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Re-use of collateral in the repo market*

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Abstract

This paper introduces a methodology to estimate the re-use of collateral based on actual transaction data. With a comprehensive dataset from the Swiss franc repo market we are able to provide the first systematic empirical study on the re-use of collateral. We find that re-use was most popular prior to the financial crisis, when roughly 10% of the outstanding interbank volume was based on re-used collateral. Furthermore, we show that re-use increases with the scarcity of collateral. By giving an estimate of collateral re-use and explaining its drivers, the paper contributes to the ongoing debate on collateral availability.

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1 Introduction

Up to now, central banks and regulators have lacked evidence on the re-use of collateral, although this issue has been at the top of regulators' policy agenda (Financial Stability Board, 2012a) and regardless of the impact that collateral re-use might have. Especially, the re-use of collateral has yet not been estimated and analysed based on actual transaction data.

This paper aims to address this issue. First, we estimate the re-use activity in an interbank repo market by developing an algorithm which identifies re-used collateral based on actual transaction data. Second, we analyse the drivers of collateral re-use. We especially focus on the availability of securities, as re-using collateral allows banks to conduct transactions regardless of a potential collateral constraint. Analysing this relationship is of particular interest because current regulatory initiatives have caused an intense debate on collateral availability. Specifically, positive aspects of the re-use of collateral have been emphasised as an increasing re-use may reduce a potential scarcity of collateral (e.g. Levels and Capel (2012) and Committee on the Global Financial System (2013)).

With the experience of the financial crisis, analysing the market for liquidity and especially the repo market is of first order relevance (Fecht, Nyborg, and Rocholl, 2011). Theoretical and empirical literature has documented and dealt with the important role of margin requirements, fire sales and potential rollover risks (e.g. Gorton and Metrick (2012, 2010a,b), Brunnermeier and Pedersen (2009), He and Xiong (2012) as well as Hördahl and King (2008)). Further, empirical studies of the structure of repo markets were provided for example by Copeland, Martin, and Walker (2011) for the US tri-party, by Mancini, Ranaldo, and Wrampelmeyer (2013) as well as Bindseil, Nyborg, and Strebulaev (2009) for the Eurozone and by Kraenzlin (2007) for the Swiss franc (CHF) repo market.

In contrast, literature on the re-use of collateral is rare. Aitken and Singh (2009) and Singh (2011) have estimated the magnitude of collateral rehypothecation. They find evidence for a considerable amount of rehypothecation prior to the financial crisis and a rapid decline after Lehman's bankruptcy. However, rehypothecation cannot be put on par with re-use. The Financial Stability Board (2012b) defines rehypothecation as "the right by financial intermediaries to sell, pledge, invest or perform transactions with client assets they hold" and the re-use of collateral as "securities delivered in one transaction [that] are used to collateralise another transaction". Thus, the right to re-use securities arises in a repo transaction automatically and does not need to be explicitly granted by the collateral provider.

The CHF repo market qualifies for a thorough analysis of the re-use of collateral as the re-use is not restricted, neither technically, legally nor economically. Having a comprehensive dataset from the CHF interbank repo market at our disposal allows us, for the first time, to estimate and analyse the re-use of collateral by considering individual transactions. Additionally, the dataset spanning from March 2006 to February 2013 enables us to analyse the re-use for different time periods such as before, during and after the financial crisis.

Our findings can be summarised as follows. Market participants in the CHF repo market re-use collateral. The re-use activity remained relatively constant until mid-2007 when roughly

10% of the outstanding volume was secured with re-used collateral. Afterwards, it increased and reached its highest value in autumn 2007, at almost 20%. In 2008, the re-use activity suddenly declined to a very low level and remained there afterwards. The collateral re-used typically originates from a long-term repo (one month and longer) and is used in a short-term transaction. Overall, the extent of re-use within the CHF repo market segment is rather low compared to the findings by Singh (2011) and Aitken and Singh (2009). However, in contrast to these authors, we only evaluate the re-use in CHF repo transactions i.e. a specific market segment and currency.¹

Based on a logit regression model we assess the drivers of collateral re-use. We find that the re-use of collateral increases with the scarcity of collateral, i.e. it decreases when the collateral availability increases. This goes along with the evidence that the re-use in the interbank market is positively related with the general securities borrowing activity of banks. Hence, banks simultaneously re-use collateral in the interbank market and borrow securities from clients. Further, we find evidence for a significant impact of the maturity of the transaction on the re-use probability. Banks re-use collateral if they lend cash long-term and borrow cash short-term. This allows them to keep a relatively small pool of securities when, for example, playing the yield curve.

Our findings have important implications for policy makers, regulators and central banks. The measure presented for the re-use of collateral can be used as an indicator for collateral scarcity and financial stress. By explaining the drivers and determinants of collateral re-use, we further create a solid foundation for a discussion about financial stability concerns and market efficiency related to the re-use of collateral. We also show that if collateral scarcity increases, banks will have an incentive to re-use collateral, which in turn increases leverage and interconnectedness in financial markets. In the light of stricter standards for initial margin requirements for over-the-counter derivatives transactions or the liquidity coverage ratio, regulators have to take into account the fact that these regulatory initiatives might increase collateral scarcity and, according to our findings, the re-use of collateral.

The remainder of this paper is structured as follows. Section 2 provides an overview of the institutional setup of the CHF repo market, while in section 3 the algorithm to determine repo transactions with a collateral re-use is explained. Section 4 discusses stylised facts about the re-use activity. Section 5 applies an econometric analysis to evaluate the factors determining collateral re-use. Finally, section 6 concludes.

2 Institutional setup

2.1 Characteristics of the CHF repo market

Until April 2014, CHF interbank repo transactions in Switzerland were mostly traded on the Eurex Repo trading platform, which was launched in 1999 (Kraenzlin and von Scarpatetti,

¹Collateral could, for example, also originate from a CHF repo transaction and then be re-used in a foreign currency repo transaction or even as an initial margin for an over-the-counter derivatives transaction.

2011).² The trading platform was set up as a non-anonymous market with bilateral trade relationships. The clearing and settlement systems and the trading platform together constitute the Swiss value chain - an infrastructure that allows the complete electronic integration of trading, clearing and settlement. The settlement is thereby based on the delivery versus payment mechanism and takes place in central bank money on the real-time gross settlement system for CHF - the Swiss Interbank Clearing (SIC) - and on the Swiss securities settlement system (SECOM).

To obtain access to the CHF repo market, the participants must have a SIC settlement account, which requires a sight deposit account at the SNB. Consequently, the number of participants in the CHF repo market depends on the access policy of the SNB. Compared to other central banks, the SNB has followed a liberal access policy (Kraenzlin and Nellen, 2014). Beside banks domiciled in Switzerland, banks domiciled abroad and certain non-banks (e.g. domestic insurance companies) are eligible for a sight deposit account at the SNB (Swiss National Bank, 2010). The liberal access policy of the SNB contributed to the steady increase in the number of participants in the CHF repo market - from 37 in 1999 to more than 170 in 2011. Similarly, the outstanding volume in the interbank repo market also increased significantly. It reached its peak in September 2008 after the collapse of Lehman Brothers. At that time, the outstanding volume was about CHF 74 billion (bn).

2.2 Collateral standards in the interbank market

In the CHF repo market, almost all interbank repo transactions (more than 99%) are traded against a collateral basket (i.e. general collateral repos - GC repos). The main motivation for a GC repo is to get cash and not a specific security, whereas the cash provider's interest is to lend without counterparty risks (Bank of England, 2012).

In the CHF repo market, the collateral standards for interbank transactions are the same as for central bank repos. In more than 95% of all CHF interbank repo transactions money is exchanged against securities from the collateral basket, which is defined by the SNB (SNB GC basket). Compared to other central banks, the SNB's collateral framework is rather liberal regarding eligible currencies but quite restrictive concerning the quality of the securities (Kraenzlin and Nellen, 2014).³ The minimum credit rating for eligible securities is AA- (A) for securities denominated in foreign currencies (in CHF). The minimum liquidity requirement is an issuance volume of at least CHF 1 bn (CHF 0.1 bn) for securities denominated in foreign currencies (in CHF). Eligible securities can be denominated in CHF, EUR, USD, GBP, DKK, SEK and NOK (Swiss National Bank, 2007). The SNB GC basket currently contains about 2,700 different securities worth CHF 9,500 bn. As the SNB GC basket is subject to daily modifications (i.e. due to new issues, redemptions and exclusions), smaller fluctuations in the size of the basket occur.

One of the main differences between the CHF repo market and other repo markets is the

²As of 1 May 2014 interbank repo transactions are mostly conducted on the new SIX Repo trading platform.

³The SNB changed its collateral framework as of 1 January 2015. In the following the criteria valid until the end of 2014 are stated.

absence of haircuts in the former. This means that, irrespective of the characteristics of the collateral delivered (e.g. asset type or currency of denomination), the cash amount is always covered by a security position with an identical market value.

2.3 The legal, technical and economic setup for re-use

The Swiss framework agreement on repo transactions and the PSA/ISMA global master repurchase agreement (GMRA) with Swiss annex form the legal basis for any repo transaction in the CHF repo market (Swiss National Bank, 2004). Both agreements state that with the transfer of collateral the parties transfer the full and unencumbered legal ownership of the security. Securities transferred in a repo are thus free of any rights of third parties. Additionally, in standard repo contracts the parties typically agree not to grant the right of substitution. Early termination is theoretically possible but not allowed in most standard contracts (Swiss Bankers Association, 1999). The re-use of securities in the CHF interbank market is therefore not restricted by any legal aspects. Further, the re-use of collateral is technically feasible in the securities settlement system (see appendix for a detailed description).

From an economic point of view, a collateral re-use can only occur if the cash taker has outstanding volume as a cash provider (i.e. received collateral) at the same time. As the CHF repo market is a market with bilateral trade relationships, one can expect two groups of institutions to re-use collateral: market makers acting as cash provider as well as cash taker at the same time and institutions that regularly lend cash long-term and refinance themselves short-term.⁴ While in the former case the re-use is typically conducted in the same maturities, the re-use in the latter case is rather done in overnight, tom-next or spot-next maturities (i.e. day2day maturities). In both cases it is rational to assume that banks might re-use collateral to reduce their own funding collateral needs (own securities used).

2.4 The bank's pool of securities

The availability of securities plays a crucial role for banks, especially in the secured money market. Without re-use, a given pool of available securities constrains the maximum possible turnover in the repo market, thus hampering the efficient allocation of liquidity.⁵

Table 1 shows the securities holdings of banks domiciled in Switzerland. By the end of 2012, Swiss banks held a stock of securities worth CHF 262 bn (9.4% of the total balance sheet) in trading portfolios and as a financial investment. Prior to the financial crisis, banks held roughly the double, worth CHF 555 bn (17.4% of the total balance sheet).

The share of securities holdings that are eligible for SNB repos increased from about 12%

⁴Market makers are defined in the federal act as institutions quoting for a specific instrument bid and offer prices for different maturities publicly or upon request (art. 3 para. 4 of the Swiss stock exchange ordinance). The typical market maker thus runs large but matched books and generates profits by charging a spread between bid and offer prices.

⁵Since the outbreak of the financial crisis banks have significantly shifted their exposures from unsecured to secured markets, which consequently increased the demand for collateral (Guggenheim et al., 2011).

to about 45% in 2010 but decreased again in 2011 and 2012.⁶ A significant share of the SNB eligible securities was held in the custody cover account “SNB” for the liquidity-shortage financing facility (LSFF) and was consequently not available for interbank repos as they can only be used for standing facility repos (Swiss National Bank, 2008). Taking the LSFF holdings into account, the securities available for CHF interbank repos fluctuate between CHF 50 bn and CHF 108 bn.

Table 1: Securities holdings of banks domiciled in Switzerland

	2006	2007	2008	2009	2010	2011	2012
Total securities holdings	555,214	551,003	298,703	309,895	321,493	266,825	261,764
In % of total balance sheet	17.4%	15.9%	9.7%	11.6%	11.8%	9.6%	9.4%
Securities borrowing	237,257	271,875	97,549	78,728	66,259	57,208	51,439
SNB eligible securities	64,877	96,995	115,237	127,683	145,394	91,932	84,088
In % of total securities	11.7%	17.6%	38.6%	41.2%	45.2%	34.5%	32.1%
Held in LSFF*	12,100	33,700	34,500	35,900	37,500	32,900	33,700
Available securities**	52,777	63,295	80,737	91,783	107,894	59,032	50,388

In CHF million; * Liquidity-shortage financing facility

**Available securities for repos = SNB eligible – held in LSFF

Source: SNB statistical publications, “Banks in Switzerland”; SNB accountability reports.

3 Methodology

To estimate the re-use of collateral in the CHF repo market, we use transaction data from the Eurex Repo trading platform and the corresponding collateral information from SECOM. Only the combination of these two datasets allows an analysis of the re-use of collateral. The repo dataset includes for each transaction the transaction id, cash taker id, cash provider id, purchase date, repurchase date and collateral basket. The collateral dataset includes the transaction id, the ISIN of delivered collateral and the respective market value. The transaction id links the repo dataset with the collateral dataset.

A repo transaction can be covered by several securities. In our sample, on average about three securities have been used per repo transaction. We analyse these collateral transactions in the following. For this reason, we usually report statistics in terms of collateral transactions rather than repo transactions.

To identify collateral transactions with re-used collateral we developed an algorithm that was written in MATLAB and works as follows. First, the algorithm sorts the dataset by purchase date (in ascending order) and duration of the repo transaction (in descending order), i.e. starting with the oldest purchase date and the longest duration. Second, the algorithm iterates over each transaction included in the dataset and checks whether the following conditions hold for all subsequent transactions:

- identical securities (ISINs) are used in both transactions (initial and re-use);

⁶This increase might have been in part due to the SNB’s issuance of own debt register claims (SNB Bills in CHF and USD) from 2008 until 2011, which are part of the SNB GC basket.

- the collateral provider in the second transaction (re-use) is the same as the collateral taker in the first transaction (initial);
- the repurchase date of the second transaction (re-use) is not later than the repurchase date of the first transaction (initial).

If these three conditions are fulfilled, the first repo transaction is flagged as a possible initial transaction and the second one as a possible re-use transaction. In the last step, the algorithm reduces the probability of overestimation. A transaction can be the initial transaction of several re-use transactions. However, as soon as the collateral value of the initial transaction is used up by re-use transactions, possible subsequent re-use transactions are no longer flagged as re-use transactions.⁷

The algorithm underestimates the re-use of collateral in the first months of the observation period, as we do not observe initial transactions before March 2006. With maturities of up to one year, there is a potential underestimation during the first twelve months. As 97.5% of all transactions have a maturity of up to three months, we expect the underestimation to be severe only during the first three months of the dataset. Therefore, we exclude this period from our re-use analysis. The fungibility of ISINs and the necessity of the repurchase condition are discussed in the appendix.

4 Stylised facts about re-use activity

4.1 Descriptive statistics

The analysed period lasts from 1 June 2006 until 28 February 2013 containing 161,108 repo transactions and 470,823 collateral transactions. During the sample period, repo transactions worth about CHF 11.6 tn were settled. Overall, 162 different institutions were active in at least one transaction. On an average trading day roughly 240 (before September 2008), respectively 140 (after September 2008) different ISINs have been used.⁸

Of the 470,823 collateral transactions, 246,271 transactions were performed by cash takers who had an outstanding volume as cash provider at the same time. Note that only those transactions could be secured with re-used collateral. Having applied the methodology described in the previous section, we identified 21,370 collateral transactions (4.5% of all transactions) serving as initial transactions for at least one re-use. Moreover, we identified 87,503 re-use transactions (18.6% of all transactions).⁹ This implies that the collateral from one initial transaction was re-used on average four times (see table 2).

As illustrated in figure 1, re-use transactions contributed on average to about CHF 2.2 bn of the total outstanding volume of CHF 33.9 bn. 108 market participants re-used collateral in

⁷The algorithm does not flag a re-use due to a too low initial value in 10% of the matches.

⁸See also figure 7, which indicates that there are no security-specific re-use effects.

⁹These re-use transactions may also have originated from initial transactions before 1 June 2006. Note that table 2 shows re-use transactions based on initial transactions after 1. June 2006, only.

Table 2: Number of initial and re-use transactions

# of re-use	1	2	3	4	5	≥ 6	Total
Initial transaction	8,352	3,893	2,352	1,538	1,079	4,156	21,370
Re-use transaction	8,352	7,786	7,056	6,152	5,395	50,430	85,171
In % all re-use transactions	9.8%	9.1%	8.3%	7.2%	6.3%	59.2%	100.0%

at least one transaction, whereas the most active five market participants contributed to 31% of all re-use transactions.

Table 3 shows that the typical re-use occurs with collateral originating from rather long-term repos (1M-3M maturities) that is re-used in short-term repos. In other words, the probability of re-use increases with the duration of the initial transaction. Especially for transactions with a maturity of three months and more the re-use probability increases significantly. Irrespective of the maturity of the initial repo, most of the collateral, i.e. 84%, is re-used in day2day repo transactions.

Table 3: Distribution of re-use by maturity of initial (rows) and re-use (columns) transaction

	day2day*	1W	1W-1M	1M-3M	3M-6M	6M-12M	Total
day2day*	100.0%	-	-	-	-	-	2,957
1W	95.3%	4.7%	-	-	-	-	5,764
1W-1M	88.1%	7.2%	4.7%	-	-	-	32,140
1M-3M	81.7%	8.7%	8.5%	1.2%	-	-	32,347
3M-6M	71.3%	9.0%	13.1%	6.3%	0.4%	-	12,534
6M-12M	86.3%	5.8%	4.3%	2.4%	1.2%	0.0%	1,761
Total	84.2%	7.6%	6.8%	1.4%	0.1%	0.0%	87,503

* day2day maturities are: overnight, tom-next, spot-next

4.2 Measures of collateral re-use

To describe the magnitude of collateral re-use, different measures have been used so far in the economic literature. In this paper we present two measures to describe the re-use of collateral: the re-use rate and the collateral multiplier.

The re-use rate is a measure used by Bottazzi, Luque, and Páscua (2012) and is defined as the ratio of the market value of the re-used securities to the overall market activity. The re-use rate (rr) is an arbitrary value in the interval $[0, 1)$, where a value of zero would imply no re-use at all and a value arbitrarily close to one would imply an almost infinite re-use. Hence, the re-use rate is a relative measure of the re-use activity in a repo market. This measure can be applied to the overall market as well as to individual institutions. The re-use rate at time t is defined as follows:

$$rr_t = \frac{\sum_{n=1}^N d_n c_{n,t}}{\sum_{n=1}^N c_{n,t}} \quad (1)$$

where $c_{n,t}$ denotes the value of collateral n of an outstanding repo at time t . To account for the re-use of collateral, a dummy variable d_n is included, which is equal to one if the collateral is re-used and zero otherwise.

The re-use rate, however, does not consider the overall pool of eligible securities and therefore does not give an indication of the impact of the re-use on the overall pool. To account for the availability of securities, the collateral multiplier can be adopted from its famous pendant, the money multiplier. For this paper, we define the collateral multiplier (m) as 1 plus the ratio of re-used collateral divided by the available pool of securities. It is thus an arbitrary value in the interval $[1, \infty)$ and defined as follows:

$$m_t = 1 + \frac{\sum_{n=1}^N d_n c_{n,t}}{\sum_{i=1}^I s_{i,t}} \quad (2)$$

where $s_{i,t}$ is the market value of the available securities (i) eligible for repos at time t (i.e. securities available from the SNB GC basket). For example, a re-use of securities worth CHF 5 bn and a pool of eligible securities amounting to CHF 10 bn would imply a collateral multiplier of 1.5. The collateral multiplier thus links the re-use to the overall availability of securities, whereas the re-use rate is a measure of the frequency of collateral re-use within the overall market.

4.3 Re-use rate and collateral multiplier over time

Figures 2 and 3 show the development of the re-use rate and collateral multiplier over time. On average, the re-use rate was about 0.05. In other words, 5% of the outstanding volume was secured with re-used collateral. Figure 2 reveals that the re-use rate remained relatively constant until mid-2007, at about 0.075 to 0.125. Afterwards, it increased and reached its highest value in autumn 2007, at about 0.2. In 2008, the re-use rate suddenly declined to a level of roughly 0.02 and remained unchanged afterwards.

The collateral multiplier shows a similar pattern (see table 1). The collateral multiplier also spiked in autumn 2007, especially when the available collateral suddenly dropped. It reached its maximum value of almost 1.2 in the third quarter of 2007 indicating a relative shortage of collateral. Afterwards, the collateral multiplier shows a similar picture as the re-use rate, even though the available pool of collateral decreased remarkably in 2011.

The re-use of collateral reached its highest value in 2007, i.e. before the outstanding volume of the CHF repo market peaked and prior to the outbreak of the financial crisis. During this period, the banks' pool of available securities decreased twice (see figure 3). Therefore, the increasing re-use activity might have been due to collateral constraints of certain banks that were consequently forced to re-use collateral.

Finally, it is worth mentioning that the re-use activity remained very low after 2009, even though the pool of available securities declined to its lowest level in the observation period. This might be due to the very low trading activity or also due to a structural change in the market. Prior to 2009, market participants acting as cash provider and cash taker were prevalent. After

the financial crisis, this share dropped significantly. For example, in August 2011, only 74% of the outstanding volume was due to market participants who had outstanding volume as cash taker and provider, whereas this share was about 97% prior to 2009.

5 Determinants of re-use

In the following we evaluate the determinants of collateral re-use. The re-use can be seen as a binary decision: either a collateral transaction is covered with a re-used security or not. Thus, we estimate a binary response model. We therefore analyse by what factors the re-use of collateral is influenced and not how much in value is re-used.¹⁰ In the following subsections, we motivate our hypotheses, describe the modifications to the dataset, specify our regression model and discuss the regression results.

5.1 Hypotheses

Without re-use of collateral, the market activity in the CHF repo market is constrained by the pool of available securities. The re-use of collateral reduces this constraint. In other words, a reduction in the availability of securities will *ceteris paribus* require the re-use of collateral to increase, given a specific outstanding volume. Levels and Capel (2012) thus argue that the re-use of collateral is a special form of collateral optimisation. Hence, we expect an increasing pool of available securities to have a negative impact on the re-use activity. The availability of securities is measured by the market value of all available (SNB eligible) securities, reported on a quarterly basis by FINMA regulated banks (i.e. banks domiciled in Switzerland).

Hypothesis 1: An increasing pool of available securities reduces the probability of a re-use.

The re-use activity in the interbank market might also be determined by the securities borrowing activity of banks from clients' accounts (SNB eligible and non-SNB eligible).¹¹ Hence, we include securities borrowing from clients' accounts in the analysis. We expect the re-use of collateral to increase if the securities borrowing activity increases (i.e. securities borrowing is a complement). In other words, banks simultaneously re-use collateral and borrow securities from clients' accounts in times of high scarcity of collateral. Note that securities borrowing is also determined by the pool of available securities. We consider this fact in the regression analysis by orthogonalising the securities borrowing variable (see next section).

Hypothesis 2: The re-use of collateral increases with the securities borrowing activity.

¹⁰The value of a collateral transaction depends on the face value of the underlying security. Thus, a censored normal regression model would not be appropriate to model the decision to re-use collateral.

¹¹In 2009, FINMA introduced a new legislation concerning SLB transactions, which resulted in a significant decline of securities borrowing from clients' accounts (see table 1).

Monnet (2011) argues that “rehypothecation lowers traders’ funding liquidity needs [or stress], the ease with which a trader can obtain funding”. This argument also applies for the re-use of collateral. In interbank repo markets banks often lend cash long-term and refinance themselves short-term. Re-using collateral in those transactions would reduce bank’s collateral needs (the own securities used) and thereby increase overall market liquidity (Brunnermeier and Pedersen, 2009). Accordingly, the re-use of collateral is especially valuable for banks in short-term refinancing operations. Put differently, the re-use of collateral facilitates playing the yield curve and allows banks to keep their pool of own securities relatively small, which reduces transaction costs. To empirically test this hypothesis, we include the share of outstanding long-term transactions (i.e. with a term longer than one month) as well as the duration of the transaction as independent variables. On the one hand, we expect a positive relationship between the share of outstanding long-term transactions and the probability of re-use. On the other hand, the re-use probability is expected to be higher if the duration of a repo transaction is shorter.

Hypothesis 3: The re-use of collateral is especially popular for banks when lending cash long-term and borrowing cash short-term.

Singh and Aitken (2010) show that rehypothecation has significantly decreased with the intensification of the financial crisis, as market participants became more and more risk-averse. If market participants in the CHF repo market were to associate risk with the re-use of collateral, one could expect a negative relation between stress in the CHF money market and the re-use of collateral. To account for money market stress, the credit risk premium, measured by the spread between the unsecured and the secured interest rate for CHF liquidity in the tom-next maturity (TOIS-fixing minus SARTN) is included in the analysis.

Hypothesis 4: The re-use activity decreases with money market stress.

Empirical and theoretical research has shown that the relationship between two market participants significantly impacts trading conditions (see for example Furfine (1990)). Recently, Duffie (2013) presented evidence that during the financial crisis prime-brokerage clients (collateral providers) made sure that the securities they held in their custodies were not rehypothecated by their broker-dealers. Theoretical models by Infante (2014) and Eren (2014) predict this behaviour and show that a collateral provider might have an incentive to withdraw its securities during crisis periods. Based on these models, one might also expect that the relationship between two market participants in the CHF repo market influences the re-use of collateral. Collateral providers that re-use collateral might be concerned about not receiving back the collateral which they have to return to the initial collateral provider. This risk amplifies with a weak diversification of the re-using counterparty. In the regression we thus control for the diversification of the collateral provider, which is measured by the sum of cash taking transactions with the corresponding cash provider to the total sum of cash taker transactions.

Thus, the measure for relationship is a value in the interval $(0, 1]$. A very low value characterises a relatively low exposure to this counterparty whereas a value close to one indicates a very large exposure. We expect a high relationship ratio to reduce the probability of a re-use of collateral.

Hypothesis 5: Weakly diversified collateral providers re-use less collateral than well diversified collateral providers.

5.2 Control variables

As the CHF repo market is set up as a market with bilateral trade relationships, counterparties might also negotiate about the specific collateral delivered. According to Ewerhart and Taping (2008), counterparties in bilateral markets prefer to use high-quality collateral in the interbank market and use it first in order to balance the counterparties' risk exposure as efficiently as possible. Therefore, they might have an incentive to deliver, and especially to re-use, good rather than bad collateral. Consequently, the credit rating of the corresponding security is taken into account.¹²

As Swiss banks have to fulfil minimum reserve requirements, one might expect that they also re-use collateral to fulfil these requirements (at least in the short run, just prior to the end of the maintenance period). Thus, we control for the individual liquidity position of market participants by including the daily gross excess reserve of a bank in analogy to Fecht, Nyborg, and Rocholl (2011).

Furthermore, we account for the overall outstanding volume in the CHF repo market. A higher outstanding volume might imply an increasing need for collateral re-use. Moreover, the re-use of securities might be conducted by market makers who are active as cash taker and cash provider in the same maturities on the same day. We therefore include a dummy variable indicating whether a market maker was involved in the transaction.

5.3 Data

For the binary response model below, the dataset is adjusted as follows. To exclude the period with very high excess liquidity and very low trading activity, we reduce the sample to the time period between 1 June 2006 and 2 August 2011¹³ reducing the number of collateral transactions to 426,042. Further, only transactions, where the cash taker has outstanding cash provider repos at the same time are involved, as those participants are the only ones, which are able to re-use collateral. This shrinks the sample to 237,094 transactions. Additionally, 852 transactions are excluded due to missing observations in the money market stress variable.¹⁴ Finally, 2,242

¹²We consider the best security credit rating from Standard & Poor's, Moody's or Fitch.

¹³On 3 August 2011 the SNB increased the supply of liquidity as a measure against strong CHF. Consequently, the trading activity decreased significantly.

¹⁴On the following days the SARTN rate was not available: 29 December 2006, 27 December 2007, 31 December 2008 and 28 October 2009.

transactions of banks, which do not exhibit a re-use of collateral are not considered in the dataset. Consequently, the final dataset contains 234,000 transactions.

Table 4: Descriptive statistics

Variable name	Unit	Mean	Std. dev.	Std. err.	Min.	Max.
Collateral re-use	dummy	0.36	0.48	0.0010	0.00	1.00
ln(Securities borrowing)	ln(bn)	5.19	0.51	0.0011	4.11	5.65
ln(Available securities)	ln(bn)	4.29	0.24	0.0005	3.88	4.77
Stress in money market	pp	0.15	0.40	0.0008	-0.09	3.28
Relationship ratio	%	11.25	16.56	0.0342	0.00	100.00
Share long-term transactions	%	63.01	10.19	0.0211	20.10	82.57
Duration of transaction	days	8.78	24.22	0.0501	1.00	370.00
Rating AAA	dummy	0.61	0.49	0.0010	0.00	1.00
Rating AA+	dummy	0.08	0.28	0.0006	0.00	1.00
Rating AA	dummy	0.06	0.24	0.0005	0.00	1.00
Rating AA-	dummy	0.04	0.19	0.0004	0.00	1.00
Rating A+	dummy	0.02	0.14	0.0003	0.00	1.00
Rating A	dummy	0.01	0.10	0.0002	0.00	1.00
No rating	dummy	0.18	0.38	0.0008	0.00	1.00
Gross excess reserves	bn	1.91	5.13	0.0106	-2.68	303.94
Market maker	dummy	0.20	0.40	0.0008	0.00	1.00
ln(Outstanding volume)	ln(bn)	3.70	0.23	0.0005	2.73	4.28
ln(Volume of transaction)	ln(mn)	2.225	1.64	0.0034	-15.53	6.02

Number of observations 234,000

The descriptive statistics of the variables can be found in table 4. Overall, in 36% of the collateral transactions a re-use of collateral is observed. This probability is higher than indicated by the re-use rate due to two reasons. First, the dataset includes only transactions where the cash taker also has an outstanding volume as cash provider. Second, short-term transactions do not contribute as strongly to the re-use rate as longer-term transactions do. For variables in cash amounts we employ the natural log, if they are strictly positive. For variables with observation frequencies lower than daily, the last available observation is used.

Table 10 in the appendix shows the correlation matrix of all independent variables. As we claim in hypothesis 1, the securities borrowing variable is closely related to the available securities variable. The correlation coefficient between these two variables is -0.85 . To avoid a potential multicollinearity problem in our regression analysis we orthogonalise the securities borrowing variable (see equation 3 and table 9 for abbreviations) with respect to the available securities variable. The orthogonalised variable (η) is denoted as securities borrowing (orth.). The correlation between the securities borrowing (orth.) and the original securities borrowing variable is 0.53, showing that the orthogonalised variable qualifies as a valid measure for securities borrowing.

$$SB_i = \beta_1 + \beta_2 AP_i + \eta_i \quad (3)$$

5.4 Binary response model

To determine the re-use of collateral, we use a logit model with clustered standard errors.¹⁵ We regress the dummy variable collateral re-use (indicating whether a security has been re-used or not) on the variables specified above. Equation 4 and 5 show our regression specifications (see table 9 for abbreviations).

$$Pr[y_i = 1 | \mathbf{x}_i] = \frac{\exp(\mathbf{x}'_i \boldsymbol{\theta})}{1 + \exp(\mathbf{x}'_i \boldsymbol{\theta})} \quad (4)$$

$$\begin{aligned} \mathbf{x}'_i \boldsymbol{\theta} = & \beta_1 + \beta_2 SB_i + \beta_3 AP_i + \beta_4 RE_i + \sum_{j=1}^{J-1} \delta_j RA_i + \beta_5 MS_i + \beta_6 GE_i \\ & + \beta_7 MM_i + \beta_8 OV_i + \beta_9 DU_i + \beta_{10} VA_i + \beta_{11} LT_i + \sum_{n=1}^{N-1} \gamma_n d_{i,n} \end{aligned} \quad (5)$$

$RA_{i,j}$ dummy variable = 1 if credit rating j was used in transaction i , else 0. J represents the credit rating categories AAA, AA+, AA, AA-, A+, A and no credit rating;

$d_{i,n}$ dummy variable = 1 if bank n was involved in transaction i , else 0.

We control for bank-specific effects by using dummy variables for $N - 1$ cash takers.¹⁶ Since for a few small market participants there are only periodical observations, we pool small banks into one category. Those institutions, which were pooled into one category, account for less than 5% of the total turnover in the CHF repo market. Overall, 50 bank-specific dummy variables were included in the regression.

To account for potential intra-class correlation, we use clustered standard errors. Some regressors are variables with a daily, monthly or quarterly frequency. Consequently, transactions e.g. settled on the same trading day exhibit the same values for some of the independent variables. Thus, the regression residuals of these observations might be serially correlated. As most of our independent variables have at least a daily observation frequency, we use standard errors clustered by trading day in the baseline regression. Another possibility would be to use standard errors clustered by cash taker. As we control for individual heterogeneity by including bank-specific dummy variables, clustering by trading day is preferred to clustering by cash taker.

¹⁵Standard probit and logit models show similar measures of goodness of fit (pseudo R^2 of about 0.19). To compare the two models, the fitted log-likelihoods are calculated (Cameron and Trivedi, 2005). Since the fitted log-likelihood of the logit model slightly outperforms the probit model, we focus on the logit model.

¹⁶Note that the dataset, containing a fixed number of participants and a large number of observations allows us to run an unconditional logit regression instead of a conditional logit regression (Cameron and Trivedi, 2005).

Table 5: Logit regression results

The coefficients of a logit regression represent the log of the odds ratios. The predicted re-use probabilities for different variables are given in figure 6. The sample period lasts from June 2006 - August 2011. For variables in cash amounts we employ the natural log if they are $\gg 0$. Bank-specific dummy variables are not reported. Standard errors are clustered by trading day. The securities borrowing (orth.) variable is orthogonalised as specified in equation 3.

Collateral re-use (dummy)	Coeff.	Std. err.
Scarcity of collateral		
ln(Securities borrowing) (orth.)	0.462***	0.0657
ln(Available securities (bn CHF))	-0.652***	0.1100
Stress in money market (pp)		
Relationship ratio (%)	-0.0539	0.0759
	-0.00735***	0.0009
Maturity of transactions		
Share long-term transactions (%)	0.0143***	0.0023
Duration of transaction (days)	-0.0245***	0.0012
Control variables		
Rating AA+ (dummy)	0.363***	0.0264
Rating AA (dummy)	-0.0538*	0.0263
Rating AA- (dummy)	-0.0439	0.0356
Rating A+ (dummy)	0.295***	0.0431
Rating A (dummy)	0.0708	0.0618
No rating (dummy)	-0.952***	0.0310
Gross excess reserves (bn CHF)	-0.0038	0.0032
Market maker (dummy)	-0.0107	0.0423
ln(Outstanding volume (bn CHF))	0.859***	0.0915
ln(Volume of transaction (mn CHF))	0.0097	0.0076
Constant	-2.076**	0.7510
Number of observations: 234,000		
Pseudo R^2 : 0.19		
Log-likelihood: -124,242.6		
Log-likelihood (0): -153,159.2		

* $p < 5\%$, ** $p < 1\%$, *** $p < 0.1\%$

5.5 Regression results

The regression results are illustrated in table 5. The log-likelihood of the null-model is significantly lower than the estimated model indicating an overall significant regression. The coefficients of a logit regression represent the log of the odds ratios. Interpretations in the following focus on the sign and the significance of the coefficients, which determine the direction of the corresponding marginal effect. The majority of the coefficients are significant at least at the 5% significance level including most of the coefficients for the bank-specific effects.

We find a significant and negative effect of the availability of securities (i.e. pool of available securities) on the re-use probability. This implies that market participants tend to re-use in times when the availability of securities is low. Shocks in the collateral universe are thus (at least partially) absorbed by an increasing re-use activity. A shortage of available securities does consequently increase the re-use activity. The re-use of collateral therefore supports market activity in the CHF repo market, especially when available securities become scarce. This evidence supports hypothesis 1 discussed in the previous subsection.

Furthermore, the coefficient for securities borrowing (orth.) is positive and significant. The fewer securities borrowed from customers, the lower is the probability of collateral re-use. This clearly indicates that banks re-use collateral when they also borrow securities from client accounts - i.e. re-use and securities borrowing are indeed complements (hypothesis 2).

The coefficients for the duration of the transaction and the share of long-term transactions are statistically significant and confirm hypothesis 3. The longer the duration of a transaction, the lower the probability for collateral re-use. Furthermore, the regression results show that collateral re-use does occur more often when the share of long-term repos in the market is high. Consequently, our findings support the hypothesis that the re-use of collateral is used to lend cash long-term and to borrow cash short-term. Re-use might thus enhance trading activity and reduce traders funding liquidity needs as proposed by Monnet (2011).

The coefficients for the relationship ratio indicate a negative impact of a weak diversification of the collateral provider on the re-use probability. Hence, if the re-using counterparty only borrows cash (lends collateral) from a few cash providers (i.e. the relationship ratio is high), it is more careful about re-using collateral. This supports hypothesis 5 that re-using intermediaries might be worried about not receiving back their collateral, which they have to return to the initial collateral provider. However, the money market stress variable does not exhibit statistically significant coefficients. This might be due to the fact that the re-use of collateral is only observable for the re-using counterparty and not for the initial collateral provider. We therefore cannot confirm that money market stress has a negative impact on the re-use of collateral. Thus, we find no evidence supporting hypothesis 4.

The coefficients of the control variables are partly significant and show the expected signs. The overall market activity (i.e. the outstanding volume) positively affects the re-use probability. The coefficients for the credit ratings show that especially the re-use probability for securities with no credit rating is reduced compared to the reference category (AAA-rating).

5.6 Predictions

The logit model is a non-linear model and therefore the coefficients cannot be interpreted as semi-elasticities (Winkelmann and Boes, 2006). We therefore calculate predicted re-use probabilities (conditional probabilities) for different levels of one independent variable, with all other variables held constant (see figure 6).

The increase in the re-use probability tends to be non-linear especially for the duration of a transaction. The re-use probability decreases sharply with an increasing duration of the transaction. Whereas the re-use probability is around 40% in overnight transactions, it decreases to almost zero in transactions with a duration of more than 200 days. Moreover, also the securities borrowed (orth.) and available securities variables have a strong and non-linear impact on the re-use probability. For example, the predictions show that the re-use probability decreases from 41% to 31% when the pool of available securities increases from 50 to 100 bn.

Furthermore, the outstanding volume exhibits a strong positive effect on the re-use probability. Since the scarcity of collateral *ceteris paribus* also increases in the outstanding interbank volume, the positive relationship further supports the hypothesis that the re-use of collateral is increasing in the scarcity of collateral.

Figure 5 shows the predicted re-use probabilities conditional on different credit rating categories. The figure reveals that the re-use activity also depends on the credit rating of the collateral. Especially, securities without credit rating (e.g. short-term government debt) are re-used less frequently.

5.7 Robustness

In order to check the robustness of our findings we run several additional regressions. First, we cluster standard errors by date, month and quarter (see table 6). Consequently, some of the coefficients lose statistical power. However, all coefficients remain significant at least on a 5% level except the constant. Second, we check the robustness with respect to the scarcity of collateral variables (i.e. securities borrowing and available securities). Table 7 reports the baseline regression results as well as the regression results when dropping one of the two variables. In both cases, the remaining collateral availability variable persists to be significant with its corresponding sign, whereas other variables change only marginally. Finally, we also run a regression without bank-specific dummy variables (see table 8). Even though we neglect individual heterogeneity in this case, the model performs relatively well and most of the coefficients keep their sign and significance. The only exception is the money market stress variable which becomes negative and significant at the 5% level.

6 Concluding remarks

This paper sheds light on the re-use of collateral in an interbank repo market. By developing and applying an algorithm on transaction data from the CHF repo market, we are not only

able to document the re-use activity, but also identify the drivers of collateral re-use before, during and after the financial crisis.

Our estimations show that on average the re-use rate was at about 10% prior to the financial crisis. With the reduction of available collateral just before the outbreak of the crisis, the re-use rate reached its maximum of almost 20%, but declined significantly in the third quarter of 2008 and has not recovered yet. The results complete recent findings by Singh (2011) as well as Aitken and Singh (2009) in at least two important areas. First, we confirm by using actual transaction data that the re-use activity substantially declined after the financial crisis. Second, we show that the re-use within the interbank repo market can significantly differ from the level of rehypothecation.

The regression analysis provides evidence that the re-use activity depends on the availability of collateral. Market participants tend to re-use when the collateral scarcity increases and in times when they also borrow a lot of securities from their client's. Further, we find evidence for a significant impact of the maturity of the transaction on the re-use probability. The longer the duration of a transaction, the lower the probability for a collateral re-use.

With the methodology and the data at hand, future research on the re-use of collateral can be done. In particular, it might be worth investigating in the cross-currency and the cross-instrument re-use of collateral as well as the re-use activity of individual banks.

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A Appendix

A.1 Selection of collateral in SECOM

The selection of securities for a repo transaction in SECOM can be done manually or automatically by the so-called 'GC select' algorithm. The majority of market participants use the automatic selection process. The GC select chooses securities from a predefined pool of available securities (SIX Securities Services, 2013). The pool of available securities (the so called 'release list') has to be maintained by the market participant. Besides other information included on the ISINs, the release list contains the corresponding quantity available, the date of the next coupon payment ('valid till date') and the date until the security is available for repos ('release till date', which is typically equal to the valid till date). Securities received in a repo are classified as 'purchased securities'. With the default setting, these securities are not shifted to the release list but to the so called 'non-release list'. Furthermore, the release till date of purchased securities is not equal to the valid till date as in the default setting, but equals the repurchase date of the initial transaction. However, market participants can change the default setting. Currently, two-thirds of all account owners adjust the default option such that purchased securities are automatically transferred to the release list.¹⁷ This means that they intend to re-use collateral. Other account owners - using the default setting - still have the option of transferring specific ISINs from the non-release list to the release list.

For a repo transaction, the GC select picks securities by using a predefined methodology. First, it selects securities from the collateral category defined, then it rejects securities that are not eligible (e.g. own banking group securities) and finally it removes all securities that have a valid till date prior to the repurchase date of the repo transaction (SIX Securities Services, 2013). From this remaining list, the GC select first chooses the securities with the shortest possible release till date (SIX Securities Services, 2013), thus preferring the securities that stem from another transaction.

A.2 Re-use activity when relaxing the repurchase condition

The algorithm identifies a transaction as a re-use transaction only if the repurchase date of the re-use transaction is not later than the repurchase date of the initial transaction. However, a re-use might also occur without satisfying this condition, since the collateral taker of the initial transactions only has to return the same ISIN at the repurchase date - but not the same security. In this case, the collateral taker needs to obtain the same collateral somewhere else (e.g. secondary market) in order to return the security to the initial owner.

Figure 4 shows the estimated re-use without the repurchase condition. It becomes clear that the re-use identified is about twice as large but has a very similar pattern. The re-use activity without repurchase condition can be seen as an upper limit of the possible re-use activity in the CHF repo market.

¹⁷Securities received from margin calls are transferred to the release list but flagged and are thus not available for the GC select.

A.3 Fungibility of ISINs and implications for the re-use

The algorithm might overestimate the re-use of collateral, as we are only able to compare the ISINs but cannot guarantee that exactly the same security has been re-used. Securities of the same issuance cannot be distinguished from each other - i.e. they are perfectly fungible. In other words, a security - with the same ISIN as the purchased security in the repo transaction - could have already been on the release list and then used in the re-use transaction. The algorithm would identify this as a re-use. However, as the GC select first chooses collateral with the youngest release till date, and purchased securities automatically have an earlier release till date than the same ISIN in the account, we do not expect the overestimation to be significant.

A.4 Tables

Table 6: Robustness check: clustering

The table shows the baseline regression results (i.e. standard errors clustered by date) such as the regression results with standard errors clustered by month and quarter. For variables in cash amounts we employ the natural log if they are $\gg 0$. Bank-specific dummy variables are not reported. The securities borrowing (orth.) variable is orthogonalised as specified in equation 3.

Collateral re-use (dummy)	Std. err. by date		Std. err. by month		Std. err. by quarter	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Scarcity of collateral						
ln(Securities borrowing) (orth.)	0.462***	0.0657	0.462***	0.1180	0.462**	0.1560
ln(Available securities)	-0.652***	0.1100	-0.652**	0.2260	-0.652*	0.2540
Stress in money market (pp)						
Relationship ratio (%)	-0.0539	0.0759	-0.0539	0.0589	-0.0539	0.0761
	-0.00735***	0.0009	-0.00735***	0.0017	-0.00735***	0.0021
Maturity of transactions						
Share long-term transactions (%)	0.0143***	0.0023	0.0143**	0.0049	0.0143**	0.0054
Duration of transaction (days)	-0.0245***	0.0012	-0.0245***	0.0021	-0.0245***	0.0024
Quality of collateral						
Rating AA+ (dummy)	0.363***	0.0264	0.363***	0.0562	0.363***	0.0794
Rating AA (dummy)	-0.0538*	0.0263	-0.0538	0.0513	-0.0538	0.0553
Rating AA- (dummy)	-0.0439	0.0356	-0.0439	0.0832	-0.0439	0.1150
Rating A+ (dummy)	0.295***	0.0431	0.295***	0.0874	0.295*	0.1240
Rating A (dummy)	0.0708	0.0618	0.0708	0.1470	0.0708	0.2090
No rating (dummy)	-0.952***	0.0310	-0.952***	0.0889	-0.952***	0.1340
Control variables						
Gross excess reserves (bn CHF)	-0.00382	0.0032	-0.00382	0.0053	-0.00382	0.0074
Market maker (dummy)	-0.0107	0.0423	-0.0107	0.0644	-0.0107	0.0652
ln(Outstanding volume market)	0.859***	0.0915	0.859***	0.1910	0.859***	0.2520
ln(Volume of transactions)	0.00974	0.0076	0.00974	0.0224	0.00974	0.0357
Constant	-2.076**	0.7510	-2.076	1.6220	-2.076	1.9020
Number of observations: 234,000						
Pseudo R^2 : 0.19						
Log-likelihood: -124,242.6						
Log-likelihood (0): -153,159.2						

* $p < 5\%$, ** $p < 1\%$, *** $p < 0.1\%$

Table 7: Robustness check: collateral variables

The table shows the baseline regression results and the regression results when dropping one of the two scarcity of collateral variables. Model 1 is without the securities borrowing (orth.) variable and model 2 without the available securities variable. For variables in cash amounts we employ the natural log if they are $\gg 0$. Bank-specific dummy variables are not reported. Standard errors are clustered by trading day. The securities borrowing (orth.) variable is orthogonalised as specified in equation 3.

Collateral re-use (dummy)	Baseline		Model 1		Model 2	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Scarcity of collateral						
ln(Securities borrowing) (orth.)	0.462***	0.0657			0.353***	0.0644
ln(Available securities)	-0.652***	0.1100	-0.457***	0.1090		
Stress in money market (pp)						
Relationship ratio (%)	-0.0539	0.0759	-0.104	0.0764	-0.106	0.0747
	-0.00735***	0.0009	-0.00764***	0.0009	-0.00827***	
Maturity of transactions						
Share long-term transactions (%)	0.0143***	0.0023	0.0161***	0.0024	0.0217***	0.0020
Duration of transaction (days)	-0.0245***	0.0012	-0.0240***	0.0012	-0.0243***	0.0012
Quality of collateral						
Rating AA+ (dummy)	0.363***	0.0264	0.360***	0.0265	0.343***	0.0265
Rating AA (dummy)	-0.0538*	0.0263	-0.0570*	0.0262	-0.0615*	0.0263
Rating AA- (dummy)	-0.0439	0.0356	-0.0326	0.0359	-0.033	0.0359
Rating A+ (dummy)	0.295***	0.0431	0.312***	0.0435	0.311***	0.0430
Rating A (dummy)	0.0708	0.0618	0.0746	0.0625	0.0694	0.0625
No rating (dummy)	-0.952***	0.0310	-0.943***	0.0313	-0.938***	0.0315
Control variables						
Gross excess reserves (bn CHF)	-0.00382	0.0032	-0.00822*	0.0036	-0.00872*	0.0038
Market maker (dummy)	-0.0107	0.0423	0.0119	0.0421	0.00827	0.0421
ln(Outstanding volume market)	0.859***	0.0915	1.073***	0.0894	0.994***	0.0858
ln(Volume of transactions)	0.00974	0.0076	0.00492	0.0077	0.00517	0.0076
Constant	-2.076**	0.7510	-3.841***	0.7290	-5.856***	0.3680
Number of observations:						
	234,000		234,000		234,000	
Pseudo R^2 :						
	0.188		0.187		0.187	
Log-likelihood:						
	-124,242.6		-124,497.1		-124,445.2	
Log-likelihood (0):						
	-153,159.2		-153,159.2		-153,159.2	

* $p < 5\%$, ** $p < 1\%$, *** $p < 0.1\%$

Table 8: Robustness check: bank-specific dummy variables

The table shows the baseline regression results and the regression results when dropping bank-specific dummy variables. For variables in cash amounts we employ the natural log if they are $\gg 0$. Bank-specific dummy variables are not reported in the baseline regression. Standard errors are clustered by trading day. The securities borrowing (orth.) variable is orthogonalised as specified in equation 3.

Collateral re-use (dummy)	Baseline		Without bank dummies	
	Coeff.	Std. err.	Coeff.	Std. err.
Scarcity of collateral				
ln(Securities borrowing) (orth.)	0.462***	0.0657	0.551***	0.062
ln(Available securities)	-0.652***	0.1100	-0.496***	0.0983
Stress in money market (pp)				
Relationship ratio (%)	-0.0539	0.0759	-0.161*	0.0671
	-0.00735***	0.0009	-0.00165*	0.000743
Maturity of transactions				
Share long-term transactions (%)	0.0143***	0.0023	0.00841***	0.00215
Duration of transaction (days)	-0.0245***	0.0012	-0.0302***	0.00138
Quality of collateral				
Rating AA+ (dummy)	0.363***	0.0264	0.209***	0.025
Rating AA (dummy)	-0.0538*	0.0263	-0.104***	0.0244
Rating AA- (dummy)	-0.0439	0.0356	-0.0926**	0.0319
Rating A+ (dummy)	0.295***	0.0431	0.258***	0.0383
Rating A (dummy)	0.0708	0.0618	0.140**	0.0523
No rating (dummy)	-0.952***	0.0310	-1.030***	0.0304
Control variables				
Gross excess reserves (bn CHF)	-0.00382	0.0032	-0.00822*	0.0036
Market maker (dummy)	-0.0107	0.0423	-0.0373	0.0408
ln(Outstanding volume market)	0.859***	0.0915	0.375***	0.094
ln(Volume of transactions)	0.00974	0.0076	0.0170*	0.00664
Constant	-2.076**	0.7510	-0.00661	0.691
Number of observations:		234,000	234,000	
Pseudo R^2 :		0.188	0.062	
Log-likelihood:		-124,242.6	-144,664.0	
Log-likelihood (0):		-153,159.2	-154,160.5	

* p < 5%, ** p < 1%, *** p < 0.1%

Table 9: Abbreviation of variables

* Frequency of variables: t = for each transaction, d = daily, m = monthly, q = quarterly.

** Aggregation of variables: i = individual, o = over all banks

Variable name	Frequency*	Aggregation**	Abbreviation
Collateral re-use	t	i	Y
ln(Securities borrowing)	m	o	SB
ln(Available securities)	q	o	AP
Stress in money market	d	o	MS
Relationship ratio	d	i	RE
Share long-term transactions	d	o	LT
Duration of transaction	t	i	DU
Rating AAA	t	i	RA
Rating AA+	t	i	RA
Rating AA	t	i	RA
Rating AA-	t	i	RA
Rating A+	t	i	RA
Rating A	t	i	RA
No rating	t	i	RA
Gross excess reserves	d	i	GE
Market maker	d	i	MM
ln(Outstanding volume)	d	o	OV
ln(Volume of transaction)	t	i	VA

Table 10: Pair-wise correlations between independent variables

	Available securities	Securities borrowing	Relationship ratio	Stress in money market	Gross excess reserves	Market maker	Outstanding volume	Duration of transaction	Volume of transaction	Long-term transaction
Available securities	1.00									
Securities borrowing	-0.85	1.00								
Relationship ratio	0.29	-0.29	1.00							
Stress in money market	0.00	0.03	-0.08	1.00						
Gross excess reserves	0.03	-0.05	-0.06	0.08	1.00					
Market maker	-0.10	0.14	-0.02	0.09	0.02	1.00				
Outstanding volume	-0.29	0.40	-0.23	0.49	0.08	0.18	1.00			
Duration of transaction	-0.10	0.13	-0.02	-0.03	0.01	-0.12	0.03	1.00		
Volume of transaction	0.17	-0.18	0.23	-0.01	-0.04	0.05	-0.04	-0.06	1.00	
Long-term transaction	-0.64	0.58	-0.21	0.03	-0.01	0.06	0.18	0.09	-0.14	1.00

A.5 Figures

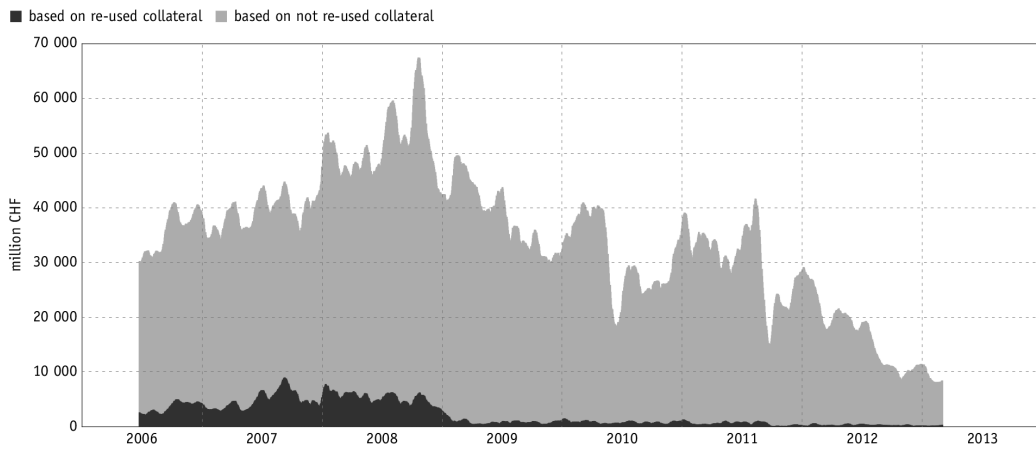


Figure 1: Outstanding volume

The dark grey area is based on re-used collateral, whereas the light grey area stacked on top corresponds to the outstanding volume without re-use (15 day moving average).

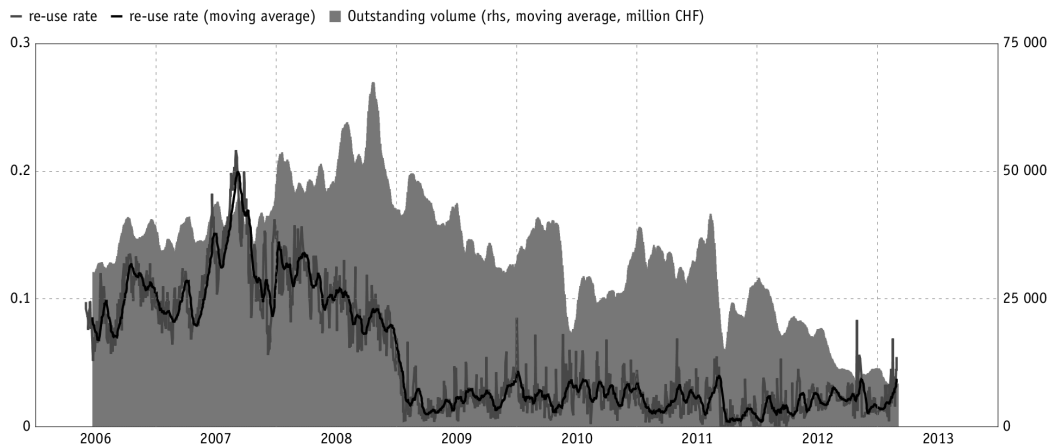


Figure 2: Re-use rate and outstanding volume

The grey area is the total outstanding volume in the CHF interbank repo market (15 day moving average). The light grey line is the daily re-use rate, whereas the black line is the re-use rate with a 15 day moving average.

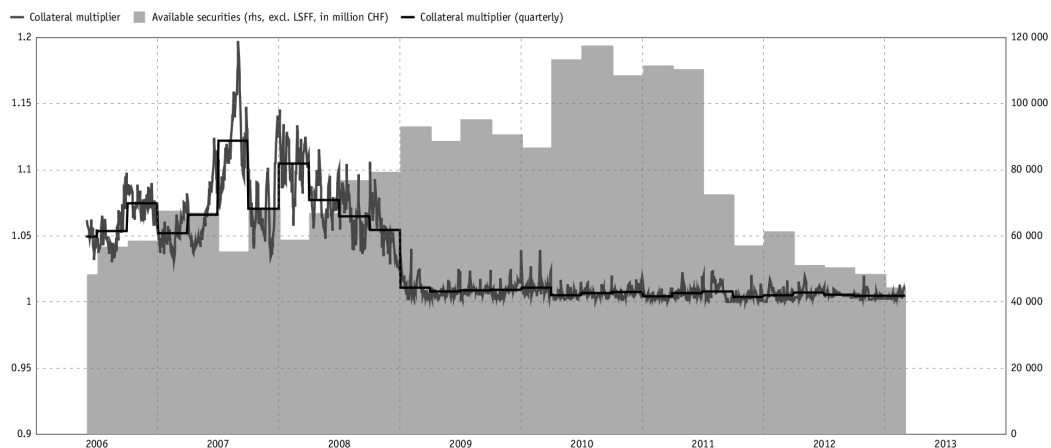


Figure 3: Collateral multiplier and available securities
 Available securities are SNB eligible securities minus the securities held in the custody cover account “SNB” for the liquidity-shortage financing facility. The light grey line is the daily collateral multiplier, whereas the black line is the collateral multiplier on a quarterly basis.

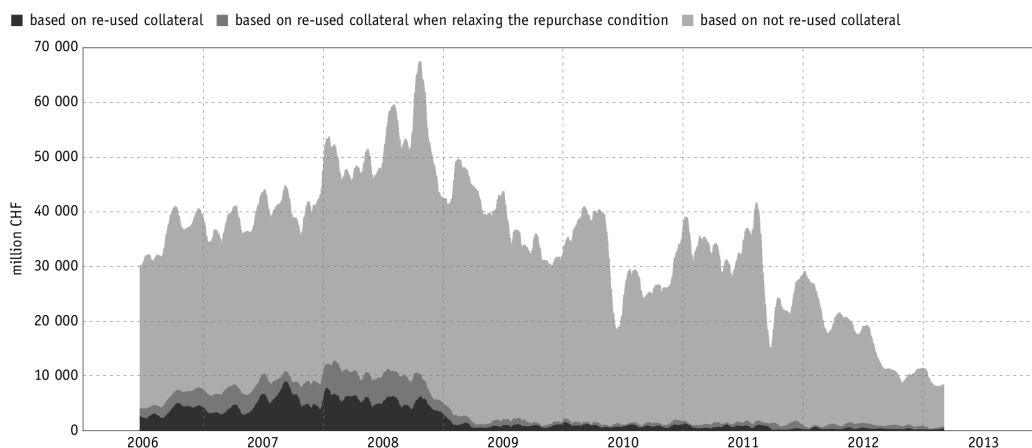


Figure 4: Outstanding volume when relaxing the repurchase condition
 The black area is based on re-used collateral with repurchase condition. The dark grey area is based on re-used collateral when relaxing the repurchase condition, whereas the light grey area that is stacked on top corresponds to the outstanding volume without re-use condition (15 day moving average).

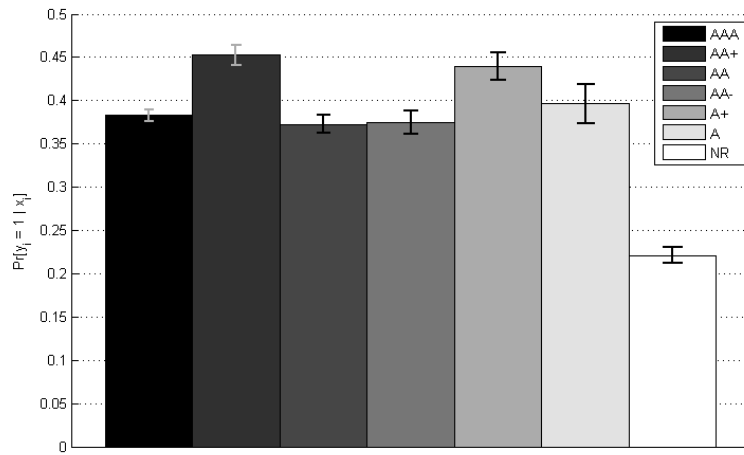


Figure 5: Predicted re-use probabilities for different rating categories

The vertical axis is the estimated probability of a re-use conditional on the rating category, with all other variables held constant. The predicted re-use probabilities are based on the regression coefficients. The vertical lines illustrate the corresponding 95% confidence intervals. Note that securities with a credit rating lower than AA- must be denominated in CHF.

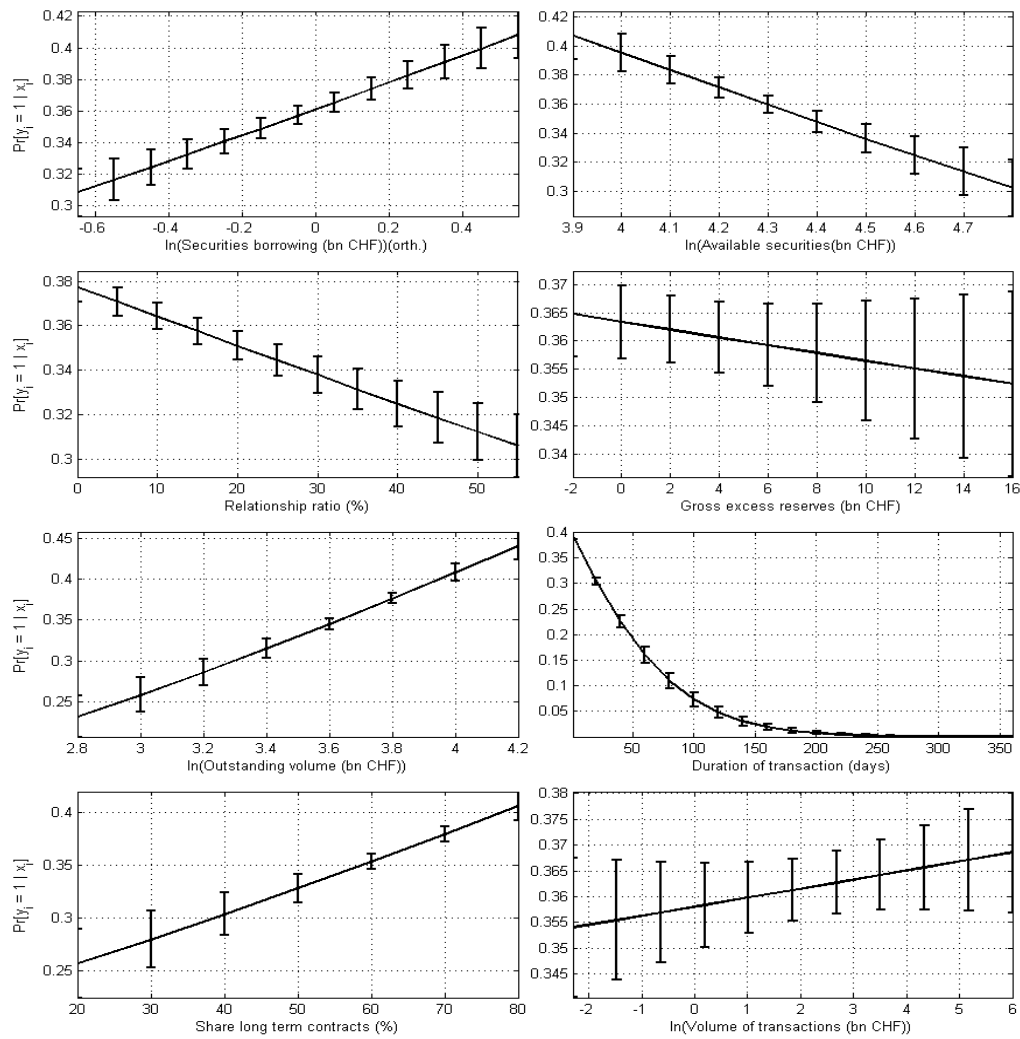


Figure 6: Predicted re-use probabilities for different levels of a variable

The vertical axis is the estimated probability of a re-use conditional on different levels of the explanatory variable, with all other variables held constant. The predicted re-use probabilities are based on the significant regression coefficients. The vertical lines illustrate the corresponding 95% confidence intervals. The predicted re-use probabilities need to be considered as hypothetical values, since certain values in certain periods simply did not exist, e.g. the gross excess reserves before the crisis never exhibited values as large as after the crisis.

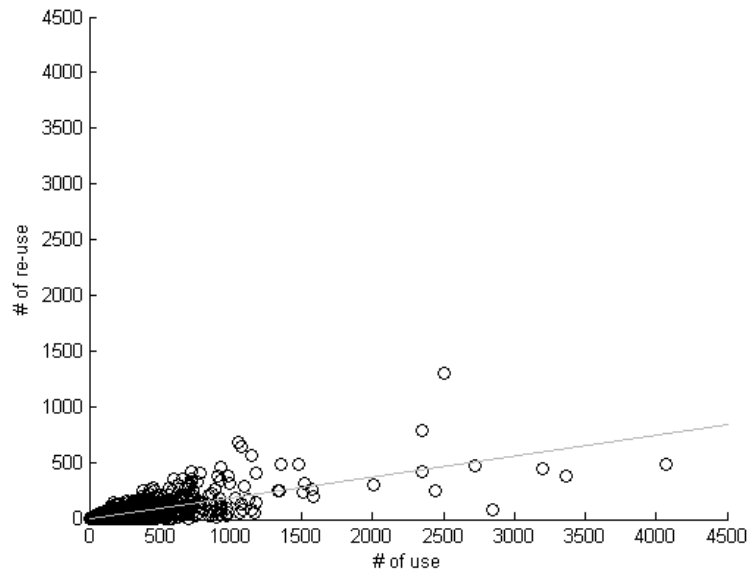


Figure 7: Use and re-use of securities

The scatter plot shows on the horizontal axis the total number of transactions, where a specific security was used and on the vertical axis the total number of transactions, where this specific security was re-used. Therefore, each point represents the number of uses and re-uses of a specific security. The grey line represents the least-squares fit with intercept -1.00 (Std. err. 0.564) and slope 0.19 (Std. err. 0.002). Overall, the plot indicates that there is no disproportionate re-use of specific securities. In total, there were 4,419 different securities used. The median security was used 44 times and re-used three times.

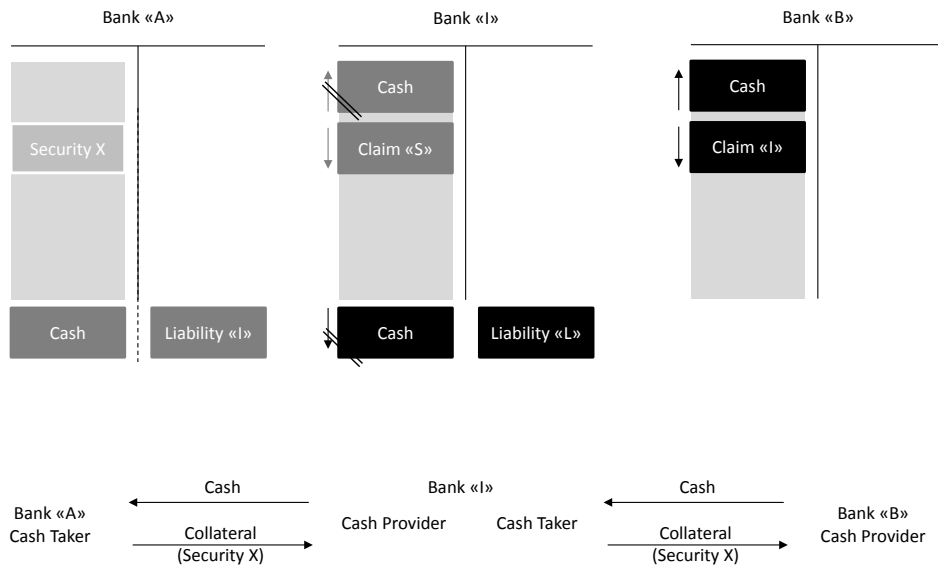


Figure 8: Balance sheet effects of repo transactions

The illustration is based on the prevailing accounting treatment of repo transactions (Wechsler, 1999). A repo transaction increases the cash taker's balance sheet, whereas it leads to a reallocation on the cash provider's asset side of the balance sheet.

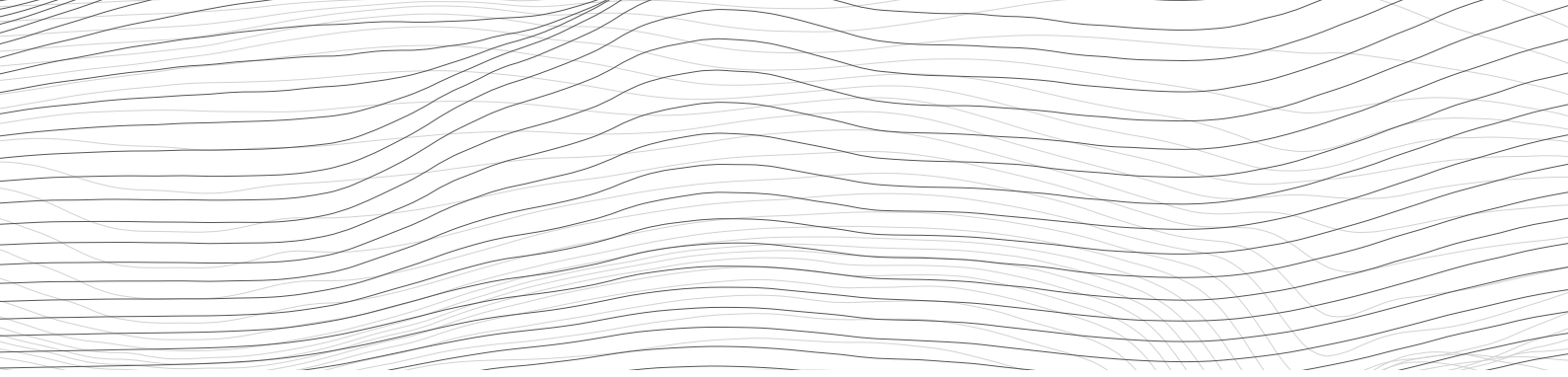
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