods have become a widely used tool. We use a simulation – employing the BoF-PSS2 simulator developed by the Bank of Finland – to analyse the systemic impact of a participant-level operational disruption in the Swiss large-value payment system, Swiss Interbank Clearing (SIC). We further identify the main factors driving the size of the systemic effect and the measures taken to mitigate it.

SIC is one of the largest real-time gross settlement (RTGS) systems in terms of number of transactions with currently 1.4 million transactions settled on an average day. Linked to almost all other payment and securities settlement systems in the country, it is the core of the Swiss financial market infrastructure. SIC also settles pay-ins and pay-outs in Swiss francs related to Continuous Linked Settlement (CLS), a multi-currency payment system for settling foreign exchange transactions. Therefore, potential systemic effects in SIC can lead to contagion effects in interdependent payment and securities settlement systems. Moreover, these other systems can also be a source of liquidity shocks in SIC.

This paper is organised as follows: Section 2 reviews the results of similar studies in other countries. Section 3 highlights the key characteristics of the SIC system. Section 4 provides a conceptual overview of the liquidity effects of an operational disruption in payment systems. This is followed by the description of the simulation methodology in Section 5. In Section 6, the results of the simulations for the systemic effects of operational disruptions are presented and compared to findings in other studies. Section 7 discusses the different factors that drive the systemic effect for SIC. Special attention is devoted to the input behaviour of participants. Section 8 presents the measures available in case of operational disruptions. Section 9 concludes and lists areas of interest for future research.

2 Literature Review

BEDFORD/MILLARD/YANG (2004) were among the first applying simulation techniques to study the systemic effects of participant-level operational disruptions. They conclude for the CHAPS Sterling payment system in the UK that systemic effects are unlikely to occur given the very high effective liquidity levels available in the system (amounting to 150% of upper bound liquidity[1]) and the other banks' fast reaction time of 10 minutes on which their simulation is based. A significant systemic effect was only identified in a theoretical scenario where three CHAPS Sterling settlement banks would be hit by an operational disruption and effective liquidity is below the upper bound.

Following BEDFORD/MILLARD/YANG (2004), various studies have investigated systemic effects of an operational disruption in interbank payment systems. Some of them found only very minor systemic effects, for example BECH/SORAMÄKI (2005) for the US Fedwire, and McVANEL (2005) and BALL/ENGERT (2007) for Canada's large-value transfer system. Others find some moderate systemic effects. For example, LEDRUT (2007), MAZARS/WOELFL (2005) and HELLQVIST/SNELLMAN (2007) identify under specific assumptions moderate indirect liquidity effects in the Dutch and French payment system and in the Finnish equities settlement system.

3 Swiss Interbank Clearing (SIC)

Swiss Interbank Clearing (SIC) plays a pivotal role in the Swiss financial market as it settles all large-value payments and a large number of retail payments in Swiss francs. Linked to almost all other payment and securities settlement systems in the country, it is the core of the Swiss financial market infrastructure. SIC settles money market transactions, the cash-leg of securities transactions and CLS related pay-ins and pay-outs in Swiss francs. Its safe and efficient functioning is critical for the implementation of the Swiss National Bank's monetary policy.

The system is operated by Swiss Interbank Clearing AG (SIC AG) on behalf of the Swiss National Bank (SNB), and transactions are settled on accounts at the SNB. It is designed as an RTGS system with central queues, and processes payments according to the "first-in first-out" rule. Through a link with the SECOM securities settlement system, SIC guarantees the settlement of securities transactions according to the principle of delivery-versus-payment (DvP). SIC operates around the clock on bank working days. Payments can be entered at any time, and up to five days in advance. Settlement takes place for 23 hours of every day, starting at around 5 pm on the calendar day before the value date and continuing until the clearing stop at around 4.15 pm on the value date. To ensure the smooth functioning of SIC, the SNB provides intraday liquidity through its repo facility. Of approximately 330 participants, the two major par-

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[1] For a description of the concept of upper bound liquidity see for example KOPONEN/SORAMÄKI (1998).

ticipants make up roughly half of the transaction values settled in SIC. For a more detailed description of SIC, see HELLER/NELLEN/STURM (2000).

4 Overview of liquidity effects of a participant-level operational disruption in interbank payment systems

The risks arising in interbank payment systems can be broadly grouped into credit risk and liquidity risks. Credit risk is the risk that a party will be unable to fully meet its financial obligations within the system on the due date and at any time in the future. Liquidity risk is the risk that a party will have insufficient funds to meet its financial obligations on the due date, although it may be able to do so at some time in the future. Operational problems and legal uncertainties can cause credit and liquidity risk. Central banks are specifically concerned with systemic risks, as these can endanger financial stability, which, in most cases, is an explicit or implicit objective of central banks. Credit and liquidity risks, operational disruptions, and legal uncertainties can be sources of systemic risk, if the failure or delay of one of the participants to meet its obligations, or a disruption in the system itself, will cause other system participants or financial institutions to be unable to meet their obligations when they fall due. Such a failure may cause widespread liquidity or credit problems and, as a result, might threaten the stability of the financial system or even the economy as a whole. SIC – being an RTGS system – eliminates credit risk in the settlement process, as settlement is final within the day. Liquidity risk is mitigated by giving participants easy access to intraday liquidity from the central bank and through a gridlock-resolution mechanism.[2]

In recent years, due to events such as the "Year 2000" date change, the terrorist attacks on financial centres like New York and London, and the threat of global pandemics like SARS or avian flu, increasing attention has been paid to potential systemic effects arising from operational disruptions. As a result, operators of payment systems have updated their business continuity plans and tightened operational requirements for critical system participants. For example, in Switzerland, an industry group has published recommendations for improving business continuity planning which were subsequently taken up in self-regulatory best practices published by the Swiss Bankers Association.[3]

In the event that a participant of an interbank payment system suffers an operational disruption, two effects can be distinguished. First, other participants will not receive payments from the disrupted participant and may cancel payments to the participant in question after a certain period of time (direct effect); and second, other participants may not be able to settle their own payments due to liquidity shortages caused by the liquidity sink arising on the account of the failing participant. The latter effect is typically referred to as the

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[2] For a detailed discussion of risks in large-value payment systems see CPSS (2005).

[3] See Industry Group (2006) and Swiss Bankers Association (2007).

indirect, second-round or systemic effect of an operational disruption. While the direct effect can have a significant impact on other participants, it can be calculated in a straightforward manner. In contrast, the systemic effect of a participant's disruption is less obvious, as it depends on the dynamics of the settlement process and participants' behaviour. However, the systemic effect can be estimated using a simulation approach.

5 Simulation methodology

5.1 Data sample

Our simulation is based on SIC transaction data in May 2004. The data sample represents 18 business days with a total number of 12,950,000 payments and a total value of 2,983 billion Swiss francs. The very large transaction volumes can be explained by the fact that SIC settles both large-value and small-value payments. In May 2004, transaction volumes and values were equal to the averages for the year 2004, and they exhibit a typical monthly pattern with a peak towards the end of the month. This provides an indication – though no certainty – that May 2004 was a representative month for SIC in that year.

5.2 Differences in the settlement algorithm

With the simulator, it is possible to mimic the functionality of an RTGS with central queues. However, there are some specific settlement characteristics of SIC which were not replicated in our simulations:

Queue release algorithm: In SIC, payments which cannot be settled due to lack of funds are stored in centrally operated queues. For each account, the queue is sorted according to the priority of the payment (first criterion) and according to the input date and time of the payment (second criterion), with the oldest payment being on top of the queue. If more than one participant has a queue and sufficient funds to settle the payment on top of the queue, the settlement algorithm in SIC starts settling for the account which has the oldest (i.e. longest pending) payment on top of the queue, irrespective of its priority. Thus, in SIC the priorities for payments are relevant only within an account, not between accounts. On the contrary, the payment algorithm used in our simulation first looks at the priority of the payment on top of the queue when determining with which account to continue settlement. The date and time are only used as a second criterion. Thus, in the simulation the priorities are relevant both within an account and between accounts.

Packet building: In SIC, once a queue is selected for settlement, the settlement algorithm will continue settling payments in the queue irrespective of the priorities, as long as funds are available and as long as the next payment is not significantly younger (e.g., input time less than two minutes later). On the contrary, the settlement algorithm used in our simulation settles all payments in a selected queue as long as funds are available, irrespective of the priority or input time.

Circle processing in case of gridlock: In SIC, if no payment is settled within a certain time frame (currently set at 15 seconds), the system initiates a so-called circle processing to solve the gridlock. Essentially, the circle processing is a bilateral off-setting mechanism. For a description of the circle processing in SIC see STURM (2000). We did not mimic such a gridlock solving mechanism in our simulation.

CLS accounts: SIC is used for the Swiss franc pay-ins and pay-outs for Continuous Linked Settlement (CLS), a multi-currency payment system. As the pay-ins for CLS are time-critical, the settlement members in Swiss francs in CLS which are direct participants in SIC can have a special CLS account in SIC to initiate these payments. This prevents queues in the regular accounts of CLS participants from blocking time-critical pay-ins to CLS. For simplicity reasons we have combined the regular accounts and the special CLS accounts for these participants for the purpose of our simulations.

Time for funding SIC accounts: Over weekends and bank holidays, a settlement day in SIC consists of more than 24 hours. As the simulator version used could only handle settlement days with a maximum time period of 24 hours, we delayed the opening of SIC in these cases. Therefore, payments which have been settled immediately in SIC were put into queues in our simulation.

We cannot judge conclusively to what extent these differences distort our findings on the liquidity in SIC and the systemic effects of operational problems. Generally, one would expect the delay indicators to be significantly impacted by these differences, while liquidity flows should be distorted to a far lesser extent. Therefore, we did not rely in our analyses on the delay indicators produced by the simulator. For the liquidity effects, test simulations with effective liquidity levels indicate that our simulations mimic these effects in SIC without any major distortion.

5.3 Simulation assumption

For our simulations we broadly follow the methodology developed by BEDFORD/MILLARD/YANG (2004) in their assessment of systemic risk in CHAPS Sterling. We simulate operational disruptions which prevent a major participant from inputting any payments into the SIC system from a certain time onward until the end of the settlement day. Queued payments, inputted by the affected participant before the operational disruption occurred, will still be settled. We assume that the other participants will cancel payments to the disrupted participant only two hours after the disruption has occurred. During these two hours a liquidity sink can accumulate, as the disrupted participant is receiving payments but is unable to initiate new payments. We also assume that the disruption occurs at the moment when the theoretical liquidity sink is largest, given the scenario described above. This implies that we actually simulate a worst-case scenario. Algebraically, we find the largest theoretical liquidity sink (and therefore the moment when the participant-level disruption occurs) by maximising the expression:

$B_{i,t} + \sum_{t}^{t+120} IP_{i,t} - Q_{i,t}$

for a participant i, where $B_{i,t}$ denotes the account balance of the participant i at the time t, the $\sum_{t}^{t+120} IP_{i,t}$ are the value of the incoming payments of participant i over the next two hours, and $Q_{i,t}$ is the value of payments in the queue of i at the time t.

The timing of the largest theoretical liquidity sink depends on the input and settlement behaviour of the participants. We call the liquidity sink "theoretical" because it does not consider any liquidity restrictions on the part of the other participants. According to our calculation and without taking into account liquidity restrictions on the part of the other participants, the potential liquidity trapped on the account of the failing participant lies between 7 and 25 billion Swiss francs.

While our methodology is similiar to BEDFORD/MILLARD/YANG (2004), a few important scenario assumptions are different. In contrast to CHAPS Sterling, SIC uses centralized queues. This explains our assumption that payment orders in the queue of the disrupted participant will still be settled after the disruption occurred. Furthermore, we also differ in our assumptions about the reaction time for other payment system participants to cancel payments to the disrupted participant. While the UK simulation assumes that the other participants stop their payments to the disrupted participant 10 minutes after the incident, we expect the participants to stop sending and executing payments to the disrupted participant only two hours after the failure occurred. Our assumption on the non-disrupted participants' behaviour is motivated by looking at their input behaviour in past incidents in SIC which were reported to SNB. Based on these incidents, we assumed for our simulations that in the case of an operational disruption, the disrupted participant would initially continue to receive payments until the operational failure is communicated and the extent of the operational problem becomes evident.

This might however not be the case for other payment systems. AMANUEL/CONOVER (2005) identify historical disruptions by looking at unusual lengths of time between payments. They then evaluate the number and value payments received by these potentially disrupted participants. They find some evidence that temporarily disrupted banks receive less payment values. This would lead to the conclusion that non-disrupted participants react to temporary operational disruptions of a participant by quickly and significantly altering their payment behaviour. This finding is in line with McANDREWS/POTTER (2002), who estimate a reaction function where the participants' payment sending behaviour is related to payment receipts. Inspired by these studies, LEDRUT (2007) simulates systemic effects of participant-level disruptions considering different scenarios for the behavioural changes.

We consider it important to distinguish two different types of behaviour changes of non-disrupted participants. First, behavioural changes of non-disrupted participants can reflect a deliberate decision to delay payments because of uncertainty about a disrupted participant and its ability to pay its obligations. Second, delays in payments to disrupted participants might not be based on an explicit decision but could rather reflect liquidity effects because of lack of incoming funds with other participants. While the first type of behaviour change would most likely be reflected in the input behaviour, the second type would be reflected in the number and value of payments actually settled. In our SIC sample data, we could rely on both the input and the settlement time of payments and we could not identify behavioural changes for both. However, it must be stressed that we only could rely on a small sample of historical participant-level disruptions which were reported to SNB.

6 Simulation results

Our simulations show significant direct effects from a disruption of a major participant in SIC, attaining on average 24% of payment values and 4% of the number of payments (see Figure 1). This equals a daily average of approximately 32,000 payments with a total value of 40 billion Swiss francs. These payments are either not inputed into or are deleted from the payment system queue following the operational disruption of a participant. In addition, the systemic (or indirect) effect can be large. In terms of payment values, an average of 22% – or 36 billion Swiss francs – would not be settled due to systemic effects. However, in terms of the number of payments, the systemic effect is much smaller, affecting only 4% of transactions. This substantial difference is due to the fact that many retail payments of small value – making up around 85% of payments volume – are settled early, i.e. before the disruption is assumed to occur. On average, around one third of all participants would be affected. It needs to be stressed, however, that significant systemic effects are limited to the disruption of the two major participants in SIC; simulating the disruption of other, smaller participants results in minor systemic effects only. Also, the size of the systemic effect varies considerably between major participants and even between different days for the same participants. The systemic effect in terms of payment values ranges from 1% to 37% depending on the day and the disrupted participant. One of the drivers for these differences is the input behaviour of the disrupted participants.

Comparing our results with other simulations, we find larger systemic effects of a participant-level operational disruption in SIC compared to similar studies conducted so far. For example, BEDFORD/MILLARD/YANG (2004) find only minor systemic effects from the operational disruption of a participant in CHAPS Sterling. One important difference is that they base their simulation on the assumption that other participants' reaction time, before they cancel payments to the affected participant, will be ten minutes, while we assume two hours. In another study, LEDRUT (2007) concludes that systemic effects from an operational disruption of a major participant in the Dutch large-value payment system TOP are limited, due to relatively high liquidity levels in the system. While MAZARS/WOELFL (2005) and HELLQVIST/SNELMANN (2007) find some systemic effects, these are clearly smaller than in SIC. The same is true for the studies conducted for the Canadian large-value transfer system by

Figure 1: Direct and systemic effect of an operational disruption of a single major participant (average for two major participants)

	Number of transactions		**Value of transactions in million CHF**	
May 2004	Daily average	% (minimum to maximum)	Daily averages	% (minimum to maximum)
Settled transactions	661'000	92 (85 to 98)	89'100	54 (33 to 93)
Unsettled transactions - direct effect	32'000	4 (1 to 7)	40'400	24 (4 to 44)
Unsettled transactions - systemic effect	26'000	4 (0 to 9)	36'200	22 (1 to 37)
Total	719'000	100	165'700	100

BALL/ENGERT (2007) and McVANEL (2005), and for the US Fedwire system by BECH/SORAMÄKI (2005). While the differing systemic effect can to some extent be attributed to the simulation assumptions, there is still some residual difference which must be explained by system-inherent factors. Therefore, in the next section, we will evaluate the main drivers for the large systemic effect in SIC.

7 Factors driving the systemic effect

There are various factors influencing systemic effects of a participant-level operational disruption in a payment system. In the following paragraphs, we will discuss these factors in the light of our simulation results for SIC.

7.1 Liquidity efficiency

One of the main characteristics of SIC is its liquidity efficiency compared to other RTGS systems. On an average day in May 2004, 165.7 billion Swiss francs were settled with only 11.6 billion Swiss francs of liquidity. Liquidity in SIC was turned over more than 14 times within a single business day. For comparison, liquidity levels in the large-value payment systems in Norway and Sweden amount to around 70% and 20% respectively (see ENGE/OVERLI (2006) and SVERIGES RIKSBANK (2003)). Even though the liquidity efficiency of SIC is an advantage in terms of costs, as participants can settle their payments with less liquidity and can therefore invest more funds in assets which may provide higher returns, it also has drawbacks. In particular, with a low level of liquidity in the system, it is likely that the emergence of a liquidity sink will drain other participants' accounts faster and lead to larger systemic effects.

7.2 Participant structure

Another factor influencing the potential size of the systemic effect is a payment system's participant structure, which is very concentrated in the case of SIC. As mentioned above, the two largest participants account for roughly 50% of all payments in terms of value. If one of these major participants faces an operational problem, the consequences are more severe than in a less concentrated system. Indeed, our simulations indicate that only the two largest participants have the potential to cause significant systemic effects. The disruption of other participants has only minor systemic effects. This finding is supported by NIER/YANG/YORULMAZER/ALENTORN (2008), who conduct simulation experiments for a theoretical banking system with interbank exposures to determine contagion effects. They conclude that the higher the concentration in the banking system, and all else equal, the more vulnerable the banking system is to systemic risk. This result holds true irrespective of the size of a given shock.

7.3 Settlement algorithm

Furthermore, the size of the potential systemic effect is influenced by the system design. As described above, SIC is an RTGS system with only limited liquidity saving mechanisms. Systems with continuous offsetting mechanisms may be able to settle more payments in circumstances when liquidity is scarce than those without these features. However, as these mechanisms are also used in normal situations, participants could anticipate their use and lower their precautionary liquidity levels and consequently the systemic effect would not necessarily be reduced.

7.4 Participant input behaviour

Our results also suggest that the input behaviour of a participant has a major impact on the size of the systemic effect. Looking at our May 2004 data sample, we find evidence of a differing input behaviour between the two largest participants, but also within the same participant depending on the weekday.

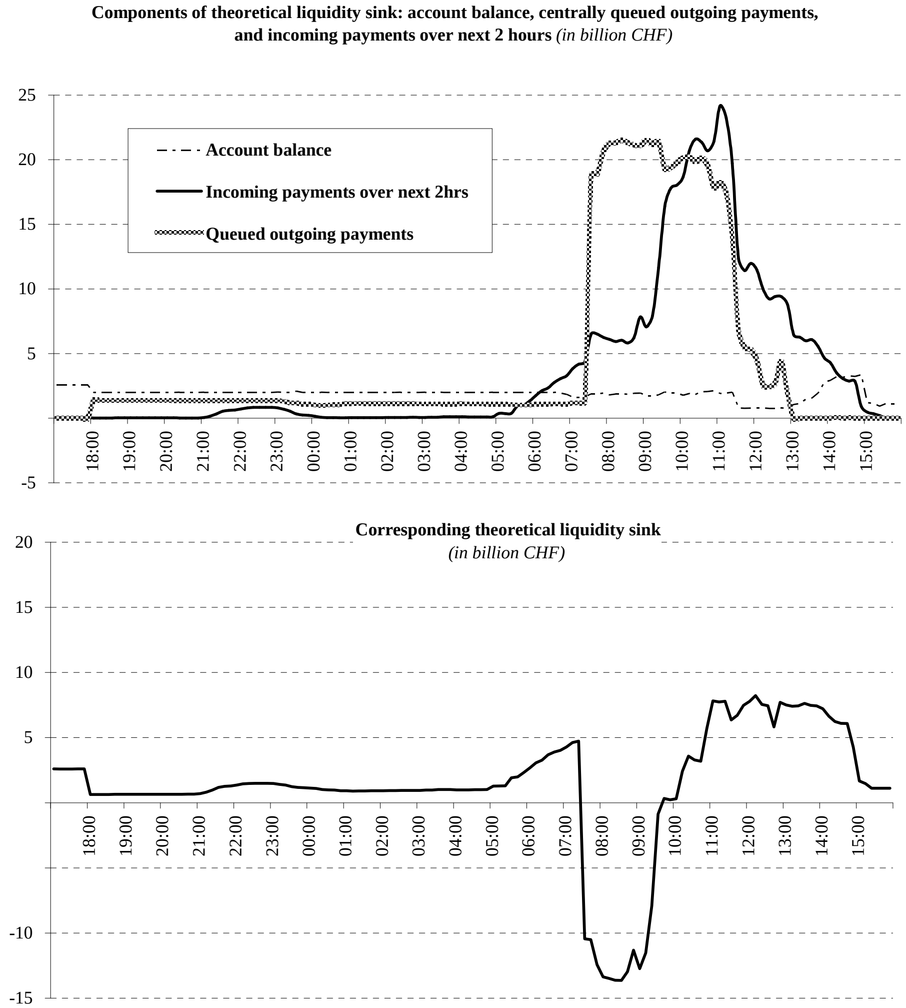
For example, figures 2 and 3 show the stylised input behaviour of two participants, A and B. A enters most of its payment instructions (in term of values) early in the morning (at around 7.30am). This leads to a large queue in the morning, which is reduced over time as SIC settles the queued payment orders automatically as liquidity becomes available on A's account (see figure 2). B, however, seems to manage its payment order flow to avoid the build-up of queues in SIC. It only enters payment instructions if settlement liquidity is available. Therefore, its queued payment values are typically low (see figure 3). This difference in input behaviour has implications if a participant faces an operational disruption and is unable to send new payment orders to SIC. In the case of A, the queued payments act as a buffer as liquidity is automatically recycled. Therefore, the potential liquidity sink on the disrupted participant A's account will be smaller and therefore the systemic effect will be reduced. By contrast, if participant B is unable to send payment instructions to SIC, this will be immediately felt from a liquidity perspective as a liquidity sink accumulates and drains other participants' liquidity levels.

In another example, we find that the input behaviour of a single participant differs depending on the weekday. This participant receives high-value payments in the morning, typically between 8am and 11am. Therefore, this is a time when a large liquidity sink could arise. For this participant, a small difference in input behaviour has a significant impact on the size of the potential systemic effect of a disruption of this participant. This is because we assume the disruption to occur when the potential liquidity sink is largest. On Mondays and on days after bank holidays, this participant inputs the majority of its payments (in terms of values) at around 7.30am. The systemic effect of an operational failure of this participant is relatively small. This results from the fact, that the value of outgoing payments already stored in the central queue is larger than the incoming payments. Therefore, the biggest theoretical liquidity sink arises rather late during the settlement day. On the contrary, the effect of an operational problem of this participant on other weekdays is very large in terms of value. On these days, it inputs its payment orders only after 8am and consequently, very large liquidity sinks can arise around 8am. This small difference in input behaviour therefore leads to large variations in the size of the systemic effect, given our assumptions.

These two examples suggest a slightly different interpretation of pending payment instructions in a payment system's central queue. Typically, queues in payment systems are seen as a consequence of a scarcity of liquidity which then leads to settlement delays. The conclusion therefore is that queues should be avoided. Our results show, however, that central queues which reflect the early input of payment orders act as a potential shock-absorber for liquidity effects should a participant-level disruption occur. Therefore, central queues arising early in the settlement day can have positive effects and should not necessarily be discouraged. Of course, central queues arising late in the day can be a potential source liquidity effects, as settlement fails or even minor operational disruptions can have significant consequences on the liquidity planning of other participants and can lead to short-term liquidity needs.

In general, we can conclude that early input of payment orders into the system (even if queued centrally and not immediately settled) reduces the potential liquidity sink, compared to late input of payments. In the event that a participant with early input experiences an operational disruption and is unable to send new payment orders to the system, the queued payment orders would help recycle liquidity. This would prevent the emergence of a systemic effect or at least limit its size. If, however, a participant inputs payments only late in the day, an operational disruption will be felt immediately in the settlement process, as no payments are queued. The time span before the liquidity sink

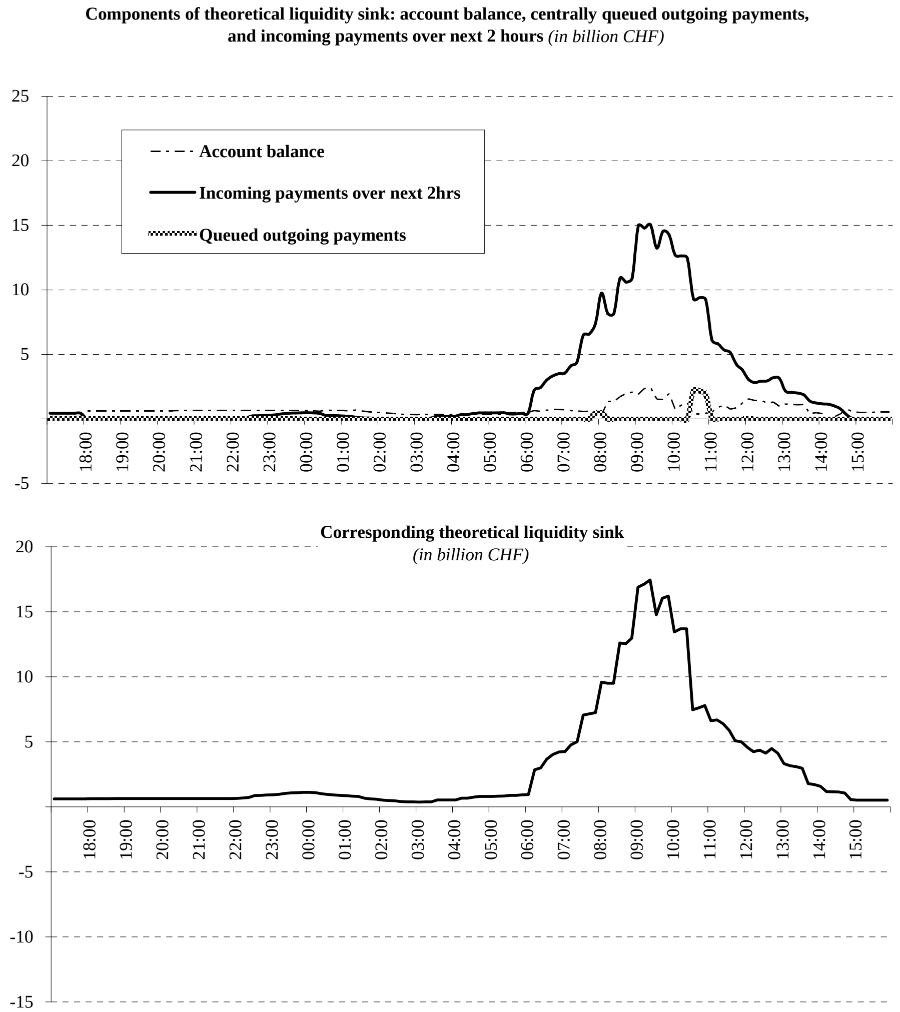
Figure 2: Participant A - Early morning input of payment instructions (stylised)



Components of theoretical liquidity sink: account balance, centrally queued outgoing payments, and incoming payments over next 2 hours *(in billion CHF)*

Corresponding theoretical liquidity sink *(in billion CHF)*

Figure 3: Participant B - Continuous input of payment instructions over the course of the day (stylised)



Components of theoretical liquidity sink: account balance, centrally queued outgoing payments, and incoming payments over next 2 hours *(in billion CHF)*

Corresponding theoretical liquidity sink *(in billion CHF)* builds up will be shorter and the effects on other participants greater. The variation in the input behaviour of major participants from day to day explains, to a large extent, the wide range of potential systemic effects experienced in our simulations (between 1% and 37%, depending on the day and the disrupted participant).

7.5 Simulation assumption

Several assumptions were made for our simulations which can significantly affect the results. For example, we presumed that the disruption of a major participant takes place at the time when the theoretical liquidity sink is highest. Our simulation results should therefore be considered as a worst-case scenario. Further, we supposed that non-disrupted participants only cancel their payments to the affected participant two hours after the disruption has occurred. This assumption is based on anecdotal evidence from real temporary disruptions to participants in SIC and the subsequent behaviour of the other participants. If the reaction time of the non-disrupted participants were shortened, this would reduce the potential systemic effect.

Our assumption for the time at which the disruption occurs is derived from the moment when the theoretical liquidity sink is highest. However, this does not necessarily correspond with the largest potential systemic effect. To identify the moment when a disruption triggers the largest systemic effect, we would need to take into account not only the liquidity sink, but also the number and value of payments occurring after a disruption, and their distribution between the participants. Therefore, the largest systemic effect can not be derived directly but would require conducting a multitude of simulations for every participant for every settlement day on a trial-and-error basis.

8 Measures taken to mitigate systemic effects

As shown, the operational disruption of a major participant in SIC can – in a worst-case scenario – cause significant systemic effects. This highlights the pivotal role of sound business continuity measures – not only at system- but also at participant-level – and the importance of adequate incentives and instruments for all involved parties to mitigate systemic effects.

First, preventive measures have been taken to minimise the likelihood of a prolonged operational disruption of a participant in SIC. An industry group has established recommendations for the maximum down-time of critical participants in SIC. In its report, this industry group suggested that critical participants should be able to resume operations within four hours after the loss of any key building including the staff working in this building.[4] These recommendations have been integrated in self-regulatory best practices published by the Swiss Bankers Association.[5] Specific measures taken to adhere to these

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[4] See Industry Group (2006).

[5] See Swiss Bankers Association (2007).

best practices include the establishment of redundant data centres and backup communication networks to access the payment system.

Second, there are a variety of incentives and instruments to reduce systemic effects should a prolonged disruption occur. As illustrated above, early input of payments can reduce the size of the potential systemic effect. In SIC, early input is encouraged by a progressive fee structure. Further, the end-of-day cut-off time can be postponed, should a temporary operational disruption occur. Participants also have access to intraday liquidity provided by the SNB, with a wide range of collateral accepted. Also, payments on behalf of the affected participant can be entered by the SNB, which would help to reduce a potential liquidity sink. In addition, there are facilities for physical data input via tapes should the telecommunication infrastructure be unavailable. Finally, an interbank alarm and crisis organisation exists to coordinate the industry reaction.

Our analysis of the driving factors of the systemic effects also highlights other potential measures which might be evaluated to deal even more effectively with disruptions. The input behaviour of critical participants could be influenced, for example by establishing "through-put" requirements. These would require major participants to settle a certain percentage of payment obligations before a given time on the settlement day. Also, the size of a liquidity sink arising from an operational disruption could be limited by establishing bilateral or multilateral sender limits. The settlement mechanism could be adapted to include additional liquidity optimisation mechanisms. Finally, the existing interbank alarm and crisis organisation could be extended to include communication network operators.

9 Conclusions and Outlook

Our simulations suggest that, in a worst-case scenario, the systemic effect of an operational disruption to a major participant in SIC can be large. On an average day, 22% of payment values – i.e. a total of 36 billion Swiss francs – would not be settled and about one third of the other participants could be affected. We find that some of the factors accounting for this effect are participants' input behaviour, the relatively low liquidity levels in SIC and the high concentration ratio of its participants. Since pending payment orders can act as a shock absorber for liquidity effects, our results suggest a slightly different interpretation of the desirability of centrally queued payment instructions. To the extent that queues are managed centrally in the payment system and reflect an early input of payment orders by the participants, the build-up of such queues – at least early in the day – should not be discouraged. In SIC, the fee structure encourages early input of payment instructions into the payment system, even if they are not immediately settled, but initially queued in SIC's central queue.

Our results also highlight the criticality of the measures taken to mitigate systemic effects in SIC. Regular testing of these instruments is critical to ensure that all participants are familiar with them. SIC is also closely connected to other Swiss payment and securities settlement systems as well as international systems. These interdependencies can lead to contagion effects if liquidity shocks are transfered to other systems.

There are two important caveats to our analysis. First, our simulations only broadly replicate the functioning of SIC. Second, and more importantly, our simulations only take into account one behavioural change, which is that participants cancel payments to the affected participant two hours after a disruption has occurred. Other behavioural changes – for example the re-prioritisation of certain payments, the input of payments by SNB on behalf of the disrupted participant, or access to additional intraday liquidity from the SNB – are not considered.

Looking forward, an intriguing extension of our analysis would be to vary the assumed reaction behaviour of non-disrupted participants. For example, the measures already taken to mitigate systemic effects in SIC (which are highlighted in Section 8) could be incorporated in our simulations. Also, similarly to LEDRUT (2007), the assumptions regarding participants' behavioural changes in response to a participant-level disruption could be varied to analyse the impact on systemic effects. Finally, the usefulness of potential new measures could be evaluated. Specifically, the work of MAZARS/WOELFL (2005) suggests that bilateral limits can be a powerful instrument to contain systemic effects of a participant-level disruption in interbank payment systems.

10 Bibliography

AMANUEL, D., CONOVER, D. (2005): "Operational Disruptions in Fedwire: Simulating Liquidity Needs and Understanding Counterparty response", Presentation at the BoF-PSS Seminar, August 25.

BALL, D., ENGERT, W. (2007): "Unanticipated Defaults and Losses in Canada's Large-Value Payments System, Revisited", Bank of Canada Discussion Paper 2007-5.

BECH, M., SORAMAKI, K. (2005): "Systemic risk in a netting system revisited", in: Leinonen, H.(Ed.).2005.

BEDFORD, P., MILLARD, S. YANG, J., (2004): "Assessing operational risk in CHAPS Sterling: a simulation approach", Bank of England, Financial Stability Review, June 2004, Issue 16, pp. 135-143.

COMMITTEE ON PAYMENT AND SETTLEMENT SYSTEMS (CPSS) (2005): "New developments in large-value payment systems", BIS/CPSS, May2005.

ENGE, A., OVERLI, F. (2006): "Intraday liquidity and the settlement of large-value payments: a simulation-based analysis", Economic Bulletin, NorgesBank, 01/2006, pp41-47.

HELLER, D., NELLEN, T., STURM, A. (2000): "The Swiss Interbank Clearing System", Finanzmarkt und Portfolio Management, Volume 14(4), pp. 413-431.

HELLQVIST, M., SNELLMAN, H. (2007): "Simulation of operational failures in equities settlement", in Leinonen, H.(Ed.) (2007).

INDUSTRY GROUP (2006): "Business Continuity Planning in the Swiss Financial Centre", January 2006, available on www.snb.ch.

KOPONEN, R., SORAMÄKI, K. (1998): "Intraday Liquidity Needs in a Modern Interbank Payment System – A Simulation Approach", Bank of Finland Studies, E:14, 1998.

LEDRUT, E. (2007): "How can banks control their exposure to a failing participant?", in Leinonen, H.(Ed.) (2007).

LEINONEN, H. (Ed.) (2005): "Liquidity, risks and speeding payment and settlement systems – a simulation approach", Bank of Finland Studies, E:31, 2005.

LEINONEN, H. (Ed.) (2007): "Simulation studies of liquidity needs, risks and efficiency in payment networks", Bank of Finland Studies, E:39, 2007.

MAZARS, E., WOELFL, G. (2005): "Analysis, by simulation, of the impact of a technical default of a payment system participant, in Leinonen H.(Ed.) (2005).

McANDREW, J., POTTER, S. (2002): "Liquidity effects of the events of September 11, 2001", Federal Reserve Bank of New York, Economic Policy Review, November 2002.

NIER, E., YANG, J., YORULMAZER, T., ALENTORN, A., (2008): "Network models and financial stability", Bank of England, Working Paper No. 346, April 2008.

STURM, A. (2000): "Bilaterales Offsetting", ClearIT, 2000 (13), pp.10-11.

SWISS BANKERS ASSOCIATION (2007): "Recommendations for Business Continuity Management (BCM)", November 2007, available on www.swissbanking.org.

SVERIGES RIKSBANK (2003): "Financial Stability Report", 2003(2), pp.43-54, Stockholm.

McVANEL, D. (2005): "The Impact of Unanticipated Defaults in Canada's Large Value Transfer System", in Leinonen, H.(Ed.) (2007).