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Insights from the LVTS overnight loan market: Implications for Lynx collateral

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Insights from the LVTS overnight loan market: implications for Lynx collateral

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Abstract

This study produces a series of stylized empirical facts about the overnight loan market activity in the Canadian high-value payment system. The in-depth exploration of overnight loans for the period of 2004–2020 was conducted using the Furfine algorithm. We find that almost all overnight loan activity between participants takes place via Tranche 2. The paper also provides a heterogeneity analysis based on the bank size and pair type. We suggest the relationship between a bank's size and its market activity and find that large banks tend to lend more frequently, but the average value of a loan is usually smaller compared to smaller banks. Our findings shed light on the downward trend in overnight market activity during financially unstable times, specifically the recession of 2008/2009 and the latest COVID-19 crisis. We also discover a time-of-day pattern in the market activity and conclude that the overnight market activity spikes prior to the end-of-day settlement. Further, we contribute to the better identification and measurement of payments data and its importance for monitoring systemically important payment systems.

Keywords: overnight loans, LVTS, Lynx, interbank lending, liquidity, global financial crisis, COVID-19

1. Introduction

With the move from the Large Value Transfer System (LVTS) to Lynx, collateral requirements for participants have changed materially; gauging the level of required collateral could be important to inform collateral policy and eligibility expansion. Liquidity efficiency in Lynx is important for the smooth functioning of the payments system, achieving the Bank of Canada's cash setting[1] and minimising participants' use of overnight Standing Liquidity Facility (SLF). As a result, the exchange of liquidity between participants is an important component of monetary policy implementation.

LVTS unsecured overnight loans occurred between participants intraday to 1) help flatten positions towards the end of the day and 2) provide a source of intraday liquidity to meet payment obligations in lieu of collateral (Tranche 1) or sufficient credit limit (Tranche 2). In Lynx, the evolution of the overnight loan market could be an important determinant of participant collateral needs. Currently, overnight advances are not identified by any field in the y-copy of payment messages. Algorithms such as Furfine are used to probabilistically identify advances ex-post.

LVTS employed a hybrid Real-Time Gross Settlement (RTGS)-deferred net settlement risk model across two payment tranches; Tranche 1 (T1) was fully funded (RTGS equivalent), while Tranche 2 (T2) operated under a shared collateral pool and cover-one risk model. As a result, liquidity savings stemmed from the use of Tranche 2 for the majority of inter-bank payments. In contrast, the majority of collateral apportioned to LVTS was employed by Tranche 1, where almost all payments involved the Bank as a sender or recipient[2]. Collateral apportioned in T1 tended to be correlated with payment obligations to the Bank of Canada in order to settle major financial market infrastructures (FMIs).

As a result, collateral needs in Lynx follow similar patterns as in Tranche 1, whereby participants require a collateral buffer to anticipate payment shocks and collateral levels vary with payment volumes. However, the role of Liquidity Saving Mechanisms (LSMs), as well as the overnight loan market, could help to minimise collateral needs.

[1] Cash setting is a settlement-balance management practice that helps to adjust the level of settlement balances and is used to neutralise the effect of public sector flows to/from the Bank of Canada's balance sheet.
[2] The Bank does not grant sufficiently large BCLs to its counterparts in Tranche 2.

In this paper, we produce a series of stylized empirical facts about the overnight loan market in LVTS. From a historical perspective, we shed light on overnight loan activity during the financial crisis of 2008/2009 and the current crisis. Our analysis aims to draw implications for collateral needs in Lynx; therefore informing collateral policy. Further, we contribute to the better identification and measurement of payments data and its importance for monitoring systemically important payment systems.

2. LVTS and Monetary Policy

The Large Value Transfer System (LVTS), a hybrid risk model between a pure RTGS and a deferred net settlement system (DNS), was used to operate Canada's large-value payment system. Payments were processed with finality in real-time while settlement of the system occurred on a multilateral net basis at the end of the business day/payments cycle[3]. Participants could submit payments via one of two streams (or tranches). Tranche 1 was operated on an RTGS-collateralized basis (or defaulter-pay risk model) where a participant's Tranche 1 net debit cap was fully secured on a 1 to 1 basis based on collateral apportioned to the central bank. Tranche 2 was operated on a survivor pay loss allocation mechanism whereby a participant's payment activity was restricted based on bilateral credit limits as well as an overall multilateral net debit cap. Each participant's collateral apportioned for Tranche 2 was based on a (system-wide) percentage of the highest bilateral credit limit it has granted to other participants; collectively, the sum of all participants' collateral contributions formed a survivor pay collateral pool that was always sufficient to cover exposure that could arise from a default (corresponding to the largest net debit position observed throughout the payments cycle) (Bewaji, 2018). Participants can manage their exposure by adjusting their bilateral credit limits. In a same-day multiple default scenario, the Bank of Canada would provide a residual guarantee. Over the course of the business day, a concept of netting by novation carries forward a participant's joint multilateral net position across both tranches until settlement occurs on the books of the central bank during the end of the day settlement cycle (Engert et al., 2008).

As the large-value payments system processed almost all wholesale payments and facilitated settlement of other major financial market infrastructures (CLS, CDCS, ACSS, and CDSX), it was the focus of the central bank's monetary policy framework. Because LVTS was a closed-loop

[3] Finality is defined as the inability to revoke or unwind a payment under any circumstances. Finality occurs because settlement of LVTS at the end of the day is guaranteed due to system risk controls whereby participant net debit limits are secured by collateral and a central bank residual guarantee (certainty of settlement). See Arjani/McVanel (2006).

system, as the end of the day approaches, a participant in a positive net position has incentives to trade with a participant in a net negative position. Under normal course, the central bank sets and reinforces a target for the overnight interest rate as well as an interest rate corridor via its market operations. A participant with a positive end-of-day net position must leave funds on deposit with the central bank at the deposit rate, while a participant in a deficit position must borrow from the central bank through the SLF at the Bank rate; the operating band is 50 basis points. However, in exceptional circumstances, such as the financial crisis of 2008/2009 or the most recent pandemic crisis, the Bank of Canada conducts extraordinary lending and asset purchases to support the financial system. As a result, settlement balances expand to fund these operations, so the Bank of Canada has to adjust its operating framework and implement monetary policy using a floor system. In the floor system, the operating band is narrowed to 25 basis points compared to the normal 50 basis points, and the deposit rate becomes equal to the target for the overnight rate (see Table 1).

	2020-03-04	2020-03-16	2020-03-23	2020-03-27
Bank Rate	1.50	1.00	1.00	0.75
Operating Band / Low	1.00	0.50	0.75	0.50
Operating Band / High	1.50	1.00	1.00	0.75
Target Rate	1.25	0.75	0.75	0.50

Table 1 – Monetary Policy Implementation[4]

As a result, participants are incentivized to trade with each other close to the target rate, midway in the operating band. In the event that a participant is unable to find a willing lender from another participant on short notice, it can secure an advance via the SLF. A participant experiencing an ongoing persistent, as opposed to temporary, liquidity shortage over a period of time may be required to access Emergency Lending Assistance (ELA). As a result, a participant's ability to secure liquidity from the overnight unsecured loan market is an important element of intraday liquidity risk and is a source of intraday liquidity available to participants (Arjani et al., 2021).

In practice, the design of LVTS—that participants were presented with the option to send payments via one of two tranches—has important implications for liquidity for individual

[4] Source: https://www.bankofcanada.ca/rates/indicators/market-operations-indicators/

participants as well as at the system level. First, the cover-one survivor pay risk model of Tranche 2 economised on the need for collateral to settle a given volume of payments. For instance, a participant could be granted a net debit cap to the tune of CA$4B; while its collateral contribution could be in the order of CA$500M (based on the largest bilateral credit limit (BCL) it has granted, scaled by the system wide percentage (SWP)). In other words, BCL setting by participants determines a participant's available liquidity via its net debit cap and not its own pledging of collateral (Bewaji, 2018). Second, because a participant could submit a payment using a partially collateralized credit line, relative to the fully collateralized Tranche 1 credit line, incentives to delay payments or hoard liquidity (free ride) could be reduced[5]. Third, revealed preference suggests that participants' historical use of either tranche as well as their BCL setting activity provide some indication of the trade-off between balancing the cost of liquidity relative to the cost of bearing credit risk. In the event of participants deeming themselves un-creditworthy, BCLs could be retracted (by setting them to zero), rendering the LVTS a Tranche 1 only together with a payments system, corresponding to the RTGS equivalent (Byck and Heijmans, 2020). Historically, virtually all payments were submitted via Tranche 2, and no participant has faced an episode where its BCLs were adversely or quickly retracted. As a result, the historical experience with LVTS partially provides a quasi-natural experiment or laboratory to study payment choice and settlement models.

Of particular interest from a historical perspective is the Canadian experience during the Global recession of 2008–2009 and the relationship between financial stress and the role of the large value payments system. While the financial crisis was less severe in Canada, Allen et al (2011) document that market perceptions of Canadian banks' degrees of risk or insolvency were heightened, as evident by increases in CDS prices. In contrast, the authors suggest that any increase in actual counterparty risk was more benign based on actual bank-level transactions. For instance, the overnight market remained active during the crisis and the willingness to pay for liquidity remained low (based on the spreads relative to the target rate)—specifically, the authors do not find any change in average prices, loan size, or composition of borrowers/lenders. Further, bilateral credit lines, which reflect counterparty risk, were not materially lowered at any time during the crisis and, in fact, were increased. With respect to liquidity hoarding or the willingness of participants to send payments in LVTS, Zhang (2015) found that payment timing was also unaffected. The divergence between perceptions of counterparty risk from market-based measures relative to actual participant behaviour in the payment system poses an interesting conundrum. Whether the fact that the design of LVTS under a risk-sharing model with the

[5] see Bech (2008) for a model with theoretical predictions on the cost of liquidity and participant behaviour

provision of intraday liquidity based on BCL setting (and partially collateralized basis) in fact helped reduce temporary liquidity frictions and by so doing alleviated some financial stress in Canada remains an open question.

3. Data and Furfine Algorithm

3.1 The Algorithm

In order to gather detailed information on interbank overnight loan market activity, various algorithms have been developed to identify the interbank payments that represent these loans. These algorithms are typically based on the seminal work of Furfine (1999), who was the first to describe the overnight loan market in the United States. He documented the methodology he used to detect federal funds loans from Fedwire, which is a U.S. large-value payment system. By using transaction-level payments data, Furfine identified possible federal funds sales as all payments whose amounts were greater than CA$1 million and rounded to the nearest CA$100,000. Then, according to his methodology, he identified a pair of transactions that could feasibly be counted as the "first" or initial payment, and the "second" or repayment parts of a potential overnight loan. Over two consecutive days, the algorithm matched transactions for each pair of counterparties where the repayment payment went in the reverse direction and the amount was equal to the first transaction plus a feasible amount of interest. Feasibility in this case was the approximation of the implied interest rate and was calculated by comparing the values of the potential initial and repayment payments.

An illustrative example of a payment pair matched using the Furfine algorithm can be the following: Bank A lends CA$31 million to Bank B for one month at an annualised interest rate of 0.87%. In the LVTS system, the following loan appears as two separate payments. On March 25th, 2020, Bank A transfers CA$31 million to Bank B. Then, a month later, Bank B transfers a slightly higher amount, CA$31,022,350, back to Bank A. In this case, the first payment is considered the initial payment, whereas the second payment is a repayment. This pair of payments can be referred to as an interbank overnight loan.

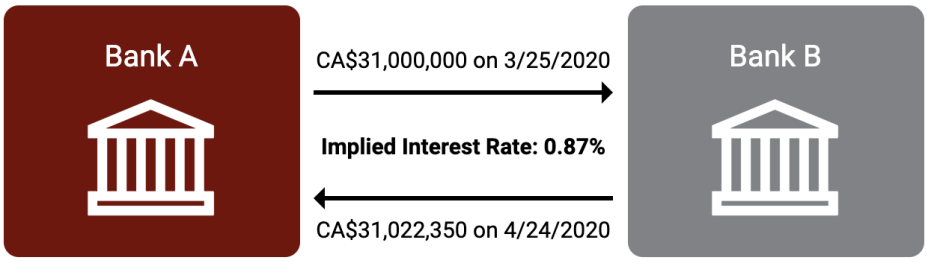

Figure 1 - Payment pair example

3.2 Data Components

The input data used for running the Furfine Algorithm consists of several parts. First of all, we take the overnight rates data for the 2004-2020 period from the Bank of Canada, which was used as the target rate for the algorithm. During tough economic periods, the Bank of Canada tends to implement additional measures to support market functioning. One of those measures is adjusting the operating band (overnight rate). In order to account for those adjustments, we prepared two additional target rate data files for each effective lower bound (ELB) adjusted sample period, where the first one contains data from April 21, 2009, until May 31, 2010, and the second one has data after May 23, 2020. In both cases, the BoC has lowered its overnight rate by ¼ percentage points to ¼ percent, which is considered an effective lower bound for that rate.

The next data component of the algorithm is LVTS transaction-level data obtained from Payments Canada's data storage. For each payment in the dataset, we have information on sending and receiving banks, the amount sent, the time the payment was sent and received, as well as the tranche associated with it for the same period of 2004-2020. The payments dataset excludes any transactions made to or from the Bank of Canada and only includes payments with a transfer amount above CA$1 million. Besides that, delays may exist between when an overnight loan is negotiated between financial institutions and when the payment is processed by LVTS. However, we are currently not able to capture or approximate any possible delay.

3.3 The Furfine Algorithm Implementation

This section summarises the main steps used in the Furfine-type algorithm implementation after all relevant data has been obtained:

1. On a particular business day *t*, the algorithm considers every single pair of banks {*i,j*}. Then, it creates the matrix of possible send payments X_{ijt} containing all the transfers from bank *i* to bank *j* on day *t* that are greater than CA$1 million. In that case, each payment x_{ijt} in X_{ijt} accounts for the principal on a possible interbank overnight loan from bank *i* to bank *j* on day *t*.

2. Following that, the Furfine algorithm constructs a new set $Y(x_{ijt})$, consisting of possible return payments for the next business day (*t+1*). Then, every payment in the y_{jit+1} from bank *j* to bank *i* on day *t+1* is assessed whether it can be identified as a potential principal x_{ijt} plus a plausible interest payment.

3. In order to identify potential loans, the Furfine algorithm calculates the annualised interest rate implied by the pair of payments x_{ijt} and y_{jit+1}. This implied interest rate is then compared with the target rates provided by the Bank of Canada. Essentially, if the implied interest rate is indeed within the range, then the payment $y_{jit+1}$is added to the set $Y(x_{ijt})$of possible return payments for x_{ijt}. Otherwise, it is excluded from the set.

4. Then, for each payment x_{ijt}in X_{ijt}, the algorithm determines the most likely return payment. There are three possible scenarios. First, if $Y(x_{ijt})$ = ∅, meaning that there is no candidate return suitable for a certain payment, then x_{ijt} is not considered as a potential overnight loan. Second, if $Y(x_{ijt})$ is a singleton, meaning that there is a unique matching return payment, then x_{ijt} and its unique $y_{jit+1}$are linked and considered to be an overnight loan. Lastly, if $Y(x_{ijt}) > 1$, meaning that multiple return payments can be associated with a certain x_{ijt} payment, then the Furfine algorithm calculates the median interest rate implied by all the candidate return payments in $Y(x_{ijt})$ and then chooses the return payment that is closest to the median rate.

3.4 Methodological Drawbacks

Although we focus on maximising the accuracy of overnight loan identification, it is important to note that our calculations must be considered as estimates only and may lead to slightly biased

results. For example, when selecting the transaction-level dataset, we remove all payments with a value lower than one million dollars. However, even though it is uncommon, these payments might still take place in reality.

Another possible drawback can be related to the assumption of choosing the repayment closest to the median rate in the event there is more than one possible repayment for a certain transaction. As a result, some unsecured loans detected by the algorithm might be purely coincidental since there are a large number of similar transactions happening between a small number of participants.

Furthermore, it is important to keep in mind that our model fails to identify correspondents or brokers of transactions made. It is assumed that sending and receiving banks are actual parties, whereas in reality, they might be representing lending arrangements between other financial or even non-financial firms operating through correspondents of the funds.

Despite all the methodological drawbacks mentioned above, we believe that the Furfine algorithm as well as the dataset give a unique opportunity to analyse the overnight loan market and examine the behaviour of its participants on a daily basis.

4. Results and Stylized Facts of Overnight Loan Activity

At the end of these steps, the Furfine Algorithm produces a data table consisting of a series of paired high-value payments labelled as overnight loans. For the period of time used in the original payments dataset, the algorithm managed to identify 885,812 overnight loans, which is 7.5% of total payments in the original transaction-level dataset for the 2004-2020 period, taking into consideration filters that were applied while constructing the dataset. The overnight loan output dataset represents the advance and return dates of the loan as well as the exact time, the sender and receiver financial institutions, advance and return values, payment IDs associated with those payments, and the implied interest rate for each pair of payments.

4.1 Stylized Fact 1: Overnight loans take place exclusively in Tranche 2

Interestingly, we find that almost all overnight loan activity between participants takes place via Tranche 2. Specifically, 99% (876,945) of all detected loans take place in T2 and only 1% (8,867) go through T1. As mentioned earlier, one of the most crucial differences between T1 and T2 is their collateral mechanism. Tranche 1 is fully funded (RTGS-collateralized basis) and has the majority of total LVTS collateral. In contrast, Tranche 2 uses a shared collateral pool and operates

on a survivor pay loss allocation mechanism. As a result, liquidity savings stem from the use of Tranche 2 for the majority of inter-bank payments. Since the Bank of Canada undertakes the role of setting the target for the policy rate (or overnight interest rate), all transaction-level data that involves the central bank as one of the operating parties was excluded from the dataset.

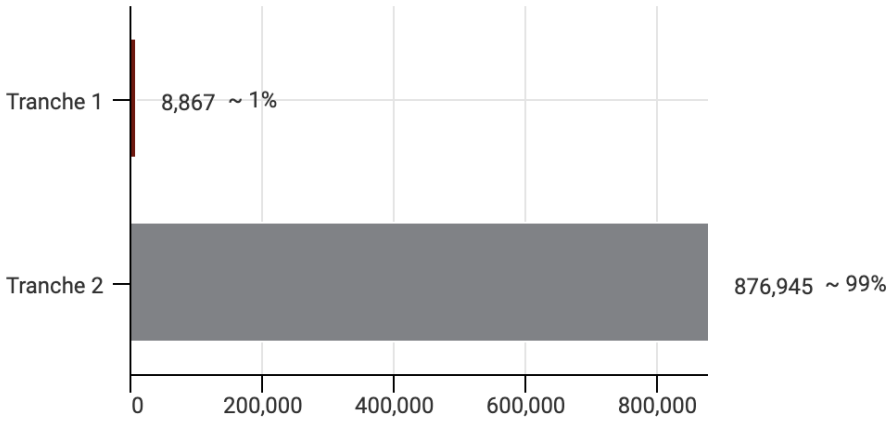

Figure 2 - Overnight loan volume comparison, Tranche 1 vs. Tranche 2

4.2 Stylized Fact 2: Large and small participants act differently in the overnight market

4.2.1 Heterogeneity analysis based on the bank type

With the help of the transaction-level data produced as the result of the algorithm, we can analyse the behaviour of senders (lenders) and receivers (borrowers). In order to obtain more details, we split the 15 participants in the overnight loan market into two categories: small and large banks. Large banks represent Canada's 7 largest financial institutions based on their asset size, whereas small banks represent the remaining participants in the market. We look at 4 different criteria for the comparison: the daily average number of loans sent, their average value, the daily average interest rate in basis points, and the average loan term calculated in business days.

Based on the summary statistics of these two groups, we prove that large and small banks indeed act differently in the overnight loan market (see Figure 3). Over the entire period of time used in the analysis, large banks gave a total of almost 800 thousand loans, whereas small financial institutions' volume did not exceed 100 thousand loans. Daily, large banks tend to lend

around 186 loans while small banks lend 22 loans. The average loan size for small participants in the market is CA$71.2 million, while it is only around CA$40.9 million for large participants.

With respect to the average interest rate, there is a less significant difference between large and small lenders. On average, large banks tend to lend at slightly above the 156 basis point interest rate, and small banks lend at the 158 basis point interest rate. Initially, the banks were split into two groups based on their asset size. However, large asset-sized banks often come with higher market capitalization and liquidity. Well-capitalized banks are positioned as less risky since they are better able to raise funds in the event of any sudden fluctuations in the market (Peek and Rosengren, 1995). Therefore, well-capitalized and highly liquid banks can afford to lend at a lower overnight rate, compared to small banks (Gambacorta and Mistrulli, 2011).

The last part of the overnight loan market activity comparison focuses on the average loan term, which is calculated based on business days. The daily average length of loans given by large banks varies around 8 business days, whereas small banks tend to lend money for an average of 4-5 business days. The reason for this deviation could be the difference in the liquidity levels between large and small asset-size banks. Thus, large financial institutions have higher liquidity and can afford to lend money for almost twice as long as small financial institutions.

As a result, it can be concluded that large banks tend to lend more frequently and at a lower rate, but the average value of a loan is usually smaller. Meanwhile, small banks lend generally less frequently and at a higher rate, but on average, loans tend to have a higher value. These findings are mostly in line with the research that was conducted by Hendry and Kamhi in 2007. Even though the trends are generally similar, it is important to note that the overnight market activity has expanded throughout the years.

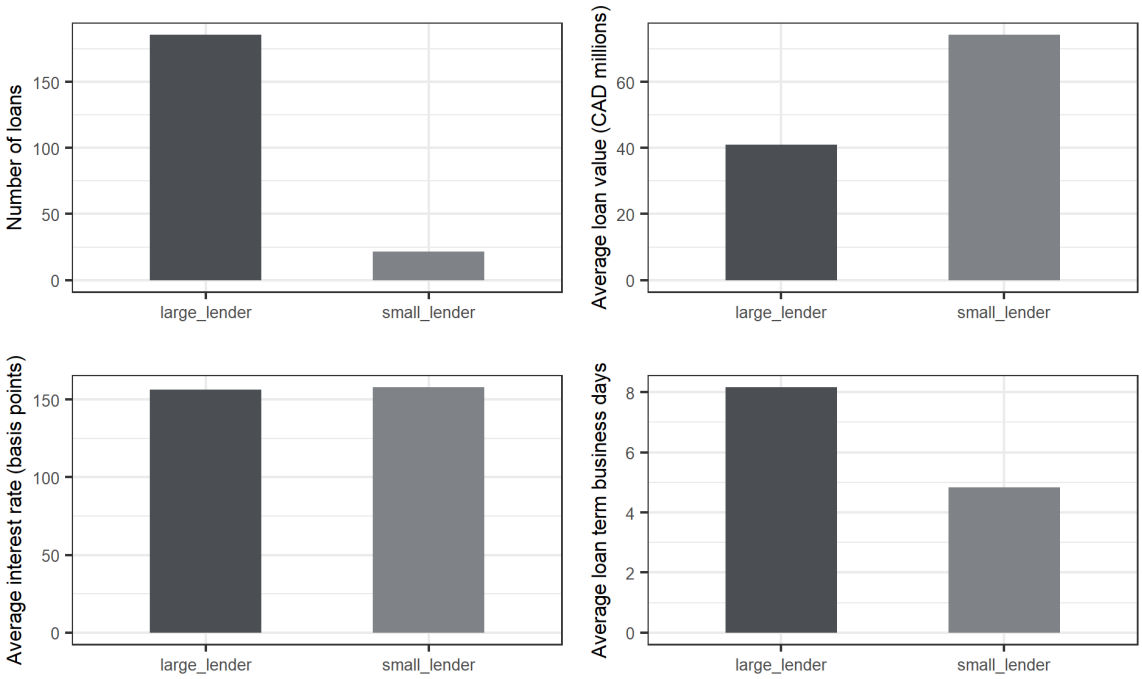

Figure 3 - Overnight loan market activity comparison between large and small lenders on a daily basis

4.2.2 Heterogeneity analysis based on the pair type

Going further into heterogeneity analysis, we enhance our findings by splitting overnight loan senders and receivers into pairs. Based on the bank type that was assigned earlier in the analysis, we created 4 groups: large to large, large to small, small to large, and small to small. The first part of the pair name corresponds to the type of bank that is sending the loan, in other words, the lender, whereas the second part corresponds to the type of bank receiving the loan, the borrower.

In order to keep the analysis consistent, we used the same 4 comparison criteria as before: the daily average number of loans sent, their average value, the daily average interest rate in basis points, and the average loan term calculated in business days. Based on the results obtained, we can conclude that different pair types indeed act differently in the overnight market (Figure 4). For example, looking at the volume of loans, we can see that on any given day there are approximately 168 thousand larger-to-large loans, which takes up more than 80% of the daily amount of loans flowing in the market. The second highest group is small-to-large loans, with 21 thousand daily payments. Interestingly, we find that the highest daily volume of loans has large banks as the borrowers. On the other hand, small banks tend to borrow less frequently, but mostly

from large banks. The large-to-small group has a daily flow of 18 thousand loans, whereas the small-to-small is just below 2 thousand.

In terms of the values, we observe a slightly different tendency. In our bank-type-based analysis presented earlier, we concluded that small banks tend to lend loans of higher value, compared to large banks. Thus, we can broaden this finding based on the pair type. Even though small banks do lend the highest dollar amounts of loans, it is important to note that the loan value tends to be higher when small banks are involved on any side of the loan. The highest daily average loan value comes from the small-to-large bank pair and is approximately CA$75 million. That is almost 40% higher than the daily average value of the large-to-small and small-to-small groups, with CA$53 and 54 million, respectively. The lowest value among all groups is associated with the loans between large banks. The large-to-large group has a daily average value of approximately CA$40 million.

From the interest rate perspective, the small-to-small bank group stands out the most. Among all other groups, it has the highest daily average interest rate of 170 basis points. Meanwhile, other groups have an average interest rate varying around 156-158 basis points. The lowest interest rate is used by the large-to-large bank group. This trend can be attributed to the differences in liquidity risks and bank ratings. Smaller banks tend to be riskier and have a lower rating. Thus, when lending to or borrowing from a small bank, the interest rate tends to be significantly higher. Especially in the case of small-to-small banks, both parties have lower market capitalization and liquidity levels.

Lastly, our heterogeneity analysis touches upon the average loan term that is calculated in business days. As it was observed in the bank type analysis, the larger the bank, the longer the loan term it can give. However, based on the pair type comparison, we see that the trend is the same for the borrower side. If we compare two groups where the sender of the loan is the same but the borrower differs, we find that the average loan term would be higher for larger banks. Thus, the large-to-large group has the longest average loan term of 8.5 business days, whereas the shortest average length of the loan is 2.5 business days and is associated with the small-to-small pair group. The large-to-small and small-to-large groups take the second and third places with 5.5 and 5 business days, respectively.

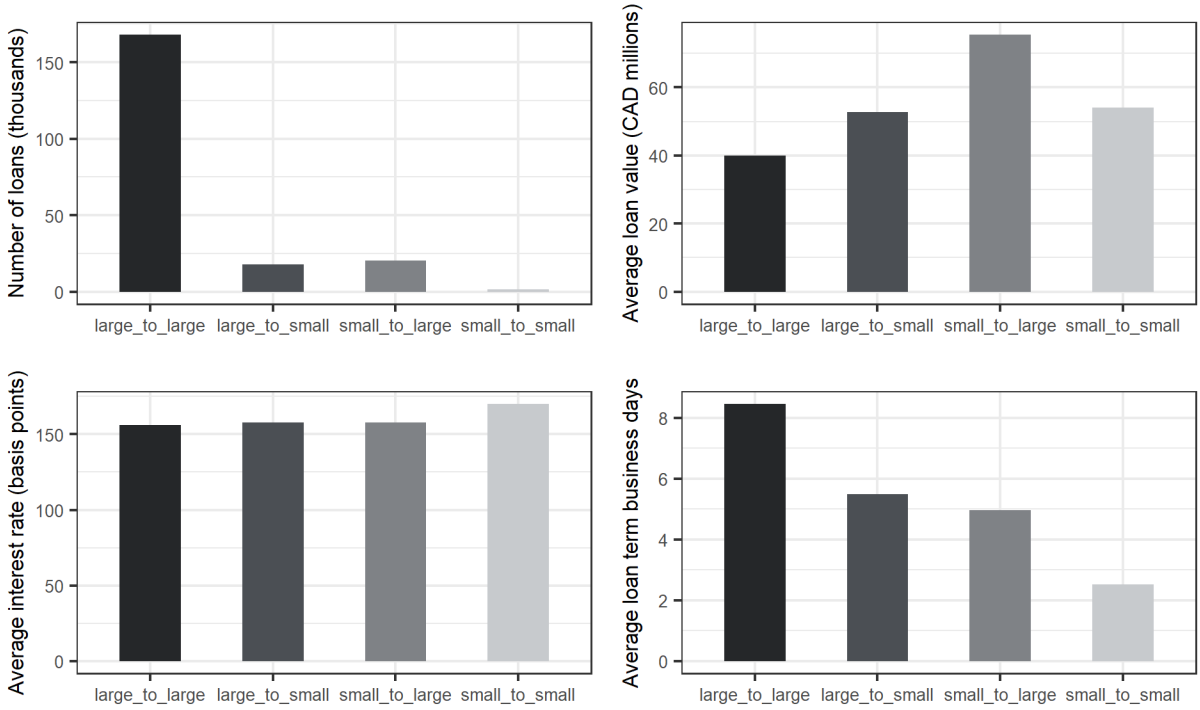

Figure 4 - Overnight loan market activity comparison between different pairs of banks on a daily basis

4.2.3 Overnight interest rate analysis

Another important thing to consider is the interest rate of loans provided by large banks versus small ones. The average daily interest rate set by the large banks is approximately 156.3 basis points, whereas small banks tend to set a higher daily interest rate of approximately 159.5 basis points. This contributes to the above-mentioned finding. Larger banks are more active and give loans more frequently at a lower rate compared to the smaller banks that lend money less frequently and at a higher rate. Interestingly, we find that the interest rate set by the large banks is not only lower than smaller banks but also tends to be lower than the target rate. If we look at the yearly average interest rate data presented below, we can notice that during financially stable times, specifically during the period of time between 2011 and 2019, the large banks' interest rate is the lowest among all. The interest rate set by the small banks is on average equal or lower than the target rate, however still higher than the large banks' interest rate. During crisis times, central banks stimulate the economy and its financial institutions by setting the target interest below the bar.

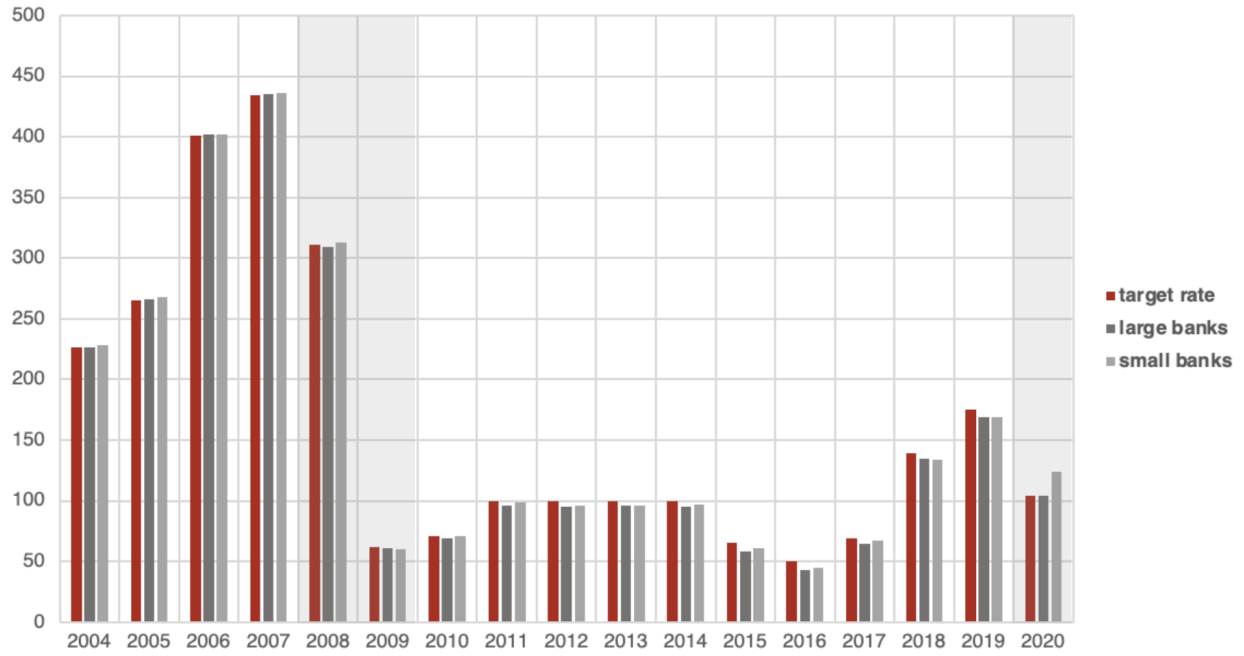

Figure 5 - Yearly overnight interest rate of small and large banks vs. target rate set by the Bank of Canada

4.2.4 Lending and borrowing activity

Finally, the last key finding to highlight based on the differences between large and small banks is the proportions of lending and borrowing. If we look at the pie charts presented below, we can see how the distribution varies depending on the size of the bank. Looking exclusively at the first chart, it can be concluded that small banks act as net selling institutions in 53.5% of their overnight activity and as net buying institutions in 46.5% of it. Large banks have the opposite trend. 50.4% of the time, large banks act as net buyers, and only 49.6% of payments represent their net selling activity. As a result, it can be concluded that in the overnight loan market, small financial institutions tend to lend more frequently than they borrow, whereas large financial institutions borrow more frequently than they lend. This finding is indeed consistent with the insights provided by Furfine in his original model, where he concludes that both types of institutions participate in both sides of the overnight market. However, small banks, on average, tend to lend more often than they borrow. The probability of being a net buying institution is positively correlated with asset size.

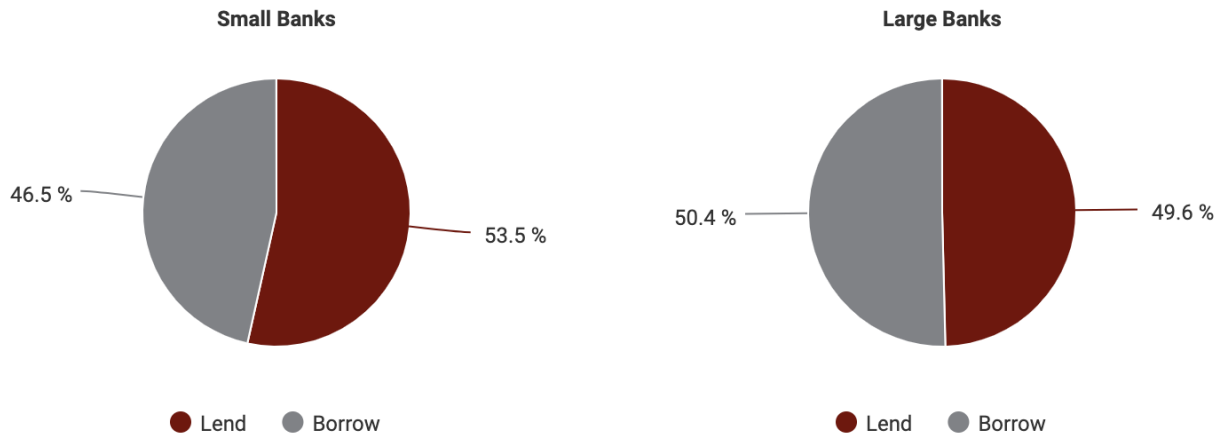

Figure 6 - Proportions of lending and borrowing (small vs. large banks)

To summarise, the difference in the behaviour of small and large banks can be described in the following way: Large Canadian banks tend to give high volumes of lower value loans at a lower rate, whereas small Canadian banks lend less in total volume at higher interest rates but loans tend to be on average higher in value.

4.3 Stylized Fact 3: The overnight market activity trends downwards during financially unstable times

4.3.1 The global financial crisis of 2008/2009

When the global credit crisis began in 2007, the majority of the global economy rapidly went into recession, and Canada was not an exception. Even though Canada was not affected as much as the United States or Europe, the Canadian recession still had enough power to cause a significant reduction in output and employment and to require relevant actions by its policy-makers. After the 1985 collapse of Northland Bank and Canadian Commercial Banks, financial regulations became more strict. Canadian banks were obligated to keep lower debt-to-equity ratios than the majority of other countries. Although higher debt-to-equity ratios tend to enable higher profit rates, highly leveraged banks become more sensitive to negative shocks to the value of their assets. Due to these regulations, Canadian banks were not at a high risk of insolvency during the financial crisis of 2008. Reviving the stability and liquidity of financial markets has become the priority of Canadian policy-makers.

Keeping liquid assets such as cash and government treasury bills at a high level is costly for banks, especially when these resources could be used for other purposes. According to Allen et al. (2011), the level of liquid assets held by Canadian banks has decreased from 30% to 15% since 1980. Unlike American and European banks, Canadian financial institutions did not face any reserve requirements after 1994. In late 2007, a concern over asset-backed securities in the US and Europe reached Canada and resulted in a freeze of the asset-backed commercial paper (ABCP) market (Zorn et al., 2009). As a response, the Canadian banks took ABCP back on their balance sheets and reduced their overall liquidity levels.

During the summer and fall of 2007, the Bank of Canada adhered to the traditional policy plan and continued adding liquidity to the overnight loan market. However, in late 2007, many banks around the world began reporting dismal financial returns. As a result, the interbank loan market became tighter, which signalled that the traditional endogenous liquidity creation mechanism was not able to handle increased flow. The Bank of Canada, like other central banks, rethought its approach and introduced term liquidity auctions, called term purchase and resale agreements (PRA), in order to alleviate pressures in the short-term funding market. With term PRAs, the Bank of Canada was able to buy securities from primary dealers of Canadian government securities with an agreement to sell them back to that bank after a certain extended term, which could range up to a year. In addition, the Bank of Canada also expanded the set of eligible collateral in LVTS, which allowed participants to secure funds more easily. Specifically, the Bank allowed some types of ABCP to be pledged in LVTS, which could then be used in the term PRA auctions or even in the repo market.

In Figure 7, we begin to disentangle the impact of the financial crisis on the overnight loan market. From the perspective of volume, we can see a sharp initial drop during the crisis. In 2007, the average overnight lending volume varied around CA$12.5 billion; in 2008, it fell by more than 35% to the CA$8 billion level. A deeper decline of approximately 75% took place in 2009, which summed up to a total drop of more than 84% in overnight volume activity from pre-crisis levels.[6] Meanwhile, the average loan term increased by approximately 2 days, but quickly returned to pre-crisis levels once the recession was over.

[6] It should be noted that loan volume decline during the 2006-2010 global financial crises does not necessarily translate to an unwillingness of financial institutions to lend to one another or stress in the LVTS, but rather a natural result of increased system liquidity due to the Bank of Canada policy of increasing the System Wide Percentage (SWP). The increase in the SWP expanded the liquidity generated through the same level of bilateral credit limit pledges. Acceptable collateral classes were also expanded.

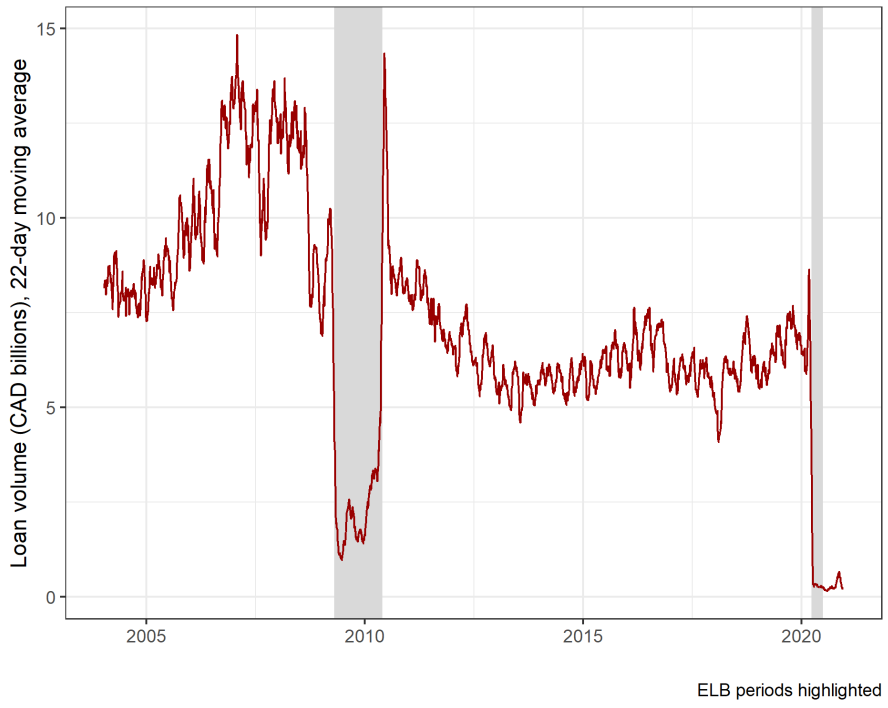

Figure 7 - Loan volume (22-day moving average)

The overnight lending volume has rebounded since the 2008 crisis. However, it did not reach its historical levels of activity, mainly because of the difference in the levels of liquidity before and after the financial crisis. After the 2008 recession, liquidity levels were higher than they were historically, and there was no need to remain as active in the overnight loan market as before.

In October 2008, the Bank of Canada cut its overnight target rate from 3 percent to 2.5 percent. Following the first rate cut, the reduction continued until the Bank of Canada's target rate reached its lower bound of 0.25 percent in April 2009. Due to the balance sheet expansions, the Bank of Canada began implementing its monetary policy using the floor system. In the floor system, the operating band is narrowed to 25 basis points compared to the normal 50 basis points, and the deposit rate becomes equal to the target for the overnight rate (see Figure 8). In addition to the reduction of the policy rate, the Bank of Canada implemented a "conditional commitment" to maintain the Bank's target rate at its lower bound until the middle of 2010 (Gordon, 2017).

Figure 8 plots the daily overnight interest rate as well as target rate and its lower and upper bands from 2004 until 2020. The lower band represents the deposit rate of the Bank of Canada, or in

other words, the interest rate that the bank pays on any surplus left on deposit overnight at the bank. The upper band is called the bank rate and represents the interest rate that the Bank of Canada charges on one-day loans to LVTS participants. The overnight rate tends to be very close to the target rate since LVTS participants know that they can always borrow money from the Bank at its top rate and get interest on deposits at the borrowing rate, so there is no incentive to trade at interest rates outside the operating band. When the liquidity level is low, banks lend cash overnight at the rate above the target rate set by the Bank of Canada. However, as soon as there is excess liquidity in the market, banks are willing to lend cash at rates below the target rate.

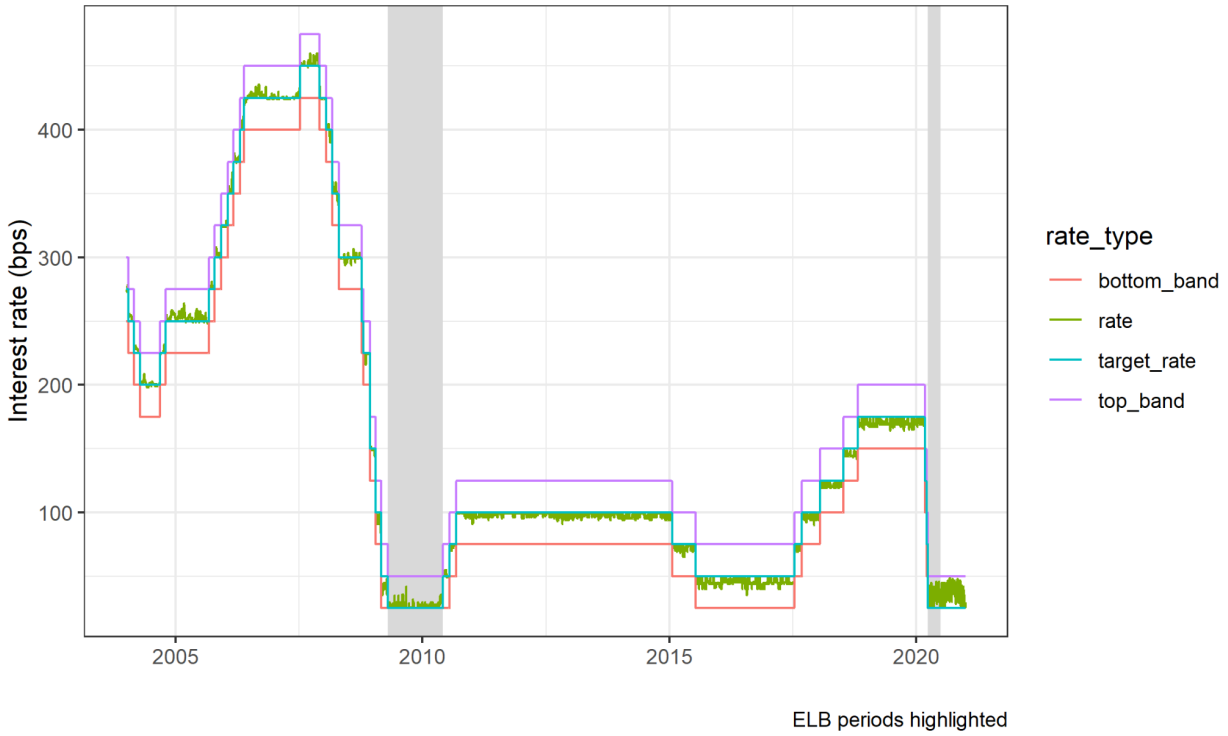

Figure 8 - Overnight interest rate (lower and upper bound) and target rate

The average spread between the overnight rate paid for a loan and the Bank of Canada target rate in the Canadian unsecured interbank market is presented below in Figure 9 and is calculated by deducting the target rate from the overnight rate. As the global financial crisis started, the spread initially dropped. However, due to the lower overnight market activity and the fact that banks were not lending as actively as before, the interest spread jumped during 2008-2010. The policy measures introduced in 2008 aimed at achieving financial and economic stability during and after

the financial crisis impacted settlement liquidity. As mentioned earlier, the Bank of Canada restructured its liquidity facilities and massively expanded its liquidity framework in all of the four dimensions: terms of maturity, amounts, counterparties, and eligible securities (Bank of Canada, 2010). This resulted in additional liquidity that not only helped the economy to recover during the crisis but also lasted many years until the latest COVID-19 crisis, which is one of the main reasons why overnight loan activity has not reached its historical levels after the crisis. Once excess liquidity became available, banks started lending cash below the target rate, which resulted in the negative spread between the two crises.

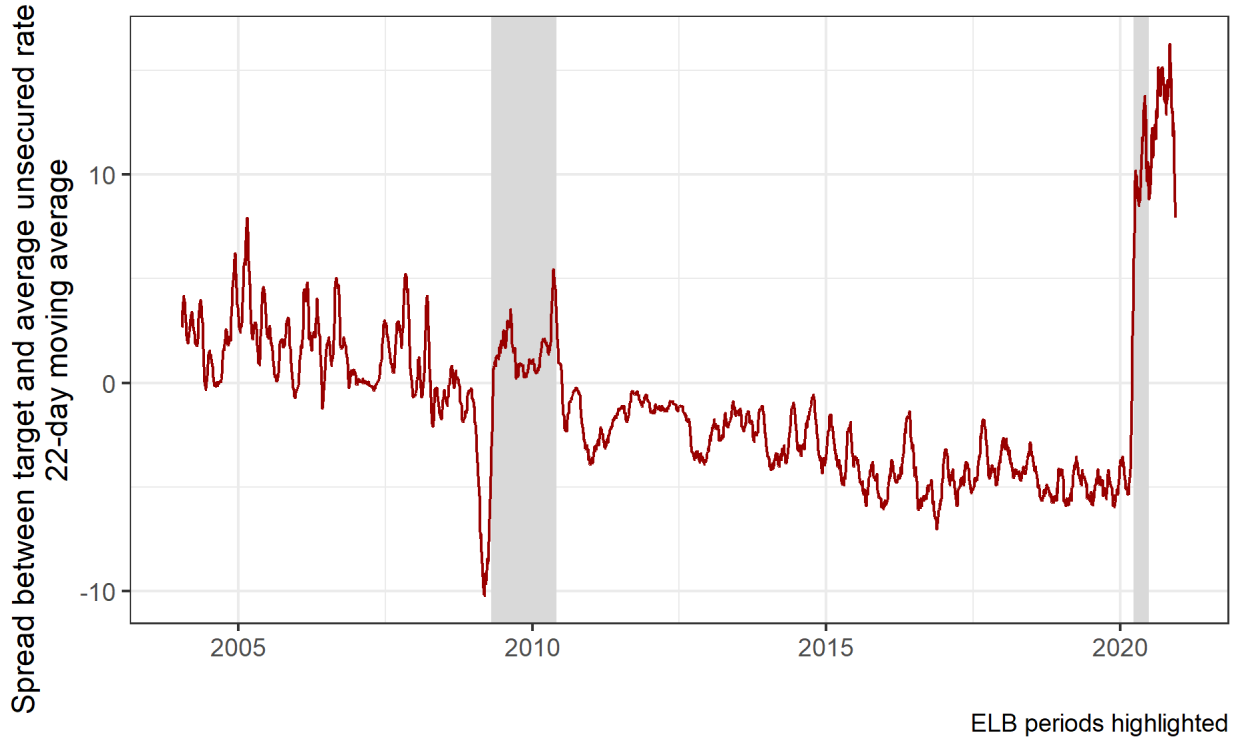

Figure 9 - Spread between target and average overnight rate (22-day moving average)

4.3.2 The current COVID-19 crisis

The Canadian economy has been strengthening for several years since the global financial crisis. The overnight target rate has steadily risen over the past few years. In 2017, the target rate reached 1.75%, remaining at that level for almost three years. However, the economic situation dramatically changed in 2020. In March 2020, the rapid spread of the COVID-19 virus around the

world forced the Bank of Canada to cut the overnight target rate three times, from 1.75% to its effective lower band of 0.25%. The target rate has remained at the 0.25% level for the rest of 2020 and the majority of 2021.

Since March of 2020, the Bank of Canada has been pursuing several large-scale asset purchase programs, whereby it purchases assets such as Government of Canada bonds or mortgage bonds from financial institutions, in order to keep markets active, credit flowing, and allow interest rate cuts to work their way through the economy. The Bank paid for these assets with settlement balances, which LVTS participants could leave in their settlement accounts at the Bank of Canada overnight, earning the deposit rate. For example, the Government of Canada Bond Purchase Program (GBPP) aimed to support the financial market and provide monetary stimulus by focusing on quantitative easing, whereas other programs focused on other types of financial risk by including term-to-maturity limits, minimum credit ratings, counterparty limits, and concentration limits. In order to help financial institutions to obtain funding for their lending, the Bank of Canada implemented enhanced term repo operations and the new Standing Term Liquidity Facility (STLF). The Bank has increased the term over which it lends money, widened the collateral it accepts, and expanded the list of eligible financial institutions that can access its lending.

The overnight activity during the COVID-19 crisis followed a trend very similar to the global financial crisis. However, this time the decline in activity exceeded other financially unstable times. The lending volume dropped by more than 90%, which is deeper than ever before (see Figure 7). The lending average value remained nearly the same, whereas the average term of loans doubled from 7 days to more than 14 days. The mean interest rate varied by around 60 basis points. One of the outstanding differences between the previous and current crises is the spread between the target and overnight interest rates. The average spread level jumped over 10 basis points, even reaching 13 basis points in some cases, which is more than two times higher than it was during the financial crisis of 2008/2009 (see Figure 9).

4.4 Stylized Fact 4: The market for intraday loan advances pre-4pm, pre-dating CDSX settlement and end-of-day settlement

The main hours of operation used for the payments processing cycle in the LVTS system are from 00:30 (half past midnight) until 18:00 Eastern Time (ET)[7], for a total of 17.5 hours every business day, which provides a considerable amount of time for high-value payments to take place.

[7] Please note that unless otherwise indicated, all references to time of day refer to Eastern Time Zone

According to the phases of the LVTS cycle, presented in Figure 10, the commencement and initialization period starts at 23:00. At this time, participants wishing to exchange Continuous Linked Settlement (CLS)[8]-related or bilaterally agreed (non-CLS) payments must sign-on, pledge and apportion collateral, confirm their profile information, as well as set bilateral limits. Participants not active during the overnight period are required to sign on by 8:00. The Bank of Canada values participant collateral prior to the start of the cycle (00:30) no matter when they become active.

Between 00:30 and 6:00, only CLS payments or (non-CLS) bilaterally agreed payments could be exchanged by participants. From 6:00 to 18:00, participants conduct their regular payment activity, exchanging client payments (MT103) and interbank payments (MT205). The pre-settlement period starts at 18:00 and ends at 18:30. During this period, LVTS members may transact with each other to flatten both "long" and "short" positions within LVTS and, as a result, provide an alternative and reduce the need to borrow from, or have on deposit with, the Bank of Canada overnight. Only bilaterally agreed interbank payments (MT 205) are accepted during this window. After 18:30, no further payment exchange can go through the LVTS. The window from 18:30 to 19:30 is set to be the final settlement period, during which the Bank of Canada enters the multilateral net position (either a credit for a gain or a debit for a loss of funds) of each member into its settlement account at the central bank (Bank of Canada, 2016). The Bank of Canada simultaneously settles all participants' net positions by 19:30.

[8] The Continuous Linked Settlement (CLS) Bank is a foreign exchange settlement system, operated by the CLS Bank since September 2002, in order to mitigate the risks associated with the settlement of foreign exchange transactions.

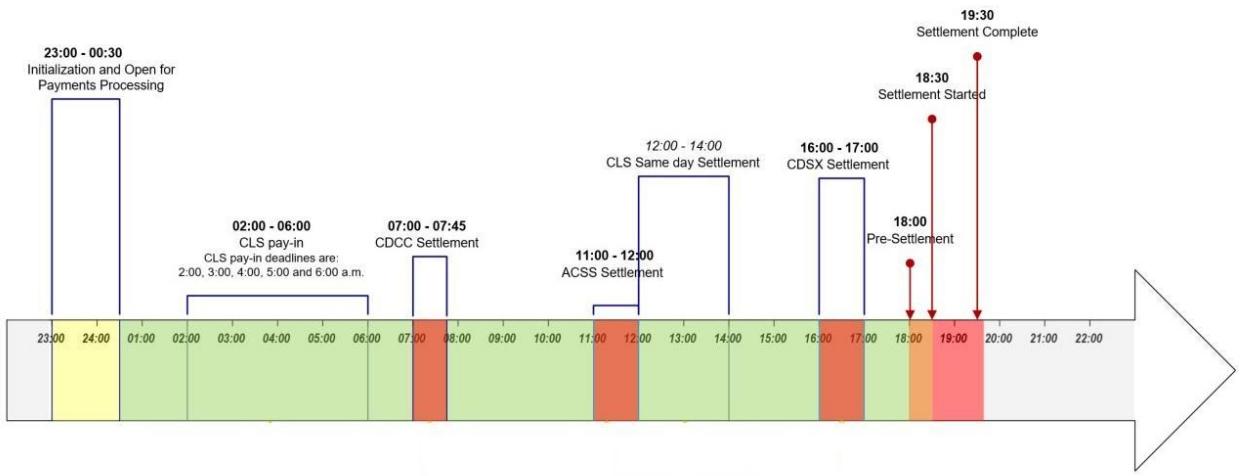

Figure 10 - LVTS cycle

Figure 11 represents the distribution of overnight loan volume, average value, and interest rate associated with each hour of operation for the 2004-2020 period. The common understanding of the hourly distribution of overnight loans in the LVTS system is that the lending participant delivers funds to the borrowing participant in the late afternoon and expects to be repaid the following morning. The volatility in the overnight volume is high during the day. We observe that the majority of loans take place in the morning, with a peak just shortly after the start of CDCC settlement (7:00 ET). Interestingly, we find that the overnight loan market advances before 16:00, pre-dating CDSX settlement, and end-of-day settlement. It then tapers off until the late afternoon. Once the CLS same-day settlement occurs, the overnight loan volume increases again, reaching its second-highest peak at around 15:00 ET. The early morning loan volume tends to be from banks that are looking to quickly reconcile their expected cash flows for the day. The overnight interest rate tends to fluctuate significantly once the LVTS operation cycle starts but stabilizes in the morning around 6:00 ET. Despite the fluctuation, the average overnight rate during the day comes to around 200 basis points and tends to be lower by the end of the day with an average of 180 basis points. The average advance value tends to be dramatically lower in the morning and slowly grow in the afternoon. Once CDSX settlement starts, the average value follows a steep incline with its peak at 18:00 ET. Based on these observations, a higher number of low-value loans

take place in the morning and a lower number of high-value loans take place in the afternoon and close to the end-of-day settlement timeslot.

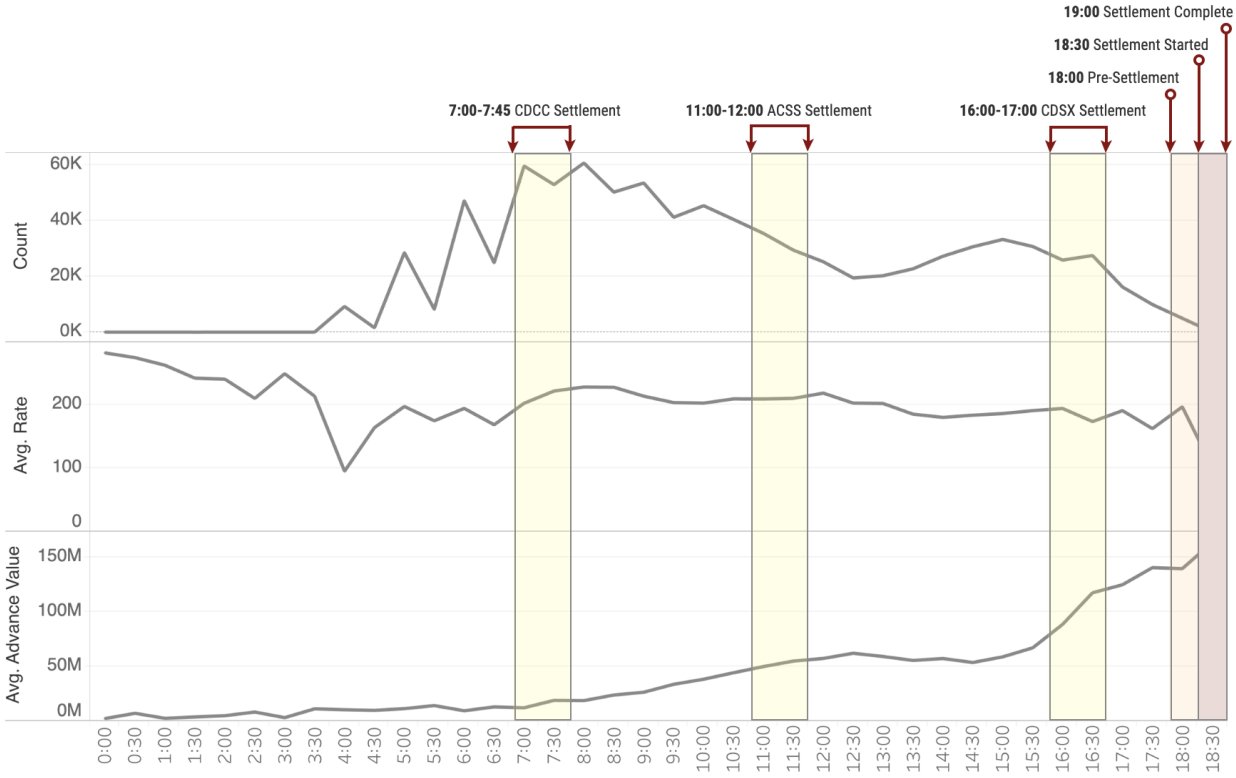

Figure 11 - The distribution of overnight loan volume, average interest rate, and average value throughout the hours of operation of the LVTS system

Based on the classification of small and large participating institutions that was done previously, we analyze the market activity of each group throughout the operating hours of LVTS. Interestingly, we find that small institutions tend to participate in the market more actively earlier in the day, specifically in the morning and afternoon, whereas large banks are more active later in the day, specifically around the end-of-day settlement (see Figure 12). According to Stigum (1990), small participating institutions tend to sell funds early in the day to larger participating institutions. These larger banks then collect money into larger round lots in order to resell it to the major market participants. In that case, large participants tend to act as brokers in the market, both buying and selling funds. However, large banks still need to maintain their position in the market and undertake transactions on their behalf. Due to that, their brokering activity happens

earlier in the day. In that case, they save time later in the day to take care of funds for their account. This implies that small banks participate in the market and deliver funds earlier in the day than large banks.

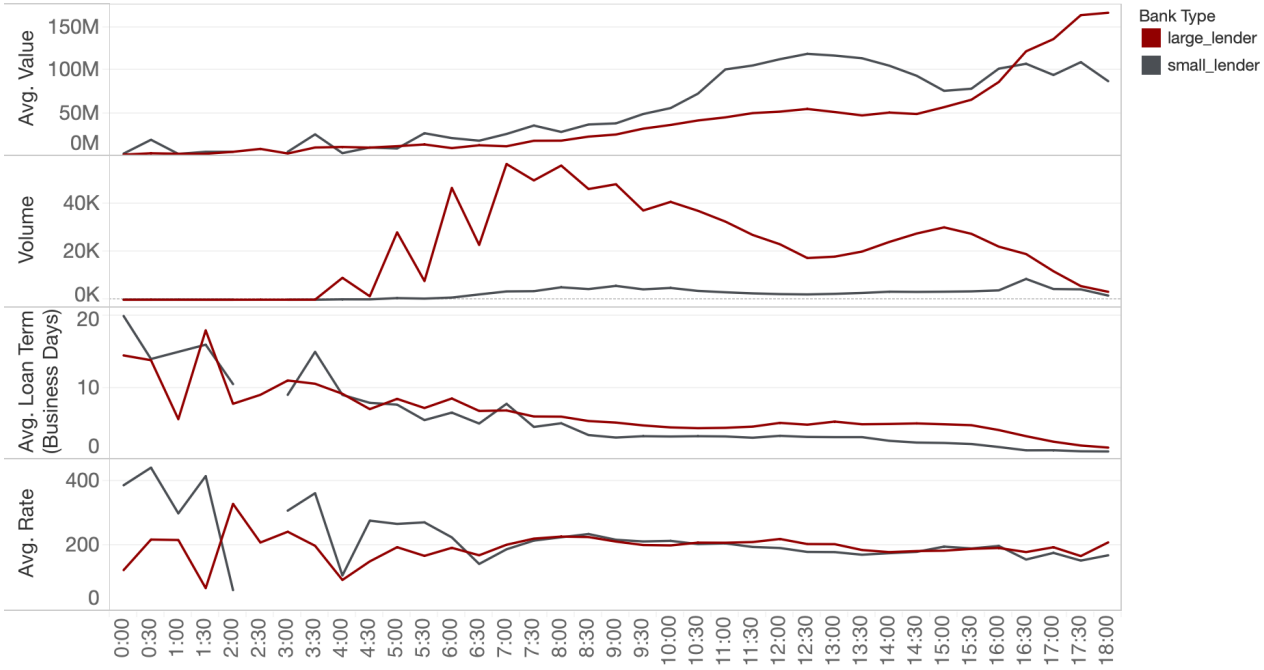

Figure 12 - Average advance value of overnight market throughout the hours of operation (Small vs. Large Participants)

5. Conclusion

The aim of this research paper was to produce a series of stylized empirical facts about the overnight loan market activity in the Canadian high-value payment system. From a historical perspective, we shed light on overnight loan activity during the financial crisis of 2008–2009 as well as draw contrasts with the current crisis. The exploration of the intraday loan market relied on the overnight loan dataset identified using the Furfine algorithm. For the 2004–2020 period, we located 885,812 overnight loans, which account for 7.5% of the payments in the original transaction-level dataset. We find that 99% of all overnight loan activity between 15 participating institutions takes place in Tranche 2.

Based on our analysis, we observe sharp differences in the overnight market activity between large and small banks. Specifically, we find that large banks tend to lend higher volumes but the average value of a loan is usually lower, whereas small banks generally lend lower volumes but at a higher average value. The higher frequency of loans given by large participating institutions is stimulated by lower interest rates. We find that the interest rate set by the large banks is not only lower than smaller banks but also tends to be lower than the target rate. During financially stable times, specifically during the period of time between 2011 and 2019, the large banks' interest rates are the lowest of all. It is important to note that both types of institutions participate in both sides of the overnight market. However, small banks on average tend to lend more often than they borrow, whereas large financial institutions borrow more frequently than they lend.

In the immediate aftermath of the global financial crisis, we find a sharp initial drop in market activity. The overnight loan volume declined by more than 84% compared to pre-crisis levels. The average loan term increased by approximately 2 days. Due to the lowered overnight market activity, the average spread between the overnight rate paid for a loan and the Bank of Canada target rate jumped during 2008–2010. Overnight lending volume has rebounded since the 2008 crisis. However, it did not reach its historical levels of activity. After the 2008 recession and the policies implemented, the liquidity levels were higher than they were historically, and there was no need to remain as active in the overnight loan market as before. Once excess liquidity became available, banks started lending cash below the target rate, which resulted in a negative spread.

Our empirical results show that overnight lending activity during the COVID-19 crisis followed a trend very similar to that of the global financial crisis. However, this time, the decline in activity exceeded the decline observed during other crises. The lending volume dropped by more than 90% and the average term of loans doubled from 7 days to more than 14 days. The average spread level reached 13 basis points in some cases, which is more than two times higher than it was during the financial crisis of 2008/2009.

Lastly, we observe that the overnight loan market advances pre-4 PM, pre-dating CDSX settlement and end-of-day settlement. Specifically, the majority of loans take place in the morning, with a peak just shortly after the start of CDCC settlement (7:00 AM ET). Once the CLS same-day settlement occurs, the overnight loan volume has its second-highest peak at around 3:00 PM ET. We find that the higher number of low-value loans takes place in the morning, and a lower number of high-value loans take place in the afternoon and close to the end-of-day settlement timeslot. Additionally, we conclude that small institutions tend to participate in the market more

actively earlier in the day, specifically in the morning and afternoon, whereas large banks are more active later in the day and after the end-of-day settlement.

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7. Appendix

Figure 13 : Summary statistics, Large vs. Small banks

```
> summary(large_participants)
  advance_date            volume          value             loan_term           rate
 Min.   :2004-01-02   Min.   :  2.0   Min.   :  7077111   Min.   : 1.000   Min.   : 25.00
 1st Qu.:2008-04-01   1st Qu.:120.0   1st Qu.: 32753040   1st Qu.: 6.387   1st Qu.: 67.84
 Median :2012-06-28   Median :169.0   Median : 39074161   Median : 7.658   Median : 96.45
 Mean   :2012-06-29   Mean   :185.5   Mean   : 40935914   Mean   : 8.160   Mean   :156.24
 3rd Qu.:2016-09-27   3rd Qu.:254.0   3rd Qu.: 46956156   3rd Qu.: 9.367   3rd Qu.:226.19
 Max.   :2020-12-30   Max.   :584.0   Max.   :260600000   Max.   :21.379   Max.   :457.67
> summary(small_participants)
  advance_date            volume          value             loan_term           rate
 Min.   :2004-01-02   Min.   : 1.00   Min.   :  1093000   Min.   : 1.000   Min.   : 25.00
 1st Qu.:2008-03-19   1st Qu.:16.00   1st Qu.: 50654816   1st Qu.: 2.750   1st Qu.: 70.77
 Median :2012-06-16   Median :21.00   Median : 71196986   Median : 4.109   Median : 98.53
 Mean   :2012-06-13   Mean   :21.57   Mean   : 74207038   Mean   : 4.843   Mean   :157.81
 3rd Qu.:2016-08-31   3rd Qu.:27.00   3rd Qu.: 94716711   3rd Qu.: 5.765   3rd Qu.:227.83
 Max.   :2020-12-30   Max.   :56.00   Max.   :500000000   Max.   :30.000   Max.   :462.71
```

Figure 14 : Summary statistics, pair types

```
$large_to_large
  advance_date         pair_type            volume          value             loan_term           rate
 Min.   :2004-01-02   Length:4282        Min.   :  2.0   Min.   :  6298838   Min.   : 1.000   Min.   : 25.00
 1st Qu.:2008-04-01   Class :character   1st Qu.:107.0   1st Qu.: 30953030   1st Qu.: 6.683   1st Qu.: 67.43
 Median :2012-06-28   Mode  :character   Median :152.0   Median : 37666293   Median : 7.969   Median : 96.21
 Mean   :2012-06-29                      Mean   :167.9   Mean   : 39929732   Mean   : 8.446   Mean   :156.21
 3rd Qu.:2016-09-27                      3rd Qu.:232.0   3rd Qu.: 45691960   3rd Qu.: 9.695   3rd Qu.:226.22
 Max.   :2020-12-30                      Max.   :536.0   Max.   :303666667   Max.   :21.379   Max.   :457.70

$large_to_small
  advance_date         pair_type            volume          value             loan_term           rate
 Min.   :2004-01-02   Length:4226        Min.   : 1.00   Min.   :1.002e+06   Min.   : 1.000   Min.   : 25.00
 1st Qu.:2008-03-11   Class :character   1st Qu.:12.00   1st Qu.:3.533e+07   1st Qu.: 3.185   1st Qu.: 69.79
 Median :2012-05-23   Mode  :character   Median :17.00   Median :4.619e+07   Median : 4.702   Median : 99.12
 Mean   :2012-05-24                      Mean   :17.77   Mean   :5.270e+07   Mean   : 5.490   Mean   :157.91
 3rd Qu.:2016-08-04                      3rd Qu.:23.00   3rd Qu.:6.194e+07   3rd Qu.: 6.808   3rd Qu.:228.97
 Max.   :2020-12-11                      Max.   :61.00   Max.   :1.562e+09   Max.   :30.000   Max.   :462.35

$small_to_large
  advance_date         pair_type            volume          value             loan_term           rate
 Min.   :2004-01-02   Length:4243        Min.   : 1.00   Min.   :  1093000   Min.   : 1.000   Min.   : 25.00
 1st Qu.:2008-03-18   Class :character   1st Qu.:15.00   1st Qu.: 50583500   1st Qu.: 2.800   1st Qu.: 70.60
 Median :2012-06-14   Mode  :character   Median :20.00   Median : 72586909   Median : 4.190   Median : 98.62
 Mean   :2012-06-11                      Mean   :20.52   Mean   : 75427911   Mean   : 4.970   Mean   :157.82
 3rd Qu.:2016-08-29                      3rd Qu.:26.00   3rd Qu.: 97264620   3rd Qu.: 5.909   3rd Qu.:228.08
 Max.   :2020-12-30                      Max.   :55.00   Max.   :500000000   Max.   :30.000   Max.   :462.71

$small_to_small
  advance_date         pair_type            volume          value             loan_term           rate
 Min.   :2004-01-06   Length:2625        Min.   :1.000   Min.   :  1008000   Min.   : 1.000   Min.   : 25.0
 1st Qu.:2007-10-18   Class :character   1st Qu.:1.000   1st Qu.: 22500000   1st Qu.: 1.000   1st Qu.: 78.0
 Median :2012-05-31   Mode  :character   Median :1.000   Median : 43500000   Median : 1.000   Median :100.0
 Mean   :2012-05-09                      Mean   :1.724   Mean   : 54140561   Mean   : 2.517   Mean   :169.9
 3rd Qu.:2016-09-21                      3rd Qu.:2.000   3rd Qu.: 70018333   3rd Qu.: 3.000   3rd Qu.:250.0
 Max.   :2020-11-17                      Max.   :7.000   Max.   :889200000   Max.   :30.000   Max.   :460.0
```

Figure 15 : Hourly distribution of average value based on different pair types

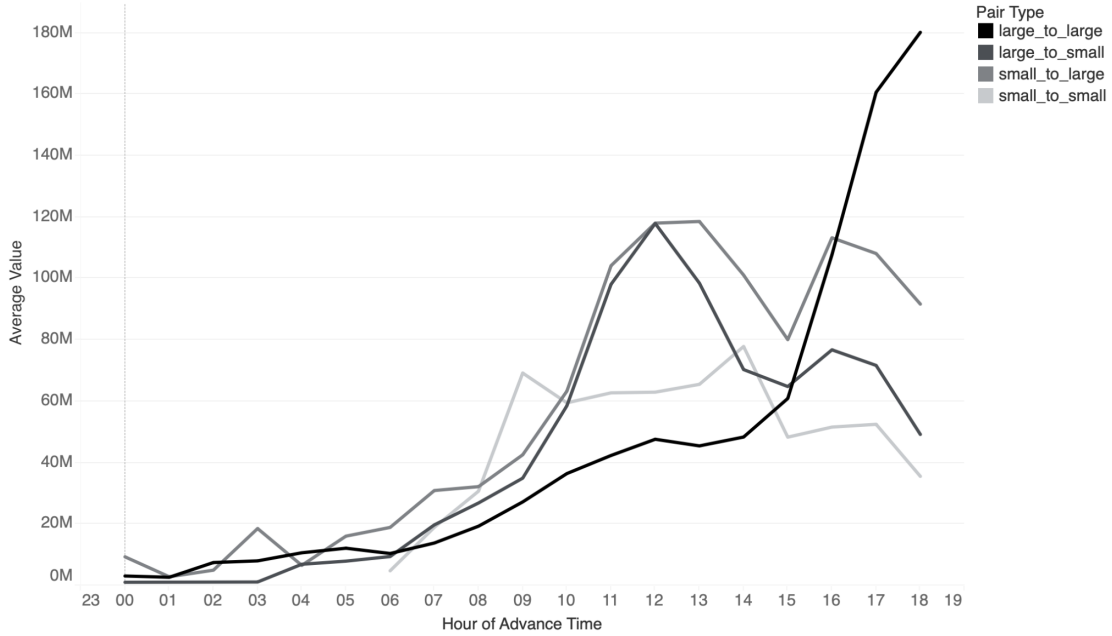

Figure 16 : Hourly distribution of average volume based on different pair types

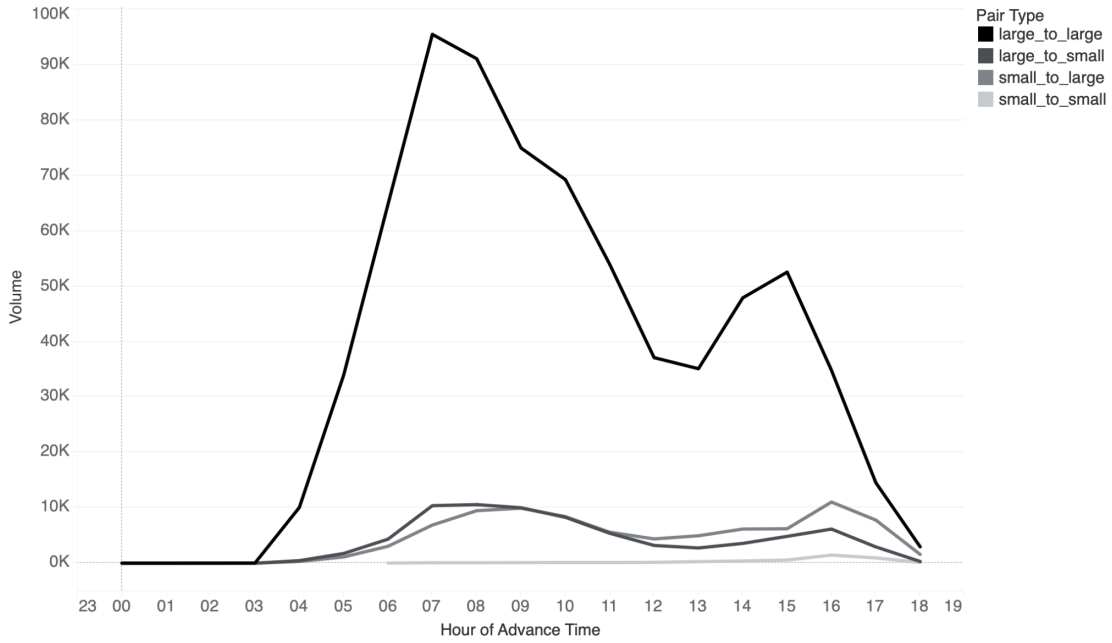

Figure 17 : Hourly distribution of average loan term based on different pair types

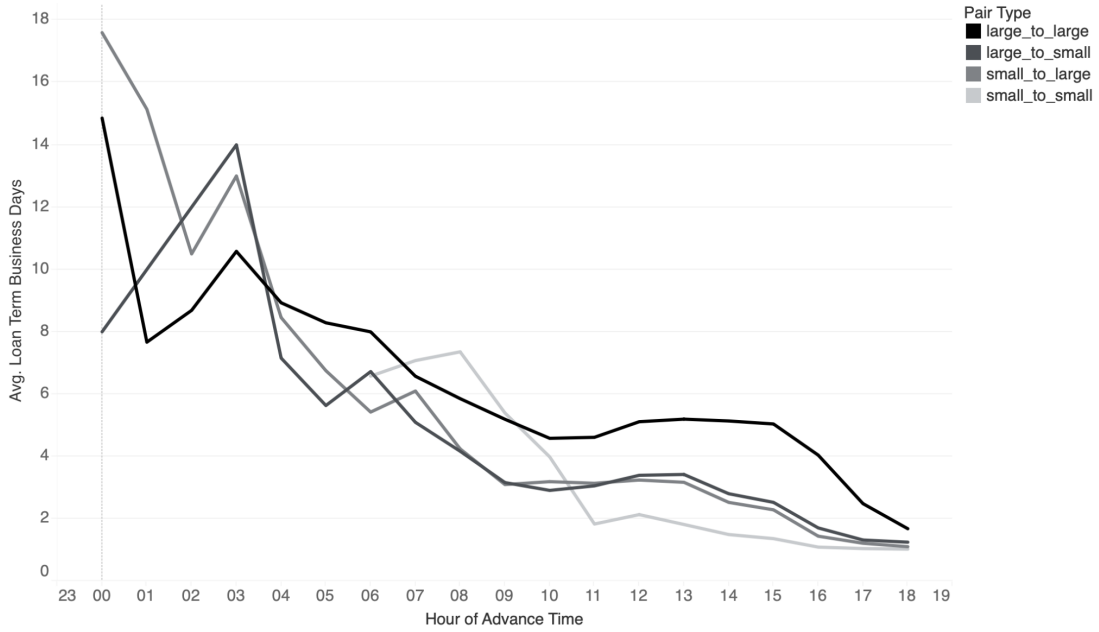

Figure 18 : Hourly distribution of average overnight interest rate based on different pair types

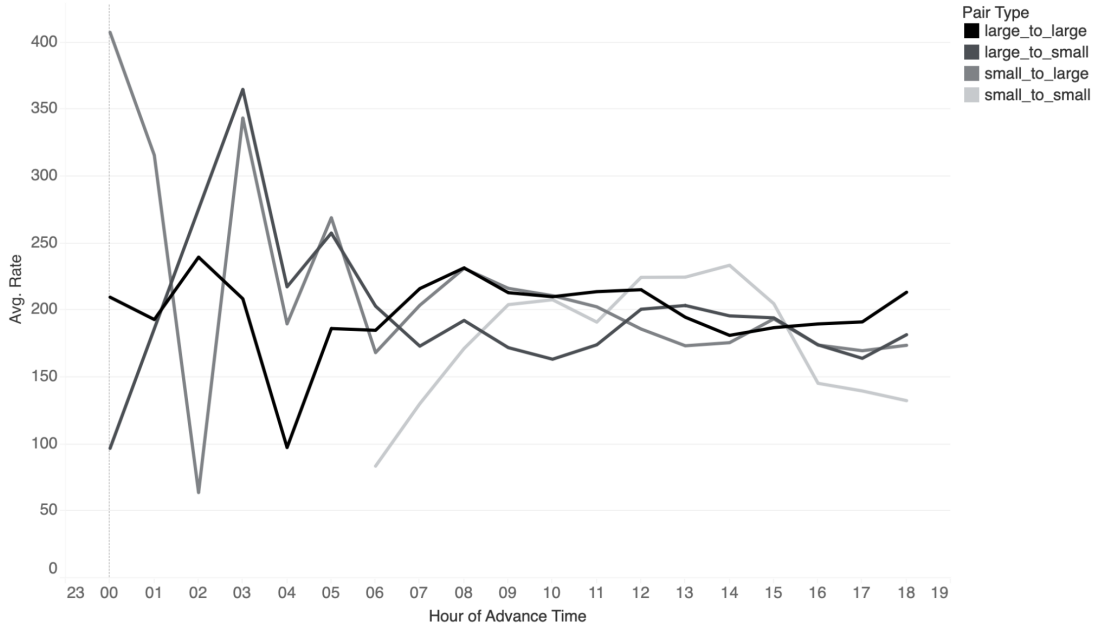

Figure 19: Intraday profile of LVTS clearing volume in dollars: 30 minute intervals
Shaded area reflects distance between 10th and 90th percentiles.

Note: Median volume of BoC payments incoming and outgoing measured in dollars over 30-minute time intervals based on April 2018 to October 2019 inclusive. Source: LVTS extract 8.

Figure 20: Average Loan Term throughout the years