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Bargaining Power in the Repo Market

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Abstract

In this paper, we analyze the price setting behavior of banks in the Swiss franc repo market by means of network topology concepts and measures. The sample ranges from October 1999 to December 2009. Hence, it covers a large part of the money market turmoil that started in August 2007. Among others, we find evidence that market participants use their bargaining power as well as private information between two trading partners for price differentiation. The effect of the bargaining power was even more pronounced during the financial turmoil.

JEL Classification: D85, E43, E58, G14, G21, G28
Keywords: interbank market, repo, network, money market turmoil, financial stability, pricing, bargaining power, Switzerland

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1 Introduction

The financial crisis, that began in 2007, affected a number of funding markets, among them the secured and unsecured interbank money markets. The phase after the collapse of Lehman Brothers in September 2008, in particular, was marked by a considerable loss in counterparty confidence. According to market participants, this loss of confidence resulted in a shift from the unsecured to the secured market. This was also the case for the Swiss franc money market (see Guggenheim et al. (2011)).

Throughout the period of observation the number of participants in the Swiss franc repo market increased steadily and hence also the activity. After the collapse of Lehman Brothers in September 2008 – at the height of the crisis – the demand for Swiss francs was particularly high. Consequently, the outstanding volume on the interbank market peaked at CHF 74 billion. During this phase banks domiciled outside Switzerland mainly sought Swiss franc liquidity on the repo market, in order to refinance Swiss franc denominated loans granted to non-banks (see Auer/Kraenzlin (2011)). As a result a substantial part of the Swiss franc liquidity went abroad. In contrast to the US and European[1] repo market, the outstanding volume on the Swiss franc repo market increased after the collapse of Lehman Brothers. A "run on repo markets" as Gorton (2009) refers to in the form of increased collateral haircuts and even the cessation of repo lending on many forms of collateral did not occur in Switzerland. The Swiss franc repo market has thus proved to be resilient against the current crisis, and has been a reliable refinancing source for banks domiciled in- and outside Switzerland (see also BIS (2010)). The resilience of Swiss franc repo market can be ascribed to sound principles of securitization and efficient risk management practices. More than 70% of the turnover was covered by AAA-rated securities and all margin calls had been satisfied since 2002.

Fecht et al. (2010) state that "If turmoil in the market for liquidity can bring the global financial system to its knees, then it is important to enhance the understanding of this market". The aim of this paper is to shed light on the secured Swiss franc money market by means of network topology concepts and measures. The Swiss franc repo market is a transparent and non-anonymous market. A non-anonymous market allows market participants to differentiate with regard to counterparty characteristics. Thus we empirically analyze banks' price setting behavior with unique data from the Swiss franc repo market. The sample ranges from October 1999 to December 2009. Hence, it covers a large part of the money market turmoil that started in August 2007.

[1] For the European repo market we refer to the non central counterparty cleared repo segment.

Afonso et al. (2010) analyze bank's price setting behavior in the unsecured Federal Funds market. They find that the turnover remained relatively constant, but that the pricing became more sensitive to borrower characteristics. In contrast to Afonso et al. (2010) we analyze the price setting behavior on the secured interbank money market, where counterparty risk considerations play a subordinate role.

In order to identify a possible price differentiation we use, in addition to other explanatory variables, the trader centrality scores of the cash provider and cash taker, respectively. This newly developed trader centrality score is a measure of bargaining power in a directed network and is outlined in von Scarpatetti (2010). A bank's centrality score is higher, the weaker the neighbors are, or as Bonacich (1987) writes: "Power comes from being connected to those who are powerless" (p. 1171). We set up the hypothesis that if cash takers have higher trader centrality scores than the cash providers, they will be in a better position to negotiate a beneficial (i.e., lower) repo rate and vice versa. We find evidence that market participants use their bargaining power as well as private information (e.g. outstanding volume or maturing volume between two trading partners) for price differentiation. The effect of the bargaining power was even more pronounced during the financial turmoil.

Holthausen/Pill (2010) state that the money markets have played a central role in recent crisis events, or better said, they were the epicenter of it. However, in the past, research and consequently profound knowledge on money markets had been limited. This paper contributes to the empirical literature by providing an in-depth analysis on the functioning and behavior of market participants on the secured interbank money market. The better understanding of banks' behavior in the money market allow central banks to more effectively design policy measures and facilities to improve or restore market functioning. In response to the recent financial crisis, the Federal Reserve for example, created various liquidity facilities such as the Term Auction Facility (TAF), the Term Securities Lending Facility (TSLF) or the Primary Dealer Credit Facility (PDCF). Their effectiveness is discussed by Wu (2008), Wu (2010) and Fleming et al. (2009).

The paper is structured as follows. The next section provides an overview on the characteristics and developments of the Swiss franc repo market. Section 3 discusses the properties of the data. Section 4 describes the different factors that may influence the repo rate as well as the econometric methodology. In the subsequent section the regression results are presented and interpreted. Section 6 discusses and concludes.

2 The Swiss franc repo market: Developments in recent years

In June 1999 the Swiss franc repo trading, clearing and settlement system was launched and has since then provided market participants with an integrated and automated infrastructure for repo transactions. Almost all repo transactions in Swiss francs are traded on the Eurex repo trading platform. Settlement subsequently takes place in the Swiss payment system and on the books of the Swiss central securities depository.[2] This trading platform is not only used by commercial banks and since June 2010 by insurance companies[3], but also by the SNB to conduct open market and fine-tuning operations with its eligible counterparties. The interbank market sets the same standards with respect to eligible collateral (its handling, pricing and settlement) as the SNB. The Swiss franc repo market is a non-anonymous market, where names of the market participants are visible in their quotes. Immediately after the conclusion of a repo transaction, the transaction size, repo rate, the term and the collateral basket are published on the platform. Hence, participants see all concluded repo transactions in real-time. The two participants involved in the transactions are not revealed.[4]

In 1999 the repo market counted 37 banks of which four were domiciled outside Switzerland. Since then, the number of banks on the platform increased steadily to 159 banks in December 2009. Of these banks, one third is domiciled outside Switzerland. Since the outbreak of the money market turmoil in August 2007, the number of new participants increased by 37 banks, of which 28 banks are domiciled abroad. Figure 1 shows the outstanding volume on the interbank market, divided into a pure domestic, a pure foreign and a cross-border segment. Overall, we find that the outstanding volume steadily increased over the years. Until the outbreak of the money market turmoil, the majority of the volume was pure domestic, implying that both the cash taker and provider were domestic banks. After the collapse of Lehman Brothers in September 2008 – in other words, at the height of the crisis – loss of confidence led to a shift from longer- to short-term maturities or even to a freeze in various money market segments (see Guggenheim et al. (2011)). This was not the case for the Swiss franc

[2]See Jordan (2007) and Kraenzlin (2007) for a further overview on the operational characteristics and development of the Swiss franc repo market.

[3]See Jordan (2009b). As the dataset only comprises transactions up until the end of December 2009, the behavior of insurance companies is not analyzed.

[4]The order book shows all prices being quoted, including the name of the quoting bank. If a quote is removed from the order book and simultaneously a new transaction – with the same rate and maturity – is visible in the list of concluded transactions one could figure out the identity of at least one bank in the concluded transaction, namely the bank which entered the quote. Nevertheless this bank cannot be identified with 100% certainty as banks can transact directly without having to enter a quote in the order book (pre-arranged trade).

repo market. Shortly after the collapse of Lehman Brothers the outstanding volume on the interbank market peaked at CHF 74 billion, and the average time to maturity was at approximately 30 days. Demand for Swiss francs was particularly high during the second part of the financial crisis. As a consequence, domestic banks – which were generally long in cash – traded with banks outside Switzerland, which sought Swiss franc liquidity (see also Auer/Kraenzlin (2011)). This eventually implies that a substantial portion of the cash volume went abroad (cross-border segment). In 2003 the average outstanding cross-border volume was CHF 9 billion (45% of the total) and fluctuated around this level until October 2007. Since then, the average outstanding cross-border volume increased steadily, reaching its peak of CHF 43 billion ($\sim$ 60% of the total interbank volume). We can conclude that the repo market became an internationally-driven repo market during the financial market turmoil and as a consequence an important refinancing source for banks domiciled abroad. Furthermore, the increase in total outstanding volume demonstrates that the Swiss franc repo market proved to be a stable refinancing platform in the recent crisis. This stands in contrast to developments in secured interbank markets outside Switzerland (see BIS (2010)). The resilience of Swiss franc repo market can be ascribed to sound principles of securitization and efficient risk management practices.[5]

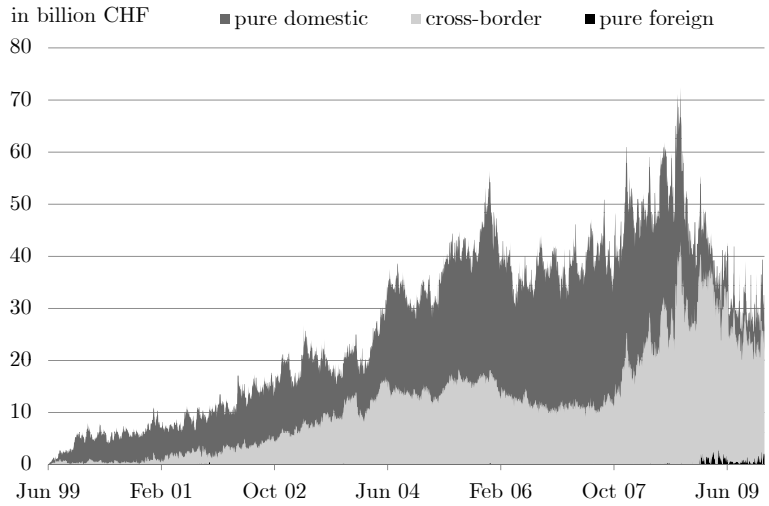

Figure 1: Division of outstanding volume

In February 2009, however, activity in the secured interbank market decreased for the following reasons: Firstly, the SNB decreased its one-week

[5]Collateral delivered in a repo transaction is mark-to-market twice daily. If undercollateralization occurs, an automatic margin call is triggered by SIX SIS Ltd. See Jordan (2007) and Kraenzlin (2007).

repo rate to 5 basis points (bps) reducing the yield and, in turn, incentives for banks to lend funds in the repo market. Secondly, the SNB increased market liquidity substantially by engaging in additional (longer-term) repo operations at 5 bps, buying Swiss franc bonds issued by private sector borrowers and purchasing foreign currency on the foreign exchange markets in March 2009.[6] This led to a situation where hardly a market participant sought Swiss franc liquidity. After the midpoint of the crisis (collapse of Lehman Brothers) the average remaining time to maturity decreased from 30 days to approximately 20 days and remained at this level.

2.1 Collateral standard in the Swiss franc repo market

A peculiarity of the Swiss franc repo market in contrast to other repo systems is that the range of collateral that the SNB accepts for its open market operations is also market standard. This stands in contrast, for example, to the Eurosystem. The European Central Bank (ECB) accepts, among others, non-marketable assets in its open market operations, while these are in general not eligible for transaction between banks. In the period of observation over 99% of all transactions in the Swiss franc interbank repo market were covered by SNB-eligible collateral.

The SNB has defined three separate collateral baskets: the CHF GC, the GOV GC and the INTL GC basket. These three baskets are packaged in a collective basket, namely the SNB GC basket. The GOV GC and the INTL GC basket contain securities denominated in foreign currency[7] and Swiss francs. The securities must have a minimum rating of at least AA-/Aa3 and the volume issued must amount to the equivalent of at least CHF 1 billion.[8] The GOV GC basket contains only government bonds, whereas all other securities issued by private-sector entities or financial institutions that meet these requirements are allocated to the INTL GC basket. The CHF GC basket contains only bonds denominated in Swiss francs that have been issued to an amount of at least CHF 100 million. For securities in CHF the minimum rating is set to A/A2.

The SNB uses only the collective basket for its repo transactions. The collective basket is also the most traded collateral basket in the interbank market. Table 1 demonstrates that more than 90% of transactions were concluded against the collective basket. In other words, cash providers were willing to trade against the collective basket and put up with the possibility that the cash taker will select the bond which is cheapest-to-deliver. In the second half of the crisis, i.e., after the collapse of Lehman Brothers, we

[6] See Jordan (2009a) and Auer/Kraenzlin (2011).

[7] Following currencies are eligible: euros, US dollars, pounds sterling, Danish kroner, Swedish kronor or Norwegian kroner.

[8] The ratings are based on credit ratings from Standard & Poor's, Moody's or Fitch.

	before crisis	during crisis		Total
		before Lehmann	after Lehmann	
CHFGC	6,933	491	34	7,458
GOVGC	2,611	790	1,144	4,545
INTGC	4,898	382	177	5,457
SNBGC	100,706	36,319	32,602	169,627
Total	115,148	37,982	33,957	187,087

Table 1: Number of repo transactions and selected collateral baskets

find that the GOV GC gained in relative importance. This can be taken as indication that cash providers preferred government bonds over securities issued by private-sector entities or financial institutions. Nevertheless the SNB GC basket remained the most relevant collateral basket. We ascribe this to the high share of delivered securities with a AAA-rating. Figure 2 shows that the quality of delivered increased during the crisis. Before the crisis roughly 67% of the turnover was covered by AAA-rated securities. This share remained relatively constant in the first phase of the crisis and increased to 75% after the collapse of Lehman Brothers.[9]

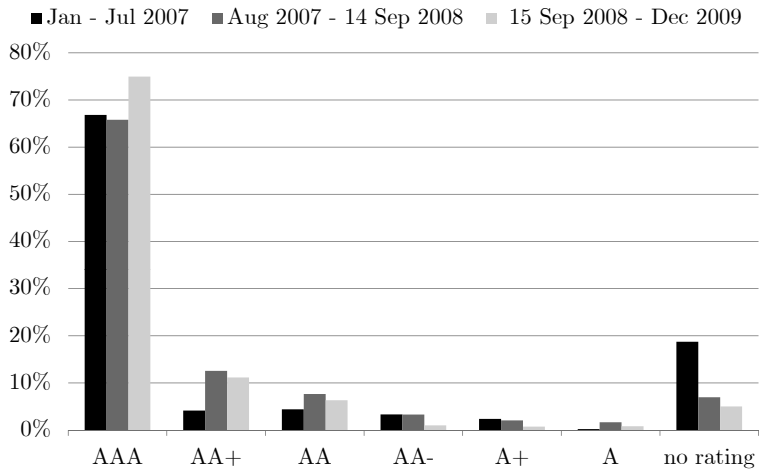

Figure 2: Quality of delivered collateral

The handling and pricing of collateral is predefined for repo transactions conducted via the Swiss repo platform. All standardized repo transactions

[9]Securities issued by supranational organizations, sovereign countries or central banks may be part of the SNB GC irrespective of the rating of their country of domicile. The share in Figure 2 can be ascribed to such securities.

are not subject to a haircut. This mainly as the net exposure a party holds vis-a-vis each participant is calculated twice daily. If there is an under-collateralization a margin call is triggered automatically. Credit and market risks are therefore offset to a great extent. The high liquidity standards on the other hand reduce liquidity risks.

3 Data

The data used in this study consists of interest rates that were charged for Swiss franc repo transactions between commercial banks.[10] In particular, each data point provides information on the two banks involved, the interest rate charged, the term, the collateral basket chosen as well as the cash amount provided. The sample covers all transactions that were concluded from 18 June 1999 to 31 December 2009. Overall, the dataset consists of 187,087 repo transactions conducted on 2,660 business days.[11] Trades can have a maturity from one day (overnight) up to one year. Sixty-one percent of the trades are of overnight maturity.[12] The one week to one month segment accounted for 13% of the trades, whereas longer terms (above one month) accounted for roughly 4%.[13]

4 Methodology

In order to empirically analyze the bargaining power of market participants, we run a regression for all interbank repo transactions (excl. non-standardized repos) and for all counterparties.[14] To account for day-to-day differences in the level of interest rates which may, for example, result from interest rate hikes or day-specific tensions, as well as for the term (maturity) structure, we derive the interest rate differential. The interest rate

[10] To guarantee anonymity of the banks involved, the information was provided in coded form.

[11] These transactions are fully comparable with each other as they are contracted against SNB eligible collateral and as the collateral is not subject to a haircut (or initial margin). Repo transactions against the SMIGC and EEAFI basket, which are not SNB-eligible and have seldom been used, were excluded from the data sample.

[12] Note, the other day-to-day maturities (Tom-Next and Spot-Next) accounted for 18%.

[13] Note, the rest of the share can be assigned to non-standardized maturities (4.4%). Non-standardized repos do not possess standardized maturities and may be subject to a haircut.

[14] When conducting a general collateral (GC) repo via the Swiss repo platform, the maturities as well as haircut/initial margins (namely 0%) are predetermined; i.e., a trader cannot conclude a trade with a maturity of nine days, but will have to choose between a one- and a two-week GC repo. If a trader wanted to conclude a nine days transaction or apply a haircut, non-standardized repos could be used. These non-standardized modalities hamper comparison with GC trades.

differential ($\hat{r}_i$) is calculated by taking the difference between the interest rate charged on the repo transaction ($r_{i,t}$) and the respective average daily volume-weighted interest rate of the same maturity ($\bar{r}_{I,t}$).[15] The average daily volume-weighted interest rate is only based on repo transactions against the collective collateral basket, namely the SNB GC basket. Similar to Kraenzlin (2009), we can thereby analyze whether a pricing differentiation was undertaken with respect to the individual collateral baskets (GOV GC, CHF GC and INTL CG basket) which form part of the collective collateral basket (see also discussion on collateral basket differentiation below).[16]

Trader centrality score: Bargaining power

As explanatory variable, we use dummies on the trader centrality scores of the cash provider (TCCP) and cash taker (TCCT), respectively. This newly developed trader centrality score is a measure of bargaining power in a directed network and is outlined in von Scarpatetti (2010).[17] Basically, the centrality score for each bank depends positively on the number of its trading partners and negatively on the centrality scores of those trading partners. The centrality scores of those trading partners, in turn, depend on the number and centrality scores of their own trading partners. Thus, the entire link structure of the network defines the trader centrality scores of each bank. In this constellation, one's centrality score is higher, the weaker the neighbors are, or as Bonacich (1987) writes: "Power comes from being connected to those who are powerless" (p. 1171). The trader centrality score also takes the traded volume between two banks into account. Thereby the intensity and strength of the interaction between two banks is accounted for. The detailed formulas can be seen in von Scarpatetti (2010) or in the Appendix.

We set up the hypothesis that if cash takers have higher trader centrality scores than the cash providers, they will be in a better position to negotiate a beneficial (i.e., lower) repo rate and vice versa. We construct three dummies that indicate if the cash provider or cash taker has a higher centrality score. In doing so, we differ between three cases: i) the centrality score of the cash provider is lower than the cash taker's score, ii) the two centrality scores are more or less equal and iii) the cash provider has a higher centrality score than the cash taker. We distinguish between the three cases the following way. The first dummy (d_{BPCT}) equals one if $TCCP/TCCT < 7/10$ and zero otherwise. In this case the bargaining power of the cash taker is

[15] We omit a further subscript for the different maturities.

[16] See Kraenzlin (2009) for a detailed description and discussion on the various collateral baskets.

[17] In a directed network not only the connection between two banks is taken into consideration but also the direction, i.e., who was the cash provider and the cash taker.

higher than that of the cash provider. The second dummy (d_{BPCP}) equals one if $TCCP/TCCT \geq 10/7$ and zero otherwise. Here, the bargaining power is on the cash provider's side. All other cases (i.e., $TCCP/TCCT$ between 7/10 and 10/7) we regard as equal and define this as the reference category (d_{noBP}) where no party is in a substantial better bargaining position. Table 2 provides an overview on the distribution of trader centrality scores. We find that before the crisis as well as in the first phase of the crisis cash takers had on average more often a higher bargaining power than cash providers. After the collapse of Lehman Brothers bargaining power shifted to cash providers, i.e., in 54% of the cases. We ascribed this to departing cash providers, which automatically increases the relative importance and consequently the bargaining power of the remaining cash providers (see also Kraenzlin/von Scarpatetti (2011)). Note, our regression results do not change substantially if we vary the boundaries. We use dummy variables instead of the absolute values because the trader centrality scores are influenced by the daily trading volume. This in turn hampers an inter-temporal comparison and may lead to ambiguous regression results. The centrality scores are lagged by 25 days and represent the average of the previous 14 days. We use lagged values to correct for the fact that changes in bargaining positions may take some time to affect the rates.[18]

	before crisis		during crisis				Total
			before Lehmann		after Lehmann		
$BPCT$	2,342	(59%)	1,042	(53%)	575	(38%)	3,959
$noBP$	460	(12%)	141	(7%)	119	(8%)	720
$BPCP$	1,142	(29%)	795	(40%)	816	(54%)	2,753
Total	3,944	(100%)	1,978	(100%)	1,510	(100%)	7,432

Table 2: Distribution of trader centrality scores

[18] On average, the volume weighted time to maturity is 39 days. It seems reasonable to assume that a change in market activity does not take longer, on average, than 39 days to impact the bargaining position of a bank. In fact, the goodness of fit is maximized if we take a 14-day average that is lagged by 25 days (i.e., the average between 25 and 39 days ago). The results do not change critically if we take shorter or longer periods than the 14 days. Further, as can be seen in the Appendix, the centrality scores depend on a parameter β that captures the influence of the centrality score of a neighboring bank. If $\beta = 0$ then the centrality scores of other banks don't matter and only the number of trading partners is important. In our dataset, we see that the goodness of fit is improved if we choose a negative β and is maximized at a value of -0.05. This indicates that not only the number of available trading partners matters but also their centrality in the network.

Cash taker and provider specific variables

In addition, we use variables that are specific to the cash taker and cash provider of each transaction, namely the maturing volume ($MatVol$), the outstanding volume ($OutVol$) and the volume-weighted time to maturity of the outstanding volume ($T2M$). These variables are only based on transactions already concluded between the cash taker and provider. The cash provider thus disposes of this information and may likely be influenced when determining conditions for a new repo transaction.[19] In general, we expect that a higher outstanding volume and volume-weighted time to maturity of the volume already lent to the cash taker decreases a cash provider's willingness to lend. This in turn implies that a cash provider will ask for a higher price in order to lend additional funds to the cash taker. Furthermore, we expect that a high maturing volume increases the refinancing pressure of a cash taker and eventually leads to a higher willingness of a cash taker to pay higher prices. We thus expect positive coefficients for all three variables.

Collateral basket differentiation

As outlined in subsection 2.1 the collateral that the SNB accepts for its open market operations is also standard for the interbank repo market. Within the range of SNB-eligible collateral market participants can either select one of the individual baskets (CHF GC, GOV GC or INTL GC basket) or the collective basket, namely the SNB GC basket. More than 90% of transactions were concluded against the SNB GC basket. Furthermore the handling and pricing of collateral follows the procedure applied by the SNB. All standardized repo transactions are not subject to a haircut. The application of no haircut, however, raises the question if traders treat all collateral baskets equivalently with respect to risk considerations or if the implied risks are offset by higher interest rates.

To quantify the mark-up in case the various collateral baskets had been treated differently, a dummy variable for each individual basket (d_{CHF}, d_{GOV}, d_{INT}) is added to the regression. To avoid perfect multicollinearity, a reference basket, namely the SNB GC basket, is defined.[20]

[19] We refrained from using the $MatVol_{total}$, $OutVol_{total}$ and $T2M_{total}$ – which are based on all interbank transactions – in the regression for two reasons: Firstly, the cash provider does not know how many other repo transactions a cash taker has concluded. The total outstanding volume of a cash taker is thus private information. Secondly, correlation, e.g., between $MatVol$ and $MatVol_{total}$ is high and significant and would lead to multicollinearity.

[20] The range of eligible collateral and the standards applied (including haircut policy) are the same for all standardized maturities; hence, a collateral differentiation can be analyzed directly by using dummy variables. The terminology of the baskets changed regularly. Before the introduction of the SNB GC basket in September 2003, the CHF GC basket is taken as the collective basket. The change in labels for the various baskets are outlined in Kraenzlin (2009), p. 356.

Econometric Methodology

We thus run the following regression for the entire period of observation:

$$\begin{aligned}\hat{r}_i = \beta_0 &+ \beta_1 d_{BPCT,i} + \beta_2 d_{BPCP,i} + \beta_3 OutVol_i + \beta_4 T2M_i + \beta_5 MatVol_i \\ &+ \beta_6 d_{CHF,i} + \beta_7 d_{GOV,i} + \beta_8 d_{INT,i} + \beta_9 d_{bl,i} + \beta_{10} d_{al,i} \\ &+ d_{bl,i}\left(\beta_{11} d_{BPCT,i} + \beta_{12} d_{BPCP,i} + \beta_{13} OutVol_i + \beta_{14} T2M_i + \beta_{15} MatVol_i\right) \\ &+ d_{bl,i}\left(\beta_{16} d_{CHF,i} + \beta_{17} d_{GOV,i} + \beta_{18} d_{INT,i}\right) \\ &+ d_{al,i}\left(\beta_{19} d_{BPCT,i} + \beta_{20} d_{BPCP,i} + \beta_{21} OutVol_i + \beta_{22} T2M_i + \beta_{23} MatVol_i\right) \\ &+ d_{al,i}\left(\beta_{24} d_{CHF,i} + \beta_{25} d_{GOV,i} + \beta_{26} d_{INT,i}\right)\end{aligned}$$

In order to directly evaluate the effects of the financial market turmoil, we add dummy variables. The dummy variable, $d_{bl,i}$, covers the phase after the outbreak of the financial crisis until the collapse of Lehman Brothers on September 15, 2008. $d_{al,i}$, finally, comprises the phase after mid-September 2008 to the end of the data sample. The dummy variables are used to adjust both the intercept and slope. The regression results are in Table 3.

5 Regression results

Trader centrality score: Bargaining power

In the regression, the dummy variable d_{BPCT} equals 1 if $TCCP/TCCT < 7/10$ and zero otherwise. The coefficient on the dummy variable is negative and highly significant. This states that if a cash taker has a higher centrality score than its counterparty, it can enforce a more beneficial (i.e., lower) repo rate compared to where both parties have equal trader centralities. Bargaining power of the cash taker was on average awarded with 0.5 basis points. On the other hand, if the cash provider has a higher centrality score (i.e., d_{BPCP} equals 1) it is able to ask a higher repo rate than otherwise. The coefficient on this dummy is 0.79 and also highly significant. Regression results show that the benefit of bargaining power increased during the crisis. On average, bargaining power for a cash taker was awarded with 1.1 basis points (before the collapse of Lehman Brothers) and 3.1 basis points (after the collapse). For a cash provider the benefit of a higher centrality score was similar with 1.7 basis points (before the collapse of Lehman Brothers) and 3.0 basis points (after the collapse). All coefficients are statistically and economically significant.

As mentioned previously, loss of confidence – after the collapse of Lehman Brothers – led to a freeze in various money market segments. Banks which used the unsecured market to refinance themselves abruptly faced an illiquid market and were excluded from this market. Consequently, they had to turn

to the secured interbank market in order to fulfill their payment obligations. Banks with excess liquidity, in turn, were in general only willing to lend money against high quality collateral. In case of doubt these banks even refrained from lending and hoarded the liquidity despite opportunity costs. Banks with excess liquidity were thus in a more comfortable situation than banks seeking liquidity in order to fulfill their payment obligations. Furthermore the distribution of trader centrality scores in Table 2 shows that after the collapse of Lehman Brothers bargaining power shifted to cash providers. In light of these considerations we interpret the regression results as follows: Cash providers became the more powerful players in the money market and were able to enforce a higher repo rate during the financial crisis. We thus conclude that during the crisis the bargaining power shifted toward the cash providers. In other words "cash became king". These results are also in line with the theoretical prediction stated in Acharya et al. (2009).

Cash taker and provider specific variables

The cash taker-specific variables ($MatVol$, $OutVol$ and $T2M$) also have a significant influence on the repo rate. Except for the coefficient on $T2M$, all statistically significant coefficients have the expected positive coefficient. The outstanding volume that a cash taker has toward a specific cash provider ($OutVol$) has a highly significant influence on the repo rate before as well as during the crisis. This signifies that the more cash takers have already borrowed from specific market participants, the higher the price will be that they have to pay for additional funds. The significant coefficients during the first phase of the crisis further reveal that cash providers became even more reluctant to lend additional funds to their counterparties. After the collapse of Lehman Brothers, the overall effect attributed to the outstanding volume is not significantly different from zero.

The coefficients on the maturing volume ($MatVol$), in turn, reveal that if cash takers have a higher maturing volume they will most likely need to pay a higher price. However, the coefficients during the crisis are not significant. This means that during the crisis market participants did not face higher costs when trying to roll-over a maturing repo transaction with the same cash providers.

The coefficients for the average time to maturity ($T2M$) do not show a clear pattern. Before the crisis, the coefficient is negative and highly significant. This signifies that the more funds cash takers have borrowed on a longer term basis, the less the cash takers have to pay for additional funds. We explain this finding on the grounds of banking relationships (see Furfine (1999a), p. 8.). Cash providers could, for example, build up a relationship with a particular market participants to establish that they are a good credit risk in the sense that they fulfill their margin requirements

in time and are trustworthy. Notwithstanding that a repo transaction is a secured loan and a potential loss is negligible in case of default, a cash provider may refrain from longer-term lending if such a relationship has not been established. The longer the lending's term, the more likely it is that such a relationship exists and hence the lower the interest rate that a cash taker may need to pay. The positive and significant coefficient on $T2M$ during the first phase of the crisis counters the effects of the banking relationship. After the collapse of Lehman Brothers, the effects attributed to the banking relationship are similar to those before the crisis.

Collateral basket differentiation

To answer the question whether the collateral choice had a significant influence on the repo rate, the coefficients on the basket dummies in the regression have to be considered. For the period before the financial market turmoil, the dummy variables for the GOV GC basket is not significantly different from zero. A coefficient not significantly different from zero implies that the hypothesis of no difference in pricing between the individual basket and the reference basket (here SNB GC basket) cannot be rejected. On the contrary, we find that when the CHF GC and INT GC basket was chosen, the cash taker had to pay a mark-up of roughly 0.2 and 1.5 bps, respectively. In the first as well as in the second phase of the financial market turmoil, the mark-up increased. For the CHF GC basket, we find that in the first phase of the crisis a significant mark-up of 1.1 bps was charged. In the second phase the change in mark-up is not significantly different from zero. Regarding the INT GC basket we find that the mark-up increased from a pre-crisis level of 1.5 bps to 2.1 and 6.6 bps during the first and second phase of the crisis respectively. For the GOV GC basket – which comprises only government securities – in contrast a cash provider was willing to accept a mark-down of 1.6 bps and 5.9 bps, respectively.

It thus seems that the different collateral baskets were not treated equivalently. During the crisis this unequal treatment of the basket became even more pronounced. Cash providers were willing to accept a lower price in order to receive government securities in return, whereas they requested a compensation if the cash taker wanted to provide non-government securities. The results are in line with Kraenzlin (2009) and are economically significant.

The finding for the collateral differentiation is confusing to some extent for the following reason. The collective basket (SNB GC basket) was used in 90% of the cases, indicating that cash providers were willing to accept securities from all individual collateral baskets. However, when a specific basket had been selected, a mark-up/mark-down was applied. On the basis of these findings, it can be concluded that the majority of the cash providers and/or

takers on the Swiss franc repo market behaved inconsistently as they treated the individual collateral baskets differently than the collective one. The interest rate differentiation leads to arbitrage opportunities; i.e., a bank could in a first step obtain the funds via a repo transaction against the collective basket and subsequently offer these funds on the market against the INT GC basket, for example. From a theoretical and market efficiency point of view, the exploitation of these arbitrage opportunities finally leads to a uniform pricing of these baskets. Kraenzlin (2009) explains the persistence of pricing differentiation and the resulting arbitrage opportunities on the Swiss franc repo market as a result of temporarily low market liquidity, transaction costs and trading relationships. Temporarily low market liquidity on the Swiss franc repo market may lead to a situation where a cash taker has no other option than to conclude a trade based on an individual basket and pay a higher price. A repo transaction also involves – apart from the transaction costs on the trading platform – collateral transfer costs. Total costs are in general higher than the benefits of exploiting these arbitrage opportunities. Furthermore the exploitation of arbitrage opportunities requires that the arbitrageur can conclude trades within a short time with numerous counterparties. On the Swiss franc repo market an interbank relationship has to be enabled by both banks. In the period of observation between 20 and 25% of all potential interbank relationships were activated bilaterally. After having obtained the funds against the collective basket, the arbitrageur thus faces the risk that he may not be able to pass the liquidity – against INT GC basket – to a bank due to an inexistent trading relationship.[21] The inexistence of a trading relationship in combination with transaction costs may thus hinder a bank from exploiting arbitrage opportunities in the first place.

[21] The inexistence of this trading relationship can either result if the arbitrageur may not enable the bank due to restriction imposed by its risk management or if the counterparty has not enabled the arbitrageur.

	Coeff. (in bps)	Std. err
constant	-0.2077^{***}	0.0006
d_{BPCT}	-0.4938^{***}	0.0005
d_{BPCP}	0.7871^{***}	0.0007
$OutVol$	0.0002^{***}	0.0000
$T2M$	-0.0038^{***}	0.0000
$MatVol$	0.0004^{***}	0.0000
d_{CHF}	0.2261^{*}	0.0013
d_{GOV}	0.5441	0.0035
d_{INT}	1.4712^{***}	0.0012
d_{bl}	-1.2204^{***}	0.0030
d_{al}	-1.4032	0.0089
$d_{BPCT,bl}$	-0.5938^{**}	0.0029
$d_{BPCP,bl}$	0.9196^{***}	0.0029
$OutVol_{bl}$	0.0004^{***}	0.0000
$T2M_{bl}$	0.0062^{***}	0.0000
$MatVol_{bl}$	-0.0004	0.0000
$d_{CHF,bl}$	0.8938^{*}	0.0052
$d_{GOV,bl}$	-2.1271^{**}	0.0085
$d_{INT,bl}$	0.6323^{**}	0.0030
$d_{BPCT,al}$	-2.5589^{***}	0.0093
$d_{BPCP,al}$	2.1760^{***}	0.0080
$OutVol_{al}$	-0.0002^{*}	0.0000
$T2M_{al}$	0.0078	0.0001
$MatVol_{al}$	0.0007	0.0000
$d_{CHF,al}$	0.1556	0.0087
$d_{GOV,al}$	-6.4234^{***}	0.0243
$d_{INT,al}$	5.1074^{**}	0.0202
No. Obs.	7,432	
R-squared	17.23%	
Adj. R-squared	16.94%	

*** significance on the 1%, ** 5% and * 10% level.
robust standard errors were calculated.

Table 3: Regression results

6 Discussion and Conclusion

The Swiss franc repo market has proved to be resilient against shocks, and has been a reliable refinancing source for banks domiciled outside Switzer-

land. After the collapse of Lehman Brothers in September 2008, which marks the height of the crisis, demand for Swiss francs was particularly high. Consequently, the outstanding volume on the interbank market peaked at CHF 74 billion. During this phase banks domiciled outside Switzerland mainly sought Swiss franc liquidity, whereas domestic banks figured as cash providers. Consequently, a substantial part of Swiss franc liquidity went abroad. Once the SNB turned to a full allotment in its daily one-week fixed rate tender auctions at a price of 5 bps the outstanding volume on the interbank market decreased. In other words, banks were certain of receiving the necessary funds from the SNB and consequently increasingly relied on the SNB as a refinancing source.

The Swiss franc repo market is a transparent and non-anonymous market. This allows market participants to differentiate with regard to counterparty characteristics. In order to identify a possible price differentiation we use, in addition to other explanatory variables, the trader centrality scores of the cash provider and cash taker, respectively. This newly developed trader centrality score is a measure of bargaining power in a directed network and is outlined in von Scarpatetti (2010). We set up the hypothesis that if cash takers have higher trader centrality scores than the cash providers, they will be in a better position to negotiate a beneficial (i.e., lower) repo rate and vice versa.

We find evidence that market participants use their bargaining power as well as private information between two trading partners for price differentiation. Regression results show that if cash providers are better positioned than the cash takers, they are able to enforce a higher repo rate (0.8 bps). The premium of bargaining power increased during the crisis to 1.7 basis points (before the collapse of Lehman Brothers) and to 2.9 basis points (after the collapse). Similarly, cash takers with a higher bargaining power could ask for a reduction in the repo rate by 0.5 basis points. The benefit of their bargaining power also increased during the crisis to 1.1 (before the collapse of Lehman Brothers) and 3.1 (after the collapse), respectively. All coefficients are statistically and economically highly significant.

We interpret these regression results as follows: Banks with a refinancing need in Swiss francs were forced to the secured interbank market, as the unsecured market turned illiquid. Cash providers, in turn, were in general only willing to lend money against adequate collateral. In case of doubt these banks even refrained from lending and hoarded the liquidity despite opportunity costs. This led to a reduction in the number of cash providers and increased so the power of the remaining lenders. Banks with excess liquidity were thus in a more comfortable situation than banks seeking liquidity in order to fulfill their payment obligations. This increased the number of transactions where the cash providers were in a better bargaining position

(cf. Table 2) and so were able to enforce a higher repo rate. We thus conclude that during the crisis the bargaining power shifted toward the cash providers. In other words "cash became king". These results are also in line with the theoretical prediction stated in Acharya et al. (2009).

In addition to the centrality score, we use variables that are specific to the cash taker and cash provider of each transaction as well as the selected collateral basket. Among others we find that cash takers had to pay a higher repo rate the more additional funds they wanted to borrow from a specific cash provider. Furthermore participants faced higher costs when trying to roll-over a maturing repo transaction with the same cash providers. The variable average time to maturity, in turn, reveals that the more funds cash takers have borrowed on a longer term basis, the less the cash takers have to pay for additional funds. We explain this finding on the grounds of banking relationships, which Furfine (1999a) refers to. Regression results also demonstrate that in those cases where individual collateral baskets were chosen cash providers were willing to accept a lower repo rate in order to receive government securities in return, whereas they requested a compensation if the cash taker wanted to provide non-government securities. The results are in line with Kraenzlin (2009) and are economically significant.

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