Corporate Bond Trading on a Limit Order Book Exchange

by

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This version: February 2017

Keywords: corporate bonds, trading costs, retail investors, short-term investors, bid-ask spreads, liquidity

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We thank an anonymous referee, Linda Allen, Yakov Amihud, Azi Ben-Rephael, Saul (Sam) Bronfeld, Andrew Ellul, Joseph Fan, Peter Feldhutter, David Gilo, Robby Goldenberg, Bernt Arne Odegaard, Sraya Orgad, Marco Pagano, Richard Payne, Gideon Saar, Ashok Thomas, Dimitri Vayanos, Kumar Venkataraman, Shlomo Zilca, seminar participants at Bar-Ilan University, Ben-Gurion University, Hebrew University, IDC Herzliya and Tel Aviv University, the participants in the Summer Finance Conference at IDC Herzliya 2014, the Erasmus Liquidity Conference 2015, the International Rome Conference on Money, Banking and Finance 2015, the Workshop on Corporate Bonds in Strasbourg 2016, European Finance Association (EFA) 2016, the 12th Annual Central Bank Workshop on the Microstructure of Financial Markets in Paris 2016 for helpful comments and suggestions. We thank the Tel Aviv Stock Exchange for providing the trading data. We thank valuation.co.il and Eran Ben-Horin for providing corporate bond data. We thank the Maurice Falk Institute for Economic Research in Israel for financial support. Wohl thanks the Henry Crown Institute of Business Research in Israel for its financial support.

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Abstract

We study the case of the Tel Aviv Stock Exchange, where corporate bonds (c-bonds) are traded in a limit order book in the same way as stocks. Contrary to the OTC market in the US, the TASE c-bond market is liquid with narrow spreads, low price dispersion, small short-term trader (STT) rents and unconcentrated STT activity (a low Herfindahl index). The low concentration is related in the cross-section of bonds to the low spreads, low price dispersion and small STT rents. The non-STT (including retail investors, whose participation is significant) compete with the STT on quotation and tend to tighter quotes. As takers, the retail investors do not impose adverse selection costs on the maker side, enabling narrower spreads. Using simultaneous equations we estimate that a difference of 1% in retail participation is negatively related to a change of 7.4% in bond spread.

1. Introduction

Corporate bonds (hereafter c-bonds) are mostly traded worldwide in over-the-counter (OTC) markets while stocks are mostly traded by an open limit order book (LOB) on exchanges. The c-bond OTC market in the US is illiquid (see Table 1, which summarizes empirical findings regarding the c-bond market and municipal bond market in the US). For example, Harris (2015) estimates c-bond customer costs as roughly 0.5%.[1] This figure is much higher than the volume-weighted average of the half quoted spread for US stocks, which is less than 0.02%.[2] This is quite puzzling because c-bonds should be more liquid than stocks due to their lower price variability (which makes liquidity provision less risky) and the lower degree of information asymmetry (Biais and Green, 2007).

Several researchers claim that the OTC mechanism is problematic and should be replaced by an LOB. For example, Harris, Kyle and Sirri (2015) suggest a reform in the spirit of the NASDAQ reform of the 1990s that requires dealers to post their customers' limit orders. In this context, O'Hara, Wang and Zhou (2016, hereafter OWZ (2016)) cite Rick Ketchum, CEO and chairman of FINRA, who says "*It strikes me as odd that we've spent enormous energy in equity markets to measure and save pennies or just basis points on execution quality, while in the fixed income market it's more a question of nickels, quarters and dollars.*"[3] Biais and Green (2007) find that until the 1940s bond trading was quite active on the NYSE and the trading costs of retail investors were lower than today, and conclude that the bond market in the US may have reached an inefficient equilibrium of OTC dominance. The reason is that if one market is liquid and a second market is potentially more efficient but currently

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[1] Biais and Declerck (2013) find lower effective spreads in Europe than in the US but their c-bond sample includes only large market-cap bonds.
[2] Based on CRSP data of monthly bid and ask prices of stocks during 2014 (share codes 10 or 11).
[3] FINRA (Financial Industry Regulatory Authority) is a private entity that acts as a self-regulatory organization.

illiquid, it is not optimal for each trader individually to deviate from the equilibrium and move to the currently less liquid market.[4]

This paper investigates the case of the Tel Aviv Stock Exchange (hereafter TASE), where c-bonds and government bonds have been traded for many years by the same open LOB system as stocks and with no competing exchanges, dark pools, etc. The Israeli c-bond market is quite small (~$80 billion at the end of 2014) and isolated (foreign holdings of 0.9% during 2014 – see Sub-section 2.2). Thus, one would expect it to be illiquid. Nevertheless, we find it to be a lively market with many transactions per bond-day, very little off-exchange trading and low spreads, which are lower than the comparable numbers in the US.

From the time the TASE was established in 1953, bonds have been traded like stocks. At first, the exchange offered a daily auction in each of its securities (stocks and bonds). Since the market was extremely small, there was no room for the less operationally efficient OTC mechanism. Later, the market expanded dramatically but by then the exchange trading (of stocks and bonds) was already established. This history is in line with Biais and Green's (2007) statement that a market can reach different potential equilibria. It appears that in Israel bond trading reached a different equilibrium than in other countries.

Our sample period is 2014 and we investigate 402 c-bonds denominated in NIS (New Israeli Shekels), of 143 firms, with a minimum market value of at least 100 million NIS each (approximately $28 million during 2014).[5] The market cap of these bonds was 95.3% of the TASE c-bond market cap. We use a unique and proprietary database of the TASE that includes transaction records with trader identification. The database does not include the trader's classification (for example, retail, institutional

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[4] See Duffie (2012).
[5] During 2014 $1 was equal on average to 3.58 NIS (Bank of Israel data).

etc.). We identify retail investors (RI) as "low-volume" investors with less than 2 million NIS (~ $559,000) in all TASE securities (excluding options). These low-volume investors are almost certainly RI. The second group that we identify is short-term traders (STT). We define a short-term trader as a non-retail trader that on average flips between buying and selling within a trading day. These STT are the analog for the dealers in the OTC market.

Duffie, Garleanu and Pedersen (2005, hereafter DGP 2005) and Yin (2005) claim that the OTC mechanism is inherently uncompetitive because of the lack of pre-trade transparency. The intuition is that, even if there are many dealers, they do not fully compete on the price. Each of them marks up the price, knowing that: 1) this is the strategy of the other dealers; 2) the customer may have costs for shopping further; 3) a dealer that wants to deviate from the equilibrium by approaching the potential customer with a better price cannot technically do so. Consistent with this notion, we find characteristics of the LOB market at the TASE which reflect more competition and efficiency than the comparable figures in the US OTC market (see Table 1). We find that the average half effective spread *(HES*) of c-bond transactions is 0.078% and the corresponding half quoted bid-ask spread (*HQS*) is 0.082%; a very weak relation between trade size and the effective spread; negligible price dispersion within bond-minute, and negligible trading rents of the STT.[6] While we cannot formally compare the Israeli LOB market to the American OTC market, it should be noted that size difference between the markets works against our findings. It should also be mentioned that the spreads in the TASE stock market are larger than in the c-bond market and larger than in the US stock market (LOB), supporting the notion that the

[6] The price dispersion is the standard deviation of prices divided by average price.

spread difference between the bond markets in Israel and the US is due to the difference in mechanism and it is not a "country effect".

Next, we investigate characteristics of the LOB that enhance competition and efficiency relative to the OTC. The first aspect we refer to is competition among the liquidity providers (STT). The search-based structure of the OTC is advantageous for prominent dealers, which are the natural first choice of the customers. In addition, in the LOB, trading can be done using automated trading systems that monitor many securities simultaneously, resulting in a potential activity of many STT in each security. For both these reasons, we expect to find low STT concentration in the LOB compared to OTC. Indeed, we find that although the market in Israel is much smaller than the US market, many STT are active on the TASE and in each bond. The average (median) c-bond *Herfindahl-Hirschman Index* (*HHI*) is 0.162 (0.126). This is in contrast to OWZ (2016) who find that although there are more than 400 dealer firms in the American market in many bonds there are only 1-2 active dealers per year. As a result, they find an average dealer-*HHI* of 0.61, which represents a situation between duopoly and monopoly. We link the competition among the STT to market liquidity. We show that the c-bond *HHI* is positively related (after controlling for relevant exogenous variables) to its *HES*, *HQS* and to the transaction spreads of the non-STT, consistent with the assertion that competition among the liquidity providers reduces spread.[7]

An additional form of competition is among the different investor types. LOB, as opposed to OTC, enables all traders to trade with each other and compete on quotation. Indeed, we find that 53% of the NIS trading volume is between non-STT and 48% of the NIS volume of non-STT is by "making". In non-STT "making"

[7] In our opinion, the causality is likely to be from the *HHI* to illiquidity and not the other way around, the reason being that large spreads attract more STT and therefore lead to less concentration and lower *HHI*.

transactions, the *HES* is lower than in STT "making" transactions (0.0714% vs. 0.0865%). In a regression analysis we find that, controlling for other variables, the effective spreads of non-STT as "makers" are lower by 42% than those of STT. These findings are in line with Barclay, Christie, Harris, Kandel and Schultz (1999) and Weston (2000), who find that the NASDAQ reform of the 1990s that enabled competing with the dealers by posting limit orders resulted in narrower spreads.

In the US c-bond OTC market, retail participation is negligible.[8] The LOB is more welcoming to RI because the centralized structure of the market and the pre-trade transparency make it accessible to non-professional traders. Indeed we find that at the TASE 8.8% of the NIS double-sided volume arises from RI. Next we show that the participation of RI contributes to the liquidity in several ways. In 27% of their NIS volume the RI act as "makers". In those cases the spreads are slightly lower than spreads when the "makers" are other non-STT. In the transactions where RI act as "takers" (73% of their NIS volume), they impose no adverse selection on the "maker" side. This is contrary to other non-STT. Reducing the adverse selection potential allows for tighter spreads.[9] We also examine the effect of retail participation on c-bond liquidity. The difficulty in such estimation is that causality may work on both sides. We perform a simultaneous equations analysis, taking advantage of the fact that RI tend to invest in the non-CPI-linked c-bonds. In this analysis, we estimate that an increase of 1% in retail participation (say from 8% to 9%) is related to a decrease of about 7.4% in the bond's *HQS*, for example from 0.10% to 0.0926%.

[8] From Table 2 in Edwards, Harris and Piwowar (2007) one can calculate that 1.2% of the dollar trading volume arises from transactions smaller than $100,000. Since there are many institutional transactions in this size category (see OWZ, 2016) the fraction of RI trading is probably much lower than 1.2%. Because of tax advantages, individuals' holdings are higher in municipal bonds than in corporate bonds. They hold directly (indirectly) 50% (25%) of the market cap of municipal bonds. See Aguilar (2013).

[9] See for example Proposition 5 in Glosten and Milgrom (1985), who show that the bid-ask spread is smaller as there are more "uninformed orders".

The rest of the paper is organized as follows. Section 2 describes the market and the data. Section 3 compares the LOB to the OTC and summarizes the empirical predictions following from these differences. Section 4 describes the liquidity in the TASE c-bond market. Section 5 analyzes the competition between STT. Section 6 analyzes the contribution of non-STT (including RI) to liquidity. Section 7 concludes.

[INSERT TABLE 1 ABOUT HERE]

2. Market Description and Data

2.1 The TASE market

The Tel Aviv Stock Exchange (TASE) is the only exchange in Israel. As of December-2014, the aggregate market value of the securities on the TASE was about $470 billion: stocks and warrants – $201 billion, corporate bonds – $80 billion, government bonds – $161 billion, ETNs (Exchange Traded Notes – substitutes for ETFs) – $26 billion.[10] The mechanism for all the securities on the TASE is continuous limit order book trading, with an opening and a closing auction trading session.[11] In all stages the limit orders are executed by price and time priority, and there are no hidden limit orders.[12] A minimum amount of 10,000 (2,000) NIS (New Israeli Shekels), for c-bonds (stocks) applies for orders placed during the continuous stage.

In 2014 there were 26 exchange members at the TASE. These members are banks and brokerage firms through which traders can submit orders for all the securities that are traded on the TASE. The exchange members provide their clients

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[10] See TASE annual review,
http://www.tase.co.il/Eng/Statistics/QuarterlyandAnnualReviews/Pages/annualquarterlyreviews.aspx
In addition, various types of options (on indices, stocks and exchange rates) are traded on the exchange.
[11] The opening stage of the trade in c-bonds (stocks) takes place between 9:30 and 9:31 (9:45 and 9:46), the exact time for each security being arbitrary. The pre-opening stage, where orders are posted, starts at 9:00 am. The closing call auction stage takes place on Sunday (Monday to Thursday), between 16:24 and 16:25 (17:24 and 17:25), the exact time for each security again being arbitrary. Very illiquid securities are traded by daily auctions only.
[12] Hidden orders were introduced in October 2014, but according to the TASE they were rarely used during 2014. The TASE also allows “fill or kill” and “immediate or kill” orders, but they are rarely used.

with online access to the exchange without any human intervention: the clients can see the status of the order book online and submit orders, which are transmitted immediately to the exchange. All the traders can observe the three best bids and offers on each side of the market in all securities.[13] The identity of the member firms and traders submitting orders is unknown to the market participants. The tick size at the TASE is a function of each security's market price. For most of the c-bonds it is around 0.01%. The trading fees (including clearing fees) for each side of the transaction that the TASE charged its members in 2014 were 0.0032% of the NIS transaction volume subject to a minimal fee per transaction of 1.40 NIS ($0.39).[14]

2.2 Market participants

The participants in the Israeli market are quite similar to those in other developed markets. The main types are:

1. Institutions that manage "other people's money".[15]
2. Banks and insurance companies that hold stocks and bonds as assets.
3. Firms that typically trade for short-term horizons (including automatic trading systems).
4. Individuals: controlling stockholders and retail investors.
5. Foreign investors.

The Bank of Israel publishes statistics on the holdings of exchange-tradable c-bonds.[16] As of December 2014, out of the total c-bonds that were traded on the TASE,

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[13] Since November 2014, the traders have been able to observe the five best bids and offers on each side of the market in all securities.

[14] We do not have formal information about the fees the exchange members charge their clients. According to www.hon.co.il (in Hebrew) the fees of discount brokers for individual c-bond trading were ~0.09% in January 2015. To the best of our knowledge the fees of the institutional investors can be very close to the fees the TASE charges its members.

[15] The institutions include long-term savings with tax benefits (pension funds etc.), tax-exempt nonprofit institutions and institutions that do not enjoy tax benefits (e.g., mutual funds, ETNs and hedge funds).

24.6% were held by long-term savings, 24.2% by mutual funds, 18.2% by insurance companies and banks, 6.5% by ETNs and 0.9% by foreign investors. The rest (25.6%) were divided between other trader groups: individuals, nonprofit organizations, short-term trading firms and hedge funds. We do not have information about each of these sub-group's holdings.

2.3 The history of c-bond trading on the exchange

C-bonds are traded in Israel on the exchange by the same method as stocks. Are there economic reasons that make exchange trading of c-bonds more suitable for Israel? In our opinion, the current trading characteristics were formed more than 60 years ago, when the economic conditions were entirely different than they are today. Therefore, the exchange trading is not a result of current economic conditions.

The first institution for securities' trading was established in Tel Aviv in 1935.[17] In 1953 this institution became the Tel Aviv Stock Exchange, where all the securities were traded by a daily auction.[18] The market was very small (for example, in 1960 the daily dollar volume of **all** bonds – mostly governmental and few corporate bonds – was $60,000).[19] Saul Bronfeld, past chairman of the board of the TASE,[20] explains that because the market was small, the TASE offered an efficient solution (daily auctions) for all the financial instruments and there was no need for an OTC

[16] See Tables 12 and 23 in http://www.boi.org.il/

[17] It was a daily gathering of about 10 bankers and brokers that traded a few stocks and a few c-bonds for about an hour. They traded for their own accounts and on behalf of their clients. This information appears in a publication of the TASE marking its 70 years of trading activity. See (in Hebrew) http://www.tase.co.il/resources/pdf/newsjournal/05-11_nl32_nov2005_70-year.pdf. We also rely on an article from the daily Israeli Hebrew-language business newspaper "Calcalist" of 13.5.2016 by Mickey Greenfeld, available at http://www.calcalist.co.il/markets/articles/0,7340,L-3687769,00.html and an article by Gad Lior published in 2009 in the magazine of the Open University of Israel available at http://www.openu.ac.il/publications/magazine-07/download/Pages_23-27.pdf.

[18] The Tel Aviv Stock Exchange is not an accurate translation of the Hebrew name, which uses the term "securities" rather than "stock" and is therefore more general.

[19] See Ben-Shachar, Bronfeld and Cukierman (1971).

[20] Saul Bronfeld served in several key positions in the Israeli capital market, including as vice president of the TASE, later its CEO and eventually as chairman of the board, and has a deep knowledge of the history of the Israeli capital market.

market, which requires considerable human resources. Later, the market expanded, but by then market participants were used to the fact that all instruments were traded on the exchange and that the liquidity was there, so an OTC market was not able to attract the initial liquidity.

We find this explanation very convincing. An additional explanation is that until 2005 the institutional investors (e.g., long-term savings and mutual funds) were mostly the banks, which were the potential dealers for an OTC market. Therefore, dealer activity could have exposed the banks to conflict of interest and potentially to claims of illegal activity.[21]

The c-bond market in Israel expanded dramatically in the 2000s following regulation changes that relaxed limitations on long-term c-bond investing by institutions. In 2003 the aggregate market cap of c-bonds was $6 billion and it increased to $73 billion in 2009. To sum up, the practice of c-bond trading on the exchange like stocks was instituted many years ago when market conditions were very different than they are today.

2.4 Why are many of the bonds CPI-linked?

In Israel many of the government bonds and the c-bonds are CPI-linked. Ben-Shachar, Bronfeld and Cukierman (1971) state that until 1954 all government bonds were nominal and the high inflation of the time caused heavy losses to bond investors.[22] This led the government to issue CPI-linked bonds. Since then, the Israeli investors have become used to ask for inflation protection in their bond investing. In the period from 1980 to 1985 Israel experienced hyperinflation (for example, the annual inflation in 1984 was 445%) and during that period almost all bonds (most of

[21] In 2005, this ceased to be an issue when, following a regulation change, the banks sold their funds.
[22] The cumulative rate of inflation during 1952-1954 was 113%. Data for prior years is unavailable.

which were then governmental) were CPI-linked. Currently inflation is very low (it was -0.2% in 2014) and the inflation expectations reflected in the term structure of interest rates are low.[23] However, the memory of high inflation probably affects the prevalence of CPI-linked bonds.

2.5 The TASE database

We use a unique and proprietary database of the TASE that includes transaction records in which both sides of the transaction are identified. The identification includes the identity of the exchange member and a code that identifies the trader within the member's list of traders. In addition, the database documents the transaction time, whether the transaction was "buyer initiated" or "seller initiated", and the trading stage at which the transaction was executed.

2.6 The sample of c-bonds

We focus on a sample of c-bonds which were traded on the TASE during 2014, the only requirements being a market value of at least 100 million NIS per bond (equivalent to approximately $28 million) and denomination of the c-bond in NIS.[24] The sample consists of 402 c-bonds of 143 firms, which covered 95.3% (95.7%) of the market cap (NIS trading volume) of the 676 c-bonds traded on the TASE during 2014. Most of the c-bonds in the sample are CPI-linked (272 out of 402) and investment grade (according to the average rating of the credit rating agencies):[25] at the end of 2014 (or the last trading day if the bond matured during 2014), 361 of the

[23] The Bank of Israel estimated that the expectation for 1 year ahead of January 2015 was 0.5% (see a press release at www.boi.org.il).

[24] Two US dollar-linked c-bonds were excluded because of this condition.

[25] Israel has two rating agencies: Maalot (a subsidiary of S&P) and Midroog (a subsidiary of Moody's). The rating in Israel is local, meaning that the firms are rated relative to other Israeli firms without taking into account the country risk.

c-bonds in our sample were rated investment grade (BBB and above), 13 were rated speculative grade (below BBB) and 28 were not rated. [26] Most of the bonds in the sample are CPI-linked (272 out of 402).

Table 2 reports summary statistics of the c-bond sample. The average number of daily transactions is 61 with a daily NIS volume of 1.95 million NIS (around $0.55 million), resulting in an average transaction size of about 32,000 NIS (about $9,000). This transaction size is much lower than the transaction size in the US c-bond market. For example, the average transaction size in Edwards, Harris and Piwowar (2007) is $0.75 million (see their Table 1). The average of the c-bonds' NIS proportion outside the exchange is 6.76%. This means that most of the trading needs are fulfilled on the exchange.

[INSERT TABLE 2 ABOUT HERE]

2.7 Identification of retail investors and short-term traders

The database does not include the trader's classification (institutional, retail, short-term, etc.). Therefore, we rely on technical information such as trading volume and trading frequency to classify investor types. We focus on two investor groups: **short-term traders (STT)** and **retail investors (RI)**.

The STT provide liquidity to other investor types (institutional, retail) that trade for a longer horizon. In an OTC market, the short-term traders are the dealers. We define the STT as traders that flip from buying to selling within a short period of time and are not identified as RI. For each trader in each c-bond of the sample that she traded, we calculate the number of switches from buying to selling or *vice versa* and divide it by the number of trading days that the trader was active in the c-bond. Then

[26] The data on credit rating and the c-bond characteristics are from www.valuation.co.il. We thank Eran Ben-Horin for providing the data.

we calculate the value-weighted average of this ratio across the c-bonds that the trader traded, and classify the trader as "short-term" in the case that this measure is equal to or greater than 1.[27] Formally, trader *j* is considered a STT if

$$\frac{1}{\sum_{i=1}^{n} trader\_vol_i} \cdot \sum_{i=1}^{n} \left(trader\_vol_i \cdot \frac{sign\_switches_i}{ntd_i} \right) \geq 1$$

where n is the number of c-bonds that the trader traded during the sample period, $trader\_vol_i$ is the trader's NIS trading volume in c-bond i, $sign\_switches_i$ is the number of times the trader switched positions in c-bond i during the sample period and ntd_i is the number of trading days of the trader in c-bond i.

The cutoff of "1" to identify STT is of course arbitrary. We choose it because flipping from buying to selling and vice versa within a trading day can be naturally interpreted as short-term trading especially in c-bonds. Slightly longer horizons may also be interpreted as short-term trading but to be on the safe side we prefer a cutoff of "1". As a robustness check, we also examine a cutoff of 0.5. All our main findings (reported in Tables 4, 5) remain qualitatively similar.

We find 280 STT that were active in our c-bond sample during 2014. Their mean annual trading volume at the TASE is quite large (about 768 million NIS), with a smaller median annual volume (about 88 million NIS). The fact that the median is quite low implies that many of these traders are small trading firms or individual traders. However, most of the transactions and the trading volume of this group arise naturally from the large traders, as presented in Sub-section 5.1.

We identify **RI** as "low-volume" investors with less than 2 million NIS (roughly $559,000 during the sample period – 2014) in all the securities that are traded on the TASE (excluding options). It is possible that there are RI with higher

[27] A ratio of 1 means that on each day the investor traded the security, a sale transaction was followed with a buy transaction (or vice versa), on average.

trading volumes but non-retail investors with such low trading volumes are probably rare. Therefore, this definition can be viewed as restrictive. As a robustness check, we also examine a cutoff of 3 million NIS, showing that our findings in Section 6 are not changed qualitatively.

We find 159,738 RI that were active in our c-bond sample during 2014. Their activity is low and infrequent. The average (median) trading volume, in all TASE securities (excluding options) is 379,862 (232,485) NIS. The average (median) number of trading days at the TASE (out of the 245 possible trading days) is 6.16 (4.00).[28] These RI are quite "long-term". In only 10.2% of the cases do we find both buying and selling during 2014.

3. A Comparison between LOB and OTC

In an OTC market trades occur between customers and dealers or between dealers, while in an LOB market all participants can trade with each other. The OTC markets have no pre-trade transparency (there are no binding bid-ask spreads) and the customers need to shop between the dealers and negotiate for the price.[29] In an open LOB market there is pre-trade and post-trade transparency. STT in an LOB are the equivalent of dealers in the OTC, but unlike the OTC the other traders do not have to trade only through them.

In the model of Yin (2005) the customers pay the dealers a spread depending on customers' searching costs. The intuition is that, even if there are many dealers, they do not fully compete on the price. Each of them marks up the price, knowing

[28] It is possible that a trader trades through different exchange members or through different accounts of a given exchange member. Casual observation suggests that RI tend to concentrate their trading activity in one account. In any case, however, an account that trades less than 2 million NIS per year is likely to be an account of a small RI.

[29] In many OTC markets there is no post-trade transparency as well. In the US c-bond market there is partial post-trade transparency – the transactions are reported with some delay.

that: 1) this is the strategy of the other dealers; 2) the customers may have costs for shopping further; 3) a dealer that wants to deviate from the equilibrium by approaching the potential customer with a better price cannot technically do that. The intuition of Yin (2005) is in line with the claim of DGP (2005) that "*…a search economy is inherently uncompetitive*".

The empirical implications of Yin's (2005) model are higher spreads in the OTC market than in the LOB and higher dealer profits in the OTC than STT profits in the LOB. An additional empirical implication is that OTC is characterized by greater price dispersion between transactions on the same side (buy or sell) that occur at approximately the same time. Additionally, assuming that search costs are negatively related to trade size, Yin's (2005) model predicts a negative relation between transaction size and its spread in the OTC market.[30]

Yin's model predicts higher spreads in OTC vs. LOB if the number of dealers is the same in both markets. Other things being equal, it is reasonable to assume a larger number of STT in the LOB because:

1) The search-based structure of the OTC is advantageous for prominent dealers, which are the natural first choice of the customers. This is likely to wipe out smaller dealers from the market or force them to concentrate in small niches of assets or clients.

2) In an LOB, trading can be done using automated trading systems that monitor many securities simultaneously, enabling cheap activity in many securities simultaneously.

A large number of STT competing in each security should further lower the spreads and STT rents.

[30] This relation in the OTC market may arise from trading relations between dealers and customers. See the model and supportive empirical evidence in Bernhardt, Dvoracek, Hughson and Werner (2005).

An additional assumption in Yin's (2005) model is that in the LOB market customers can trade only with dealers, so the difference from the OTC market is only in the pre-trade transparency. Enabling the customers to trade with each other in the LOB should lower the spread paid by the customers and the price dispersion in the market because:

1) If two customers trade with each other, their average spread is zero by definition
2) The competition from customers lowers dealer's spreads
3) Non-STT tend to post tighter quotes than STT because they do not require compensation for the inventory risk and for the direct costs of transacting.

These predictions are in line with Barclay, Christie, Harris, Kandel and Schultz (1999) and Weston (2000), who find that the NASDAQ reform of the 1990s that enabled competing with the dealers by posting limit orders resulted in narrower spreads.

An additional issue is investor composition. the models of Yin (2005) and DGP (2005) take customer population as given. It is likely that investors' asset selection depends on their trading costs. Therefore, investors with high searching costs (for example RI) may refrain from trading in the OTC and may prefer investing in substitutes that are traded in an LOB. Assuming information asymmetry (unlike Yin and DGP), if investors with high searching costs have less information about the asset, then their inclusion in the market lowers the adverse selection and contributes to spread narrowing.[31]

[31] The comparison of the degree of information asymmetry in the two market types is not straightforward. On one hand, the fact that the dealers in the OTC market know the identity of their counterparties can mitigate the information asymmetry that they face (see the model of Benveniste, Marcus and Wilhelm, 1992, in the context of a system with specialists and the empirical support in Battalio, Ellul and Jennings, 2007). On the other hand, in the OTC market, an informed trader can act roughly simultaneously against several dealers, increasing their information disadvantage (see Pagano and Röell, 1992).

The empirical predictions derived from the above analysis can be divided into two groups. The first group involves predictions that compare between LOB and OTC. The second group of predictions relates to the LOB trading.

A. Compared to an OTC market, an LOB market is characterized by:

1) Lower spreads
2) Lower price dispersion
3) Lower STT profits (relative to dealer profits in the OTC)
4) A weaker negative relation (or no relation) between transaction size and its spread
5) Less concentrated short-term trading (in the aggregate market and in the individual c-bonds)
6) Higher participation of RI.

B. In the LOB:

1) In the cross-section of bonds: A positive relation between STT concentration and their trading profits, spreads and price dispersion [??]
2) A significant trading volume between non-short-term traders (non-STT)
3) In the transactions where non-STT are the makers the transaction spreads are smaller than the transaction spreads where the makers are STT
4) RI impose no adverse selection in their taking transactions
5) The participation of RI contributes to spread narrowing

Predictions "B" are examined using the TASE c-bond data. For predictions that compare LOB to OTC, we do not have an OTC counterfactual to the TASE LOB. Therefore, we compare our findings regarding the items in "A" to the corresponding findings about the American market reported in Table 1. The comparison is strongly consistent with the predictions, though the Israeli market is much smaller than the

American one – a fact that works against the likelihood of finding evidence consistent with the predictions.

4. Liquidity in the TASE c-bond market

4.1 Magnitude of spreads

We estimate the liquidity of the TASE c-bond market using the fundamental measures of liquidity: the **half quoted bid-ask spread** (*HQS*) and **the half effective spread** (*HES*). *HQS* is the average cost of an investor who trades a small quantity immediately after arriving at the market and *HES* compares the transaction price to the mid-quote prevailing before the transaction.[32] Panel A of Table 3 reports statistics of the *HQS* and *HES* of the transactions. The *HQS* of a c-bond is the average of *DAILY_HQS*, which is the average of the half quoted bid-ask spread at six time points each trading day, on the hour from 11:00 to 16:00. The *HES* is the average over all the transactions in the continuous stage.[33] The *HQS* (*HES*) across the transactions of our sample is 0.082% (0.078%) and the value-weighted average *HQS* (*HES*) is 0.077% (0.067%). These figures are much lower than the estimates in the US market, especially for transactions of less than $100,000 (see Table 1 for the findings in the US market) – consistent with prediction A1.

[INSERT TABLE 3 ABOUT HERE]

Since both stocks and c-bonds are traded on the TASE it is of interest to compare their liquidity. It is well-known that the OTC c-bond markets are less liquid

[32] Definitions of *HQS* and *HES* appear, for example, in Foucault, Pagano and Röell (2013), hereafter FPR (2013). At the TASE a transaction cannot occur inside the spread but the *HES* may be systematically different than the *HQS* because transactions tend to occur where bid-ask spreads are relatively narrow and because large quantity orders "walk on the book", that is, are executed against different layers of the limit order book.

[33] The observations are winzorized to 10% in the rare cases where the bid or ask are missing or they are greater than 10%. The *HQS* (*HES*) was winzorized in 0.043% (0.019%) of the sample.

than stock markets (large spreads and few transactions per day). This finding is quite puzzling, because c-bonds should be more liquid than stocks due to their lower variability (which makes liquidity provision less risky) and the lower degree of information asymmetry (Biais and Green, 2007). We focus on a sub-sample of 102 firms from our c-bond sample that traded stocks on the TASE during 2014.[34] This sub-sample includes 102 stocks and 346 c-bonds. We find that both the *HQS* and the *HES* of the c-bonds are considerably lower than the comparable measures of the stocks. The mean of the *HQS* of c-bonds (stocks) is 0.18% (0.65%) and for the *HES* the means are somewhat lower: 0.16% (0.55%). To demonstrate this difference graphically, Figure 1 plots *HQS* at the firm level, averaging the c-bonds of the same firm into a single observation. Panel A of Figure 1 presents a scatter plot of the 102 pairs of *HQS*. In most cases (81 out of 102) the points are below the 45^0 line, indicating that the average *HQS* of a firm's c-bonds is lower than the corresponding *HQS* of the firm's stock. The mean (median) *HQS* is 0.65% (0.27%) for stocks and 0.25% (0.16%) for c-bonds.[35] The *p*-value of a double-sided binomial test in this case is <0.0001 and the *t*-statistic for the series of difference between the numbers in each pair is 5.26. The difference in the *HES* between c-bonds and stocks is qualitatively similar to the difference in *HQS*. To present a clearer picture, in Panel B of Figure 1 we focus on firms with an average *HQS* (of stocks and c-bonds) that is smaller than 0.5%. In sum, at the TASE c-bonds are very liquid and more liquid than stocks. The fact the stock spreads are higher than the c-bond spreads (and higher than US stock spreads – see Exhibit 3 in Avramovic and Mackintosh, 2013) supports the notion that the low c-bond spreads at the TASE are not due to an "Israeli effect".

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[34] In Israel, there are firms with publicly traded bonds that have stocks that are not traded publicly. These firms are not included, of course, in our comparison sample.

[35] The results are qualitatively similar when we consider a sub-sample of non-dual listed firms with stocks and c-bonds (it includes 84 firms). In 73 out of the 84 the average *HQS* of a firm's c-bonds are lower than the corresponding *HQS* of the firm's stocks.

[INSERT FIGURE 1 ABOUT HERE]

4.2 The relation between transaction size and its spread

In the US c-bond market, the smaller the quantity the higher the transaction costs (see Schultz, 2001; Edwards, Harris and Piwowar, 2007; Harris and Piwowar, 2006, among others in Table 1). Biais and Green (2007) suggest that this relation is due to the weaker bargaining power of small traders.[36] The evidence at the TASE is consistent with the American evidence, but on a much smaller scale. We divide the transactions of each c-bond into quintiles according to their NIS trading volume and then group the transactions of each quintile (roughly 700,000 transactions in each quintile). The average NIS values are 4,508, 12,487, 20,243, 33,159 and 130,250, respectively. The average *HES* of the transactions in each quintile are 0.066% (the highest volume deals), 0.075%, 0.081%, 0.086%, 0.082% (the lowest volume deals). The difference between the lowest-volume and the highest-volume quintiles is significant (the *t*-statistic for the series of daily differences is 13.85). The magnitude of the difference, however, is quite small: 0.025% between the lowest and the top quintile. A simple explanation for this difference is that the smaller the quantity the less the pay-off from efforts to minimize trading costs. To demonstrate this, look at the average deal volume in the lowest quintile, which is roughly $1,250. With this amount, saving 0.016% for example (the difference between the lowest and top quintile) means only $0.2.

To sum up, we find very small differences in transaction half spread (*THS*) according to deal volume. This difference, consistent with prediction B1, is much smaller than in the US (see Table 1).

[36] See the theoretical models of DGP (2005) and Bernhardt, Dvoracek, Hughson and Werner (2005).

4.3 Price dispersion

A c-bond may be traded at different prices within a very short time period. Randall (2015) uses price dispersion to measure price competitiveness in the US market. The dispersion is the standard deviation of prices within each minute, divided by the mean of those prices for customer-dealer and inter-dealer trades. At the end of 2010 the mean dispersion for inter-dealer (customer-dealer) trades are around 0.04% (0.24%), consistent with inefficiency of the customer-dealer transactions. We find much smaller price dispersion at the TASE than in the US. To compare the price dispersion in the TASE c-bond market, we calculate the average of this measure. Consistent with prediction A3, the dispersion at the TASE is much lower than in the US market. The average price dispersion in the overall sample is 0.02% and this is also the figure for transactions between STT and non-STT (the analog for dealer-customer transactions in the US). The price dispersion transactions on the same side are even smaller. We filter bond-minute periods with transactions of STT as makers and non-STT as takers and the STT either buy or sell in all transactions. In these transactions the average dispersion is 0.015%.

4.4 Trading rents of short-term traders

Bearing in mind the claim of DGP (2005) that "*...a search economy is inherently uncompetitive*", we expect STT profits in an LOB to be lower than dealer profits in the OTC. In about 56% of their NIS volume the STT act as "makers". We measure their trading profits in these transactions using the "realized half spread" – *RHS* (see Section 2.2.3 in FPR, 2013) which is the *THS* minus the adverse selection component (*AS*).[37] The *RHS* is usually measured using the mid-quote a short time after the transaction. We tried several mid-quote horizons (30 minutes, 60 minutes, 120 minutes, 240 minutes and 24 hours).[38] The 30/60/120/240 minute horizons seem too short relative to the closing price, because the price reversal following the transaction is not completed within these horizons. That is, we find predictable price changes beyond these horizons. We do not, however, find predictable price changes from the closing price to the 24-hour mid-quote, indicating that the time interval from the closing to 24 hours only adds noise. Therefore, we focus on the closing price as the benchmark price for the transactions. This is consistent with the high frequency traders' profit estimation in Van Kervel and Menkveld (2016) and the estimations of NYSE specialists' revenues in Comerton-Forde, Hendershott, Jones, Moulton and Seasholes (2010).

Panel B of Table 3 reports the average of these daily measures. The first line reports these measures in the case that the STT are "makers". The value-weighted average (equally weighted average) of the *THS* is 0.069% (0.081%), of *AS* it is 0.040% (0.044%) and of *RHS* it is 0.029% (0.037%).[39] All these measures are highly statistically different from zero. The second line of the table presents the spread measures in the cases where the STT are takers. In these transactions, the value-weighted *RHS* is -0.006% (the p-value is -2.69) indicating a small trading profit (a negative cost).

[37] Specifically, we calculate the *AS* as $d \cdot (close/m_t - 1)$, where *close* is the closing price of the c-bond, m_t is the mid-quote before the transaction and *d* is an indicator that equals one (minus one) if the transaction is buyer (seller) initiated. In addition, FPR (2013) mention in their Sub-section 5.2.2 that if the market makers require compensation for inventory risk, it may induce price change persistence in the short run (and long-run reversal). This may bias upward (downward) the estimated *AS* (*RHS*). We think that this is not the case here, since we find that in the cases where the STT are makers and RI are takers the *AS* is roughly zero (and not statistically different from zero), as expected.

[38] In the 30/60/120/240 minute horizons we used the closing price if the horizon ended after the closing.

[39] The value-weighted *THS*, *AS* and *RHS* of all the STT "making" transactions across all days are 0.071%, 0.041% and 0.030%, respectively.

Looking at both "maker" and "taker" transactions we find that the average daily trading profits (*RHS* as makers and minus *RHS* as takers; transactions are value weighted) are 0.019%. This small number does not include the trading fees paid to exchange members. The TASE charges exchange members about 0.005% for the transactions of STT.[40] It is reasonable to assume that the STT pay the exchange members at least this figure as trading fees. This leaves a very small amount to cover monitoring costs and compensate STT for the risk. Therefore, if there are rents beyond that, they are negligible. This is consistent with a competitive market where the liquidity providers earn very low rents.

Consistent with prediction A4, the STT rents we find are much smaller than the dealer rents in the US and the difference is especially large when the comparison is to small/medium size transactions in the US (see Table 1). Goldstein, Hotchkiss and Sirri (2007) estimate (see their Table 6) that round-trip markups for BBB rated c-bonds are 2.37% (0.56%) for transactions smaller than $10 thousand (larger than $100 thousand). Therefore, the figures for one side are 1.18% and 0.28%, respectively. Green, Hollifield and Schurhoff (2007) estimate (see their Table 7) that round-trip markups in the municipal bond markets are 2.30% (0.16%) for transactions smaller than $100 thousand (larger than $500 thousand). Their figures for one side are 1.15% and 0.08%, respectively.

5. Competition between Short-term Traders

5.1 STT activity and concentration

As discussed the in Section 3, LOB-STT activity is likely to be less concentrated (more competitive) than OTC-dealer activity. The reason is that the

[40] We calculate this figure applying the 0.0032% fee and the minimum of 1.40 NIS per transaction.

search-based structure of the OTC is advantageous for prominent dealers, which are the natural first choice of the customers (see Section 3). Indeed, we find that although the TASE c-bond market is small its STT activity is very unconcentrated. We find that the top 10 STT account for 50% of the aggregate STT trading volume. The corresponding figure in Hendershott, Li, Livdan and Schürhoff (2016), who investigate a database of aggregate c-bond trading by insurance companies in the US, is 75%. In contrast, at the TASE, 75% of STT activity is done by the top 27 STTs. Therefore, consistent with prediction A5, STT activity at the TASE is less concentrated than the dealer activity in the US c-bond market. To estimate market concentration, we use the common measure of the *Herfindahl-Hirschman Index* (*HHI*), calculated as:

$$HHI = \sum_{i=1}^{n} S_i^2$$

where S_i is the NIS market share of STT_i. The *HHI* ranges from *1/n* to 1 (monopoly) and it may be interpreted as the reciprocal of the "equivalent" number of equal-share traders. We find that the *HHI* of the c-bond market is 0.0382. This implies a very unconcentrated market with an "equivalent" number of equal-share STT of 1/0.0382= 26.[41]

This is at the aggregate level, but what about the concentration in the individual c-bonds? Since LOB trading can be done using automated trading systems that monitor many securities simultaneously, the monitoring costs per security are small. That is, an LOB enables a presence of STT in many bonds, even though the activity in each of the bonds can be small. Indeed looking at the 20 largest STT (which account for two-thirds of the total NIS volume of the STT) we find that each of them is active in 171 bonds on average, with an average daily transaction volume

[41] The Horizontal Merger Guidelines of the U.S. Department of Justice and the Federal Trade Commission generally classify markets into three types: Unconcentrated Markets (*HHI* below 0.15), Moderately Concentrated Markets (*HHI* between 0.15 and 0.25) and Highly Concentrated Markets (*HHI* above 0.25).

of about $18,000 per bond. That is, an LOB enables a presence in many bonds, even though the activity in each of the bonds can be small. Hence, although the Israeli market is quite small, we expect to find less concentration of STT activity relative to US dealer concentration at the individual bond level too (and not only at the aggregate market level).

Table 4 report statistics on the number and concentration of STT in the cross-section of c-bonds. The mean (median) *HHI* is 0.162 (0.126). Consistent with prediction A5, dealer concentration in the US c-bond market is much higher. For comparison, OWZ (2016) find that the *HHI* of dealer activity in the US is much larger: the mean is 0.61 and the median is 0.54. These figures represent a highly concentrated market – roughly a duopoly. Moreover, at the TASE, for the median corporate bond, the market share of the top STT is 24.15% and for the top three STT it is 51.42%. These figures are much smaller than the corresponding figures in OWZ (2016), who find that the median market share of the top dealer (three top dealers) is 69% (100%).

[INSERT TABLE 4 ABOUT HERE]

5.2 The relation between liquidity and STT concentration

As showed theoretically by Yin (2005) the spreads in an LOB mechanism are lower than those in an OTC mechanism, assuming an equal number of dealers. As discussed in Section 3, the LOB mechanism leads to less concentrated short-term trading than in an OTC mechanism (prediction A5) and we find consistent evidence for this in Sub-section 5.1. It is reasonable to assume that the low concentration of STT contributes to spread narrowing. In this sub-section we show supportive evidence for this hypothesis.

Table 5 presents regressions of liquidity measures on c-bond characteristics with and without *HHI*. The illiquidity measures are *LOG_DAILY_HQS*, *LOG_DAILY_HES*, and the average *THS* of non-short-term traders (hereafter non-STT) in their "taking" transactions.[42] We run 245 daily regressions, reporting the averages of the coefficient series. As control variables, we use c-bond characteristics which are supposed to be exogenous determinates of liquidity. Since the explained variables are liquidity measures we focus on explanatory variables which are **not** liquidity measures (such as volume). The variables are:[43]

LOG_STD – the log of the standard deviation of the daily returns

LOG_SIZE – the log of the bond's size, calculated as the average of the market capitalization at the beginning and end of the sample period for each security

LOG_FIRM_SIZE – the log of the market value of the firm's tradable securities; this variable is a proxy for the firm's market value

DURATION – the c-bond's duration. Harris and Piwowar (2006) find that in the US municipal bond market c-bonds with higher duration have higher spreads

RATING – we consider the average rating according to the two Israeli rating agencies. A c-bond gets a credit rating if at least one of the agencies rates it. The variable RATING equals 0 if the bond has no rating. Otherwise it ranges from *1* (D) to *26* (AAA). Harris and Piwowar (2006) find that the bid-ask spread measures are negatively related to credit rating in the US municipal bond market. Edwards, Harris and Piwowar (2007) find similar results in the US c-bond market

[42] *DAILY_HQS* is the daily half quoted bid-ask spread, calculated at six time points each trading day, on the hour from 11:00 to 16:00. *DAILY_HES* is the average effective spread, calculated as the average over all the daily transactions in the continuous stage.
[43] It is possible that liquidity affects *LOG_STD* and *LOG_SIZE* but the effect is likely to be small.

DUMMY_RATING – a dummy variable that equals *0* if the c-bond has no credit rating from the two Israeli rating agencies and *1* otherwise.[44]

NON_LINKED – a dummy variable that equals *0* if the c-bond is CPI-linked and 1 otherwise.

PRICE – the closing price of the c-bond on each trading day. Edwards, Harris and Piwowar (2007) find that the inverse of a bond's price is positively related to its transaction costs. The reason is that this variable captures credit issues which are not reflected accurately in the credit rating. In our sample, bond prices range from *0.33* NIS to *1.51* NIS and they are indeed positively related to bond ratings

AGE_0.5 – a dummy variable that equals 1 if the bond was issued in the last 6 months and 0 otherwise. Hendershott, Li, Livdan, Schürhoff (2016) find a positive relation between a bond's age and execution costs

AGE_1.5 – a dummy variable that equals 1 if the bond was issued in the last 18 months and 0 otherwise.

The results are reported in regressions (1), (2), (4), (5), (7) and (8). The *t*-statistics of each explanatory variable are calculated using the Newey-West (1987) method, with the number of lags varying according to the auto-correlation of the coefficient. For each of the dependent variables, *HHI* is significantly positively related to the illiquidity measure. That is, more concentration of STT is related to less liquidity. In our opinion, the causality is likely to be from STT concentration to illiquidity and not the other way around, since large spreads attract more STT and therefore lead to less concentration (i.e., lower *HHI*). This analysis and its finding are consistent with OWZ (2016), who find a positive relation between bond dealers' *HHI*

[44] Using this dummy variable allows the inclusion of all the c-bonds (including c-bonds without credit rating) without affecting inferences on the slope coefficient. See, for example, Pontiff and Woodgate (2008).

and transaction price differences among institutional clients. One may argue that the causality is in the opposite direction because STT are attracted to high volume c-bonds (which have low spreads). Therefore, as a robustness check, in regressions (3), (6) and (9) we add *LOG_VOL* (the log of the c-bond's annual NIS volume) to the explanatory variables and the *HHI* coefficients remain positive and significant.

In Sub-section 4.3 we find that at the TASE price dispersion is much less than in the US. Is it also related to STT competition? The answer is positive. In the regression analysis in Table 5 we find a significant positive relation between *HHI* and price dispersion (in general and in STT vs. non-STT transactions). That is, weaker competition between STT (e.g. higher *HHI*) is related to greater price dispersion.

[INSERT TABLE 5 ABOUT HERE]

6. Non-short-term Traders Also Provide Liquidity

In OTC markets, traders must interact with dealers and cannot compete with them on providing liquidity.[45] In an open LOB every trader can potentially trade with anyone else. Indeed, in our sample, consistent with prediction B1, more than half (53.4%) of the NIS trading volume is between non-STT. Therefore, the competition on liquidity provision is not only among STT. It is intensified by the participation of other traders, who also compete on liquidity provision.

We present some evidence on liquidity provision by non-STT. First, non-STT act in many cases (47.78% of their NIS trading volume) as "makers" by posting limit orders. In addition, we find that consistent with prediction B3, that when acting as makers the non-STT post narrower spreads than the STT. To demonstrate this, we run

[45] McAllister (2015) reports that 52% of the volume in dealer-client institutional-sized ($1 million or greater) transactions in the US are crossable, meaning that customers bought and sold the same security in matching sizes on the same day. Hypothetically these transactions could occur between customers. See http://tabbforum.com/opinions/how-trace-data-demystifies-corporate-bond-liquidity

245 daily regressions where the observations are the transactions; the explained variable is the log of the *THS* (*LOG_THS*) and the explanatory variables are the control variables we use in Table 5 and a dummy variable, *D_NST*, which gets the value 1 if the "maker" side is non-STT and 0 otherwise. The coefficient of *D_NST* is -0.549 and it is highly statistically significant. The interpretation is that if the maker is a non-STT, the *THS* decreases by about 42% ($e^{-0.549}-1\approx-0.42$; note that the explained variable is *LOG_THS*). As background, it should be noted that the NASDAQ reform of the 1990s that enabled competing with the dealers by posting limit orders resulted in narrower spreads. See Barclay, Christie, Harris, Kandel and Schultz (1999) and Weston (2000).

6.1 Retail participation contributes to market liquidity

The OTC market is not designed to attract RI. The decentralized structure of the market, the lack of pre-trade transparency and the fact that the prices are bargaining based are not appropriate for non-professional traders. The empirical evidence in the US (see Table 1) indicates larger trading costs for smaller quantities and for less active traders. Indeed, the participation of RI in the US is negligible (see footnote 8). Consistent with prediction A6 we find much more retail participation in the TASE c-bond market. In our c-bond sample RI participation is 8.84% of the double-sided NIS trading volume, contravening the popular belief that RI are not interested in c-bonds.[46] Naturally, the trading mechanism enables RI to trade with low trading costs and this is probably one of the main reasons for retail participation being higher than in the US.

[46] In a sub-sample of firms with both stocks and c-bonds the retail trading volume is 6.53% in stocks and 8.56% in c-bonds.

We show that retail participation contributes to market liquidity. The intuition is that RI are uninformed and therefore do not impose adverse selection costs for trading with them. Indeed, Peress and Schmidt (2016) find that distractive news (not related to the economy; such as the verdict in the O.J. Simpson trial) that distracts the attention of RI adversely affects stock liquidity. This is because RI contribute to liquidity by serving both as noise traders and as liquidity providers. We present evidence that in the TASE c-bond market RI contribute to the liquidity of c-bonds in the same manner: RI act also as "makers" and with lower spreads than others and as "takers" RI impose less adverse selection costs than others. Sub-section 6.2 measures the contribution of RI to the market liquidity using simultaneous equations analysis.

In 26.84% of their transactions RI act as "makers". The *THS* in those cases are much lower than in the cases where the STT are makers, and about 5% lower than in the cases where the makers are not STT but not RI.[47]

In 73.16% of their transactions RI act as "takers". In these cases, consistent with prediction A4, they impose practically no adverse selection costs on the "maker" side of the transaction. To see this, we measure the *AS* of RI as detailed in Sub-section 4.4. The average (weighted average) of the daily average of AS is 0.004% (-0.002%). The series of AS (equally weighted and value weighted) are not statistically different than zero. This is contrary to the AS of non-RI as takers (an average of 0.0815% across transactions). A regression analysis like Table 5 (e.g., 245 daily regressions) validates that the *AS* is lower in the transactions in which the RI is taker.

[47] To demonstrate this, we run 245 daily regressions, as in Section 5 where the observations are the transactions; the explained variable is *LOG_THS* and the explanatory variables are the control variables we use in Table 6 and two dummy variables: *D_NST*, which gets the value 1 if the "maker" side is non-STT and 0 otherwise, and *D_RI*, which gets the value 1 if the "maker" side is non-STT and 0 otherwise. The coefficients of *D_NST* and *D_RI* are -0.540 and -0.051 and both are highly significant.

6.2 The effect of retail participation on liquidity – simultaneous equations analysis

In this sub-section we estimate the effect of retail participation on liquidity and more specifically on the spreads (*HQS* and *HES*). The difficulty in such estimation is the likelihood that causality works in both directions. To solve this problem, we use a simultaneous equations approach. The variables of interest are:

LOG_HQS_j – the log of the annual *HQS* of c-bond *j*

$PROP\_RI_j$ – the percentage of the NIS trading volume of RI in c-bond *j* out of the total double-sided NIS volume in our transactions of c-bond *j* (of the continuous stage)

NON_LINKED_j – a dummy variable that gets the value 1 if c-bond *j* is non-CPI linked and 0 if it is CPI linked.

We assume the following structural-form equations:

$$Log\_HQS_j = \alpha_0 + \alpha_1 \cdot PROP\_RI_j + \sum_{i=3}^{11} \alpha_i \cdot \tilde{X}_{ij} + \tilde{\varepsilon}_{HQS_j} \quad (1)$$

$$PROP\_RI_j = \beta_0 + \beta_1 \cdot HQS_j + \beta_2 \cdot NON\_LINKED_j + \sum_{i=3}^{11} \beta_i \cdot \tilde{X}_{ij} + \tilde{\varepsilon}_{RT_j} \quad (2)$$

where X_{3j}, ..X_{11j} are the following control variables as in Table 5: *LOG_STD*, *LOG_SIZE*, *LOG_FIRM_SIZE*, *DURATION*, *RATING*, *RATING_DUMMY*, *PRICE*, *AGE_0.5* and *AGE_1.5*. The structural equations assume that *NON_LINKED* does not affect the spread directly but through its effect on other variables (like *STD* and *RI*).[48] The reduced-form equations have the following form:

[48] Indeed, the *HES* (*HQS*) of CPI-linked c-bonds is similar to the *HES* (*HQS*) of non-CPI linked c-bonds: 0.078% (0.083%) vs. 0.078% (0.080%), respectively.

$$Log\_HQS_j = \gamma_0 + \gamma_2 \cdot NON\_LINKED_j + \sum_{i=3}^{11} \gamma_i \cdot \tilde{X}_{ij} + \tilde{e}_{HQS_j} \qquad (3)$$

$$PROP\_RI_j = \delta_0 + \delta_2 \cdot NON\_LINKED_j + \sum_{i=3}^{11} \delta_i \cdot \tilde{X}_{ij} + \tilde{e}_{RI_j} \qquad (4)$$

where $\gamma_2 = \frac{\alpha_1 \cdot \beta_2}{1 - \alpha_1 \cdot \beta_1}$ and $\delta_2 = \frac{\beta_2}{1 - \alpha_1 \cdot \beta_1}$, which enables us to set the value of α_1 using the ratio of

$$\frac{\gamma_2}{\delta_2} = \alpha_1 \qquad (5)$$

Since the number of exogenous variables that do not appear in Equation (1) (*NON-LINKED*) equals the number of endogenous variables that appear in Equation (1) (*PROP_RI*), the coefficients of Equation (1) have an exact identification.

Table 6 presents an estimation of the reduced-form Equations (3) and (4), which are cross-section regressions on the c-bond sample. Regression (1) estimates Equation (3) and regression (2) estimates Equation (4). The estimated values of the coefficients of *NON_LINKED* in regressions (1) and (2) are -0.387 and 5.072, respectively.[49] These values represent the estimates for γ_2 and δ_2, respectively and from Equation (5) the estimate for α_1 is $\alpha_1 = \frac{\gamma_2}{\delta_2} = \frac{-0.387}{5.072} = -0.076$. The economic interpretation of this value is that a 1% increase in *PROP_RI* (say from 8% to 9%) is related to a decrease of about 7.4% in the bond's *HQS* ($e^{-0.076} - 1 \approx -0.074$), say from 0.10% to 0.0926%. As a robustness check, we also estimate the effect of retail participation on *HES* by substituting *LOG_HES* for *LOG_HQS* in Equation (3). The

[49] A side issue that requires clarification is the positive value of δ_2 that we find; that is, we find that RI tend toward non-CPI-linked investment. This seems plausible to us because the non-RI are mostly institutional investors for long-term saving. They are regulated by the Ministry of Finance, which requires each institution to calculate risk measures regarding its portfolios and the expected effect of possible changes in risk factors. Therefore, these institutions are much more aware of the inflation risk than the average RI (in recent years inflation in Israel has been close to zero). Therefore, it is reasonable to find relatively more RI in non-CPI-linked bonds.

results are qualitatively similar: a 1% increase in *PROP_RI* (say from 8% to 9%) is related to a decrease of about 5.6% in the bond's *HES*.

It can be shown that α_1 is highly statistically significant and its *p*-value is roughly zero. The reason is that from Equation (5) we get

$$P(\alpha_1 > 0) = P(\gamma_2 > 0 \text{ and } \delta_2 > 0) + P(\gamma_2 < 0 \text{ and } \delta_2 < 0) \tag{6}$$

Since

$$\begin{aligned} P(\gamma_2 > 0 \;\; \text{and} \;\; \delta_2 > 0) &< P(\gamma_2 > 0\,) \\ P(\gamma_2 < 0 \;\; \text{and} \;\; \delta_2 < 0) &< P(\delta_2 < 0) \end{aligned} \tag{7}$$

we get by combining Equation (6) and Equations (7):

$$P(\alpha_1 > 0) < P(\gamma_2 > 0\,) + P(\delta_2 < 0) \tag{8}$$

Since the *t*-statistics of *NON_LINKED* in regressions (1) and (2) are -5.73 and 7.13 we get:

$$P(\gamma_2 > 0\,) \approx 0 \;\; \text{and} \; P(\delta_2 < 0) \approx 0 \tag{9}$$

Therefore, the sum of these probabilities is roughly zero and from Equation (8) we get that

$$P(\alpha_1 > 0) \approx 0 \tag{10}$$

[INSERT TABLE 6 ABOUT HERE]

We cannot empirically examine a situation of no retail trading because in our sample all c-bonds have retail participation. Even after bond issuance there is some retail trading (though its volume is smaller than in other months). Therefore, to get a rough idea of this hypothetical situation we take the point estimate from the simultaneous equations analysis and calculate an estimate for an average of *HES* for a hypothetical "zero retail trading" situation. The estimate is 0.130%, which is higher than the current average of 0.078%. This calculation should be treated as a rough estimate since it is not clear that the coefficient value is intact for such a large change from the current situation. Taking this estimate on its face value it seems that RI contribute a lot to market liquidity but even without their presence the bid-ask spread is still reasonably low.

7. Conclusion

We investigate the case of c-bond trading at the TASE, which is conducted, as for stocks, by an LOB mechanism. This is in contrast to the common practice worldwide of c-bonds being mostly traded in OTC markets. We identify two trader groups: retail investors (RI) which have low trading volume in all TASE securities, and the short-term traders (STT), which are the analog for the dealers in the OTC market.

DGP (2005) and Yin (2005) state that the OTC mechanism is inherently uncompetitive because of the lack of pre-trade transparency. Consistent with this notion, we find low spreads (average *HES* and *HQS* are around 0.08%, lower than the comparable figures for the US c-bonds and for the stocks of the comparable firms.); a very weak relation between trade size and the effective spread; negligible price dispersion within bond-minute , and negligible trading rents of the STT. While we cannot formally compare the Israeli LOB market to the American OTC market, it should be noted that size difference between the markets works against our findings.

We investigate the characteristics of the LOB that enhance competition and efficiency relative to the OTC. The first aspect we refer to is the concentration among the liquidity providers (STT). We find that although the TASE is much smaller than the US market, many STT are active in the market as a whole and in each bond. Consequently, the average *Herfindahl-Hirschman Index* (*HHI*) is 0.162 (0.126). This is in contrast to OWZ (2016) who find that in many bonds there are only 1-2 active dealers per year and as a result the average *HHI* is 0.61. We link the competition among the STT to market liquidity and show that the c-bond's *HHI* is positively related (after controlling for relevant exogenous variables) to its *HES*, *HQS* and to the transaction spreads of the non-STT, consistent with the assertion that competition among the liquidity providers reduces spread.

Another characteristic of the LOB that contributes to liquidity is that it enables all traders to compete on quotation. Indeed, we find that more than half (53%) of the NIS trading volume is between non-STT and 48% of their NIS volume is by "making". In the "making" transactions of the non-STT, the *HES* is lower than in transactions in which the "makers" are STT (0.0714% vs. 0.0865%). Controlling for other variables, the effective spreads of non-STT as "makers" are lower by 43% than those of STT. These findings are in line with Barclay, Christie, Harris, Kandel and Schultz (1999) and Weston (2000), who find that the NASDAQ reform of the 1990s that enabled competing with the dealers by posting limit orders resulted in narrower spreads.

Next, we focus on retail participation. We show that 8.8% of the trading volume arises from RI, and that this participation contributes to liquidity in several ways: First, the RI also compete on quotation and being the "maker" RI further decreases the transaction spread. Second, as "takers" they impose no adverse selection on the "making" side (as opposed to other non-STT) – which enables narrower spreads. In a simultaneous equation analysis, we show that RI presence decreases the spreads: a 1% difference in retail participation is negatively related to a change of 7.4% in the bond's spread.

The comparison to the US c-bond market is striking. Although the size of the TASE c-bond market is only 1% of American market ($80 billion vs. $7840 billion) and quite isolated (foreign holdings of 0.9%) it has much lower trading costs, especially for RI.[50] Our paper provides empirical support for the views expressed in Harris (2015), and Harris, Kyle and Sirri (2015), among others, that c-bond markets should move in the direction of a centralized open limit order book. The direct effects of such a change are expected to be a reduction of trading costs and enabling RI and small institutions fair and cheap access to the market. The change may have also the indirect effect of reducing the cost of capital of firms (in line with Amihud and Mendelson, 1986).

[50] See www.sifma.org for the aggregate market cap of US c-bonds in 2014.

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Table 1: Summary of Empirical Findings Regarding the American Markets for Corporate Bonds and Municipal Bonds

The table reports key findings from papers that investigate the corporate bond market and the municipal bond market in the US. The points drawn from the papers are those that are most relevant to our paper. Detailed explanations about the methodologies employed by the papers can be found in Harris (2015).

Paper	sample	Sample period	Findings
Schultz (2001)	C-bonds (a sample of insurance companies' trades)	1/1995 – 4/1997	• Average trading costs (one way): 0.135% • Active institutions pay less than inactive institutions. • The cost decreases with trade size (especially for inactive traders)
Bessembinder, Maxwell and Venkataraman (2006)	C-bonds (a sample of insurance companies' trades)	Pre-TRACE period (1/2002 – 6/2002) and post-TRACE period (7/2002 – 12/2002)	• Transaction costs decrease with trade size. • TRACE decreases transaction costs. • The adverse selection (information) component of the spread is not significantly different from zero.
Harris and Piwowar (2006)	Municipal bonds	11/1999 – 10/2000	Transaction costs (one way) decrease with trade size. For example, 1.34% (0.24%) for $5K ($1M) transactions
Edwards, Harris and Piwowar (2007)	C-bonds	1/2003 – 1/2005	• Transaction costs (one way) decrease with trade size. For example, after the introduction of TRACE: 0.86% (0.15%) for $5K ($1M) transactions of bonds rated "A" and above, with original issue size between $100 million to $1 billion. • Costs dropped after the introduction of TRACE. • Transaction costs decrease significantly with trade size • Cost decrease for better credit rating, larger issue size and closer time to maturity. • 1.2% of Dollar volume arises from transactions <$100K
Goldstein, Hotchkiss and Sirri (2007)	BBB-rated c-bonds that have an original issue size between $10 million and $1 billion	7/2002 – 2/2004	• Markup: transactions <10K$: 2.37%, >1000K$: 0.56% (Table 6. Panel A) • Transaction costs decrease with trade size. • TRACE decreases transaction costs
Green, Hollifield, and Schurhoff (2007)	Municipal bonds	5/2000 – 1/2004	• Markup: 0-100K$: 2.30%, 100K-500K$: 1.10%, >500K$: 0.16% • Dealer's bargaining power is decreasing in transaction size.
Chen and Zhong (2016)	C-bond trades	11/2008 – 3/2011	• The spreads of bonds that are also traded on the NYSE are lower by 0.10% than the effective spreads of OTC- only bonds (after controlling for relevant

			factors). • The spread – an average of the differences between selling prices and buying prices on the same day
Harris (2015)	C-bond trades	12/2014 – 4/2015	• The mean relative half quoted spread for all trades with two-sided quotes standing for at least two seconds is 0.435% (0.439% for customer trades) (Table 14). • The mean half effective spread for customer trades are greater for retail-size trades (under $100,000) (0.772%) than for institutional-size trades (0.421%). • There are many instances of trade-through (trading outside the spreads).
Hendershott and Madhavan (2015)	C-bonds regular ("voice") vs. MarketAxess ("electronic") transactions	1/2010 -4/2011	• Trading cost: Investment grade voice (electronic) 0-100K$ 0.88% (0.22%), 100K-1M$ 0.47% (0.14%), 1-5M$ 0.15% (0.11%), >5M$ 0.11% (0.10%) • Cost (one way) is calculated using a benchmark such as the last trade in that bond in the inter-dealer market.
O'Hara, Wang and Zhou (2016)	C-bond trades by US insurance companies	2002-2011	• Less active investors pay on average 0.49% more for buys and receive 1.78% less for sales than do more active investors. • The differences decrease, but remain significant, after the introduction of TRACE. • These differences hold for trading with the same dealer. • The differences are larger for small size transactions. • The top dealer does on average 70% of the annual volume and the average Herfindahl-Hirschman measure is 0.61. • More concentration worsens execution quality differentials between trades for active and less active investors. • Many small trades coming from institutions.
Randall (2015)	C-bond trades	From the start of TRACE in 2002 to 12/2010	• Dealer markups are larger when dealers' inventory costs are higher. • Mean percentage dispersion of prices within a bond within a minute at the end of 2010 (Figure 5): for customer-dealer trades ~0.24% and for inter-dealer trades ~0.04%.
Hendershott, Li, Livdanand Schürhoff (2016)	C-bond trades by US insurance companies	1/ 2001 – 6/2014	Execution costs are higher for smaller insurers and insurers with smaller networks.

Table 2: Summary Statistics

The table reports the cross-section statistics of the corporate bond sample. The sample period is 2014 (245 trading days). The sample includes 402 corporate bonds with a market cap of more than 100 million NIS. *Average return* and *STD* are the average daily returns and standard deviation of the daily returns, adjusted for coupon payments, respectively. *Daily volume* (*Daily volume during the continuous stage*) is the average daily NIS volume (the average daily NIS volume during the continuous stage) in NIS millions. *Number of daily transactions* (*Number of daily transactions during the continuous stage*) is the average number of daily transactions (the average number of daily transactions during the continuous stage). *Trading outside exchange (%)* is the proportion of NIS trading outside the TASE relative to the total trading volume. *Size* is the market capitalization, calculated as an average of the values at the end of each month the bond was traded during 2014, in NIS millions. *Firm size* is the market value of the firm's tradable c-bonds and stocks (an average of the monthly observations). *Duration* is the average duration of the c-bonds during the sample period. *Rating* is the average credit rating of the c-bonds during the sample period. This variable equals 0 in the 28 cases of no rating. Otherwise it ranges from *1* (D) to *26* (AAA). *Price* is the average NIS price of the c-bond during the sample period. *Number of traders* is the number of accounts that participated in at least one transaction of the corporate bond during 2014. "VW mean" is the value-weighted mean according to "Daily volume (in NIS millions)".

	N	Mean	VW mean	Median	SD	Min	Max
Average return (%)	402	0.02%	0.02%	0.01%	0.06%	-0.42%	0.51%
STD (%)	402	0.48%	0.47%	0.29%	0.45%	0.02%	3.11%
Daily volume (in NIS millions)	402	1.95	4.86	0.98	2.70	0.03	25.41
Daily volume during the continuous stage (in NIS millions)	402	1.70	4.19	0.87	2.26	0.03	18.18
Number of daily transactions	402	60.99	121.81	47.79	56.45	0.96	363.74
Number of daily transactions during the continuous stage	402	41.80	90.90	24.87	47.48	0.79	332.29
Trading outside exchange (%)	402	6.76%	7.41%	3.58%	9.05%	0.00%	78.15%
SIze (in NIS million)	402	647.26	1,388.53	407.07	724.73	100.50	5,421.06
Firm size (in NIS million)	402	5,159.85	7,893.93	2,456.94	5,988.70	79.77	26,868.87
Duration	402	3.62	4.30	3.35	2.02	0.11	10.41
Rating	402	19.44	21.12	21.29	6.13	0.00	25.89
Price	402	1.15	1.19	1.14	0.16	0.33	1.51
Turnover	402	63.01%	87.91%	48.85%	48.89%	4.58%	391.76%
Number of traders	402	2,351.1	4,807.5	1,407.5	2,460.6	71.0	17,686.0

Table 3: Spreads and Trading Profits of Short-term Traders

Panel A reports the bid-ask spread measures. The c-bond sample is defined in Table 2. The sample period is 2014 (245 trading days). *HQS* is the average of the c-bond's half quoted bid-ask spread across the transactions. An hourly observation of the half quoted bid-ask spread is calculated at six time points each trading day, on the hour from 11:00 to 16:00. This hourly observation is winsorized if the value is greater than 10% or if there is no valid bid-ask spread. The half quoted bid-ask spread of a c-bond is the average of the hourly observation for each day and then across days. *HES* is the average of the half effective spread across the transactions. For each transaction, it is measured as the absolute value of the difference between the transaction price and the mid-quote prior to the transaction, divided by the mid-quote. This observation is winsorized in the case that the half effective spread is greater than 10% or there is no valid bid-ask spread. "VW mean" is the value-weighted mean according to the NIS volume of the transaction. Panel B reports the rent of short-term traders (STT). STT are defined as follows. For each trader in each corporate bond in the sample, we calculate the number of switches from buying to selling or *vice versa* and divide it by the number of trading days that the trader was active in the bond. A trader is classified as STT if the NIS volume value-weighted average of this ratio across the securities the trader traded is equal to or greater than 1 and the trader total trading volume is higher than 2 million NIS in all TASE securities (excluding options). *THS* is the half effective spread of the transaction (defined above). *RHS* is the realized half spread, calculated as the c-bond's closing price divided by the transaction's price minus one if the seller is a "maker", and the minus of that value if the buyer is a "maker". AS is the adverse selection component of the transaction, calculated as the *THS* minus the *RHS*.

Panel A: Bid-Ask Spread Measures

	N	Mean	VW mean	Median	SD	Min	Max
HQS(%)	3,498,596	0.082%	0.077%	0.055%	0.102%	0.012%	2.910%
HES(%)	3,498,596	0.078%	0.067%	0.039%	0.202%	0.003%	10.000%

Panel B: Trading Profits of Short-term Traders (STT)

		Equally Weighted			Value Weighted		
STT as	N	THS(%)	RHS(%)	AS(%)	THS(%)	RHS(%)	AS(%)
makers	245	0.081	0.037	0.044	0.069	0.029	0.040
		(29.46)	(23.26)	(15.62)	(28.81)	(16.89)	(14.38)
takers	245	0.067	-0.009	0.076	0.055	-0.006	0.060
		(28.00)	(-3.76)	(16.45)	(22.79)	(-2.69)	(15.17)

Table 4: Concentration of Short-term Trading

The table reports the market share of short-term traders (STT) and their concentration in the cross-section of c-bonds. The c-bond sample is defined in Table 2. The sample period is 2014. STT are defined in Table 3. The table relates to transactions of STT vs. non-STT. *Number of STT* is the number of STT that traded in the corporate bond during the sample period. *HHI* is the Herfindahl-Hirschman index, calculated as the sum of the squares of the proportion of each STT's NIS volume relative to the total NIS volume of the STT in the corporate bond. *1/HHI* is the reciprocal of the Herfindahl-Hirschman index. *Proportion of largest trader out of STT volume in the corporate bond*/*Proportion of 3 largest traders out of STT volume in the corporate bond*/ *Proportion of 5 largest traders out of STT volume in the corporate bond* is the NIS volume of the largest STT / 3 largest STT / 5 largest STT in the corporate bond divided by the total NIS volume of all STT (in their transactions vs. non-STT) in the corporate bond, respectively. *Proportion of largest trader out of the corporate bond volume*/ *Proportion of 3 largest traders out of the corporate bond volume*/ *Proportion of 5 largest traders out of the corporate bond volume* is the NIS volume of the largest STT/ 3 largest STT / 5 largest STT in the corporate bond divided by the corporate bond's NIS volume, respectively. "VW mean" is the value-weighted mean according to the c-bond's annual NIS volume.

Variable	N	Mean	VW mean	Median	STD
Number of STT	402	32.11	49.64	30.00	18.06
HHI	402	0.162	0.112	0.126	0.122
1/HHI	402	8.14	10.32	7.92	3.48
Proportion of largest trader out of STT volume in the corporate bond	402	27.76%	22.07%	24.15%	0.14
Proportion of 3 largest traders out of STT volume in the corporate bond	402	54.77%	45.89%	51.42%	0.16
Proportion of 5 largest traders out of STT volume in the corporate bond	402	70.04%	60.95%	68.81%	0.14
Proportion of largest trader out of the corporate bond volume	402	7.23%	7.10%	6.47%	0.04
Proportion of 3 largest traders out of the corporate bond volume	402	14.70%	14.81%	14.40%	0.05
Proportion of 5 largest traders out of the corporate bond volume	402	19.13%	19.75%	19.21%	0.07

Table 5: The Relation between Short-term Traders' Concentration and Liquidity

The table presents the average coefficients of daily cross-section regressions of the security's bid-ask spread measures. The c-bond sample is defined in Table 2. The sample period is 2014. *LOG_STD* is the log of the standard deviation of daily returns. *LOG_SIZE* is the log of the security's size, calculated as an average of the values at the end of each month. *LOG_FIRM_SIZE* is the log of the market value of the firm's tradable corporate bonds and stocks. *DURATION* is the corporate bond's duration. *NON_LINKED* is a dummy variable that equals 0 if the bond is CPI-linked and 1 otherwise. *RATING* is the average corporate bond's rating according to the Israeli rating agencies. The value of the variable ranges from 1 (credit rating of D) to 26 (credit rating of AAA), and equals 0 if the bond has no credit rating. *RATING DUMMY* is a dummy variable that equals 1 if the corporate bond has a credit rating and 0 otherwise. *PRICE* is the closing price of the c-bond on each trading day. *AGE_0.5* is a dummy variable that equals 1 if the bond was issued in the last 6 months and 0 otherwise. *AGE_1.5* is a dummy variable that equals 1 if the bond was issued in the last 18 months and 0 otherwise. *HHI* is defined in Table 4. *LOG_VOL* is the log of the annual c-bond NIS trading volume. In regressions (1) – (3) the dependent variable is *LOG_DAILY_HQS*, which is the log of the c-bond's daily half quoted bid-ask spread. The daily half quoted bid-ask spread of the c-bond is calculated as the average of the quoted bid-ask spread at six time points each trading day, on the hour from 11:00 to 16:00. The hourly observation is winsorized if the value is greater than 10% or if there is no valid bid-ask spread. In regressions (4) – (6) the dependent variable is *LOG_DAILY_HES*, which is the log of the security's daily half quoted effective spread. For each transaction we calculate the half effective spread as described in Table 3. The daily half quoted effective spread is the daily average of the half effective spread of the c-bond transactions. In regressions (7) - (9) the dependent variable is *THS_NST*, which is the half effective spread of the non-STT in their taking transactions. A trader is classified as non-STT if she is not an STT (STT are defined in Table 3). The *t*-statistics of each explanatory variable are calculated using the Newey-West (1987) method, with the number of lags varying according to the auto-correlation of the coefficient. The number of lags ranges from 0 to 4.

	LOG_DAILY_HQS			LOG_DAILY_HES			LOG_THS_NST		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	14.013	10.283	9.595	9.788	7.350	7.061	5.430	4.045	4.485
	(86.32)	(57.06)	(60.52)	(65.77)	(49.70)	(51.33)	(36.92)	(27.06)	(29.71)
LOG_STD	0.044	0.112	0.271	0.104	0.154	0.258	0.105	0.138	0.224
	(2.68)	(7.64)	(20.19)	(7.51)	(11.05)	(21.37)	(6.17)	(8.49)	(15.54)
LOG_SIZE	-0.613	-0.533	-0.070	-0.450	-0.393	-0.086	-0.337	-0.307	-0.062
	(-92.19)	(-71.58)	(-8.24)	(-72.94)	(-60.62)	(-8.12)	(-66.85)	(-59.93)	(-5.50)
LOG_FIRM_SIZE	-0.150	-0.092	-0.075	-0.104	-0.073	-0.061	-0.029	-0.018	-0.015
	(-34.29)	(-22.36)	(-17.59)	(-24.87)	(-18.21)	(-15.56)	(-5.27)	(-3.35)	(-3.40)
DURATION	0.159	0.160	0.121	0.125	0.128	0.104	0.091	0.092	0.081
	(30.48)	(31.11)	(33.01)	(39.65)	(36.68)	(33.33)	(29.77)	(30.40)	(28.89)
NON_LINKED	-0.356	-0.284	-0.193	-0.195	-0.150	-0.094	-0.078	-0.047	-0.037
	(-32.19)	(-28.67)	(-16.80)	(-20.16)	(-15.56)	(-7.96)	(-7.98)	(-5.50)	(-4.38)
RATING	-0.059	-0.058	-0.047	-0.058	-0.055	-0.048	-0.056	-0.052	-0.047
	(-26.67)	(-27.54)	(-21.64)	(-24.81)	(-25.17)	(-22.47)	(-18.71)	(-16.26)	(-14.92)
RATING_DUMMY	0.776	1.142	0.851	0.734	0.959	0.773	0.718	0.869	0.774
	(15.50)	(21.45)	(16.51)	(15.66)	(20.67)	(16.64)	(10.69)	(13.48)	(12.43)
PRICE	-0.689	-0.557	-0.230	-0.742	-0.662	-0.452	-0.642	-0.601	-0.512
	(-28.13)	(-25.26)	(-9.67)	(-28.70)	(-26.91)	(-17.01)	(-25.31)	(-24.71)	(-21.32)
AGE_0.5	-0.278	-0.276	-0.282	-0.310	-0.302	-0.301	-0.388	-0.385	-0.416
	(-13.37)	(-15.34)	(-11.78)	(-18.85)	(-20.32)	(-18.03)	(-19.81)	(-19.64)	(-15.81)
AGE_1.5	-0.228	-0.154	0.028	-0.157	-0.123	-0.003	-0.096	-0.080	0.015
	(-25.37)	(-16.48)	(3.11)	(-16.80)	(-12.69)	(-0.31)	(-7.50)	(-6.38)	(1.36)
HHI		2.591	1.352		2.004	1.160		2.120	1.109
		(50.53)	(17.77)		(41.28)	(18.10)		(31.10)	(14.22)
LOG_VOL			-0.457			-0.312			-0.268
			(-35.49)			(-22.96)			(-20.06)
R^2	0.5305	0.5751	0.6243	0.4684	0.4973	0.5283	0.2294	0.2402	0.2571
N	245	245	245	245	245	245	245	245	245

Table 6: Explaining a Bond's Bid-Ask Spread and Retail Participation: Simultaneous Equations

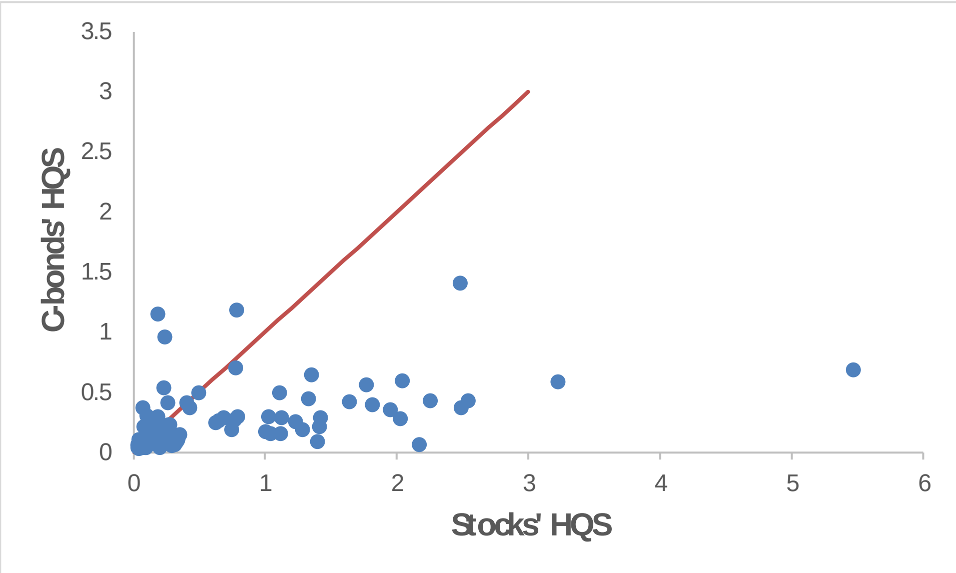
The table reports the coefficients of cross-section regressions. The regressions are the reduced-form regressions of the simultaneous Equations (1) and (2). The reduced-form regressions appear in Equations (3) and (4). The sample is defined in Table 2. The sample period is 2014. The explanatory variables *LOG_*STD, *LOG_SIZE, LOG_FIRM_SIZE*, *NON-LINKED* and *RATING_DUMMY* are defined in Table 5. *DURATION* is the average duration of the corporate bond during the sample period. *RATING* is the average credit rating of the corporate bond during the sample period. *PRICE* is the average closing price of the c-bond. *AGE_0.5* (*AGE_1.5*) is the average of a dummy variable that equals 1 if the c-bond was issued in the previous 6 (18) month and zero otherwise. In regression (1) the dependent variable is *LOG_HQS*, the log of *HQS*, which is defined in Table 3. In regression (2) the dependent variable is *PROP_RI*, which is the proportion of retail investors' NIS trading volume from the total NIS trading volume of the c-bond during the sample period. Retail investors are traders with less than 2 million NIS (~ $559,000) in all TASE securities (excluding options). In regression (3) the dependent variable is *LOG_HES*, the log of *HES*, which is defined in Table 3. Standard errors are clustered by firm.

	LOG_HQS	PROP_RI	LOG_HES	PROP_RI
	(1)	(2)	(3)	(4)
Intercept	15.720	7.840	14.356	7.840
	(14.60)	(0.97)	(14.88)	(0.97)
LOG_STD	0.105	0.541	0.053	0.541
	(0.93)	(0.64)	(0.62)	(0.64)
LOG_SIZE	-0.699	-0.527	-0.646	-0.527
	(-13.29)	(-1.29)	(-15.12)	(-1.29)
LOG_FIRM_SIZE	-0.154	1.378	-0.136	1.378
	(-3.84)	(3.39)	(-3.51)	(3.39)
DURATION	0.141	0.217	0.131	0.217
	(4.94)	(1.06)	(5.78)	(1.06)
NON_LINKED	-0.387	5.072	-0.292	5.072
	(-5.73)	(7.13)	(-4.68)	(7.13)
RATING	-0.043	0.020	-0.046	0.020
	(-2.16)	(0.14)	(-2.82)	(0.14)
RATING_DUMMY	0.500	-6.693	0.466	-6.693
	(1.22)	(-2.22)	(1.34)	(-2.22)
PRICE	-0.419	-11.738	-0.502	-11.738
	(-1.30)	(-5.90)	(-1.82)	(-5.90)
AGE_0.5	-0.172	-2.814	-0.117	-2.814
	(-1.15)	(-1.95)	(-0.93)	(-1.95)
AGE_1.5	-0.259	-1.026	-0.270	-1.026
	(-2.29)	(-0.94)	(-2.96)	(-0.94)
R^2	0.7431	0.3464	0.7427	0.3464
N	402	402	402	402

Figure 1: Bid-Ask Spreads of Corporate Bonds and Stocks of the Same Firm

The figure reports the half quoted bid-ask spread (*HQS*) for a sub-sample of firms that traded stocks on the TASE as well as corporate bonds. The sample is defined in Table 2. *HQS* is defined in Table 3. Corporate bonds of the same firm are averaged into a single observation. Panel A relates to the entire sub-sample. Panel B presents the firms for which the average *HQS* (of stocks and corporate bonds) is smaller than 0.5%.

Panel A: $\overline{HQS}(\%)$



Panel B: $\overline{HQS}(\%) < 0.5$