Corporate Bond Markets: Liquidity Determination and Overview

Analytics
Investment Industry Regulatory Organization of Canada

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1. Introduction

The Investment Industry Regulatory Organization of Canada (IIROC) is the national self-regulatory organization that oversees all investment dealers and trading activity on debt and equity marketplaces in Canada. In 2016, the Canadian Securities Agency (CSA) designated IIROC to be the information processor (IP) for debt markets in Canada (IIROC 2016, OSC 2015). As the designated IP, IIROC provides post-trade transparency on corporate issues on a T+2 basis to increase transparency and market integrity in Canadian debt markets without negatively impacting liquidity. The implementation of post-trade transparency of corporate bond trading is in two phases[1]:

- Phase 1 – Beginning July 6, 2016 all retail trades were reported; institutional trades were reported on a designated subset of liquid bonds.
- Phase 2 – Beginning July 1, 2017 all retail and institutional trades were reported for all bonds.

In this paper, we outline the method we developed to identify liquid vs. non-liquid bonds for the purpose of Phase 1. The methodology may potentially be used for surveillance and analysis of the Canadian debt market.

An asset is considered liquid if it can be purchased or sold quickly without causing a significant change in its price. Liquid financial assets have small transaction costs, trade easily, settle on time, and large trades have a limited impact on the market price (IMF 2011). Additionally, liquid markets exhibit the following five characteristics:

1) tightness, referring to low transaction costs (e.g. bid-offer spread)
2) immediacy, indicating the speed with which an order can be executed, and reflecting trading efficiency
3) depth, quantifying the existence of abundant orders at multiple prices above and below the current price of the asset
4) breadth, referring to orders that are both numerous and large in volume with minimal impact on prices
5) resiliency, reflecting the characteristic of markets in which new orders quickly correct order imbalances, returning prices to those warranted by fundamentals.

Given that liquidity cannot be reliably measured using any one metric, academic research and industry reports have focused on using multiple factors for liquidity determination. Fleming (2003) used principal component analysis across a number of factors to (1) determine those factors that contribute the most to explain variation in liquidity, and (2) track liquidity using first and second major principal components. The study shows that bid-offer spread is a useful measure for assessing and tracking liquidity while quote size and trade size are modest proxies for market liquidity. Bloomberg (2015) adopted a clustering technique - a machine learning approach to classify bond liquidity. The input factors include trade volume, fair asset value, bid-offer spread, price volatility, and turnover. The model outputs a number of

[1] IIROC receives trade information for government bonds, but does not disclose this information as part of Phase 1or 2.

liquidity indicators including time to liquidation, liquidity score, and market impact probability distribution. The method requires a labelled sample set, a sample of bonds with known input factors and known liquidity indicators to train the model. This model effectively leverages the granular trade and order-book level data available to an aggregator such as Bloomberg, but is not feasible with partial datasets such as the one available to IIROC.

We propose an alternative model for corporate bond liquidity determination that leverages the characteristics of the bond and certain trade metrics in order to rank corporate bonds. Our results show that the proposed model effectively segments corporate bond issues by liquidity when evaluated in aggregate against liquidity metrics such as bid-offer spreads and price impact. We begin by providing an overview of trading in the Canadian fixed-income market. We then introduce our model inputs and present our final liquidity determination model and results.

2. Overview of Canadian Corporate Bond Trading Activity

i. Market structure and data

In Canada, bonds trade primarily on over-the-counter (OTC) markets either directly between dealers or on intermediary dealer trading platforms. Trading occurs mostly on quote-driven systems and execution is over the phone (OSC 2014). Non-electronic execution accounts for approximately 70% of the volume. In addition, Canadian bond markets are concentrated with the top 10 broker-dealers conducting an estimated 93% of total trading activity. The following factors may account for the dominance of the OTC model in bond markets (OSC 2014, BIS 2013):

1) A large number of unique and non-standard bonds – natural supply and demand benefit from intermediation
2) Prevalence of buying and holding over the term of the bond, especially towards the maturity date of the bond
3) Dominance of large volume orders by institutional investors – intermediation results in less price impact

To support our oversight of debt trading in Canada, IIROC requires dealers to submit trade-level data on a T+1 basis. Beginning in November 2015, dealers who are Government Securities Distributors (GSDs) , began submitting data to IIROC. Trading by GSDs represents the majority (greater than 99%) of the total Canadian debt trading flows. The trade data includes the trade date, security ID, execution price and volume[2]. The dataset covers all bonds, including corporate bonds, regional government bonds and Canadian treasuries[3].

[2] Additional relevant fields include: counter party identity information, reporting dealer and client information, electronic trading flag, and primary trading flag, etc.
[3] Other types include: euro bond, asset-based securities, and foreign sovereign bonds, etc.

ii. Corporate bond trading

In this section we provide an overview of trading activity in the Canadian corporate bond market using trading data from January to December 2016. To do so, we compare a subset of liquid bonds as identified using our liquidity determination model ("liquid bonds") that we describe in section 3 against the other bonds ("non-liquid bonds"). This overview elaborates on the characteristics of Canadian corporate bond markets already noted in previous work (OSC 2014).

Government bonds represent the majority of the overall trade volume (see figure 1):

- sovereign/federal government bonds represent more than 60%
- regional government bonds represent 9%

Corporate bonds trade a smaller portion of the overall volume:

- bank company securities represent 9%
- non-bank corporate bonds represent 2%

The rest of this section discusses trading in corporate bond issues in Canada. We provide similar statistics on government-issued bonds in the appendix.

As expected, liquid bonds as a group represent a greater number of unique bonds, number of trades, trade volume measured in par value[4] and turnover (see figures 2-5). Investment grade[5] bonds represent greater than 90% of trading in both liquid and non-liquid categories (see figure 6).

We see minimal participation by retail investors in the Canadian corporate bond markets. Figures 7-8 compare retail vs. institutional trades. Institutional trading represents 97% of activity (when measured by trade volume) on both liquid and non-liquid securities. When measured by number of trades, the retail group trades a larger percentage - 75% and 39% for liquid and non-liquid respectively. This is consistent with the view that retail participation is minimal. Further, retail trades are usually for smaller trade sizes (see figure 9).

Figure 10 shows the liquidity characteristic of corporate bonds over time, beginning with the week a bond is issued. Using trade volume as a proxy for liquidity, we observe that liquidity is highest within the first week of issuance. Within four weeks of issuance we see a 90% decay in liquidity.

Table 3 and Figure 11 (section 3.4) show transaction costs and price impact measures for liquid and non-liquid bonds. Mean bid-offer spreads for liquid bonds range from 15 to 53 cents, while price impacts range from 4 to 8 cents. For illiquid bonds, bid-offer spreads range from 23 to 85 cents, while price impacts range from 11 to 12 cents. We provide range values since these measures are estimated using different models.

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[4] Par value is the face value of a bond.
[5] Bond grades use S&P rating.

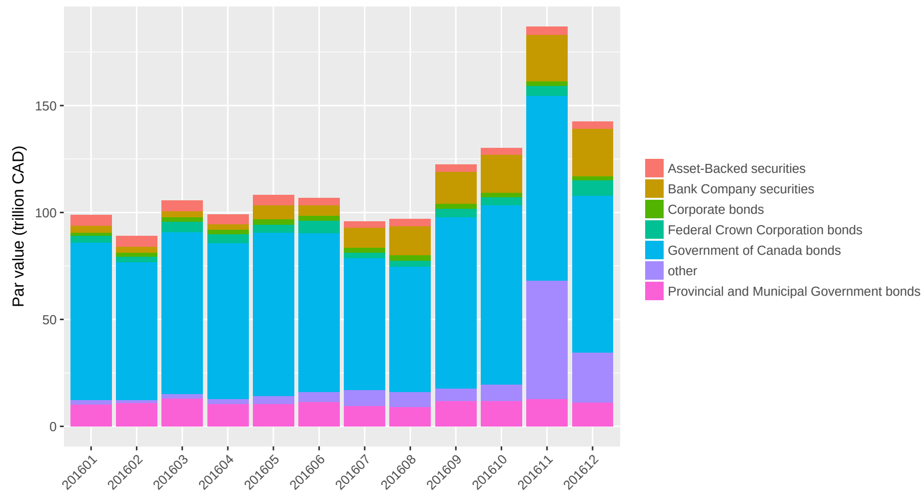


Figure 1. Monthly average trade volume (par value) split by instrument type.

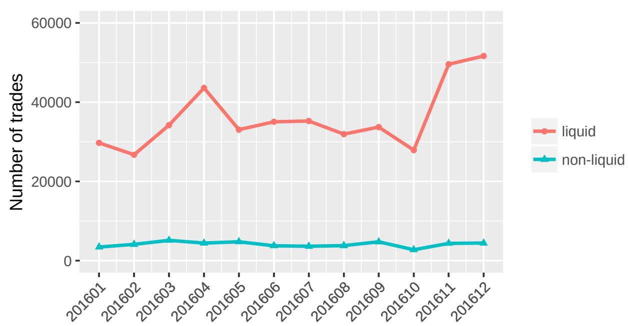


Figure 2. Number of trades split by liquid vs. non-liquid bonds. Liquid bonds trade more often than non-liquid bonds (approximately 10 times more on average).

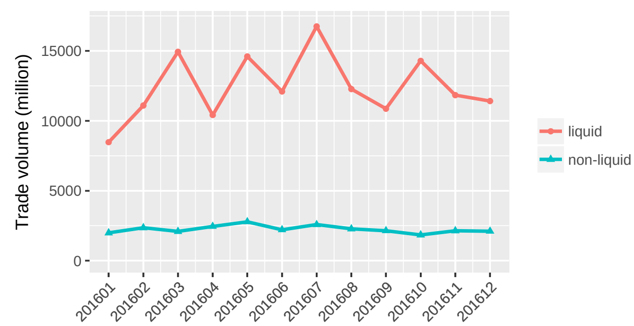


Figure 3. Trade volume (par value) split by liquid vs. non-liquid bonds. Liquid bonds trade more volume than non-liquid bonds (approximately 4.5 times more on average).

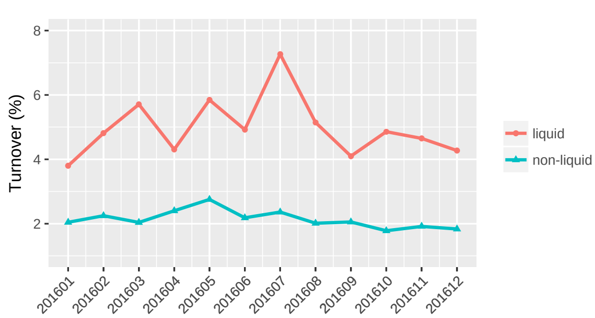


Figure 4. Daily average turnover split by liquid vs. non-liquid bonds. Liquid bonds have a larger turnover than non-liquid bonds (approximately 3.5 times larger).

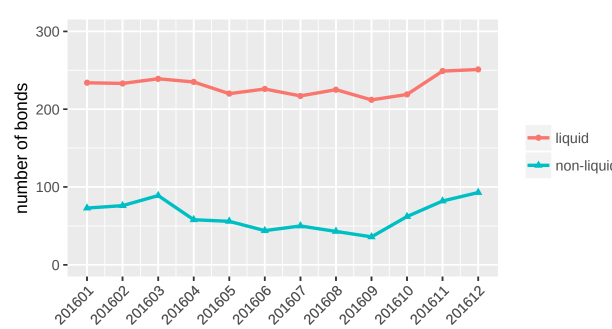


Figure 5. Daily average number of unique bonds traded split by liquid vs. non-liquid. As expected, more than twice as many different liquid bonds trade each day compared to non-liquid bonds.

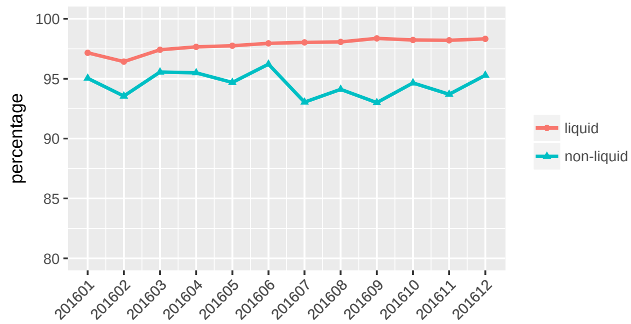
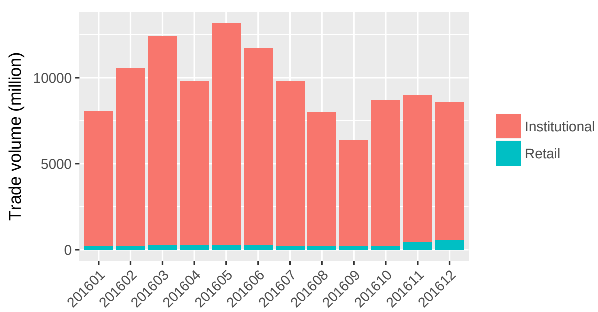
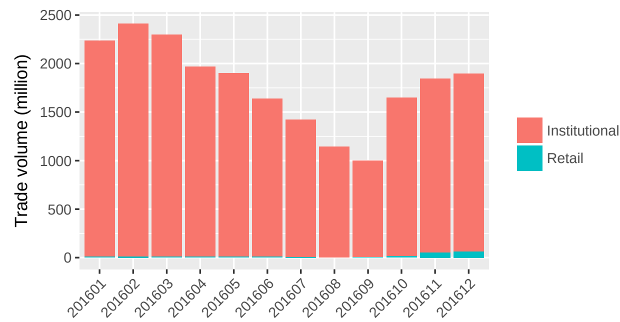


Figure 6. Daily average percentage of investment grade bonds traded split by liquid vs. non-liquid. Most trading is in investment grade bonds (both liquid and non-liquid). Both liquid and non-liquid bonds have a high percentage of investment bonds traded (higher than 90%).

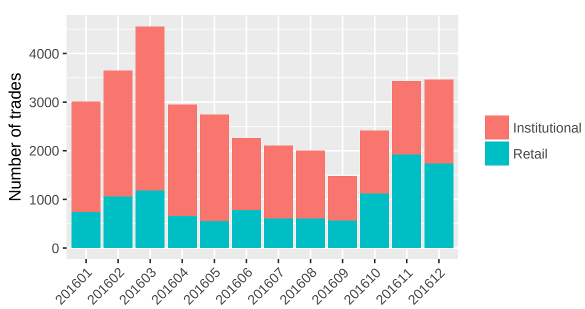


A. liquid bonds

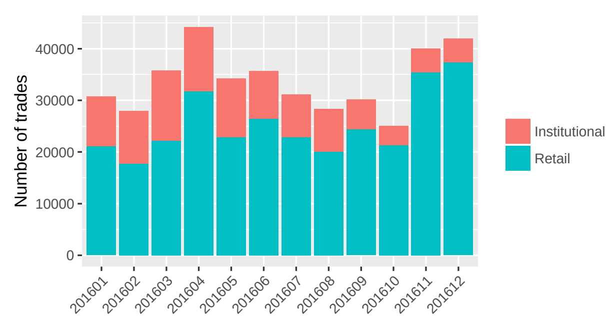


B. non-liquid bonds

Figure 7. Trade volume (par value) split by retail vs. institutional clients. On average, institutional trades are 97% and 99% of the total liquid trade volume in liquid bonds and non-liquid bonds respectively.

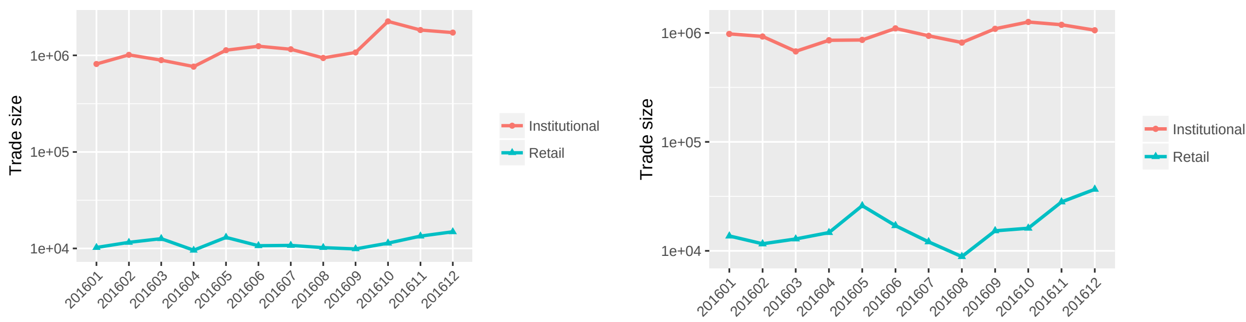


A. liquid bonds



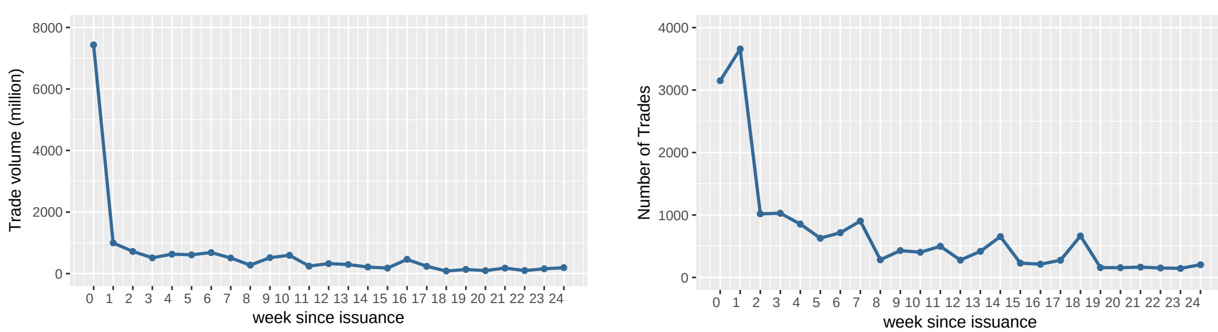
B. non-liquid bonds

Figure 8. Number of trades split by retail vs. institutional clients. On average, institutional trades are 50% and 20% of the total number of trades in liquid and non-liquid bonds, respectively. When we consider Figure 7 A, we can deduce that retail typically trades a large number of small size transactions, compared to institutional. Retail trades are a smaller percentage of liquid bond trades compared to non-liquid bond trades.



A. liquid bonds B. non-liquid bonds

Figure 9. Comparison of average trade size split by retail vs. institutional. For both liquid and non-liquid bonds, institutional trades are far larger than retail trades, with average institutional trade sizes over 1 million versus retail trade sizes over 10,000.



A. trade volume B. number of trades

Figure 10. Liquidity decay: A. weekly trade volume (par value); B. Weekly number of trades for newly issued bonds. Using trade volume as a proxy for liquidity, we observe that the liquidity is at its highest level in the week the bond was issued. By week four, liquidity decays to less than 10% of the liquidity in the week the bond was issued. The number of trades decreases significantly by week two, and continues to decline over time.

3. Liquidity Determination Model

The IIROC liquidity determination model is based on an equally-weighted ranking of key input factors. The steps in developing the liquidity determination model are as follows:

1. Metrics and factor selection: We identify a set of input metrics and liquidity indicators (evaluation metrics) based on previous related work and input from industry stakeholders and practitioners. Using principal component analysis (PCA) [6], we identify a subset of these metrics as input to our liquidity determination model. Sections 3.1 and 3.2 present a detailed overview of this step.
2. Equal-weighted ranking: For each bond, we compute Z-scores based on the value of each of the input factors. We then sum the Z-score for each factor to obtain a total score for every bond. Subsection 3.3 describes our methodology in detail.
3. Evaluation: We validate our model using two metrics (bid-offer spread and price-impact) and evaluate the top 50% of the ranked list versus the bottom 50% of the list. The results are outlined in subsection 3.4 and shows that liquid bonds (as determined by the model) tend to have tighter bid-offer spreads and lower price impact, as expected.

i. Metrics and factor selection

Model input metrics

Turnover

Where quote data is available, depth of book can be quantified to measure the market participants' willingness to trade. Due to lack of quote data, we use the total traded volume (par value) as the proxy for the depth measure. The traded value is then normalized relative to the outstanding issues to calculate the turnover ratio as follows:

$$turnover = \frac{total\ trade\ volume}{outstanding}$$

Higher turnover tends to indicate higher liquidity. However, one should interpret this metric with caution because the traded value may be highly correlated with market volatility and macro-economic events.

Number of days traded

This metric quantifies the number of dates a bond has traded. A higher number of days traded indicates that a bond is more active, and thus more liquid. One shortcoming of this metric is that it does not distinguish the trade volume (par value) or number of trades. For example, a bond that usually traded once per day with a total traded volume of $1,000 could have the same number of trading days as a

[6] PCA reveals the internal structure of the data in a way that best explains the variance in the data. It uses an orthogonal transformation to convert a set of possible correlated variables into a set of linearly uncorrelated variables. The first principal component is calculated such that it accounts for the greatest possible variance in the data set, and each succeeding component accounts for the next highest variance under the constraint that it is orthogonal to the preceding components (Jolliffe 1986).

bond that usually traded 1000 times per day with a total traded volume of $1,000,000. Despite this caveat, this metric is effective in measuring trading interest and is therefore a good candidate to be an input factor to the model.

Counterparty breadth

This metric quantifies the daily average number of unique counterparties to the reporting dealer. A larger value indicates broader interest.

Outstanding bond issue

Outstanding bond issue is a measurement of the par value of bond that is outstanding, and is the only metric used in this study not based on a measurement of trading activity. A large outstanding bond issue may indicate that quantities of the bond will be more readily available, and thus the bond is liquid.

Trade Volume (Par Value)

Trade volume is the par value traded.

Trade Value

Trade value is the par value multiplied by the price, divided by one hundred.

Trade Count

Trade count is the total number of transactions.

Liquidity indicators

Bid-Offer spread

The bid-offer spread is a transaction cost metric, measuring the difference between bid and offer quotes. In cases where quote data is not available, such as bond markets, we can estimate spreads using trade prices.

Roll (1984) estimates the effective bid-offer spread using the first-order serial covariance of price changes:

$$spread_{Roll} = 2\sqrt{-cov(R_i, R_{i-1})}$$

where:

$$R_i = \frac{price_i - price_{i-1}}{price_{i-1}}$$

is the time series of return. i is the time period for which the measure is calculated. If the covariance is negative, the observation is discarded. The intuition is that price bounces back and forth between the bid and the offer price, leading to a negative covariance between lagged return series.

Thompson (1988) estimates the spread as:

$$spread_{TW} = \begin{cases} |price_{t+1} - price_t|/price_t & if\ price_{t+1} \neq price_t \\ NA & otherwise \end{cases}$$

Here, bid-offer spread is calculated only when two successive prices are different.

In this study, we also estimate the spread as:

$$spread_{IIROC} = \begin{cases} (sell\ price_{t+1} - buy\ price_t)/buy\ price_t & if\ sell\ price_{t+1} > buy\ price_t \\ (sell\ price_t - buy\ price_{t+1})/sell\ price_t & if\ buy\ price_{t+1} < sell\ price_t \\ NA & otherwise \end{cases}$$

The sell and buy is from the dealer's perspective. We calculate the bid-offer spread only when the dealer's subsequent sell price is higher than previous buy price or subsequent buy price is lower than previous sell price. This metric attempts to measure the round trip gain for the dealers other than the price movement. It can also be viewed as the round trip cost for the counterparties who transaction against dealers.

Amihud illiquidity metric and price impact

Amihud (2002) proposed the Amihud liquidity metric to relate the price change and traded volume:

$$Amihud = \frac{1}{N}\sum_{i=1}^{N}\frac{|r_i|}{Q_i} = \frac{1}{N}\sum_{i=1}^{N}\frac{\left|\frac{price_i - price_{i-1}}{price_i}\right|}{Q_i}$$

where N is the number of returns on a given day; Q_i is the trade size (in millions); and r_i is the return. A smaller value of the Amihud metric indicates lower price fluctuations relative to trade size, and a more liquid asset.

We proxy price impact as:

$$PI = \frac{1}{N}\sum_{i=1}^{N} PI_i$$

where

$$PI_i = \begin{cases} (buy\ price_{i-1} - buy\ price_i)/buy\ price_{i-1} & for\ buy\ trades \\ (sell\ price_i - sell\ price_{i-1})/sell\ price_{i-1} & for\ sell\ trades \end{cases}$$

The PI is calculated for two trades in the same direction from dealer's perspective. We interpret price impact as the change in price offered by a dealer as their position in a bond changes.

ii. Factor selection

The correlation coefficients among the various liquidity measures are presented in Table 1. The table shows that metrics such as turnover and traded value, and breadth and trade count are highly correlated and thus one measure is a good proxy for the other. However, we prefer turnover to traded value or trade count as it reflects the normalized traded amount, which is a better metrics for cross-sectional comparison. In addition, a large number of small value trades by retail investors could inflate trade count.

Principal component analysis (PCA) provides an effective way of reducing the dimensionality of variables and analyzing the original variables' contributions in explaining the variance. In this study, we use PCA to present the factor effectiveness, similar to Fleming 2003. Results of the principal-components analysis for the corporate bonds are presented in Table 2. The eigenvalues of the principal components show that three components provide a good summary of the data, explaining 85 percent of the standardized variance. We observe that the first component measures variation in liquidity that is negatively related to trading activity measures, as it loads negatively on all factors that are positively related to liquidity. The factors that show the largest sensitivity to the first three principal components include: outstanding amount, turnover, days traded, and breadth. We choose these four factors as the inputs to our liquidity model as a result of this analysis.

Table 1. Correlation of Liquidity Measures for Corporate Bonds

The table presents the correlation matrix of liquidity measures (outstanding bond issue, turnover, days traded, breadth, trade volume, trade size, and trade count).

	outstanding	turnover	days traded	breadth	trade volume	trade size	trade count
outstanding	1	0.07	0.41	0.50	0.33	0.14	0.50
turnover	-	1	-0.03	0.18	0.83	0.50	0.08
days traded	-	-	1	0.69	0.04	-0.21	0.56
breadth	-	-	-	1	0.32	-0.04	0.74
trade volume	-	-	-	-	1	0.57	0.18
trade size	-	-	-	-	-	1	-0.08
trade count	-	-	-	-	-	-	1

Table 2. Principal-Components Analysis of Liquidity Measures for Corporate Bonds

The table presents the eigenvalue of the principal components and the sensitivity of liquidity measures (outstanding bond issue, turnover, days traded, breadth, trade volume, trade size, and trade count) to each principal component. Liquidity measures are normalized using $x_{norm} = (x - \bar{x})/s$, where $\bar{x}$ and s are the mean and the standard deviation of each measure.

	Principal Components						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Eigenvalue	2.82	2.32	0.80	0.43	0.35	0.20	0.10
Sensitivities							
outstanding	-0.66	-0.04	1.31	-0.49	-0.53	-0.003	0.36
turnover	-0.26	-0.83	-0.67	-0.36	-0.29	0.03	0.94
days traded	-0.43	0.21	-0.09	-0.29	-0.59	0.36	0.07
breadth	-0.35	0.09	-0.11	0.08	0.07	-0.53	-0.03
trade volume	-0.16	-0.32	-0.05	-0.13	-0.06	0.06	-0.42
trade size	-0.01	-0.24	0.15	0.26	0.22	-0.001	0.06
trade count	-0.15	0.06	-0.06	0.19	-0.13	0.14	-0.001

iii. Equal-weight ranking model

Liquidity is generally considered multi-faceted and cannot be reliably measured using any single metric. This is pronounced in the case of Canadian corporate bonds, where the majority of the bonds are not traded frequently. In this study, we develop an equal-weighted ranking model[7] using a set of liquidity measures to (1) measure liquidity by taking into account multiple factors and thereby construct a more reliable measure; and (2) reduce noise from trading activity anomalies.

The input factors include (1) outstanding issue; (2) quarterly turnover; (3) quarterly number of days traded; and (4) daily average breadth of counterparties. In order to normalize the model input, a Z-score[8] for each of the four bond metrics is calculated, and then added together with an equal weight assigned to each measure, for a total score for each bond. The Z-score measures the distance to the mean normalized by the standard deviation. For all of our input factors, a higher factor value (and equivalent Z-score) indicates higher liquidity. Thus, we are able to use the Z-score without inverting signs. Our model ranks the total score in descending order and categorizes the top 50% of all bonds as liquid and the bottom 50% as non-liquid.

We use the transaction costs metrics such as spread and price impact metrics as verification measurements instead of input factors to the model. This is because many bonds trade only a few times a day. The estimates of spread and price impact may not be reliable as they may capture fundamental price movements rather than short-term transaction costs.

iv. Results

We use the equal-weight ranking model to classify bonds' liquidity each quarter. The analysis below uses data from Q4, 2016.

Table 3 shows how we have evaluated the quality of our liquidity model. As expected, non-liquid bonds have higher average spreads and price impacts with high statistical significance. We present a visualization of these metrics in Figures 11 and 12.

4. Conclusion

We propose a multi-factor liquidity determination model for corporate bonds that relies primarily on trading metrics. We show that this model effectively ranks corporate bonds based on liquidity and is important in cases where common liquidity measures such as bid-offer spreads are not directly measurable due to a lack of data. This model determined which Canadian corporate bonds were subject to transparency requirements and may have additional applications in enhancing IIROC's surveillance and investigative functions.

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[7] In this study, we also experimented with non-equal weighted models (results not shown here). However, due to the limited data set (about one year's data), the in-sample optimized coefficients may not perform well when using future out-of-sample data. Therefore, we use the equal weighted model to determine liquidity.

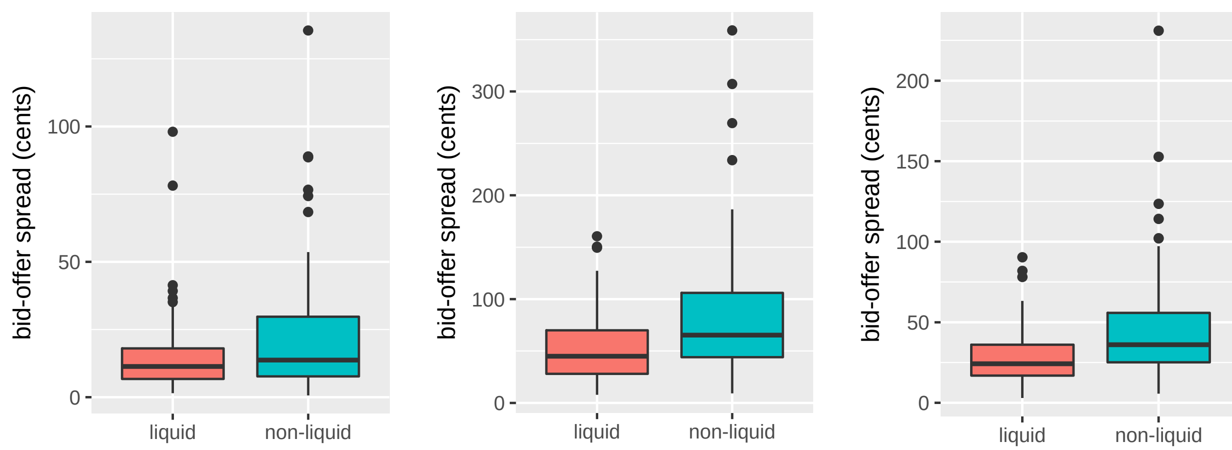
[8] The calculation of the z-score for the metric x uses $z = (x - \bar{x})/s$, where $\bar{x}$ and s are the mean and the standard deviation of the metrics.

Table 3. Evaluation indicator statistics.

This table presents the t-test of liquid and non-liquid bonds over spread and price impact measures (bid-offer spread estimated using IIROC, Thompson Waller, and Roll's methods, price impact and Amihud illiquid measure).

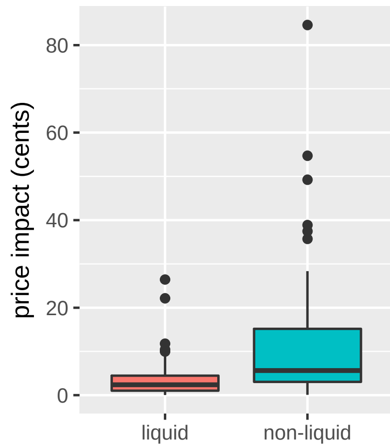
*/**/*** denote significance at the 10%/5%/1% level, respectively.

	liquid	Non-liquid	difference
bid-offer spread IIROC	14.9	23.1	8.2 (2.62**)
bid-offer spread Thompson Waller	28.1	47.1	19.0 (4.33***)
bid-offer spread Roll	52.5	85.1	32.6 (4.06***)
price impact	3.6	11.0	7.4 (4.68***)
Amihud illiquid measure	8.2	11.5	3.3 (2.33**)

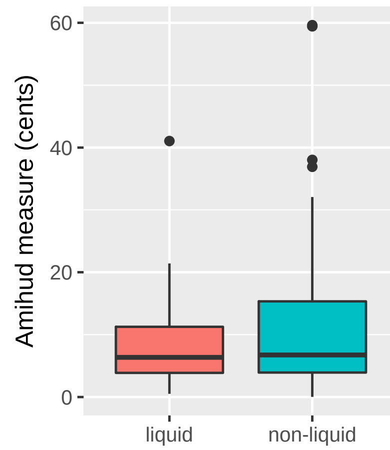


A. IIROC B. Roll C. Thompson Waller

Figure 11. Bid-offer spread liquidity indicator. As expected, liquid bonds have lower transaction costs as measured by spread compared to non-liquid bonds.



A. Price impact



B. Amihud illiquidity

Figure 12. Price impact and illiquidity measure. As expected, liquid bonds have lower transaction costs as measured by price impact compared to non-liquid bonds.

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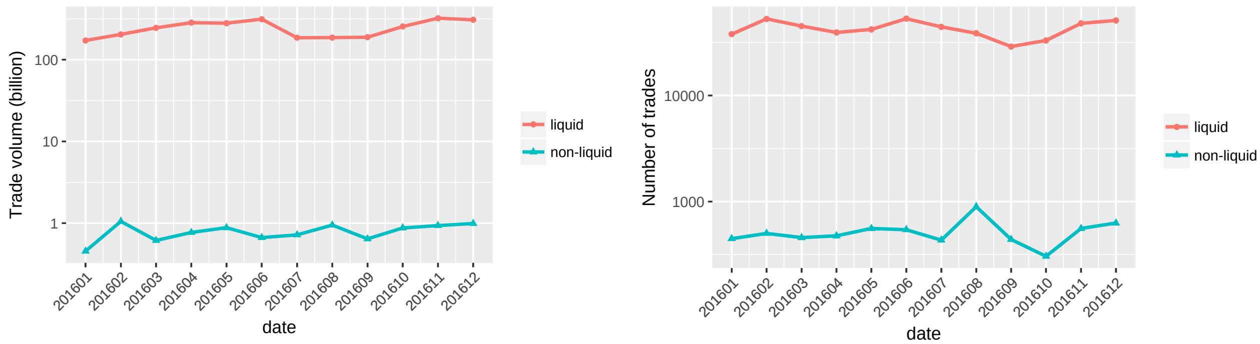
Appendix

Sovereign and Government Bond Trading



A. trade volume (par value) B. number of trades

Figure A.1. Trading activity split by liquid vs. non-liquid bonds. Liquid bonds trade much more often than non-liquid bonds.

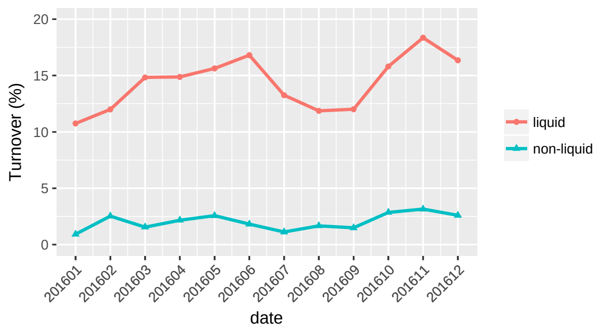


Figure A.2. Daily average turnover split by liquid vs. non-liquid bonds. Liquid bonds have a larger turnover than non-liquid bonds (approximately 5 times larger, on average).

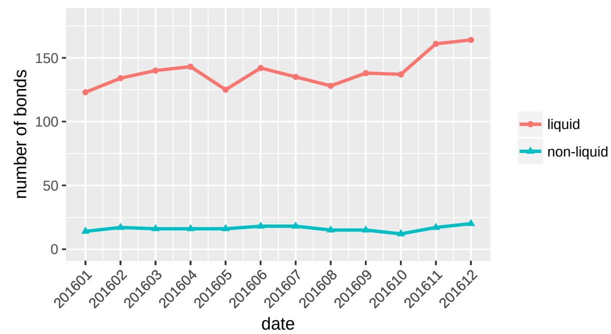


Figure A.3. Daily average number of unique bonds traded split by liquid vs. non-liquid. As expected, more unique number of liquid bonds trade each day compared to non-liquid bonds.

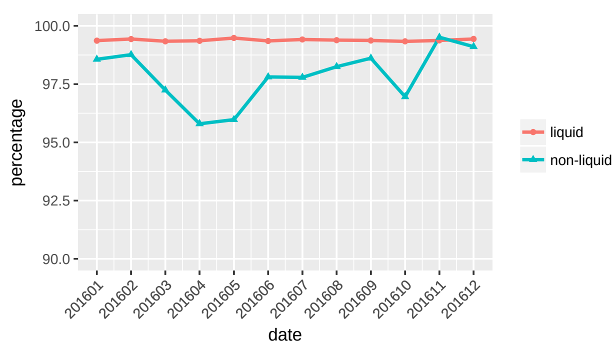
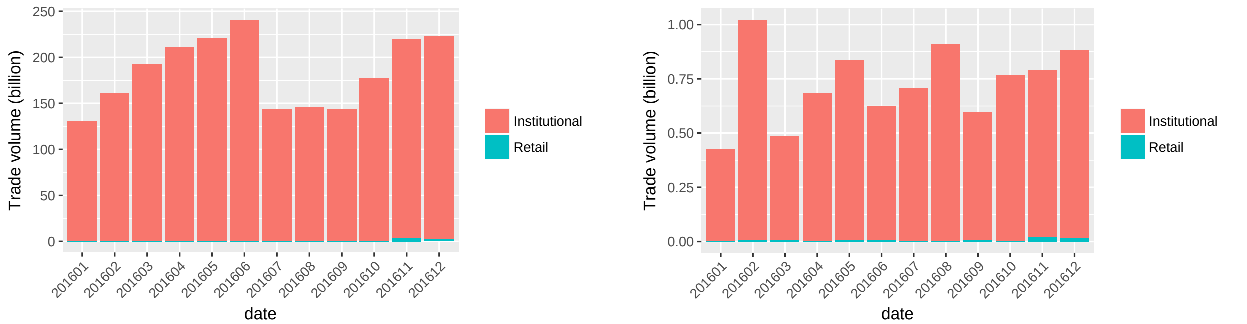
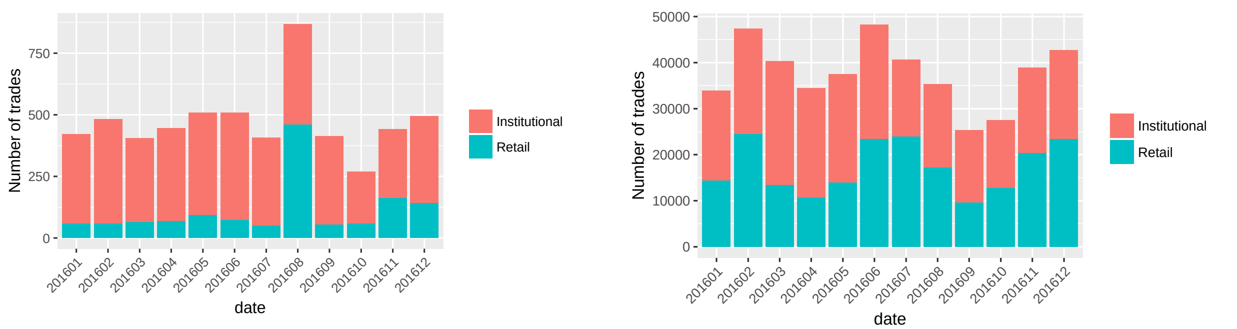


Figure A.4. Daily average percentage of investment grade bonds traded split by liquid vs. non-liquid. Most trading is in investment grade bonds (both liquid and non-liquid). Both liquid and non-liquid bonds have high percentage of investment bonds traded (higher than 95%).



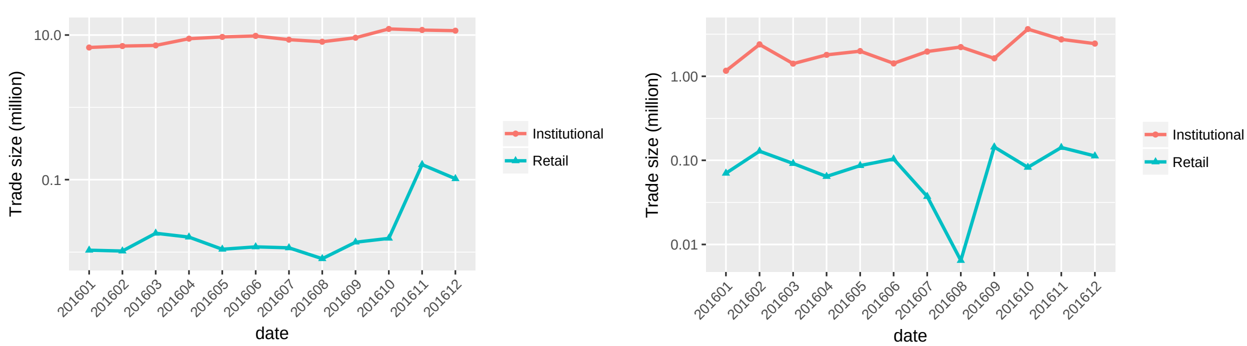
A. liquid bonds B. non-liquid bonds

Figure A.5. Trade volume (par value) split by retail vs. institutional clients. On average, institutional trades take 99% of the total liquid trade volume in both liquid bonds and non-liquid bonds.



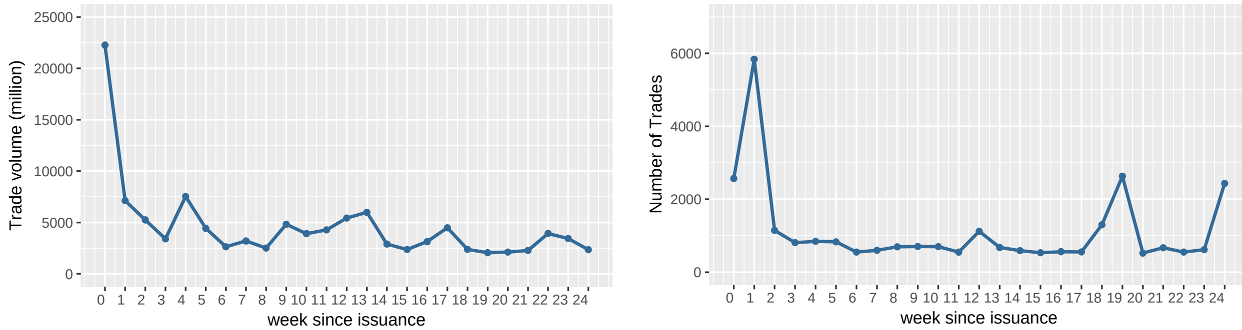
A. liquid bonds B. non-liquid bonds

Figure A.6. Number of trades split by retail vs. institutional clients. On average, institutional trades take 20% and 50% of the total number of trades in liquid and non-liquid bonds, respectively. When we consider Figure A.5.A, we can deduce that retail typically trades a large number of small size transactions, compared to institutional. Retail trades are a smaller percentage of liquid bond trades compared to non-liquid bond trades.



A. liquid bonds B. non-liquid bonds

Figure A.7. Comparison of average trade size split by retail vs. institutional. For both liquid and non-liquid bonds, institutional trades are much larger than retail trades.



A. trade volume B. number of trades

Figure A.8. Liquidity decay: A. weekly trade volume (par value); B. Weekly number of trades for newly issued bonds. Using trade volume as a proxy for liquidity, we observe that the liquidity is at its highest level in the week the bond was issued. By week four, liquidity decays to less than 10% of the liquidity in the week the bond was issued. The number of trades decreases significantly by week two, and continues to decline over time.