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Market structure, interest rates and the risk of financial contagion: An examination of the Swedish overnight market

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The current financial crisis has demonstrated the importance of well functioning interbank markets for the financial system. However, as interbank exposures are often uncollateralized and of large amounts these markets constitute a channel through which financial contagion can spread. This paper uses unique transaction level data from the Swedish payment system RIX to study the interbank segment of the Swedish market for overnight deposits. In a first part, the microstructure of the market is assessed. Specifically, market size, interbank activity, counterparty relationships and the pricing of overnight loans are examined. In a second part, the risk of financial contagion to the Swedish banking sector implied by the overnight loan exposures is analyzed using a round-by-round simulation. The paper shows that most banks use the overnight market nearly every day. Still, most of the activity in terms of transaction value is concentrated to an inner tier of a few large banks. Indications of systematic lending and borrowing patterns and interbank relationships are presented. The majority of the overnight loans are found to be made to the repo rate, without a risk premium, indicating that market participants meet the "gentlemen's agreement" that is said to exist between them. Furthermore, the paper finds that subsequent failures due to the unexpected failure of one of the participating banks are unlikely, however possible. The greatest risk of financial contagion is identified to be associated with specific institutions and can not be related directly to the size of the total overnight exposure or number of exposures. The data used cover the period July 2007 to October 2008, i.e., the first 15 months of the current financial crisis. Despite the stress and uncertainty characterizing the surrounding, the paper finds nearly no indications of changes in the behavior of financial institutions in the overnight market during the period.

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1. Introduction

The overnight market is the market in which banks and other financial institutions manage their liquidity in the shortest term, i.e., from one day to the next. This market constitutes an important means for allocating liquidity between financial institutions. Hence, a well functioning overnight market increases the efficiency of the payment system and allows for a more efficient financial intermediation in the economy. In addition, the overnight market is one of the channels used by central banks to implement monetary policy. At the same time however, the overnight market constitutes a potential channel for financial contagion. Specifically, the large uncollateralized interbank exposures, resulting from overnight lending, compose a channel through which an isolated shock causing the failure of one bank may spread through the financial system and lead to subsequent failures of other banks (Rochet and Tirole (1996)).

During the current financial crisis the importance of well functioning interbank markets, including overnight markets, for the financial system has been demonstrated with unpleasant clarity. The crisis has highlighted the weakness of these markets: their dependency on confidence between financial institutions. A main concern, both for market participants as well as for central authorities, has been the issue described above; that problems in one financial institution can spread to other institutions through the direct counterparty exposures that institutions have towards each other. On the part of financial institutions, an increased uncertainty about their counterparties' ability to meet their obligations has resulted in that they either decreased or refrained entirely from lending to other institutions (The Riksbank (2008a)). Also, many of the decisions made by central authorities in different countries to support or bail out institutions have been openly motivated by the potential contagious effects if these measures were not taken. The capital injections by the Federal Reserve in AIG, or, in Sweden, the liquidity assistance given by the Riksbank to Carnegie[1] are two examples.

To date, the behavior of financial institutions in overnight markets has not been given much attention in the academic literature. An important reason for this is that micro data, because of the bilateral nature of interbank transactions, is usually not available. This paper uses unique transaction level data on overnight loans from the Swedish large value payment system, RIX, to study the Swedish overnight market at the micro level. The objective is twofold. First, the paper aims to provide a general assessment of the microstructure of the Swedish overnight market. Second, it uses the information about overnight transactions to analyze the risk of financial contagion owing from interbank overnight exposures. Alongside with pursuing these two objectives, the paper exploits the fact that the data on which the analysis is based extend over the initial 15 months of the current financial crisis. More specifically, it investigates to what extent the behavior in the Swedish overnight market was affected by the turmoil during the initial phase of the crisis.

[1] See the Riksbank's press release: "Liquidity assistance to Carnegie Investment Bank", 2008-10-27, www.riksbank.se

In the light of the current financial crisis, when interbank markets ceased to function properly, or functioned only because of the support and guarantees given by the authorities, it is more relevant than ever to study the structure of the trading in overnight markets as well as to assess its intrinsic risks. The current paper is the first study of the Swedish overnight market to use transaction data. Consequently, it contributes to the understanding of Swedish financial markets by exploiting a unique data source. Also, it complements previous studies on overnight markets by studying a market with fewer institutions, in a more concentrated banking system, than most markets previously studied. In addition, the Swedish overnight market in itself present an interesting case to study. The reason for this is that except being concentrated, the Swedish banking sector is also very large in relation to GDP. The total assets of the banking sector amounting to more than three times GDP in 2008 (The Riksbank, 2008b). Understanding the relationship between risk and interbank market structure may therefore be even more relevant in markets such as the Swedish since in the case of a systemic crisis, in which several banks at once need assistance, the banking system might be "too-big-to-save" (Degryse and Nguyen (2007)). Finally, the influence of the financial crisis on the data offers a unique opportunity to study how the behavior of banks is affected during a period characterized by severe stress and uncertainty which also motivates this study.

Reflecting the two objectives, this paper is organized in two parts. In the first part the microstructure of the Swedish overnight market is examined. The analysis is based on transaction data from the Swedish large value payment system RIX between July 16, 2007 and October 7, 2008, i.e., the initial 15 months of the current financial crises. Section 2 gives an overview of the institutional arrangements that constitutes the framework for the trading in this market. A review of the literature on overnight market structure is given in Section 3. Section 4 describes the data and section 5 presents the results of the assessment of the microstructure of the Swedish overnight market. In turn, section 5 examines the size of the overnight market (5.1), market activity (5.2), net behavior (5.3), interbank relationships (5.4) and the pricing of overnight interbank loans (5.5). Focus is on overnight loans made between banks, i.e., interbank lending. Last in section 5, and closing the first part, the overall results and the possible implications are discussed.

The second part of the paper examines the risk of contagious failures following from an unanticipated and immediate failure of a bank active in the Swedish overnight market. This part starts with a review of the most recent empirical studies of financial contagion in section 6, followed by a description of the simulation methodology and the underlying assumptions in section 7. The simulation exercise is a round-by-round simulation in which one bank at the time is allowed to fail, and thereafter the effects of each bank-failure on the other banks' solvency is studied. The analysis is based on the same transaction data as part I. The results of the simulations are presented and discussed in section 8. To conclude, section 9 summarizes the overall results of the paper and possible future developments of this paper are suggested.

Part I – The microstructure of the Swedish overnight market

Already in the summer of 2007 when problems in the U.S. sub-prime mortgage sector first were recognized, the function of interbank markets was negatively affected. Suddenly interbank interest rates jumped and market activity declined, especially in the longer maturities. The main reason for this was doubts arising among market participants about the other participants' solvency and liquidity (Idier and Nardelli (2008)). Although interbank markets have a central role in the financial system and for the implementation of monetary policy, little is known about the behavior of financial institutions in these markets. In this first part of the paper, the microstructure of the Swedish overnight market is examined.

The analysis is based on transaction data retrieved from the large value payment system RIX run by the Swedish central bank, the Riksbank. The sample runs from July 16, 2007 until and including October 7, 2008, i.e., over the initial 15 of the current financial crises. Taking advantage of this opportunity, explicit focus is in the following put on identifying changes in the banks' behavior during the period that could be attributed to the surrounding uncertainty. Because the transaction data used in the study is non-public, the banks are not identified by name.

2. Institutional framework

The overnight market is commonly defined as the segment of the money market which involves trading in the shortest maturities, i.e. maturities ranging from one day to the next and up to one week (The Riksbank (2008b)). Instruments traded in this market include repurchasing agreements, FX-swaps as well as standardized contracts for cash deposits. Mostly, a narrower definition of the overnight market which refers only to trading in deposit contracts is used. This paper studies the deposit segment of the overnight market and will therefore use this narrower definition of the overnight market.

The overnight market differs from other financial markets in two fundamental ways. First, trading in overnight markets is driven by the specific need to balance temporary shortages and surpluses of liquid funds. Practical motivations hence dominate the trading, although it cannot be excluded that some actors also let speculative motivations guide their behavior. In addition, overnight markets are greatly influenced by central banks' operational framework for implementing monetary policy and the specific conditions determined by the central bank for using the payment system (Beaupain and Durré (2008)). Accordingly, before examining the structure of the Swedish overnight market the reasons underlying the banks' need for trading in the overnight market and the institutional set-up of the Swedish payment system are explained.

2.1. The role of the overnight market

Financial institutions use the overnight market primarily for balancing temporary shortages and surpluses of liquidity. This need arise because of the large volumes of payments that these institutions

process each day on their own or their clients' behalf. Whereas retail payments are fairly predictable, rearrangements of foreign exchange or security portfolios by the banks themselves or their clients can often generate large and unpredictable flows of liquidity (Kronestedt-Metz (2005)).

To some extent incoming payments can be used to cover outgoing payments. However, in- and outgoing payments almost never match perfectly. To assure that they can meet their liquidity need banks therefore make forecasts over their expected payment flows. Based on these forecast they borrow and invest funds in the money market. In general, banks try to match their need of liquidity as precisely as they can; as it is important to have enough liquidity to be able to make all payments, but also costly to have liquidity in excess of what is needed (Kronestedt-Metz (2005)). Even if the forecast is good, it is nevertheless difficult for a bank to exactly manage their liquidity need in advance. Moreover, not all payment flows are possible to forecast and as a consequence there will always be liquidity flows that have to be managed in a very short perspective.

Payments between banks, so-called interbank payments, are sent via electronic and centrally administrated payment systems, mostly managed by a country's central bank. In order to make the payments flow more efficient, temporary liquidity deficits can in many systems be managed to a relatively low cost by using intraday credit, i.e. so-called *intraday facility*, offered by the central bank against eligible collateral. This means that during the day a bank can send payments even though it does not have enough cash on its transaction account to cover the payment. During the night, the intraday credit is not granted. Therefore, the banks have to finance deficits and invest surpluses of liquidity in some other way over the night. This can be done either by depositing or lending in the central bank's *standing facilities* or through interbank trading in the overnight market. (Banks can borrow in the interbank market to cover their liquidity need also during the day. This is referred to as intraday lending.) Hence, banks use the overnight market to offset the net balance of all their transactions made via the payment system during the day in order to balance their payment system transaction account in compliance with the requirements of the central bank.

To lend or borrow in the overnight market a bank directly contacts the other bank it likes to trade with. The contracts used are deposit contracts for which the exact conditions; the amount, interest rate, duration etc., can be negotiated at each occasion. These contracts are unsecured, meaning that they are associated with credit risk for the lending institution and, consequently, that reputation and trust are likely to be important when a bank choose whom to trade with (Beaupain and Durré (2008)).

The attractiveness of interbank trading compared to using the central bank facilities ultimately depends on the precise conditions for using the payment system and the facilities. For the banks, the conditions for using the central bank facilities can be seen as the alternative cost for trading in the overnight market. As a result, the activity in the overnight market is closely related to the institutional set-up which regulates the payment system and the related credit facilities. Normally, the conditions

for intraday credit are relatively favorable, while the conditions for utilizing the overnight facilities are not.

2.2. The influence of the RIX payment system on the overnight market

In Sweden the central payment system is called RIX and is administrated by the Riksbank. All payments in Swedish kronor that are sent between accounts in two different banks pass directly or indirectly through this system.[2]

During 2007 and 2008 RIX had 19 participants beside the Riksbank; 14 commercial banks and mortgage institutes (henceforth referred to as banks); 4 clearing organizations and the Swedish National Debt Office (SNDO). Out of the banks that were participants in RIX during 2007 and 2008, 8 were Swedish banks and 6 foreign bank affiliates or subsidiaries. The size of these institutions' operations differs substantially, with the four major Swedish banks dominating the activity in the system. All except one of the banks participating in RIX also had access to the Riksbank's standing facilities and five were primary dealers to the Riksbank. The latter meaning that these banks act as counterparties to the Riksbank in for example the Riksbank's fine-tuning operations (explained below). A list of the participating banks, their respective permissions and size, are provided in the appendix.

Each RIX-participant has a transaction account in the system which it uses to transfer funds to other financial institutions in the system. A large number of small Swedish banks as well as foreign banks do not participate directly in RIX. To send payments to other institutions in the Swedish market and to access the overnight market, these institutions instead use one of the large commercial banks as their correspondent bank.

The RIX-system is open between 07.00 a.m. and 17.00 p.m. Interest-free intraday credit (known as the intraday facility) is granted by the Riksbank provided that the bank pledges eligible collateral. During the night the Riksbank requires that the banks' RIX-accounts are in balance. The institutions with a deficit can balance their account by borrowing from other financial institutions in the overnight market. Likewise, banks with surpluses in their account can deposit funds with another RIX-participant. The institutions which have access to the Riksbank's standing facilities can also chose to borrow and deposit their overnight need or surplus of liquidity in the standing facilities. The deficits and surpluses in the banks' RIX-accounts always sum close, or exactly, to zero. Consequently, there is always enough "surplus liquidity" in the system for all banks with a deficit to be able to finance most of it by lending from another bank in the system.

The interest rates charged for loans in the Riksbank's standing facility is 75 basis points above the repo rate, whereas the interest rate granted for deposits in the Riksbank's standing facility is 75 basis points below the repo rate. The difference between the interest rates for depositing and for

[2] The RIX-system is also used by the Riksbank for repo-transactions and other transactions with its primary dealers as part of the operational procedures for implementing the monetary policy rate. These aspects are not described in this section. For a description of how monetary policy is implemented in practice see for example Otz (2005).

borrowing funds in the standing facilities are meant to give the banks an incentive to trade with each other. As long as an institution is willing to lend funds to an interest rate lower than the repo rate plus 75 basis points, institutions which need to borrow funds should prefer to borrow from that institution instead of using the Riksbank's standing facility. Likewise, an institution with a daily surplus has an incentive to lend its surplus to another institution instead of depositing the money in the Riksbank's facility if it can charge an interest rate higher than the repo rate minus 75 basis points. Because of the relatively unattractive conditions for using the standing facilities compared to interbank loans and deposits, the facilities have traditionally only been used for "round-off money", i.e. amounts which are so small that it is not worth the effort to find a counterparty to transact with. The Riksbank's statistics show that the average daily deposits in the lending facility during 2007 amounted to SEK 50 million and the average daily loans in the borrowing facility to SEK 20 million, which can be compared to the average daily turnover in the RIX -system as a whole that during the same period amounted to SEK 496 billion (The Riksbank (2008b)).

On days when the total deficits and surpluses do not sum to zero the Riksbank carries out "fine-tuning" transactions in order to even out the net surplus or deficit of the RIX-system. These transactions are intended to prevent that banks are punished because the system as a whole is unbalanced and that large fluctuations in the overnight interest rate occur from day to day. Depending on if the Riksbank lends funds or accepts deposits, the fine-tuning transactions are carried out to an interest rate equal to the repo rate plus/minus 10 basis points. Only the primary dealers can participate in the fine-tuning transactions.[3] The value of these transactions is however relatively small, meaning that the banks cannot rely on these transactions to balance their RIX-account position. During 2007 deposits accepted by the Riksbank in the fine-tuning transactions amounted to approximately SEK 330 million per day and loans from the Riksbank in the fine-tuning transactions to SEK 425 million per day (The Riksbank (2008b)).

3. Review of the overnight market literature

Empirical studies of overnight markets can roughly be divided into two groups. First, a great number of studies focus on the overnight market as a channel for monetary policy implementation. In particular, these studies have concentrated on explaining variations in the level and volatility of overnight interest rates. The other group of studies examines the behavior in overnight markets at the micro level, i.e. the behavior of individual banks.

Within the first group, the most frequently studied market is the market for federal funds in the United States. More recently these studies have been complemented with an increasing number of studies of other overnight markets, mostly in Europe. Both in the federal funds market and in the European overnight markets, the level and volatility of overnight interest rates are found to fluctuate

[3] In October 2008 the Riksbank changed the rules for participating in the fine tuning transactions and allowed a larger group of RIX-participants to take part in the fine-tuning transactions.

significantly from day to day as well as during the day. Early studies of the federal funds market suggest that these variations are caused by different market frictions such as bank window-dressing (Allen and Sunders (1992)), fixed transaction costs and credit-line arrangements (Hamilton (1996)) or fluctuations in the aggregated volume of interbank payments (Furfine (2000)). Others have linked these variations directly to the institutional arrangements of overnight markets. For example, overnight interest rates have been shown to be more volatile when demand for liquidity is higher like at the end of the day and in the end of a reserve maintenance periods, as well as when uncertainty in the market increases in connection with the central banks' market operations, credit auctions or releases of new information (see e.g. Hamilton (1997), Bartolini et al. (2001), Bartolini et al. (2005) for studies on the U.S. and Hartmann et al. (2001) for the euro area).

Although, interest rate variations observed in various overnight markets have been found to have much in common, considerable difference between markets with regard to the frequency and the intensity with which these variations occur have also been documented. Bartolini et al. (2002) show that the "style of intervention" adopted by a central bank is more important for the nature and size of the variations observed in overnight interest rates than the mere existence of institutional arrangements such as reserve requirements and open market operations.[4] From the perspective of this study, the above findings are important since they imply that the trading mechanism of overnight markets can be expected to depend on the institutional and operational arrangements that central banks establish.

Studies within the second group which look at the behavior of individual banks in the overnight market are relatively few. The reason for this is the nature of the overnight market, where trades are negotiated privately between banks with generally no available records. The existing studies mostly rely on overnight loan transaction data extracted from payment system records. Based on payment data from the Federal Reserve's large value payment system Fed Wire, Furfine (1999) examines several aspects of the microstructure in the federal funds market.[5] Furfine finds that a large part of the activity in the overnight market, in terms of daily turnover, is concentrated to a few institutions. Additionally, he investigates networks and trading patterns, presenting evidence indicating that borrowers establish relationships with the intention to mitigate the information asymmetry that exist between banks and by that increase their chances to borrow or improve their borrowing conditions.

Based on the same type of data others have complemented Furfine's study. Abildgren and Arnt (2004) and Millard and Polenghi (2004) examine the activity in the Danish and the British overnight market respectively. Consistently with Furfine (1999) they find that a relatively small proportion of the active banks account for the major part of the activity. Cocco et al. (2003) study lending relationships in the Portuguese overnight market and find that banks do not only rely on relationships

[4] Styles of interventions can for example refer to how committed central banks are to its operations, how it communicates and its transparency.

[5] Angelini (2000) also study the Italian overnight market which, differently from Furfine (1999), is based on quotes from the electronic trading system in which overnight loans in Italy are made. This system is anonymous wherefore overnight trading in Italy is very different from in most other countries.

to overcome information asymmetry problems, but also for obtaining liquidity insurance. These authors also show that by establishing a lending relationship banks obtain lower interest rates on their overnight loans. In a later study Furfine (2001) finds that overnight interest rates paid by borrowers in the federal funds market to some extent reflect credit risk. Ashcraft and Duffie (2007) however, cannot find any evidence supporting this, but suggest that the interest rates reflect the aggregated demand of liquid funds in the market and to some extent the market power of the lending institutions.

Regarding the function of overnight market during periods characterized by great uncertainty or severe stress evidence from different markets points in different directions. The market for federal funds was for example found to have been fairly resistant during the 1998 LTCM crisis as neither the interest rate nor the volumes traded in the market were significantly altered (Furfine (2002)). On the other hand, in the euro overnight market interest rate volatility rose considerably in the millennium changeover week, suggesting that the uncertainty that the changeover meant significantly influenced the behavior of the banks in that market (Hartmann et al. (2001)).

The understanding of the Swedish overnight market is based on formal and informal interviews with market participants. Based on interviews, Kronestedt-Metz (2005) for example presents an overview over the whole Swedish market for liquidity balancing in which the overnight market represents an important part. The current paper is the first study on the Swedish overnight market to use transaction data and, consequently, contributes to the understanding of this market by exploiting a new data source. In addition, this paper complements other studies on overnight markets since it refers to a small market with few institutions compared to other markets previously studied. Finally, the data set used in the study covers a period influenced by a severe financial crisis which gives a unique opportunity to study how behavior in overnight markets is affected during periods of great uncertainty and stress.

4. Description of data

The data used in this paper consists of a detailed record over overnight loan advances and repayments processed in the large value payment system RIX from July 16, 2007 to October 7, 2008. For each transaction the exact amount as well as both the sending and the receiving institution are specified. For the repayments, the recorded amount equals the sum of the loan principal and any interest paid on the loan. The transactions in the sample include pure interbank transactions, i.e. overnight loans agreed between two banks, as well as overnight transactions where one of the counterparties is a bank and the other is either the SNDO or the Riksbank. Altogether the sample comprises 4195 overnight loans during 332 trading days.

Compared to other studies based on transaction data retrieved from payment systems, the Swedish data used in this study has the advantage that all transactions are categorized according to

type already when they are registered.[6] As a result, the overnight loan transactions can easily be identified.[7] Until recently, data from RIX have only been stored for a limited time and used solely in system-surveillance purpose. Consequently, the data used in this paper has not been available for analysis.

The first date in the sample period, July 16, 2007, is the first date for which overnight transaction data is available. The final date, October 7, 2008, is chosen because of the measures taken by the Riksbank in response of the crisis which completely changed the conditions and incentives underlying trading in the overnight market. These measures were put into effect on the following day, October 8, 2008. As is illustrated in Figure 1, there is a significant shift in the total value of daily overnight loans in October 2008. Specifically, the total daily value of overnight interbank loans falls and, instead, the value of overnight transactions with the Riksbank rises dramatically. The sudden shift in the total value and composition of the daily overnight loans owes to the Riksbank's decision to support the Swedish banking system with extra liquidity.[8] As a result of the extra liquidity, provided via the banks' RIX-accounts, the RIX-system as a whole got a surplus of liquidity. This measure made

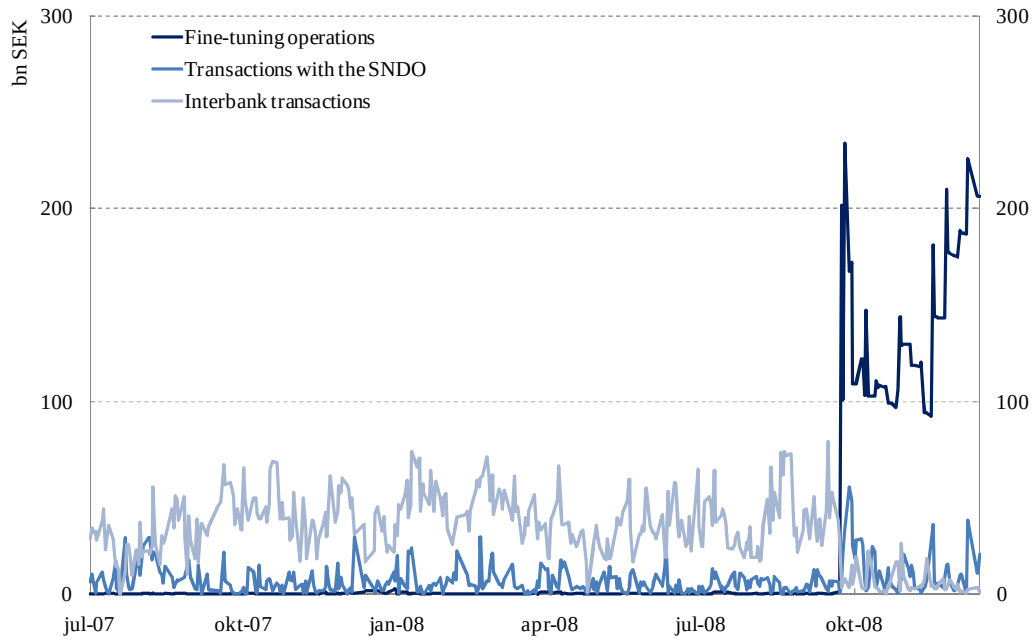

Figure 1. Value of total daily overnight deposits broken up in interbank transactions, transactions with the SNDO and fine-tuning transactions with the Riksbank. July 16, 2007 – December 31, 2008. Billion SEK.

[6] The classification is made by the sending institution and the categories into which payments are coded is regulated in the agreement which all participating institutes have to accept in order to participate in RIX.
[7] Both Furfine (1999) and Arnt and Abildgren (2004) use an algorithm to separate overnight loan transactions from the rest of the payments sent through the respective large value payment systems.
[8] On October 6, 2008 the Riksbank held its first extra auction for credit in Swedish kronor. It amounted to SEK 100 billion. The money was allotted on the following Wednesday, October 8, 2008. The decision was announced on October 2, 2008. Already before that, the Riksbank had however taken certain measures. For example, the range of collateral eligible in RIX was widened on September 22, 2008 and credits in U.S. dollars were offered in the first week of October (The Riksbank (2007), (2008a)).

it possible for the banks participating in the RIX-system to hold larger liquidity reserves than before. As a result, almost all banks since then have a surplus in their RIX transaction account at the end of the trading day. With none of the banks needing to borrow funds over night there are no incentives for the banks to trade in the overnight market and since October 8, 2008 banks have deposited their surplus in the Riksbank. At the same day, the Riksbank also changed the rules for participating in its fine-tuning operations; allowing most of the banks to participate. This also reduced the incentives for the banks to trade in the overnight market since their marginal interest rate, or alternative cost, for not trading with other banks was lowered from 75 basis points to 10 basis points (the interest rate applied in the fine-tuning transactions).

5. Results – The microstructure of the Swedish overnight market

In this section the structure of the Swedish overnight market is presented. The approach taken is closely related to the approach followed by Furfine (1999) who uses overnight transaction data from the Federal Reserve large payment system to analyze the overnight segment of the federal funds market. The section starts with an examination of the size of the overnight market on an aggregate level in order to establish a base to anchor the micro analysis in. Thereafter, the focus is shifted to the banks' individual behavior in the overnight market. In turn, market activity, the banks' net lending behavior and the interbank relationships are studied.[9] In addition to these aspects, which were also considered by Furfine, the pricing of overnight loans is examined. Any changes in the banks' behavior during the period are presented.

Throughout, focus is put on the interbank segment of the overnight market. Since the SNDO regularly participates in the market it is also included, but treated separately. Because the data used for this paper is non-public, the identities of the banks are not disclosed.

5.1. Market size

Table 1 displays aggregated statistics of the activity in Swedish overnight market between July 16, 2007 and October 8, 2008. As shown, about 13.6 overnight loan transactions with a total value of SEK 45.3 billion are on average made per day in the Swedish overnight market. Of the total value, pure interbank loans, i.e., loans were both the lending and the borrowing institution is a bank, account for about 85 per cent, loans to or from the SNDO for about 14 per cent and transactions with the Riksbank, i.e. the fine-tuning transactions, for about 1 per cent. In comparison, the daily turnover in the overnight market corresponds to around 18 per cent of the total transaction value sent through RIX on an average day. Relative to the size of the Swedish banking sector, the overnight loans settled in RIX corresponds to about 1 per cent of the sector's total assets or to about 15 per cent of the sector's equity capital at the end of 2007.

[9] Furfine also analyzes the timing of overnight loan transactions over the course of the day.

TABLE 1. Average daily value and transaction volume of overnight loans in the Swedish overnight market, July 16, 2007 – October 7, 2008.[10] Billion SEK and number of transactions.

	Total Daily Transaction Value (bn SEK)				Total Daily Transaction Volume (number of transactions)			
	mean	max	min	median	mean	max	min	median
Total overnight loans	45.3	98.3	0.0	43.6	13.6	21	1	14
of which								
Interbank transactions	38.6	79.2	0.0	37.4	11.6	18	0	11
Transactions with the SNDO	6.4	30.0	0.0	4.6	1.3	5	0	1
The Riksbank's fine-tuning transactions	0.3	3.1	0.0	0.1	0.7	3	0	1

Note: Interbank transactions are defined as transactions were both the lending and the borrowing institution is a bank. In transactions with the SNDO, the SNDO are either the borrower or the lender.

Turnover in the Swedish overnight market fluctuates slightly over the week and seasonal variations can be observed. The highest average daily turnover is observed on Thursdays (SEK 46.7 billion) and the lowest on Wednesdays (SEK 43.1 billion) when the repo-transaction of previous week is paid back to the Riksbank and the funds of the coming week's repo-transaction is paid out. This tendency of higher average turnover in the day before the weekly operations of the central bank is not unique for Sweden, but has also been observed in Denmark (Arnt and Abildgren (2004)). The largest peaks in the daily turnover are observed in the end of each quarter. During the period, the maximum value of total overnight loans in a single day was SEK 98 billion, of which interbank transactions accounted for SEK 79 billion. However, turnover does not rise significantly on International Money Market (IMM) days[11] or days close to holidays. This is in contrast to other segments of the money market (Kronestedt-Metz (2005)).[12] Seasonal variations in the turnover value are to some extent correlated to the variations of the turnover of the RIX-system as a whole; as both are lower during the summer months than during the rest of the year. Except for these seasonal variations no significant changes or trends in the daily transaction value or volume are observed during the period.

5.2. Market activity

This section looks at the overall activity level in the overnight market as well as how activity is distributed between the lending and the borrowing side of the market. Examining market participation aims to give an understanding of how important the overnight market is for the banks and how trading activity is structured. From a financial stability perspective it is desirable to find out the most active players in the market and which other institutions that depend on them. Figure 2 presents participation rates for each institution respectively active in the overnight market between July 16, 2007 and October 7, 2008.

[10] Average turnover and daily transaction volumes for the period October – December 2008 are enclosed in the appendix.
[11] The IMM-days are occur the third Wednesday in Mars, June, September and December each year. At these days many standardized contracts and financial instruments are resettled wherefore these days generally are characterized by larger turnovers than usual (Kronestedt-Metz (2005)).
[12] Further details on monthly and weekly variations in market turnover and volume are disclosed in Appendix 1.

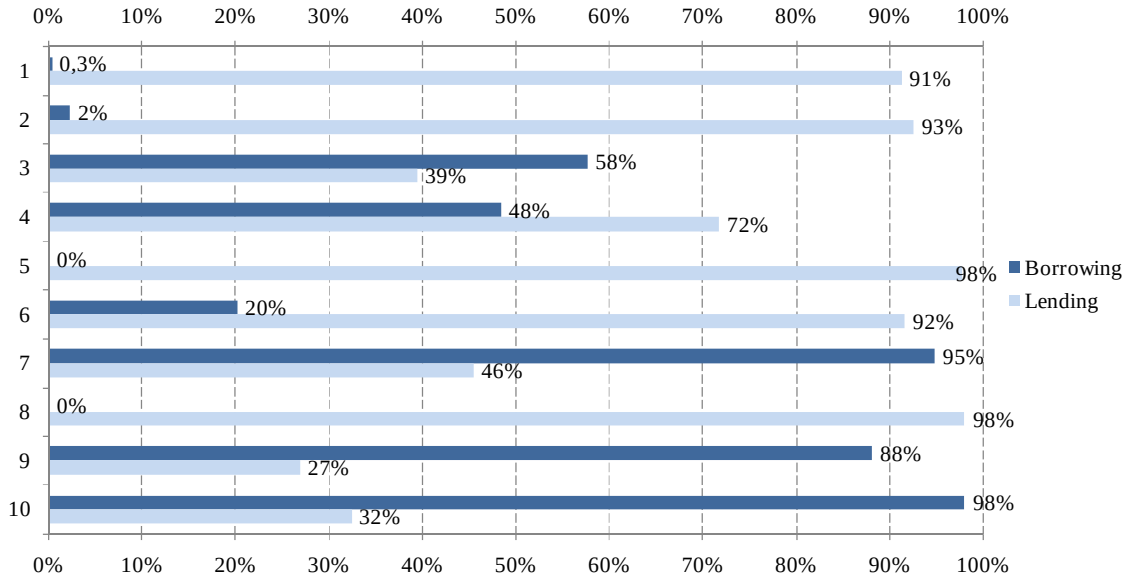

FIGURE 2. Lending and borrowing participation rates in the overnight market. The figure includes all banks that participated in the Swedish overnight market at least once during the period July 16, 2007 – October 7, 2008. X- axis: participation rates in per cent of total number of trading days in the data set. Y-axis: bank identity numbers.

As shown, ten banks participate in the overnight market during the period and consequently, four banks which had this opportunity did not. Among the participating banks, the overall participation rate is high, with all of the active institutions accessing the overnight market on more than 90 per cent of the days. However, as is shown in Figure 2, the extent to which each bank lends and borrows funds varies among the banks. Five banks access the overnight market for depositing funds on more than 90 per cent of the days and one bank on 72 per cent of the days. The other four deposit funds considerably less frequently, on average 36 per cent of the days. When it comes to borrowing, four banks distinguish themselves from the other banks by never, or only rarely, borrow in the overnight market. These four are all among the six most frequent lenders in the overnight market. Among the other six banks, three borrow on 88 per cent of the days or more and the other three considerably less.

During the period, a bank is observed both depositing and borrowing funds in the same day on 26 per cent of the days. Hence, banks generally either deposit or borrow funds in a single day, but not both. It is mainly two institutions that borrow and lend in the same day. However, all of the primary dealers, likewise the largest banks, are observed both lending and borrowing in the same day at some occasions. In other overnight markets where banks have been documented to trade on both sides of the market in the same day, it has been with the purpose to pool funds, i.e. acting as intermediaries for banks (Arnt and Abildgren (2004)). This explanation could also apply in the Swedish market. Quantitative limits towards a counterpart could for example force a bank to make a portion of a large overnight loan via another bank. Over the period all banks increase the frequency with which they access the overnight market with the purpose to deposit funds. Participation at the borrowing side, on the other hand, has been more or less constant.

Despite the high activity rate among all institutions, a large part of the turnover in the overnight market is concentrated on relatively few participants. The five most active banks account for as much as 83 per cent of the total value lent and 98 per cent of the total value borrowed during the period. The five banks that account for most of the turnover in the overnight market are also the largest in terms of assets size. The other five banks' role is limited, but not negligible since they still account for about 15 per cent of the daily value deposited in the market. It is especially two of the smaller banks that distinguish themselves as equally important lenders in the overnight market, over the whole period depositing more than two of the larger banks. The dominance of the five larger institutions is equally strong during the whole period.

Considering activity during any single day, the overnight market appears to be even more concentrated than when the whole period is considered at once. Table 2 shows the accumulated share of the daily turnover that a certain percentage of the participating institutions account for. In an average day, the two institutions depositing the most account for slightly more than 60 per cent of the total value deposited. Similarly, the two institutions borrowing the most in the overnight market on average account for more than two thirds of the daily turnover. In line with the pattern observed for the whole period collectively, the largest debtors and creditors are almost exclusively found among the five largest banks. However, in certain days the SNDO deposits such large amounts overnight that it is one of the top two lenders. Over the whole period the SNDO accounted for, on average, 4.5 billion of the daily value lent and 2.03 billion of the value borrowed in the overnight market.

TABLE 2. Accumulated share of total daily value lent and borrowed that the most active lender and borrower and the two most, five most and ten most active lenders and borrowers account for.
Per cent of total value.

Number of banks	Average accumulated share of value lent (per cent)	Average accumulated of value borrowed (per cent)
1	35.9	43.0
2	61.3	67.5
5	78.5	93.8
10	89.9	95.2

Note: The reported figures include the SNDO and the Riksbank's fine-tuning transactions.

The tendency of a large part of the daily turnover to be concentrated to a few large banks has been documented also in studies of overnight markets in other countries, including the federal funds market (Furfine (1999)) and the Danish overnight market (Arnt and Abildgren (2004)) which have a larger number of active institutions than the Swedish market, as well as in the British overnight market (Millard and Polenghi (2005)) which has only 13 participants. As pointed out by Millard and Polenghi (2005) the large banks' dominance is likely to not only be a consequence of these banks' size and more extensive operations, but also to result from that they to a larger extent than the other banks act as correspondent banks to financial institutions which are not directly participating in the overnight

market. Given that very few banks are directly participating in the RIX overnight market the dominance of the five most important banks in the Swedish market is probably partly explained by their role as correspondent banks to smaller Swedish banks and foreign banks. As a consequence, a disruption to one of these banks is likely to have consequences also outside the overnight market.

5.3. Net participation

Because of the large and often uncertain payment flows, banks have difficulties to exactly balance their transaction accounts. If a bank aims to more or less balance its account each day, its RIX-account balance should be close to zero over the longer horizon. For one or several reasons a bank may however choose to finance itself in the overnight market, or oppositely, invest (deposit) funds in the overnight market. In the case when a bank systematically takes the same position, the bank will *not* have an account balance that in the long run is more or less zero, but will be a net borrower or a net lender in the overnight market. In the following, the individual banks' net behavior is investigated.

Table 3 presents statistics over each banks net behavior from July 16, 2007 until and including October 7, 2008. Six banks are more often net lenders than net borrowers and four are more often net borrowers during the period. Since both lending and borrowing in the same day is not common, considering which side of the market the banks participate the most frequently also gives an indication of their net position. Accordingly, the banks that have a higher participation rate on the borrowing side of the market are more or less systematically net borrowers and vice versa. Two banks appear to lend approximately as often as they borrow funds. However, only one of them is in practice acting like this; the other bank changes its behavior in the middle of the period from being a net borrower to become a net lender. For the other banks no major changes in net behavior are observed over the period. All banks however intensify their "most common" behavior. That is, the banks which mostly are net lenders in the first seven and a half months are even more frequently net lenders in the following seven and a half months of that period and vice versa.

TABLE 3. Net participation in the Swedish overnight market, July 16, 2007 – October 7, 2008. Number of banks.

Percentage of days an institution is a net lender					
Never	> 0-25%	>25-50%	>50-75%	>75-100%	Always
0	2	1	1	2	2

Note: The table shows the number of institutions that where net lenders a certain per cent of the days when they participated in the overnight market. The frequency of being a net borrower out of the total number of the days the bank very active is accordingly *1–(frequency of being net lender).*

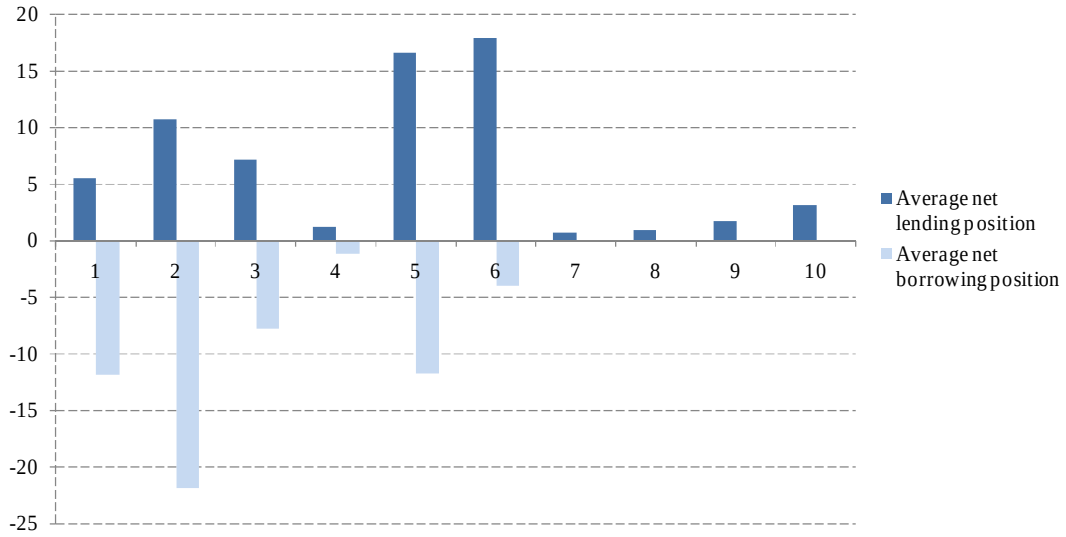

FIGURE 3. Net average position in for each bank conditional on being a net lender or net borrower respectively. Billion SEK. X-axis: Bank identity number.

Not only the frequencies at which banks are net lenders or net borrowers are interesting in an analysis of their net behavior; the value of the banks' net positions is also relevant. If net positions are very small, the banks' net behavior would be of little interest regardless of the frequency at which a certain behavior is observed. Figure 3 depicts the average value of the net lent position and the net borrowed position for each bank respectively. The average net position lent or borrowed are large in kronor value, with the average net positions amounting to between two and twenty billion Swedish kronor. The difference in net position is likely due to differences in the size of the bank's operations, to whether or not the Swedish market is their "home" market, as well as to the type of business dominating their business operations (in Sweden). On the other hand, all else equal, a more efficient liquidity management would also reduce the net position relative to the total amount of payments that the bank transfers in RIX. Relative to asset size the average net positions correspond to approximately 0.5 to 3 per cent of the respective bank's balance sheet, being larger for the smaller bank entities. If the average net position lent is compared to the average net position borrowed for each bank separately, it turns out that for all banks except for one, the net position is larger on days when the bank pursues it most frequent net behavior. This also suggests that the banks actively manage their liquidity balance towards an end-of-day position that is considerably above or below zero.

There could be several reasons for each bank to aim at an account balance below or above zero. For example, Furfine (1999) argues that smaller institutions may experience a credibility problem due to incomplete and asymmetric information which makes it difficult for them to convince other market participants of their credit worthiness. As a result, these institutions chose to manage their liquidity in a way that makes it possible for them to close their account with a surplus at the end-of-day, thus liberating them from the need of borrowing funds. In line with this argument, Furfine (1999) finds that

smaller institutions to a larger extent than larger institutions are net lenders in the federal funds market. If similar large-small analysis is conducted on the Swedish overnight market, the same pattern is observed. Out of the five institutions that are net lenders more than 90 per cent of the days, four are among the five smallest banks, and consequently, only one of these banks is among the five largest institutions.[13] Alternative explanations to why banks chose to be net lenders or net borrowers in the overnight market could for example be their respective alternative cost for funds in other markets (Furfine (2003b)) or that the banks want to honor specific relationships that the they have outside the overnight market by acting in a certain way in the overnight market (Beaupain and Durré (2008)).

5.4. Interbank relationships

Given that overnight loans are unsecured contracts negotiated on a bilateral basis, reputation and trust are likely to be important when a bank choose whom to trade with (Beaupain and Durré (2008)). Economic literature has suggested that banks tend to establish relationships with other banks in order to overcome the information asymmetries that exist in the overnight market (e.g. Furfine (2001), Cocco et al. (2003) and King (2008)). In the following interbank lending and borrowing counterparty patterns are examined. The objective is to identify and compare behavioral patterns of different banks in regard to how many and which banks they interact with, as well as any changes that have occurred in this respect over during the period.

Considering the whole period July 16, 2007 to October 7, 2008 most institutions have lent to or borrowed from the majority of the other institutions at least once. However, in a single day the banks tend to trade with only a few other banks. As shown in Figure which presents the average number of counterparties per day for each bank, banks on average have one to three counterparties when they deposit funds and one to four if they borrow funds. Two banks stick out by having on average a larger number of counterparties when they borrow than when they lend and compared to the number of counterparties that any other bank use when they borrow. These differences are likely due to that there are fewer banks that borrow funds each day than there are banks lending. Since market surplus and deficits balance, the large borrowers also have to have many counterparties in order to balance their position. Moreover, larger net positions are positively correlated to a larger number of counterparties. However, this relationship is not clear cut as two of the banks with smaller net positions typically trade with two other banks when lending which is the same number of counterparties as two of the banks with large net positions commonly trade with.[14]

[13] This is true regardless if size is measured in terms of asset book value, the size of the respective bank's Swedish operations or their daily turnover in the RIX system. For the foreign bank affiliates the size of the Swedish operating unit is considered only.

[14] The same results are obtained if the median number of counterparties is considered.

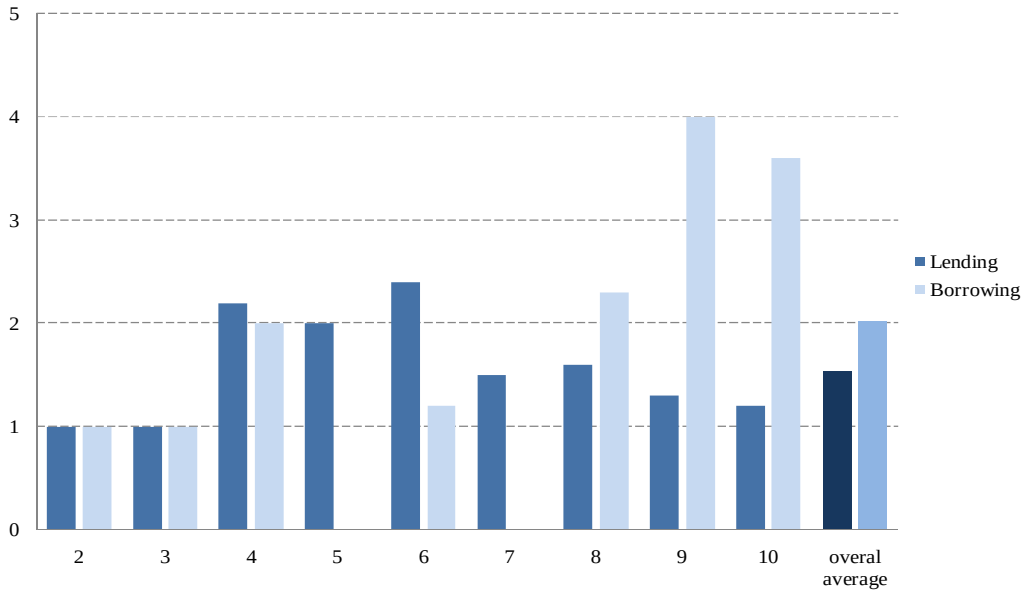

FIGURE 4. Average number of counterparties when lending and borrowing respectively, interbank transactions. July 16, 2007 – October 7, 2008. X-axis: bank identity number.

Note: Averages are calculated over the whole period for each institution separately. Only interbank transactions are included, i.e. no transactions made with the SNDO or the Riksbank are taken into account.

The information just presented is suggestive of the number of interbank links that can be expected each day, but says little about the institutions between which institutions the transactions are made. A closer examination of which banks lend to which other banks reveals that the banks tend to use the same counterparties repeatedly. Of the total funds lent during the period, the banks on average lend about 90 per cent of their total funds lent during the period to their three most frequently used counterparties. Similarly, they borrow on average 85 per cent of their total value borrowed from the same three counterparties. Yet, how the banks alternate between their three most common counterparties varies between the banks and whether lending or borrowing is considered. At the one extreme, one bank deposit as much as 80 per cent of the deposits in the period with the same bank and the remaining 20 per cent equally between two other counterparties. On the other extreme, there is on bank that deposit about one third of its deposits with each one of its most frequent counterparties. As before, that some banks mainly use one counterparty while some split their transactions between several are likely due to that it is not always possible to find a bank that need or, alternatively, has enough funds to balance a very large position. However, even when they could find a bank willing to borrow or lend the whole amount the banks tend to have different strategies in this respect. The reasons for this is probably differences in the distribution of the banks' other exposures, internal risk management strategy and internal quantity limits. That is, in order to not concentrate the credit risk from overnight exposures, banks deposit overnight funds with several rather than with one other bank. The average frequency at which banks use their five most common counterparties is presented in Table 4.

TABLE 4. Per cent of total daily transaction value and number of transactions respectively, that the banks on average lent and borrowed to their most important bank-counterparties. Interbank loans in the Swedish overnight market. July 16, 2007 – October 7, 2008.

	By value		By volume	
Ranking	Borrowing	Lending	Borrowing	Lending
1	57.9	61.9	46.8	52.6
2	20.1	19.9	20.2	21.3
3	11.6	11.5	13.1	14.4
4	4.3	5.3	7.4	8.3
5	2.6	1.3	4.6	3.1

Note: Only interbank transactions are included in the calculations represented in the table above, i.e. no transactions made with the SNDO or the Riksbank are taken into account.

The finding that market activity in terms of value is very concentrated presented in section 5.2 and the above observations of counterparty relationships points to that activity in the overnight market is divided in two tiers, with an inner and an outer tier. The inner tier, or the nucleus, consists of the five banks between which almost 45 per cent of the interbank transactions and most of the transaction value is transferred (81 per cent of the total transaction value during this period). The links within the nucleus run between all banks, but certain links appear more often than other and represent a larger part of the total daily transaction value. The second, or outer tier, includes the remaining banks which have been documented to account for a smaller part of the market and, in addition, to almost always deposit funds. Consequently, the links connecting the second tier with the first almost only run in one direction; from the outer tier into the nucleus. During the period, almost half the transactions, corresponding to 17 per cent of the total transaction value is sent from the second tier to the first tier. All banks in the nucleus are not linked to the second tier to the same extent, but three of them trade more with the banks outside the nucleus than the other two. Almost no links run between the banks in the second tier. Figure 5 on the next page illustrates the two tier structure of the Swedish interbank overnight market.[15]

The observation that banks to a large extent trade with the same counterparties has in other studies of overnight markets been interpreted as evidence of relationships existing between the banks. Even though the banks tend to trade repeatedly with the same counterparties also in the Swedish market, the same conclusion cannot be drawn directly from these observations. This could simply be a consequence of the relatively few institutions participating in the market. Especially the five banks that account for the lion part of the daily turnover in the Swedish overnight market have little or no other choice than to trade with each other, and in most days not even all of them. Nevertheless, also when the banks have a choice they tend to choose the same counterparty, indicating that even in the Swedish market banks benefit from establishing relationships with other banks.

[15] See also Appendix 1, tables A1.VIII – A1.IX.

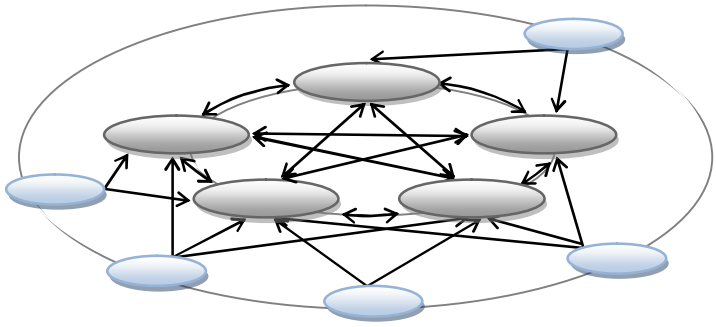

FIGURE 5. Trading structure in the Swedish overnight interbank market**.** July 16, 2007 – October 7, 2008.

Note: The figure illustrates the structure of the Swedish overnight market. The most important links in terms of value are included, their relative importance are however not illustrated in the figure. Grey ovals (inner circle) represent the inner tier and light blue ovals (outer circle) represent the banks in the outer tier.

5.5. Interest rates

The common understanding of the Swedish overnight market is that a "gentlemen's agreement" exists between the banks, under which all interbank loans are charged the repo rate (Kronestedt-Metz (2005)). This section examines the interest rates paid and charged by individual banks in the Swedish overnight market, explicitly assessing the existence of a "gentlemen's agreement".

In order to do this the implied interest rate for each overnight loan is computed. This is done by dividing the difference between the loan advance and the repayment by the amount lent. From the calculated (and annualized) rates the repo rate prevailing on the particular day is subtracted in order to make the overnight loan rates comparable over time. The differences, or spread, between the implied interest rates and the repo rate are presented in Figure 6. A spread equal to zero means the overnight loan was made to the repo rate. A difference larger than zero implies that the borrower paid the repo rate plus a premium for the overnight loan.

As shown, almost 83 per cent of the number of overnight loan transactions during the period is carried out at the repo rate. In terms of value this share is even larger, amounting to almost 95 per cent of the total transaction value. Hence, the data support the existence of a gentlemen's agreement between the banks in general. A few of the banks, however, appear to not have much such an agreement with each other. In 15 per cent of the transactions, corresponding to less than 5 per cent of the average daily turnover, the borrower pays a premium. The transactions carried out above the repo rate are almost only made between the same banks, possibly indicating some other agreement between these banks. In the first six to seven months the premium to the repo rate is 1 and 2 basis points respectively depending on the lender and 2 and 3 basis points respectively in the following eight to nine months of the sample. In kronor value the premium is small; a premium of 1 basis points (annualized) corresponds to an interest revenue of SEK 280 per day and billion kronor borrowed.

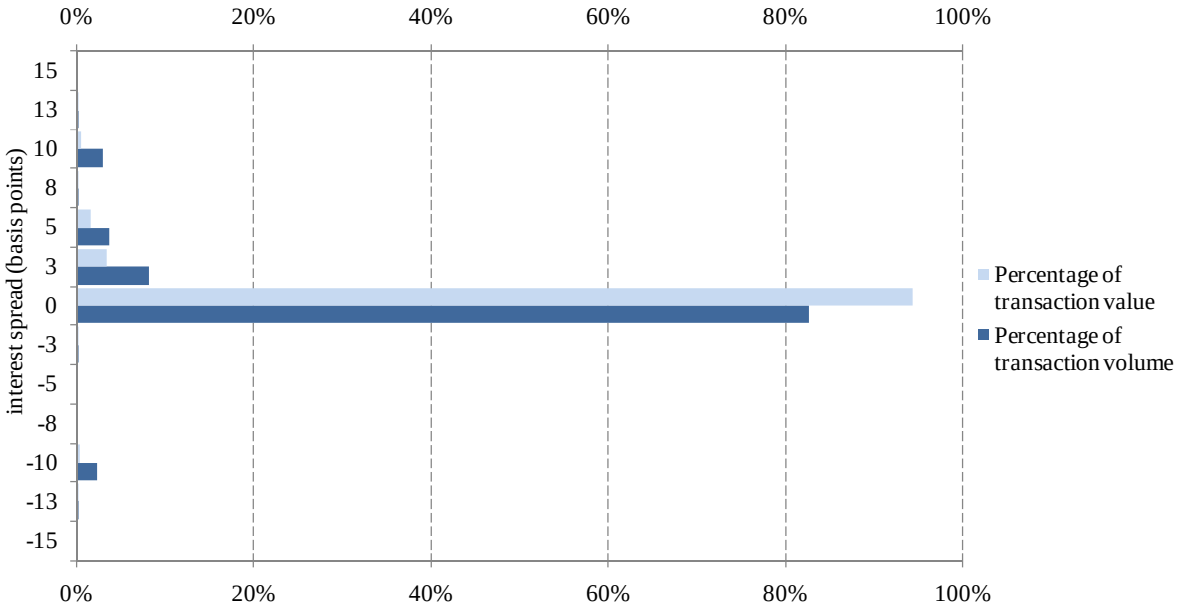

FIGURE 6. Distribution of interest rate spreads (basis points deviation from repo rate) for overnight loans made July 16, 2007 – October 7, 2008. Per cent of total transaction value and of total number of transactions respectively.

The premium charged by some banks could represent a number of things. Evidence from the federal funds market as well as the Portuguese overnight market suggests that banks charge each other a premium to compensate for counterparty credit risk when lending overnight funds (Furfine (1999), Cocco et al. (2003)). If the observed spread represents a premium for credit risk it translates into a probability of losing the whole exposure equivalent to 0.01 to 0.03 per cent within the *next 12 months.*[16] Another possibility, suggested in previous studies, is that the premium is a charge that the borrowing bank has agreed to pay in order to assure that it will always be able to borrow overnight funds from the other bank (Cocco et. al. (2003)). In that context the premium could be interpreted as a liquidity premium. Given that the bank paying the premium is a net borrower in the period studied and that the premium appears to increase as the crisis becomes more severe this explanation seems plausible. However, also credit risk and the price of credit risk increased as the crisis deepened. That the premium increases during the period as the financial crises evolves points to that it is related to risk; possibly credit risk, liquidity risk or some other market risk.

Finally, it is worth noting that the banks in general charge each other the same interest rate for the overnight loans as they charge the SNDO. This indicates either that most banks do not price risk on overnight loans or that they perceive overnight loans a risk free "investment".

[16] Expected loss is defined as the probability of default times the loss rate (EL = PDxLDG). Thus the risk premium should represent the combination of these two. Such an interpretation also requires that the amount is rolled over each day. However, for these two lenders this is almost true.

5.6. Comments on the result

In the above sections the results from the microstructure analysis of the Swedish overnight market was presented. The empirical results found in section 5 can be summarized in five main points.

First, the overall participation in the Swedish overnight market is high, but in terms of transaction value market activity is concentrated to five participants. Second, a dichotomy exists between the banks with regard to their net behavior, with some banks systematically borrowing large amounts of funds and others systematically lending. Third, the Swedish overnight market can be described as a two-tier structure; with an inner and an outer tier. Most of the value is exchanged between five banks in the inner tier and a smaller portion of the value is transferred from the second tier into the first. Fourth, the banks active in the overnight market tend to persistently lend and borrow with the same counterparties. This is likely to be a consequence of the small number of institutions in the market. However, even when the banks have a choice they tend to choose the same counterparty. Finally, the existence of a gentlemen's agreement was confirmed for the market in general, even though exceptions exist.

The results imply that the functioning of the overnight market is highly dependent on the co-operation and trust between the five banks in the inner tier. This result is not unique for the Swedish overnight market as all bilateral trading to some extent relies on trust between the parties. Nevertheless, the fact that the Swedish overnight market is very small in terms of number of banks participating is likely to make it more dependent on confidence between the banks than other markets. Even though also other overnight markets are very concentrated, there is a difference between reducing the number of available trading partners from 20 to 19 compared to from five to four. If only one of the inner tier banks would lose confidence in the other banks and instead chose to use the Riksbank's standing facility or, alternatively, experience some operational problems which prevent it from participating, the allocation of liquidity would probably be much more complicated and less efficient. Since smaller banks outside the overnight market use these banks as correspondent banks, problems in the overnight market is likely to also have consequences for an even larger number of banks than the ones directly participating in this market.

Furthermore, the results suggest that the Swedish overnight market was not affected in any practical way by the uncertainty that characterized the financial markets during the period July 16, 2007 to October 7, 2008, but continued to allocate liquidity well. In fact, very little changes in the behavior and structure of the overnight market could be observed. Even the agreement to make overnight loans to the repo rate was honored throughout the period even though some banks benefited from the agreement by systematically borrowing in the market; a behavior that is even more pronounced late in the period. Behavior in the overnight market is however not isolated from behavior in other markets. Given that overnight loans by construction have very short maturity, it is possible that banks considered it safer to go into an overnight agreement than to deposit money on other (longer) maturities. In this case the overnight market should be the last market to be affected by the

financial turmoil and could explain the absence of any evidence pointing to disruptions in the overnight market. An alternative explanation to why the Swedish overnight market appears to have been robust against the uncertainty surrounding it could be that the Swedish market actually benefited from the fact that it is small and concentrated. Compared to larger overnight markets like the euro money market, anonymity is likely to be a smaller problem in the Swedish market. Because the total number of possible counterparties is smaller, there is a greater chance for each bank to monitor all other banks. On top of that, the trading relationships prevailing in the market are very much the same during the whole period, which should increase each banks possibility to continue to evaluate their counterparties and, as a result, increase their chance to pull out at "in time". Therefore, even though the high concentration increases the risk of contagion in the Swedish overnight market, the small number of institutions might have kept it functioning during a longer period of stress compared to other markets.

When considering this last point it is however important to keep in mind that the sample mainly extends over the initial phase of the financial crisis, only covering three weeks post September 15, 2008, when Lehman Brothers filed for bankruptcy protection and the financial crisis reached what can be regarded as its climax. Reportedly, the situation in interbank markets worldwide was very problematic in the weeks following this event (ECB (2009)). Central bank measures were quickly established to counteract some of the interbank market stress. It is therefore possible, and likely, that Swedish overnight market during the last three weeks in the sample period was more affected by the crisis than what the data suggests.

Part II – The risk of financial contagion

The paper so far has analyzed the microstructure of the Swedish overnight market. As overnight loan exposures are uncollateralized and often of large amounts these exposures make up a relatively large proportion of the total exposures that banks have towards each other and hence constitute a potential source of financial contagion. During the current financial crisis one main concern in financial markets has been that problems in one financial institution can spread to other institutions through the direct exposures that they have towards each other, i.e., the risk of financial contagion. The aim of the second part of this paper is to assess the risk of financial contagion in the Swedish banking sector arising from overnight lending during the period July 16, 2007 – October 7, 2008.

In doing so, the same overnight transaction data as in Part I is used. Based on these data the event of a bank failure is simulated. The effect of the resulting losses on the other banks' capital is then computed in order to observe the risk of financial contagion during the period. Two main scenarios are considered. In the first scenario the largest borrower in the market is assumed to fail. This scenario is considered in order to gain an understanding of the importance of the size of the total

exposure for the risk of financial contagion. In the second scenario, it is instead the most interconnected borrower, i.e., has the largest number of counterparties, which is assumed to fail. While, the first scenario has also been considered by others (e.g. Furfine (2003a), Amundsen and Arnt (2005)), the second scenario has to my knowledge not been analyzed before using this type of data. Economic theory has suggested that the particular market structure is central for determining the risk of financial contagion (Allen and Gale (2000)). Following the collapse of Lehman Brothers the question if some institutions are too connected to be allowed to fail has been raised.[17] With the second scenario the paper aims to assess the importance of the number of links that exist between banks. The analysis in this second part of the paper complements the structural analysis in the first part by examining what implications the market structure of the Swedish overnight market has for the risks of contagion in the Swedish banking sector.

6. Financial contagion: overview of the empirical literature

Empirical studies that assess the risk of financial contagion have been performed for banking systems in several countries. Most of the studies use a methodology in which low frequency data, estimated or real, on total interbank claims are used to simulate the contagious effects of a single bank's failure on the banking system. This approach has recently been adopted by for instance Upper and Worms (2004) for the German banking system, Degryse and Nguyen (2007) for the Belgian banking system and Mistrulli (2007) for the Italian banking system. The above papers all find the risk of financial contagion due to the failure of a single bank to be small. Under the assumption that banks could recover 60 per cent of their claims towards the failing bank, contagion occurred in at most 6 per cent of the scenarios[18] and never affected more than 10 per cent of the aggregated assets of the respective banking system. Recently, some studies have extended this approach by also accounting for the common macroeconomic risk exposures of banks in the same system. Elsinger et al. (2006) for example use bank stock price correlations in order to account for these common risk exposures. Doing this, they find an increased risk of contagion compared to earlier studies. In their study, the probability of contagious defaults due to a bank failure that was caused by a systemic shock ranged between 2.5 per cent to 67 per cent.

Two papers have focused on the Swedish banking system. In the first, Blåvarg and Nimander (2002) use bilateral data on all counterparty exposures from the four major Swedish banks to simulate the risk of contagion due to the failure of one of these banks. Just recently Frisell et al. (2009), based on the same type of data, extend this analysis by also taking into account that the Swedish banks to a large extent are exposed to the same groups of borrowers and geographical regions. The outcomes of these two analyses differ noticeably. Whereas Blåvarg and Nimander (2002) find that financial

[17] Interconnectedness is for example discussed by IMF in its latest Global financial stability Report (GFSR April 2009).

[18] In these studies a scenario is defined as the failure of one bank. In Upper and Worms (2004) a scenario without the government safety net that was in place generated a significantly higher contagion frequency. However, this is not comparable to the scenarios in the other studies.

contagion due to a failure of one of the major banks to be unlikely and only occur if the recoveries of assets are almost non-existent, Frisell et al. (2009) find that, during certain periods and depending on the state of the economy, the risk of contagion is substantial even at as low loss rates as 20 per cent.[19]

The approach adopted in the current paper is closely related to the one used by Furfine (2003a) and later also by Amundsen and Arnt (2005). In both studies, daily settlement data from the large payment system in the respective country is used to compute the contagious effect of a bank failure. Both studies conclude the risk of contagion to be very small, however, largely dependent on the assumed recovery rate of the exposures. Different from other studies, their approach makes use of high frequency data on overnight interbank claims only, instead of monthly or quarterly observations (or estimates) of *all* interbank exposures. As actual exposures can vary significantly from day to day, one advantage of this approach is that the risk of financial contagion can be measured precisely and for successive days over a longer period of time. Using this kind of data avoids bias due to window dressing and gives a picture of how important day-to-day variations in exposures are for the risk of contagion. The cost of this approach is that the analysis concentrates exclusively on contagion arising from overnight interbank exposures. Even though these exposures have been estimated to account for up to 20 per cent of total interbank exposures (Furfine (2003a)), the analysis is therefore likely to underestimate the actual risk of contagion. Only using overnight loan exposures could however be justified not only because of that advantage of using high frequency data, but also because the contagion risk arising from this particular source can be isolated.

The analysis in this paper complements those of Furfine (2003a) and Amundsen and Arnt (2005) in at least three respects. First, this paper studies contagion risk in a market with very different structure from the markets previously studied. Compared to the federal funds market and the Danish overnight market, the Swedish overnight market is more concentrated and more dependent on a small number of very large banks which by necessity have to be very exposed to each other. Neither Furfine (2003a) or Amundsen and Arnt (2005) found the risk of contagion to be significant. However, due to the difference in market structure the results from Sweden could be considerably different. Second, the analysis is performed for a period colored by the evolution of one of history's worst financial crisis. It thus allows for an analysis of how the risk of financial contagion develops during such a period. For example, do the banks adjust their exposures in any way to mitigate the risk of failure? Finally, the analysis of the risk of contagion in the Swedish overnight market is performed in conjunction with the assessment of the market microstructure in part I, which allows the particular market structure to be related directly to the actual risk of contagion. In addition, this paper adds to that of previous studies of contagion for the Swedish banking system by considering a larger number of banks than only the four largest.

[19] At most, the probability of default in the study amounted to 40 percent.

7. Simulation methodology

To quantitatively assess the risk of financial contagion a sequential simulation is performed. The approach was used by Furfine (2003a) and Amundsen and Arnt (2005), and has been used in many other papers simulating contagion in banking systems.[20] The procedure involves three separate parts: Constructing matrices of the bilateral exposures from the overnight payment data, performing the simulations and specifying an appropriate failure criterion, including the loss rate (LGD).

7.1. Constructing bilateral matrices of overnight exposures

As a first step a matrix $\boldsymbol{X}$ is set up for each day in the sample period. Every matrix comprises $N \times N$ elements:

$$\boldsymbol{X} = \begin{bmatrix} 0 & \mathbf{L} & x_{1j} & \mathbf{L} & x_{1N} \\ \mathbf{M} & \mathbf{O} & \mathbf{M} & \mathbf{N} & \mathbf{M} \\ x_{i1} & \mathbf{L} & 0 & \mathbf{L} & x_{iN} \\ \mathbf{M} & \mathbf{N} & \mathbf{M} & \mathbf{O} & \mathbf{M} \\ x_{N1} & \mathbf{L} & x_{Nj} & \mathbf{L} & 0 \\ \hline l_1 & \mathbf{L} & l_j & \mathbf{L} & l_N \end{bmatrix} \begin{matrix} d_1 \\ \mathbf{M} \\ d_i \\ \mathbf{M} \\ d_N \end{matrix} \tag{1}$$

Each element x_{ij} represents the overnight funds that bank i deposit with bank j on the day t and N is total number of banks present in the overnight market during the period. The row sums, d_i, is the total sum of deposits made by bank i with all other banks on a particular day and the column sums, l_j, is the sum of all loans taken by bank j in the overnight market on the same day. If there, on a particular day, are no overnight loan-exposures between two banks the cells representing the exposure between these two banks are set to zero. The diagonal always contains zeros since banks cannot lend funds to themselves. The overnight loans are obtained from the RIX payment system and are the same overnight transactions that were analyzed in part I of this paper.

7.2. Simulations

After a matrix of interbank overnight exposures has been constructed for each day in the data set, a sequential algorithm is run for each day in the sample to simulate immediate and unexpected bank failures. The sequence runs as follows. A bank z is assumed to not be able to repay its overnight loans (fail). As a consequence of bank z's failure all banks which lent funds to bank z in the overnight market suffer a loss. The size of the loss depends on the direct exposure x_{iz} that bank i has towards z and an assumed loss rate, or loss-given-default (*LGD).* If the loss suffered by bank i due to its exposure towards z causes bank i's capital adequacy ratio (defined below) to fall below the statutory requirement of 8 per cent i is assumed to also fail. The effect of the exogenously assumed failure of bank z on the other banks is referred to as the *first-round* contagion effect. In the case when one or more banks fail in the first round, the algorithm is repeated. For the banks remaining after the first

[20] For an in depth description over possible approaches to set up counterfactual simulations, see Upper (2007).

round the total loss due to exposures towards all banks that have failed, i.e. to bank *z* and to all the banks failing in the first round, is calculated. Again, a failure is assumed to occur if the (total) loss suffered by a bank causes its capital adequacy ratio to fall below 8 per cent. After each round, the number of banks failing in the simulation is summarized. The simulation is repeated until no more failures occur. Figure 7 illustrates how the simulation proceeds.

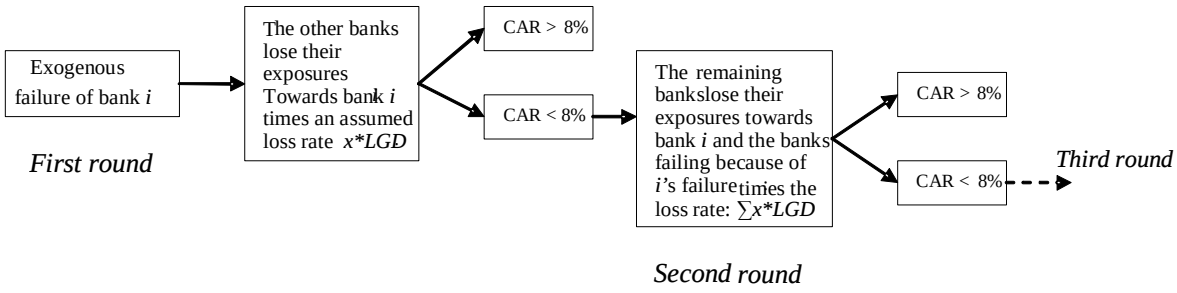

FIGURE 7. Illustration of the round-by-round simulation.

7.3. Specifying the failure criterion

The number of contagious failures resulting from the simulations depends on the specific failure criteria chosen as well as the specific *LGD* assumed. As described above, in this paper a failure is assumed to occur if the bank's capital adequacy ratio (CAR) falls below the statutory requirement of 8 per cent as a result of the induced loss. Formally the criterion for failure is:

$$\text{If CAR (bank } i\text{)} = \frac{capital - LGD * \sum_{k}^{j} x_{ij}}{RWA - w_{x_{iz}} * x_{iz}} < 0.08 \quad \text{then bank } i \text{ fails.} \qquad (2)$$

where *k* is all the banks that failed in the previous rounds and *LGD* is the loss rate and *w* is the risk weight of the overnight loan that the bank use when calculating its risk weighted assets (*RWA*).

The assumption of an immediate failure once the capital adequacy ratio fall below 8 per cent is strong. According to the Basel 2 agreement banks are required to hold a capital amounting to at least 8 per cent of their risk weighted assets.[21] However, in practice an institution will normally be given some time to solve its situation; either by taking in new capital, reducing its undertakings or merge with another institution (SFS 2006:1371). There are also other requirements that banks have to fulfill. For example, a bank is required to have a Tier-1 capital ratio of at least 4 per cent. In addition, the market arguably could have a capital requirement that deviates from the regulatory requirements.

[21] The capital adequacy ratio for credit risk exposures is defined in the Swedish Capital Adequacy and Large Exposures Act (SFS 2006:1371), which is a part of the implementation of the revised EU Directive based on the Basel 2 agreement. Source: www.finansinspektionen.se.

Nevertheless, an incident where the capital adequacy ratio falls below 8 per cent represents a serious event that would require measures to be taken, by the bank or by the authorities. [22]

In the above formula x_{ij} is derived from the overnight transaction data, while capital as well as risk weighted assets are obtained from the banks' financial statements.[23] According to the Basel 2 rules banks can either use the risk weights specified in the standardized approach in the regulation or, if permitted by the financial supervisory authorities, apply an internal risk model to calculate the risk weights used for their different exposures. Some of the Swedish banks included in the data have permission to use internal risk models. Since internally derived risk weights are not publicly disclosed, the risk weights specified in the standardized approach of Basel 2 are used in the simulations. Accordingly, exposures towards a bank with an external short term rating equivalent to A-1 or better are given a 20 per cent risk weight and exposures towards banks with an external rating of A-2 are given a 50 per cent risk weight. The effect of this assumption on the simulation results is difficult to estimate since the actual weight could be both smaller and larger depending on how a particular bank estimate the risk of another bank.[24]

The specification of the loss rate, or LGD, is an important determinant for the probability of contagion. Since relatively few bank failures actually occur, the empirical observations are rare. As a rule of thumb many studies refer to James (1991) who computed the average loss realized in bank failures in the United States in the 1980s to 30 per cent, excluding bankruptcy costs. However, the particular market, time period, size of the institute failing etc., are all important factors affecting the observed LGD. Endogenous LGDs based on balance sheet data is a possibility that solves these problems. Such estimations however require additional assumptions with implications that are not straightforward (Upper (2007)). The most common approach is to use a range of different loss rates. Such an approach gives an idea about the sensitivity of the results and is adopted also in this study.

8. Simulation Results

This section presents the result of the failure simulations. To begin with, the outcomes of two different scenarios are presented. In the first scenario the contagion risk in the Swedish banking system due to the failure of the largest debtor in the overnight market, in terms of value borrowed, is considered. The second scenario is identical to the first, except in this case the institution failing is the most interconnected borrower, i.e. the bank that has borrowed from the largest number of other banks in that particular day. The outcomes of the two scenarios are then compared to the results of simulations in which the impact of each individual bank's failure on the Swedish banking system is considered. [25]

[22] A Tier-1 capital ratio equal to 4 per cent constitutes a less hard requirement for the Swedish banks since they in general have relatively little supplementary capital (capital in excess of Tier 1 capital). A larger loss is therefore required before they default on the Tier-1 requirement than on the capital adequacy requirement.

[23] The capital base and CAR according to the transition rules constitute the requirement by the authorities during the period covered in the data and are therefore used in the simulations.

[24] Based on the requirements specified in Basel 1, previous studies use a risk weight of 0.2.

[25] Only the effects on the Swedish banks are considered. The reason for this is that foreign banks affiliates and subsidiaries, in a crisis situation, would normally benefit from the support of its parent. The extent of this support is however difficult to

The aim of analyzing both the two scenarios and the impact of each banks failure on the Swedish banking system is first of all to get a sense of the importance of these two factors, the total value borrowed and the number of counterparties. Additionally, the analysis may also show if the system is especially vulnerable to the failure of certain institutions. Figure 8 and 9 show the results for the two scenarios assuming a LGD of 50 per cent and 100 per cent respectively.

As shown in Figure 8 there is only a small risk of financial contagion when the LGD is 50 per cent, regardless of which scenario is considered. For this LGD, financial contagion occurs on 9 days when the largest debtor is assumed to fail and on 18 days when the most interconnected debtor fails (out of 332 days). Furthermore, under this assumption there is never more than one bank failing as a result of the initial failure and neither does the initial failure at any time trigger a second or third round of failures. For a LGD of 100 per cent the number of resulting failures increases considerably. In this case, first round failures occur on almost every second day (161 days) in the scenario in which the largest debtor is assumed to fail and on two days out of three (203 days) in the second scenario. Still, there is however mostly only one bank failing as a consequence of the initial failure. Only on 12 and 5 days respectively does the failure of the largest or the most interconnected borrower result in a second round of failures. And only at one time, when the largest borrower is assumed to fail, is a third round of contagion triggered. In both scenarios and for both a 50 and a 100 percent loss rate, failures are triggered mostly in the banks which in terms of asset size are the smallest, although a contagious failure of a larger bank also occurs on some days. It is also worth noting that there is a slight tendency of fewer failures to occur in the latter part of the sample period.

For all levels of LGD, the failure of the most interconnected borrower result in failures on a larger number of days than the failure of the largest borrower by total exposure value. However, as pointed out above, in most days there is only one failure. This may indicate that the reason for why the failure of the most interconnected borrower generates more failures in total is not that this borrower is actually linked to more banks, but rather the specific lender-borrower combination. This hypothesis is further supported by the results of the simulations in which each bank's failure is considered individually. In these simulations, the failures of two banks generate contagious failures on a larger number of days than in the two scenarios. In the worst case defaults are triggered on 31 days for an assumed LGD of 50 per cent and on 240 days for an assumed LGD of 100 per cent (see Appendix). As in the two scenarios, the number of banks failing in the same day is limited; never being larger than two.

Overall, the results suggest that the risk of *system wide* financial contagion in the overnight market is low as the number of resulting failures are always few. When interpreting these results it is however important to remember that the Swedish banking system comprises only a small number of banks and that one bank alone could represent as much as a fifth of the banking sector or have an

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evaluate. Furthermore, foreign bank affiliates do not disclose figures on their own capital levels wherefore they cannot easily be evaluated at a standalone basis.

essential role in the interbank markets, not least in the overnight market. Thus, even if the failure of one bank does not directly provoke a failure in another bank, such an event might undermine market confidence and by that hurt the function of the Swedish overnight market as well as other interbank markets. The consequences could therefore be severe. Furthermore, the results suggest that the Swedish banking sector is particularly sensitive to the failure of one or two institutions. A failure of one specific institution could thus have more widespread consequences than the failure of another even though they might account for an equally large proportion of the Swedish banking sector.

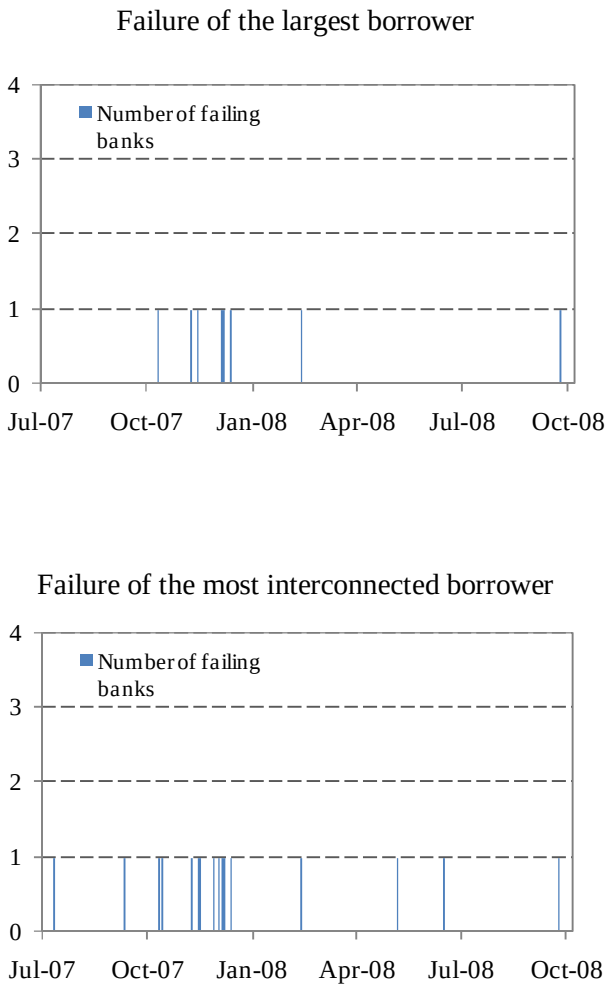
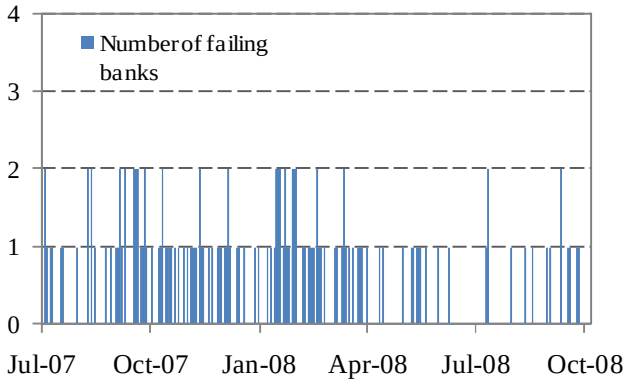


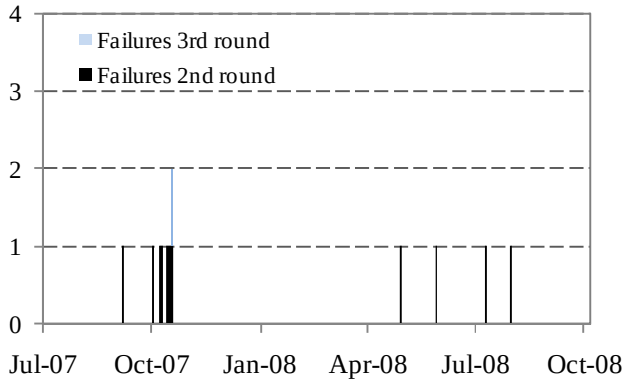
FIGURE 8. Number of banks failing in the first round as a consequence of the failure of the largest and most interconnected borrower respectively. Loss rate (*LGD):* 50 per cent.

Note: A bank is assumed to fail if its capital adequacy ratio (CAR) falls below 8 per cent as a result of the induced losses.

Failure of the largest borrower

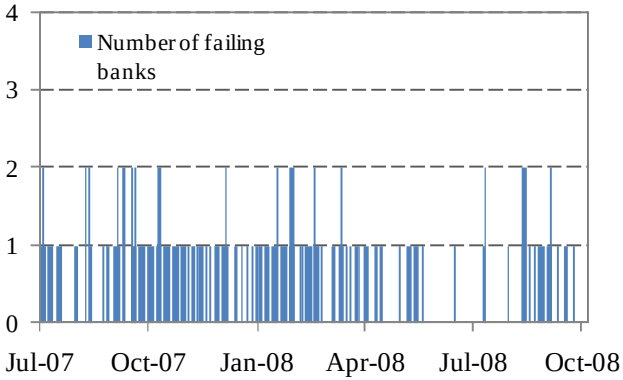


(a) – first round

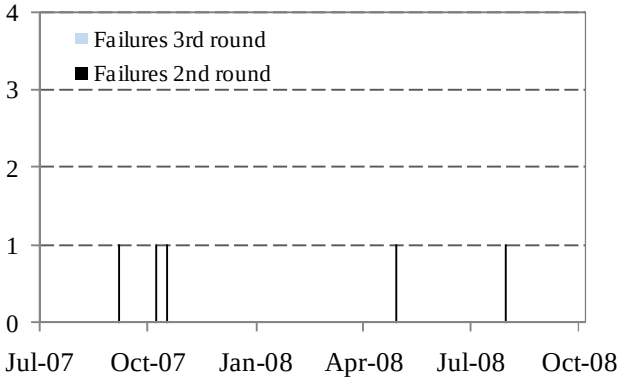


(b) – second and third round

Failure of the most interconnected borrower



(a) – first round



(b) – second and third round

FIGURE 9. Number of banks failing as a consequence of the failure of the largest and most interconnected borrower respectively. Loss rate (LGD): 100 per cent.

Note: A bank is assumed to fail if its capital adequacy ratio (CAR) falls below 8 per cent as a result of the induced losses.

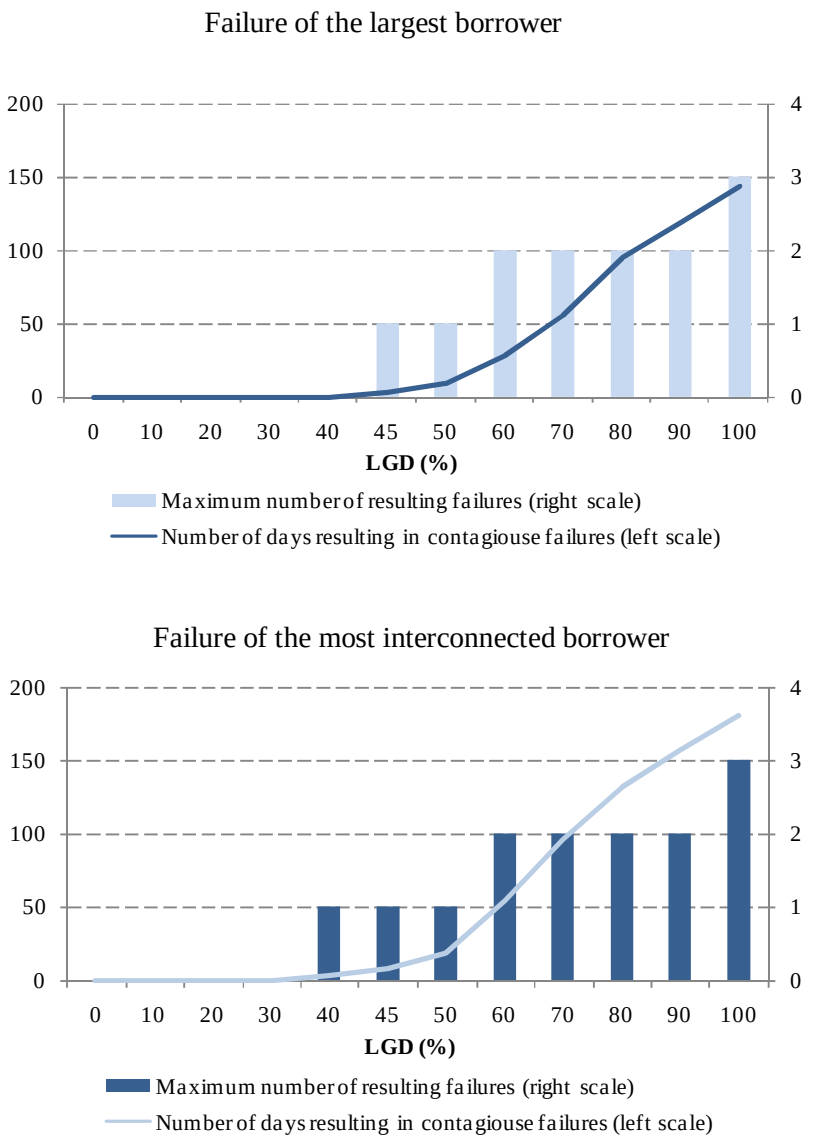


FIGURE 10. Maximum number of failures and total days with resulting failure by assumed loss rate.

Note: A bank is assumed to fail if its capital adequacy ratio (CAR) falls below 8 per cent as a result of the induced losses.

The number of days on which failures are triggered clearly depends on the assumed LGD-level. This result is not unique. Both Furfine (1999) and Upper and Worms (2004) find that failures are triggered considerably more frequently and, moreover affect a large part of the banking system, on higher LGD-levels. The threshold LGD found by these authors, i.e., the level of LGD where contagious failures are triggered on a larger scale, was between 30 and 40 per cent. The threshold LGD in the Swedish overnight market is between 40 and 45 per cent and hence at a slightly higher level. This is illustrated in Figure 10 which shows the maximum number of contagious defaults during a day assuming different LGDs for the two different scenarios. Compared to the realized LGDs documented in bank failures of around 30 per cent (James (1991)) a LGD-level of 100 per cent appear to be unrealistically high. However, these LGD levels are calculated for the total exposures of banks,

meaning that a non-negligible part of the exposures probably are collateralized. Since overnight exposures are uncollateralized the LGD is thus likely to be higher than 30 per cent. In addition, a level of LGD equal to 100 per cent can be considered as a worst case scenario, describing what would happen during a crisis situation in which everything that can go wrong goes wrong.

Compared to Furfine (2003a), Amundsen and Arnt (2005) and to Blåvarg and Nimander (2002) the results in this study indicate a higher risk of contagion, in the way that contagious failures occur more often. However, compared to Frisell et al. (2009) the risk of contagion is however found to be smaller. The higher risk of contagion in the Swedish overnight market compared to overnight markets in Denmark and the United States is likely to be a consequence of the higher concentration in the Swedish market than in the markets in the other two countries (see Part I). The results are not directly comparable with earlier Swedish studies since these studies use another type of data which includes a wider range of interbank exposures, but only for the four major banks. The results can therefore not be expected to be the same. However, since the largest banks constitute such a large part of the market interpretations in relation to previous results may still be meaningful. That the risk of contagion in this study is observed to be higher than what was found by Blåvarg and Nimander (2002) could for example result from that the time periods studied are not the same, in that case indicating that the risk of contagion increased since then. Alternatively, the different results could stem from that Blåvarg and Nimander (2002) based their study on monthly observations of (total) exposures, implying that exposures vary considerably from day to day and that their approach may in fact severely underestimate the actual risk of contagion. On the contrary, the lower risk of contagion observed in this study compared to the what was found by Frisell et al. (2009) suggest that the risk of contagion would be even higher if also the state of the economy and how that affect the overall resilience of the bank sector was to be taken into account.

9. Conclusion

In this paper unique transaction level data from the Swedish payment system RIX has been used in order to examine the microstructure of the Swedish overnight market and the risk of financial contagion in the Swedish banking sector arising from overnight interbank exposures. The data extends over the initial 15 months of the current financial crises. Using this opportunity, the paper has also examined if and in what way the stress related to the crisis influenced the behavior of the banks in the Swedish overnight market.

In the first part, market microstructure was assessed. Similar to studies on other overnight markets, a few large banks were found to account for most of the market turnover. Furthermore, the evidence presented showed that banks generally tend to systematically be net lenders or net borrowers and to a large extent lend and borrow with the same counterparties every day. Investigating the pricing of overnight loans, it was found that the lion's part of the overnight loans is priced at the repo rate with no risk premium at all. Thus, evidence supporting the common understanding of a "gentlemen's

agreement" between the banks active in the market was presented. Although the observed market structure implies that the functioning of the Swedish overnight market should rely more than other larger markets on confidence between the market participants and therefore be more sensitive to uncertainty and stress, the results suggested that this was not the case during the current financial crisis. In contrast to larger overnight markets in other countries, the Swedish overnight market seems to have been unaffected in any practical way by the surrounding turmoil. Except for a slight tendency of a more pronounced net behavior later in the period, no clear indications of any changes in the individual institutions behavior could be observed. Not turnover, the number of counterparties or trading patterns were found to have changed markedly during the period.

In the second part, the event of a bank failure was simulated to investigate what implications the observed overnight market structure had for the risk of financial contagion. The results suggested that interbank overnight exposures could give rise to a contagious default in the event of a bank failure. With a loss given default ratio of below 50 per cent such an outcome was however found to be unlikely. At higher loss rates, the risk of contagion increased and in the worst case scenario, when the whole exposure was lost financial contagion occurred on at most every second day. Furthermore, the results indicated that the Swedish banking sector is more sensitive to the failure of certain institutes than it is to the failure of the largest or the most interconnected borrower in the overnight market. Nevertheless, all else equal the failure of the most interconnected overnight market borrower resulted in financial contagion on more days than the failure of the largest borrower. Mostly no more than one bank failed as a consequence of the initial failure. However, also one bank's failure could be have severe consequences considering the very concentrated Swedish banking sector. A slightly reduced contagion frequency could be observed towards the end of the period.

The data used in this paper only extends over a very limited period of time. The possibility to extend the sample backwards is limited by data availability. However, going forward there are several interesting questions to examine and a natural continuation of this study would be to extend the sample into the future. Since the 8 of October, the final date represented in the data period, the crisis deepened and central bank measures were intensified. In Sweden, the Riksbank's measures have meant that counterparty risk in the overnight market was "transferred" from the banks to the Riksbank and that almost all interbank activity ceased. One possible path forward is therefore to follow up this study with a similar "post-crisis" study, when trading in the overnight market is revived. Such a study could focus on if and how trading in the interbank overnight market changed as a consequence of the crisis and if this is the case, has it affected the risk of financial contagion? Another reason for a "post-crisis" study is the new technical solution for the RIX payment system that was launched by the Riksbank in February 2009. One of the main objectives of the new system was to decrease the liquidity required to send payments during the day. From this perspective, it would be interesting to examine if the new system decreased the banks' need for liquidity and, accordingly, decreased the size of their overnight exposures or in some other way changed their behavior and the risk of financial contagion. Finally, the

results of Frisell et al. (2009) suggest that an important determinant for the risk of financial contagion is the common exposures banks have to macroeconomic factors. A natural way to develop the contagion analysis in this paper is thus to take into account the impact of these common exposures. The high frequency exposure data used in this study could in such a study be used in conjunction with the methodology adopted by Frisell et al. (2009).

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Appendix 1. – Statistics

- *Microstructure*

Market Size

TABLE A1. I. Average daily turnover and transaction volume of total overnight lending.

Overnight Market Transactions	Total Daily Transaction Value (billion SEK)				Total Daily Transaction Volume (number of transactions)			
	mean	max	min	median	mean	max	min	median
17 July 2007 - 7 October 2008								
All overnight loans	45.3	98.3	0.02	43.6	13.6	21	1	13.5
of which								
Interbank transactions	38.6	79.2	0.0	37.4	11.6	18	0	11
Transactions with the SNDO	6.4	30.0	0.0	4.6	1.3	5	0	1
The Riksbank's fine-tuning transactions	0.3	3.1	0.0	0.1	0.7	3	0	1
8 October 2008 - 31 December 2008								
All overnight loans	157.4	275.7	107.0	151.1	14	22	10	14
of which								
Interbank transactions	6.0	26.5	0.0	3.7	4	8	0	4
Transactions with the SNDO	13.2	55.8	0.3	8.7	2	5	0	1
The Riksbank's fine-tuning transactions	138.2	233.9	92.3	122.2	8	18	6	8
17 July 2007 - 31 December 2008								
All overnight loans	62.9	275.7	0.0	47.6	14	22	1	14
of which								
Interbank transactions	33.4	79.2	0.0	34.9	10	18	0	11
Transactions with the SNDO	7.5	55.8	0.0	5.0	1	5	0	1
The Riksbank's fine-tuning transactions	21.9	233.9	0.0	0.2	2	18	0	1

TABLE A1. II. Average daily turnover and transaction volume of total RIX transactions.

RIX turnover volume and value	Average Daily Turnover (billion SEK)	Average Daily Transaction Volume (number of transactions)
17 July 2007 - 7 October 2008	489	7872
8 October 2008 - 31 December 2008	673	7764
17 July 2007 - 31 December 2008	520	7854

TABLE A1. III. Average daily turnover and transaction volume in the Swedish overnight market. July 16, 2007 – October 7, 2008, by month.

	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08
Average daily total loan value (billion SEK)	37.6	36	42.4	52.5	44.7	51.8	51.1	50.9	60.5
Average daily total loan volume (number of transactions)	12.3	11.63	13.9	13.7	12.9	13.5	13.9	15	16.2
	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08 (01-07)	Oct-08 (08-30)	Jul 17, 2007 - Oct 7, 2008
Average daily total loan value (billion SEK)	44.3	32.1	43.3	43.2	36.8	50.3	47	159.8	45.3
Average daily total loan volume (number of transactions)	15.8	12	13.2	12.2	12.6	14.4	16.4	15.7	13.6

TABLE A1. IV. Average daily turnover of interbank overnight transactions, by weekday, July 16, 2007 –October 7, 2008 and October 8, 2008 – December 31, 2008. Million SEK.

	Total	Interbank	SNDO	Riksbank
Monday	46 236	39 416	6 480	340
Tuesday	46 382	40 181	5 847	354
Wednesday	43 071	36 551	6 310	210
Thursday	46 713	39 331	7 127	254
Friday	43 870	37 182	6 384	304

Market Activity

TABLE A1.I. Overall participation rate and participation rates for lending and borrowing respectively in the overnight market, by bank. July 16, 2007 – October 7, 2008. In per cent of total number of days in the data period.

Bank id	Overall	Borrowing	Lending
1	91.4%	0.3%	91.4%
2	93.9%	2.2%	92.6%
3	95.5%	57.7%	39.4%
4	97.1%	48.4%	71.8%
5	97.8%	0.0%	97.8%
6	97.8%	20.2%	91.7%
7	97.8%	94.9%	45.5%
8	98.1%	0.0%	98.1%
9	98.1%	88.1%	26.9%
10	98.4%	98.1%	32.4%

Trading Relationships and Counterparty patterns

TABLE A1.II. Trading patterns, transactions as a percentage of total transaction value.

	Lender												
Borrower	1	2	3	4	5	6	7	8	9	10	Riksbank	SNDO	Total
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	2%
4	0%	0%	0%	0%	0%	5%	0%	1%	2%	0%	0%	1%	10%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	1%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	0%	0%	0%	2%	3%	6%	0%	0%	1%	0%	0%	2%	15%
9	0%	1%	1%	17%	1%	13%	1%	4%	0%	2%	0%	3%	43%
10	1%	0%	0%	3%	3%	9%	3%	1%	1%	0%	0%	4%	24%
Riksbank	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
SNDO	0%	0%	0%	1%	0%	3%	0%	0%	0%	0%	0%	0%	5%
Total	2%	2%	1%	25%	7%	36%	4%	7%	4%	3%	0%	10%	100%

TABLE A1.III. Trading patterns, transactions as a percentage of total transaction volume.

	Lender												
Borrower	1	2	3	4	5	6	7	8	9	10	Riksbank	SNDO	Total
1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	2%	0%	1%	0%	1%	0%	0%	0%	0%	5%
4	0%	1%	0%	0%	0%	3%	0%	1%	1%	0%	0%	1%	8%
5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	2%
7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	1%	0%	1%	2%	7%	4%	1%	0%	1%	0%	0%	2%	19%
9	1%	6%	1%	5%	2%	5%	2%	3%	0%	2%	1%	2%	30%
10	5%	0%	1%	2%	6%	4%	7%	1%	1%	0%	1%	3%	30%
Riksbank	0%	0%	0%	1%	0%	1%	0%	0%	0%	0%	0%	0%	3%
SNDO	0%	0%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	3%
Total	8%	7%	3%	14%	15%	20%	11%	6%	4%	3%	3%	7%	100%

Trading patterns and relationships, by market tier

TABLE A1. VIII. Total transaction value and volume in the overnight market, interbank lending and borrowing respectively, by market tier.

Daily value (share) of transactions, in million SEK and per cent of total value

Lender	Borrower inner	outer	**Total**
inner	31 253	699	**31 952**
	(81.0%)	(1.8%)	**(82.8%)**
outer	6 643	2.6	**6 646**
	(17.2%)	(0.01%)	**(17.2%)**
Total	**37 897**	**702**	**38 598**
	(98.2%)	**(1.8%)**	**(100%)**

Daily volume (share) of transactions and per cent of total volume

Lender	Borrower inner	outer	**Total**
inner	5	1	**6**
	(44.83%)	(5.36%)	**(50.2%)**
outer	6	0	**6**
	(49.78%)	(0.03%)	**(49.8%)**
Total	**11**	**1**	**12**
	(94.61%)	**(5.39%)**	**(100%)**

TABLE A1. VIX Total transaction value and volume in the overnight market, interbank lending and borrowing respectively, by market tier and including the SNDO and the Riksbank's transactions.

Daily value (share) of transactions, in million SEK and per cent of total value

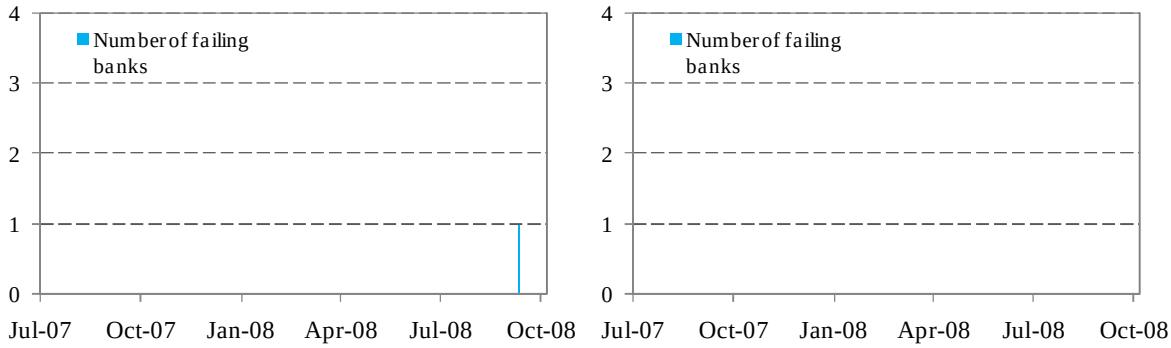
	Borrower			
Lender	inner	outer	Riksbank and SNDO	**Total**
Inner	31 253	699	2 173	**34 125**
	(68.8%)	(1.54%)	(4.78%)	**(75.12%)**
outer	6 643	3	24	**6 670**
	(14.6%)	(0.01%)	(0.05%)	**(14.7%)**
Riksbank and SNDO	4 622	11	-	**4 633**
	(10.17%)	(0.02%)	-	**(10.2%)**
	42 518	**713**	**2 197**	**45 428**
Total	**(93.59%)**	**(1.57%)**	**(4.84%)**	**(100%)**

Daily volume (share) of transactions and per cent of total volume

	Borrower			
Lender	inner	outer	Riksbank and SNDO	**Total**
Inner	5.21	0.62	0.67	**6.50**
	(38.3%)	(4.6%)	(4.9%)	**(47.7%)**
outer	5.79	0.002	0.03	**5.82**
	(42.5%)	(0.02%)	(0.2%)	**(42.7%)**
Riksbank and SNDO	1.26	0.05	0	**1.31**
	(9.3%)	(0.3%)	-	**(9.6%)**
	12.3	**0.67**	**0.70**	**13.63**
Total	**(89.99)%**	**(4.93%)**	**(5.08%)**	**(100%)**

- *Financial contagion*

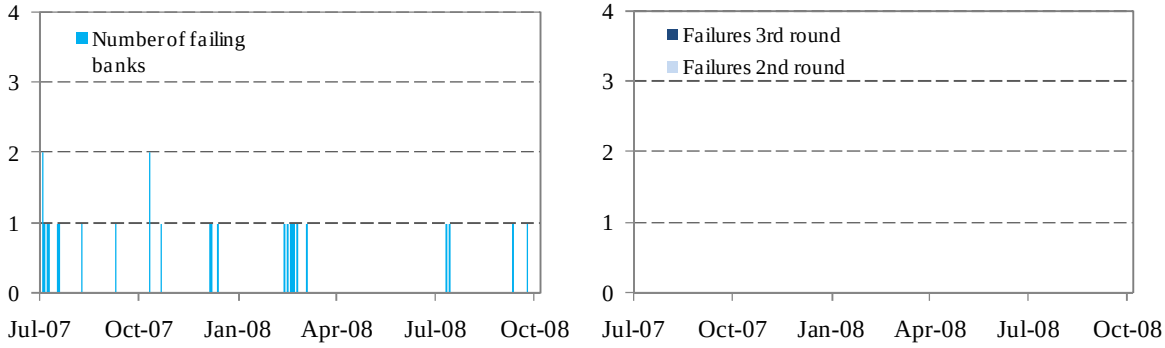
Failure criterion: Tier-1 capital ratio < 4 per cent. Contagious failures after the most contagious bank failed for an LGD of 50 per cent and 100 per cent respectively.



(a) Failure of the largest borrower (b) Failure of the most interconnected borrower.

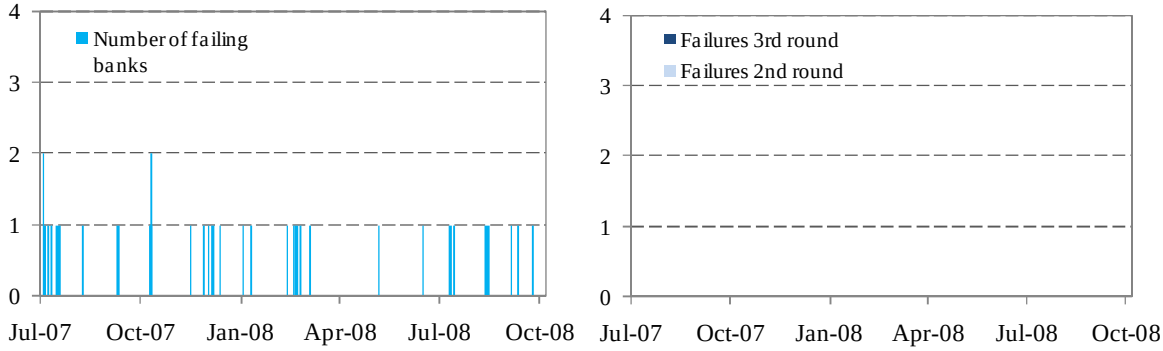
Figure A1. 1 Number of Banks Failing in First Round (*LGD* = 50 per cent)

Failure of the largest borrower



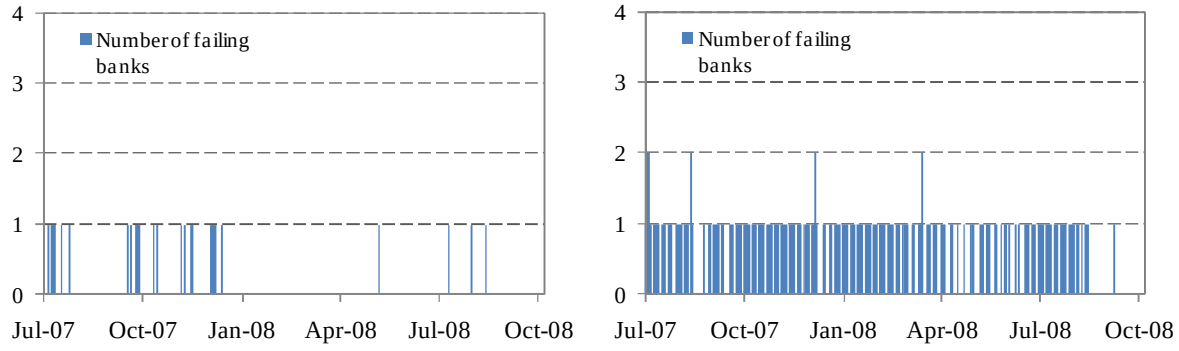
(a) – first round (b) – second and third round

Failure of the most interconnected borrower



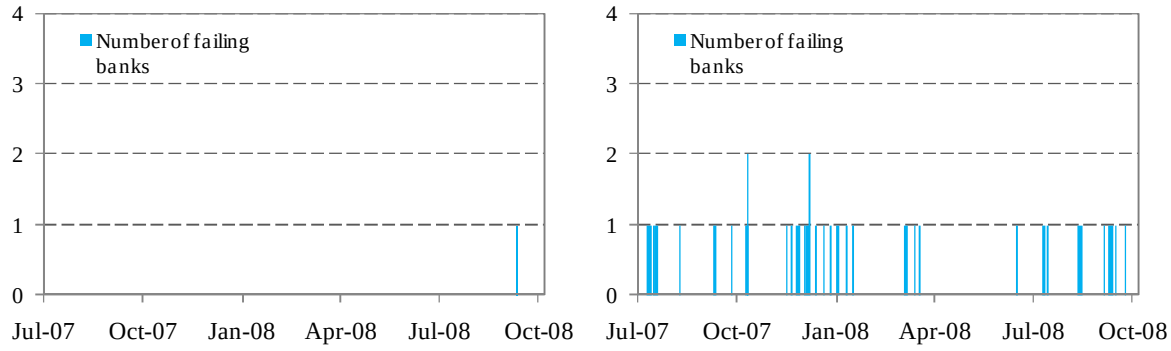
(c) – first round (d) – second and third round

FIGURE A1. 2. Number of Banks Failing (*LGD* = 100 per cent).



(a) – LGD = 50 % (b) – LGD =100 %

FIGURE A1. 3. Worst case scenario – simulation results of the individual bank that causes the highest number of contagious defaults, total failures. Failure criterion: CAR < 8 per cent.



(a) – LGD = 50 % (b) – LGD =100 %

FIGURE A1.4 Worst case scenario – simulation results of the individual bank that causes the highest number of contagious defaults. Failure criterion: Tier-1capital ratio < 4 per cent.

Appendix 2. – Descriptives: Market Participants

TABLE A2. I. Institutions which were active in the Swedish overnight market between July 16, 2007 and October 7, 2008.

Institution	Type	Asset Size (bn SEK)[1] December 2007	Deposit and lending facility	Counterparty in monetary policy repos	Primary monetary policy counterpart (primary dealer)
ABN Amro Bank	Foreign bank affiliate	16	Yes	Yes	No
Citibank	Foreign bank affiliate	8	Yes	No	No
Danske Bank	Foreign bank affiliate	617	Yes	Yes	Yes
DnB NOR Bank	Foreign bank affiliate	39	Yes	No	No
Kaupthing Bank Sverige	Foreign bank subsidary	21	Yes	No	No
Länsförsäkringar Bank	Swedish commercial bank	51	Yes	No	No
Nordea Bank	Swedish commercial bank	3679	Yes	Yes	Yes
The Riksbank	Central bank	-	-	-	-
The Swedish National Debt Office (SNDO)		-	No	No	No
SBAB	Swedish mortgage institution	246	Yes	No	No
SEB	Swedish commercial bank	2344	Yes	Yes	Yes
Skandiabanken	Swedish commercial bank	56	Yes	No	No
Svenska Handelsbanken	Swedish commercial bank	1859	Yes	Yes	Yes
Swedbank	Swedish commercial bank	1608	Yes	Yes	Yes

[1] Assets size of the Swedish banking arm for all companies except for Nordea, SEB, Swedbank and Handelsbanken for which assets are shown at the group level.

Source: The Swedish riksbank

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