Does Liquidity Information Matter?

-- A view from fixed income market makers

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1. Introduction

Market liquidity study is gaining attention due to the recent crisis events, which depress asset return and affect financial market operation. With the recent available transaction data, liquidity study has extended from the equity market to the foreign exchange market, government market and most recently, the corporate bond market[1].

Liquidity study usually focuses on two areas: First, the relationship between asset return and its liquidity, and second, identifying and comparing different liquidity proxies. Most researches from the first area find liquidity priced in asset price, that liquidity premium does exist in equity market, foreign exchange market, and fixed income securities market. Researches in the second area are also expanding quickly.

If liquidity does affect asset return, then information on liquidity is valuable. In a dealership market, the market makers[2] are the liquidity provider. They directly observe the liquidity status of the security. Then, should they gain profit from their liquidity information?

In the market microstructure theories where dealer's pricing rule and trading behavior are modeled, they are not modeled as having advantages on liquidity information advantages[3].

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[1] See for example, Brennan and Subrahmanyam (1996), Datar et al (1998) in equity markets, Ito et al (1998) in foreign exchange market. Amihud and Mendelson (1991), Houweling (2002) in government bond markets, and Chen et al (2004), Houweling et al (2003) in corporate bond market.

[2] In this paper we use market maker and dealer interchangeably.

3 Inventory theory models assume no information relate to asset payoff prevailing in the market. Dealer's trading rule is governed by his perception of incoming order flow in order to keep his inventory in equilibrium. Asymmetric information theories realize that informed traders have private fundamental information on the asset value, and dealers trade to balance his loss to informed traders. In this type of theory the information prevailing is the fundamental information that relate to the payoff of the asset, and it is the informed public trader but not the dealer that have the information. Although later theories suggest dealers may act strategically to gain information from informed order flow, none of the theories suggests that dealers have information advantage and could be benefit from their information advantage.

Therefore, there is a gap between the market microstructure theories and the liquidity study. It is the aim of this paper to bridge this gap. Specifically, we examine the significance of liquidity information by examining dealer's trading revenue in the London risky fixed income securities market.

Because bond's future cash flows are well scheduled, private fundamental information in the risky fixed income securities market is less severe than that in the equity market. So, liquidity information may play a more significant role in this market. For fixed income securities, trading activity, numbers of dealers and the bond specific characteristics can be used as liquidity proxies to reflect the different aspects of bond liquidity. Some of these proxies, such as bond specific characteristics, can be directly observed by public. But proxies that related to trading activities are not directly observable to publics. It is because fixed income market is mainly an over-the-counter market. Trading information is not directly and immediately disseminated across the market. Dealers, however, as the liquidity providers, observe the most part of the trading and therefore can observe the market liquidity better than other participants.

We decompose the dealer's trading revenue into two parts, the spread revenue and the position revenue. The position revenue should summarize dealer's ability to profit using his information. We find that in general, dealers make positive trading revenue, and liquidity does significantly correlated with dealer's trading revenue. However, the trading revenue is mainly come from the spread revenue. While we focus on the difference between dealers, we find that dealers who have higher level of liquidity information do earn more than dealers with less liquidity information. Our results thus support the conjecture that, not only liquidity status affect asset value, but also, the liquidity information itself brings profit.

The rest of the paper is organized as follows. Section 2 presents literature review of dealer's trading revenue from theoretical and empirical aspects. Section 3 describes the data we use. Section 4 presents the methodology used and the estimation procedure. Section 5 discusses the empirical results. In section 6 we summarize the study.

2. Literature Review

2.1 Implications from market microstructure theory

In traditional market microstructure theories, market maker's trading behavior is usually modeled from two main considerations: the inventory control consideration and the asymmetric information consideration.

In inventory models such as Garman (1976), Amihud and Mendelson (1980), and Ho and Stoll (1983), the underlying assumption is that no traders (including the market makers and the public traders) have superior information on security's fundamental value. Even in a multiple dealership market, dealers have the same level of knowledge on the fundamental value of the security. In such a setting, dealer's main problem is to set the price to balance the incoming order flow and keep his inventory in certain preferred range. It happens because the direction of next period's incoming order flow is never certain and order flow imbalance is bound to happen. The preferred inventory works purely as a buffer to balance the incoming orders. As a result, dealers do not expect to earn profit from their inventory. Furthermore, because dealers do not trade on their knowledge of fundamental information, dealer's effect on security price is only temporary, as in the long run the price converge to true value when order flows are balanced. So whether the inventory position will eventually earn them profit is even ambiguous. In inventory model, dealers will earn spread revenue, but if they execute trades that will lead the inventory deviate from the desired level, their spread revenue will be eroded by inventory deteriorate.

If prediction of dealer's profit from inventory model is only inferential, asymmetric information theories make strong predictions about dealer's trading profit.

In asymmetric information models of market making such as Copeland and Galai (1983), Glosten and Milgrom (1985), Kyle (1985), and Admati and Pfleiderer(1989), the common fundamental assumption is the asymmetric information prevail in the market.

Dealer faces two types of traders: the informed trader and the uninformed trader. The informed trader has certain level of private information of the security value, so they can buy low and sell high. The uninformed trader trade because of liquidity reasons that are unrelated with security's fundamental value. Dealers have no superior information to the informed trader but he does know that if he trade with an informed trader he will always lose. Dealer's problem of price-setting becomes a problem of how to offset the losses from trading with informed trader by the gains from trading with uninformed trader.

Copeland and Galai (1983) modeled a risk neutral dealer's one-period pricing rule. Dealer's gain is a weighted-average of expected loss from informed trade and expected gain from uninformed trade. The weight is the probability of informed trades and the probability of uninformed trades. Bid-ask spread arises as dealer maximizes this gain. If competition is introduced in this monopolistic framework, dealer's gain will in equilibrium reaches zero, and as the result, spread revenue will just compensate the losses to informed trader. This is explicitly the assumption of Glosten-Milgrom (1985) model. In this model, risk neutral dealers set prices under the zero expected trade profit condition. Because each market maker has the same level of knowledge of security value and trade information, they will have the same pricing rule. This zero-profit equilibrium condition is also found in other models which model the strategic trading behavior of traders, as in Kyle (1985) and Admati and Pfleiderer(1989).

To sum up, the asymmetric information model has two implications on dealer's profit: First, in a competitive dealership market, spread revenue shall be perfectly offset by position loss, so dealers should earn zero total profit in equilibrium. Second, dealers are homogeneously non-informed traders. They have the same level of fundamental information and market information, so in cross-sectional they all earn zero total profit.

In practice, at least three facts contradict to the previous theory: first, as we discussed in the introduction, dealers do have market information that is not available to informed trader. Second, the information that dealers have is not homogeneous. Dealers may either have better skill that they can interpret trade information better than others do, or they simply observe more trade than others do and so have a better image on market liquidity. All the liquidity information helps him make better prediction on asset price and thus affect his trading decision. Third, dealers do have other ways to infer the information contained in a security rather than trade with informed trader. It is common practice that dealers usually hold more than one security. If the securities are correlated, information can be implied from trading in other securities. This information, either fundamental or non-fundamental, helps dealer to reach better trading decision.

2.2. Empirical researches on dealer's trading revenue

In most previous market microstructure empirical studies, investigation on dealer's trading revenue is limited to spread revenue only. Results on position revenue are only inferential. It is only recently when detailed transaction data are available that detailed estimation on dealer's trading revenue become possible. But even with the detailed transaction data, estimation of position revenue is still to some extent subjective, because the position revenue depends on dealer's inventory and the liquidity price of the inventory, while the benchmark for the liquidity price is difficult to decide.

Manaster and Mann (1999) analyze the trading revenue of futures traders on the Chicago Mercantile Exchange during the first six-month of 1992. Their data gives the details of transaction including the trading capacity of each participants and trade direction, that enable them to break down dealer's trading profit into execution component and timing component on a trade-by-trade basis. The execution component of trading profit is the effective spread that the dealer charged against customers, while the timing component of trading profit is the position revenue that dealer earns from price movement. As futures market is a very liquid market, Manaster and Mann use the one-minute price benchmark and five-minute price benchmark to calculate the position revenue.

A few of their finding are contradict to the theory predictions. First, they find that when customer trade with market makers, they do not necessary have executive disadvantage (negative execution in their paper). In fact, cross-sectional they frequently have positive execution. Second, on average, market makers earn positive trading profit, and not only they enjoy positive execution profit, they also have positive timing profit as well. This finding is more pervasive at higher volume quartiles. Third, they find that when market maker's timing profit is high, customer execution costs are also high. They also find that that market makers seem to give up some of their execution advantage in order to make a favorable trade. This finding suggests market makers may act strategically, and this strategic trading behavior is the focus of Neuberger and Hansch (1996).

Neuberger and Hansch (1996) investigate the strategic trading behavior of equity dealers in the London Stock Exchange. They argue that if dealers can learn information from the order flow, they may trade strategically to make money on their own account while not fully reveal the information. They project that dealers can differentiate informed trades and uninformed trades, and if they act strategically, it should be reflected in the profitability of different types of trade. The informed trades and uninformed trades are defined based on trade size and trade direction relative to dealer's pre-trade inventory position. So in this paper, the focus is on breaking down trade type and estimates the revenue from different trade type rather than decomposing the components of revenue itself.

Using a one-year detailed transaction data from 1991 to 1992 for 30 liquid stocks, they find that the majority of market makers actually made trading losses over the year, and overall, the trading revenue margin is statistically indistinguishable from zero. They find that the revenue from different trade types is different, that dealer earns less from informed trades than they earn from uninformed trades. However, they find the higher proportion of uninformed trades a dealer executed the less his overall trading revenue margin. The finding that dealers do more informed trades make significantly more money on their informed trades than do dealers who do less informed trades suggest that dealer learn from the informed order flow.

Other researches that examine dealer's trading behavior from different aspects also have similar findings that dealers may trade strategically but overall they make very low profit margin not significantly different from zero. For example, Hansch et al. (1998) examine the effects of preferencing and internalization of order flows on execution cost and dealer's profit in London Stock Exchange. They find that on average, dealers have net trading loss as their spread revenue is exceeded by the position loss. When breaking down the trade into size categories, they find dealers make money on small trades, break even on large trades, but lose money on medium-sized trades.

One important aspect that those papers haven't investigated, is the portfolio effect of dealer's trading on the profit. Many papers have argued the importance of considering portfolio effect on dealer's trading. In the original inventory model of Ho and Stoll (1983), the inventory position of the dealer is one determinant factor of his pricing rule. Later empirical works such as Naik and Yadav (2002) particularly emphasis the importance of dealer's portfolio consideration in dealer's trading behavior.

Hansch and Saporta (2000) investigate the trading revenue of UK government bond (gilts) market makers. In this study, they have detailed transaction records of gilts market makers, including their derivative transaction records and actual daily inventory position. They find that contrast to equity dealers, although not significant in a statistic sense, gilts dealers earn positive gross trading revenue. This positive gross trading revenue are not affected whether take into consideration of dealer's derivative position or not, although they do find there are offsetting effect between cash market and derivative market. Trade types have effects on dealer's trading revenue. Dealers earn high trade margins in small and large sized trade, with medium sized trade offering the lowest margins. After decomposing dealer's revenue into spread revenue and position revenue, they find that in sharp contrast with other previous findings in equity market, dealers still earn positive position revenue.

The analysis of dealer's trading revenue has also been conducted in the foreign exchange market. Lyons (1998) examine the trading revenue of one active DM/$ dealer for a week. He find that this dealer earns significant profit, and besides that the main profit source is the spread revenue, part of the revenue comes from position. Does that imply that dealers have information advantage in the foreign exchange market? Ito et al (1998) argue that there are private information exist in foreign exchange market, and they define this private information as the semifundamental private information which, in contrast to fundamental private information, is unrelated to the payoff of the security but relevant to interim prices. This semifundamental private Information including trader's risk aversion, supply and distribution of the risk assets, and any information about trading environments.

At the first glance, trading revenue of dealers vary according to specific market examined. But it may well support our conjecture that liquidity information itself will bring profit. In the equity market, when fundamental private information plays an important role in driving stock price, dealers generally make loss on their position revenue. In markets where fundamental private information plays a minor role, dealers can use their advantages in liquidity information to benefit. That may be the reason behind the positive position revenue found in foreign exchange market (Lyons, 1998) and government bond market (Hansch and Saporta, 2000). In the corporate bond market, where trades has less fundamental private information content than equity market, but higher information content than government bond market or foreign exchange market, to what extent can dealers benefit from their information advantage? This is a question that has not been well examined.

All the above research focuses on whether dealer can gain information from informed order flow. Our research is different from the previous ones as we focus on the liquidity information.

3. Data

In this study we used two sources of data. The first data set is the London Stock Exchange TDS transaction data, which gives the details of trade information. The second data is the Quiscore[4] from Qui Credit Assessment Ltd. This data gives the credit quality information of U. K. domestic issuer, which we used to infer credit quality of the issues.

3.1 The transaction data and the cleaning procedure

The transaction data contain trade participants' trade reports. It contains the trade volume, trade price, trade time, the identities of both trade parties and their capacities, and also indicates the trade direction for the reporting party (a buy or sell).

The data is very reliable. However, there are few problems with the data that need to be sorted out. First, some trade records that are contra-transaction records. It indicates that another trade record that has the same trade details contains mistakes. In these cases, we delete the contra-transaction records and the trade records associated with it.

Second, in most trades, both sides of the trade party reported the transaction details, so we have two records for the trade. But some transaction was only reported once by one of the trade party. The way to find out whether the trade records are the same transaction is to look at its transaction number. For each security, every day the Exchange will assign a unique transaction number for each trade. So if a trade was reported twice by both trade parties, the two records will bear the same transaction number.

Third, there are shaped trades where a dealer or broker splits a big order into a few smaller trades. The shaped trade can happen between more than one dealer/broker, so we have several reports on a trade that may have different trading volume, value and trade party records. It often happens that one party may omit the volume or trading value while report the trades so we have zero volume or zero value trade records. Again, we rely on transaction number to match all these records. Some times we find that the trading value of the buy side of the shaped trade does not exactly equal to the trading value of the sell

[4] The QuiScore is based on statistical analysis of a random selection of companies. To ensure that the model is not distorted, three categories are screened out from the initial selection: major public companies, companies that have sort insignificant amounts of unsecured trade credit and liquidated companies that have a surplus of assets over liabilities.

side of the trade, perhaps result from rounding error, as the differences never exceed 10 pence. In these cases we take the average trading value as the real trading value for this trade.

Fourth, it appears that some prices were wrongly recorded, as we found that the prices reported at a time is more than 10 times larger (or smaller) than the trade price immediately before or after it. We apply a filter rule as follows: first, we calculate the par value price for each trade. We index the transaction from 1 to T, and let P_i denotes the individual trade price. For each trade, we calculate the price ratio as $PR = P_i / P_n$, $n = 1,...T$, and $n \neq i$. We define $PR \geq 10$ and $PR \leq 0.1$ as the out-of-range price ratio, and the band within the in-range price ratio. For each trade record, if the number of the out-of-range price ratio is bigger than the number of the in-range price ratio, this trade record is excluded from the sample.

We also exclude trades on convertible bonds, floating rate bonds, etc, and bonds with different dealing rules.

As many previous studies (such as Neuberger and Hansch (1996)) do, we have to ignore the trade gains or losses on the initial inventory due to lack of information on the initial inventory. This could affect the results because a dealer may have long or short initial inventory and then close out during the sample period, while the trading revenue we calculated will be based on the trades executed during the sample period and the end period price. There is no perfect solution for this problem, so when we calculate the trading revenue, we only consider the cases where a dealer has made at lease two buy and two sell trades on a security.

3.2 Credit rating

Credit rating on individual fixed income security is rare in UK in our sample period. Instead, we have to rely on credit risk information on issuers to infer the credit quality of issues. We use Quiscore[5] from Qui Credit Assessment Ltd to identify the credit status of firms. As further information on bond's seniority is not available, we assign the same credit score to every security that this firm issues. We acknowledge that this is just a rough proxy for a security's credit quality.

The Quiscore is a measure of the likelihood of company failure in the twelve months following the date of calculation. It is given as a number in the range 0 to 100. There are five bands of Quiscore:

1. 81-100 is the secure band. Companies in this band tend to be large and successful public companies. Failure is very unusual and normally occurs only as a result of exceptional changes within the company or its market.

2. 61-80 is the stable band. In this band, company failure is a rare occurrence and will only come about if there are major company or marketplace changes.

3. 41-60 is the normal band. This sector contains many companies that do not fail, but some that do.

4. 21-40 is the unstable band. In this band, there is a significant risk of company failure: they are on average four times more likely to fail than those in the normal band are.

5. 0-20 is the high-risk band. Companies in the this sector are unlikely to be able to be able to continue trading unless significant remedial action is undertaken, there is support from a parent company, or special circumstances apply. But a low score does not mean that failure is inevitable.

5 The QuiScore is based on statistical analysis of a random selection of companies. To ensure that the model is not distorted, three categories are screened out from the initial selection: major public companies, companies that have sort insignificant amounts of unsecured trade credit and liquidated companies that have a surplus of assets over liabilities.

Based on these explanations, we categorize the companies into investment grade and non-investment grade companies. Investment grade companies include band 1 and band 2 companies (Quiscore 61-100), and the non-investment grade companies include band3, band 4, and band 5 companies (Quiscore 0-60). Then we assign the securities with the same credit status as the issuers.

4. Methodology and estimation procedure

4.1 Bid-ask Spread Estimation

Fixed income market is an opaque market. Different from in the equity market, market makers of fixed income securities are not obliged to display bid-ask quotes in fixed income securities on SEAQ so no quotes are available in the market. The bid-ask spread has to be estimated.

We estimate the realized bid-ask spread by matching the daily buy-side and sell-side transaction prices of a security. This method is similar to the method used by Chakravarty and Sarkar (1999) and Hong and Warga (2000). These two previous studies exclude from their sample bonds that do not have both bid and ask prices for the same day. As a result, their samples are likely to contain only the more liquidity bond. Such a filtering procedure may not be appropriate if in general the market is at the low end of the liquidity spectrum.

We calculate the bid-ask spread as follows:

$$Bid_t - Ask_t = \frac{1}{N}\sum_{i=1}^{N} P_i^A - \frac{1}{M}\sum_{j=1}^{M} P_j^B$$

where $Bid_t - Ask_t$ is the realized bid-ask spread for a give bond in day t, $P_i^A\,(P_j^B)$ is the price of transaction i (j) occurring at the ask (bid), and $N(M)$ is the number of ask (bid) transaction for a particular bond on day t. If bid (or ask) transaction price is not available on a particular day, we use the bid(or ask) transaction price of the previous day. If both bid and ask transaction prices are not available, no bid-ask spread was calculated for that day.

4.2. Estimation of Credit spread, Liquidity spread, and the Interest rate exposure

Bond's price is affected by its credit risk, liquidity risk and interest rate risk. How do bond's credit risk and liquidity risk affect their bid-ask spread, and so the trading revenue? To answer this question, we need to estimate the credit spread and the liquidity spread. We do so by decomposing the price premium between a risky bond and a hypothetic risk-free bond with same payoff structure into credit spread and liquidity spread.

The daily price of the hypothetic risk-free bond is constructed using the Bank of England spot rates. Bank of England provide daily spot rate with maturity range from 0.5 year to 22.5 years. For bond having maturities longer than 22.5 years, there are two choices for long term spot rates: first is to assume flat spot rate after 22 years, and second, use the war loan stock yield to proxy the yield. We choose the second one, as the war loan stock yield is the only indicator that investors can have as the long-term interest rate at that point of time, although it does not different much from the 22.5 year spot rate.

First we price the corporate bonds based on the Bank of England spot rates. The daily hypothetic prices are calculated as the dirty prices minus the coupon accruals. For each bond at day t, we calculate the hypothetic dirty price as follows:

$$p_t^i = \frac{c}{2}\left(\sum_{t=1}^{T}\frac{1}{(1+0.01*sp_t)^{f_t}}\right)+\frac{100}{(1+0.01*sp_T)^{f_T}}$$

where
i: bond i,
t: current trading date.
c: annual coupon rate.
f: the period of compounding.

$$f_t = f_{t-1} + {(P_{t+1} - P_t)}\big/{365/2}$$

sp_t : the interpolated spot rate at the payment date
$sp_t = s_{t-1} + (s_t - s_{t-1}) * (P_{t+1} - D_t)/365/2$
where s_t is the half-year spot rate known at trading date t.

Where y_t is the Bank of England spot rate at day t, c is the semiannual coupon payment, and N is the total number of semiannual cash flows.

Then the hypothetic clean price is calculated as the dirty price minus coupon accrual.

The price premium is estimated by taking the difference between the hypothetic price and the actual transaction prices, at the day when there are trades. If the actual transaction price is a principal bid price, the price premium is calculated as the bid price+spread/2-hypothetic price; if the actual transaction price is a principal ask price, the price premium is calculated as the ask price-spread/2- hypothetic price.

Liquidity risk estimation

Liquidity risk can be measured in different dimensions. In this paper we consider the following liquidity proxies:

A. The price impact measure.

When market liquidity is low, price impact of a certain size trade is higher than the price impact of the same sized trade when market liquidity is high. For a thinly traded market, this measure may be better than the estimated bid-ask spread, which may contain noise introduced by the estimation procedure.

We estimate the price impact measure using the following regression:

$$\left| r_{i,d} - r_{f,d} \right| = \alpha + \beta v_{i,d} + \varepsilon$$

where:

$r_{i,d}$: the return of bond i on day d.

$r_{f,d}$: the return of a hypothetic bond with same structure as bond i on day d.

$v_{i,d}$: the pound sterling volume for bond i on day d.

The estimated β is our measurement for price impact. Bond returns in a given day are defined as the difference between the bond price in transaction day t-1 and transaction day t plus coupon accrual divided by the price in transaction day t-1, where the bond price is the mid price (bid price+spread/2 or ask price-spread/2). If there are more than one bid or ask trades in a day, we take the average trade volume and volume weighted average price. The formula for bond return is as follows:

$$r_{i,d} = \frac{p_t - (p_{t-1} + c * day / 180)}{p_{t-1}}$$

where p_t is the mid price of day t. day is the number of days between the last coupon payment day to the transaction day t. c is the half-yearly coupon payment of this bond.

When liquidity is low, price impact is large per unit of volume. So the price impact measure should be negatively related to liquidity status.

B. Turnover, which is the total pound value of transaction during the sample period, is presented in million pounds.

C. Number of trading days, which is the total number of days when a security has been traded. This is an indicator of trading frequency.

D. Number of market makers, which is the total number of dealers who have traded the security as principal.

Interest risk estimation

The interest risk exposure is measured by duration. The most widely used duration measure is the modified Macaulay duration (henceforth, simply referred to as duration). The duration D at time t of bond *i* maturity at time T is calculated as follows:

$$D_{i,t} = \frac{1}{P_{i,t}} \sum_{s=1}^{T} \frac{sC_{i,t+s}}{\left(1 + y_{i,t}\right)^{s+1}}$$

Where $P_{i,t}$ is the market price of bond *i* at time t; $C_{i,t}$ is the coupon received from bond *i*, s periods after time t; and $y_{i,t}$ is the yield to maturity on bond *i* at time t.

A dealer's portfolio duration S is defined as follows:

$$S_{k,t} = \sum_{i=1}^{n} \frac{V_{i,t}^{k} D_{i,t}}{100}$$

where $V_{i,t}^{k}$ is the pound sterling value of the position (duly signed) of dealer k in bond *i* at the end of day t and $D_{i,t}$ is the duration of bond *i* as defined in equation above.

There are some practical issues to consider in estimating the duration. First we only have clean price for transaction. Based on market practice, the duration is calculated using dirty price, that is, the clean price plus the coupon accruals.

$$p_{dirty}^{t} = p_{clean}^{t} + c * day / 180$$

where *c* is the half-yearly coupon payment, and *day* is the number of days between the last coupon payment date to the transaction time t.

Second, bonds are traded daily, and it possible that the next cash flow is not exactly six months later. So the duration calculate has to be revised to include the fractional period discount (See Tuckman (2002) for examples of bad day). So we calculate the modified duration as follows:

$$D_{Mod} = \frac{1}{p}\frac{1}{1+y/2}\left[\sum_{i=0}^{N}\frac{i+\tau}{2}\frac{c}{(1+y/2)^{i+\tau}} + \frac{N+\tau}{2}\frac{100}{(1+y/2)^{N+\tau}}\right]$$

Where N is the number of semiannual coupon payments, c is the semiannual coupon payment, and τ is the fraction of semiannual coupon that is unpaid.

4.3. The trading revenue estimation

In this study we estimate dealer's total trading revenue over the period of August 1st, 1994 through October 30th, 1994. An accurate estimation of trading revenue requires the knowledge of dealer's initial inventory position. Due to lack of this information, we assign all the dealers zero initial inventories as previous studies do. Therefore we only look at the revenue that dealer generated over this specified period. Same as all the previous studies, we also ignore dealer's commission[6].

Dealer's trading revenue contains spread charges for executing trades and profit from inventory through price movements. Fixed income security also pays coupon that shall be included in trading revenue.

Our notations are explained as follows: let J denotes the total number of dealers in the market, and letter j indicates the individual dealer. K denotes the overall security sample in the market, and k indicates the individual security. Transactions are indexed with t, and T denotes the end transaction. D denotes the last day in the sample period. P denotes the prices, and VWAP is the value-weighted average price. Q denotes the signed quantity of transaction, for fixed income security, it is the nominal value. If it is a dealer buy

[6] It shall be point out that we consider the trading behavior of both market makers and dealers who trade as principals. Market makers don't charge commissions for making markets, but dealers do. Since trades with commission are only part of the total sample, and it will be arbitrage to assign commissions, we ignore the commissions in calculating total trading revenue. Most other researches also ignored the commission.

(customer sell), Q<0, and if it is a dealer sell (customer buy), Q>0. C denotes coupon payment, with the daily coupon rate denoted by c. Dealer's inventory is denoted by letter I.

The accrued interest is the amount of interest that would be paid if the interest were paid each day. We calculate the coupon payments on dealer's end of day inventory on a daily basis. The total coupon a dealer j receives is

$$C_j = \sum_{k=1}^{K} \sum_{d=0}^{D} c_k I_{jkd}$$

The revenue measure, TR, include three components, i.e. the spread revenue, the position revenue from end-of-period inventory, and the accrued interest earned during the trading period. We define dealer j's total revenue as follows:

$$TR_j = \sum_{k=1}^{K} \left(\sum_{t=0}^{T} Q_{jkt} P_{kt} + VWAP_{kD} \sum_{t=0}^{T} Q_{jkt} \right) + \sum_{k=1}^{K} \sum_{d=0}^{D} \left(I_{jkd} - I_{jk0} \right) c_k$$

The first term shows the revenue generated from trading, and the second term shows the estimated value of accumulated inventory. The third term is the accrued interest during the trading period.

Similarly, we define that for a security, the accumulated trading revenue is as follows:

$$TR_k = \sum_{j=1}^{J} \left(\sum_{t=0}^{T} Q_{jkt} P_{kt} + VWAP_{kD} \sum_{t=0}^{T} Q_{jkt} \right) + \sum_{j=1}^{J} \sum_{d=0}^{D} \left(I_{jkd} - I_{jk0} \right) c_k$$

In this measure, the revenue from trades between dealers will be cancelled, so it shows dealer's gain as a whole against the customers in security k.

Trading revenue margins are calculated by dividing the revenue earned by the dealer's total pound turnover during the sample period. They are defined as:

$$M_j = \frac{TR_j}{\sum P_t |Q_t|},$$

and,

$$M_k = \frac{TR_k}{\sum P_t |Q_t|}$$

These margins show dealer’s profit per Pound Sterling turnover.

5. Empirical results

5.1 Descriptive statistics

Table 1 gives the descriptive statistics for the transaction data. Fixed income securities with similar characteristics are highly substitutes. As we discussed previously, trading revenue may reflect this pattern. We group bonds into different categorizes based on their credit risk status and term to maturity. Based on the credit status of issuers, we group securities into investment grade bond, non-investment grade bond according to their Quiscore bands, and bonds that we do not know their credit status. Only UK domestic firms have Quiscores. So our investment and non-investment bonds are limited to domestic bonds, and majority of sample securities is bonds with unknown credit status, including domestic bonds without credit risk indicator, all the foreign bonds and some Eurobonds.

For each category of bonds, we further stratify them into Shorts (less than 7 years to maturity), Mediums (between 7 and 15 years to maturity), longs (more than 15 years to maturity), and Undated (including irredeemable bonds and preference shares).

Pane A reports the overall market activities of security trading. We have1,452 fixed income securities traded in the market over the sample period. Of all the securities, 352 were investment grade bonds, and 148 were non-investment bonds, and 952 were securities with unknown credit grade. Over the sample period, total market turnover was £5.45bn. Transactions on investment grade and non-investment grade securities account for 26.23% of total market turnover. Trading in investment grade bonds is concentrated in Longs (68.38% of turnover), and trading in non-investment grade bonds is concentrated in Mediums (44.31% of turnover). Across the time to maturity span, trading is heavier in long end than the short end: total turnover in Shorts was £0.84bn(15.46%), turnover in Mediums is £1.21bn(22.19%), in Longs is £1.5bn(27.41%), and in Undated is £1.91bn (34.94%).

Trading activities are different across security categories. In investment grade bonds, short-term bonds were traded most actively, while in non-investment grade bonds, undated bonds were traded most actively. The undated bonds also received most trades in bonds with unknown grade.

Over this period, 91 dealers make markets (trade as principals) for 1,452 securities. Although we can only identify credit status for 34.95% of total securities, we find that most market makers have made markets on them, especially on the investment grade bonds. Undated security received more market making than any other fixed term security.

Over our sample period, the average trade size in the market is £0.17m nominal[7]. Mean trade size generally exceed median, suggesting strong left skewness of the size distribution. The different concentration of trading activity and turnover imply that trade size varies across bond categories. Short investment grade bonds were traded very actively, but the mean trade size is small (£16,170) and the mean far exceed the median (only £1,150), indicating that most trade in this sector are retail trades. This pattern can be found in both medium and undated investment grade bonds, except that the long investment grade bonds received average trade size as high as £0.6m with £0.1m as the median trade size. It suggests that institution trades are concentrated in long bond in the

[7] Hansch and Saporta (2000) estimated that the average trade size in the gilts market is roughly £2.9m nominal, over the period of October 10, 1995 to May 31, 1996.

investment grade. For non-investment grade bonds, average trade size are generally higher, but median trade size never excess £50,000. For unknown grade bonds, long bonds received the biggest trade size (roughly £0.9m), more than 5 times of market mean trade size. The median trade size (£0.3m) is almost 30 times of overall market median (£13,650). The largest trade size reached as high as £101m!

Panel B reports the dealer's trading activities according to transaction category. Not surprising, most trades happened between dealer and institutions (including brokered trade and direct trading between principals and customers). This type of transactions accounts for 90% (28,640) of total number of transactions. Direct and brokered inter-dealer trades are few in this period, perhaps reflecting the illiquidity of the market and/or the reluctance of risk sharing among dealers. 2,338 (7%) trades are executed by agency cross, that the public orders are matched exactly.

Total turnover between principal and institution trade accounts for 87% of total turnover. The average trade size is £0.165m, mostly are wholesale trades. The brokered and direct inter-dealer trades, although account for only 6.7% of total turnover, have the largest trade size of £0.8 and £0.28m, respectively. Agency crossed trade account for 6.6% of total turnover, but the trade size are the least. Most agency crossed trades are retail sized trades.

The distribution of number of trades and trading size is stable across different bond categories.

5.2 The credit spread and liquidity spread

5.2.1 The price premium

For each security that we know the credit status, we estimate the price premium between the actual transaction price and the hypothetic price. We only consider bonds that have been traded in at least three days, having at least three principal bid trades and three principle ask trades, where the trades are not happened simultaneously.

Table 2 summarizes the price premium. We have 66 investment grade bond with a total turnover of 6.11 million pounds. The average price premium is 10.86 pence. Because they are investment grade bonds, some of them have very good credit quality. The minimal price premium is only 0.01 pence, but the maximal price premium is 51.88 pence. We also have 35 non-investment grade bonds with a total turnover of 3.43 million pounds. The average price premium is 15.26 pence, with a minimal price premium of 1.26 pence and maximal price premium of 83.26 pence. On average, the price premium is higher for non-investment grade bonds than the investment grade bonds, which may reflect the higher credit spread for non-investment grade bonds.

5.2.2 the components of price premium

The price premium between the transaction price and the hypothetic price has at least two main components: the credit risk premium and the liquidity risk premium. In this section we decompose the two components.

We assume that credit risk and liquidity status stay the same over three months.

$$Premium_i = \alpha * Credit_i + \beta * liq_i + \varepsilon \qquad (1)$$

Where $Premium_i$ is the average daily price premium for bond i. *Credit* is the Quiscore for bond *i* and *liq* is the following liquidity measures for bond *i*: the price impact measure, total turnover, and total number of dealers. All explanation variables have been standardized. We assume that cross sectional bond risk premium is linear to credit risk and liquidity risk, and the components of this premium is constant all through the three month sample period. We use the White's method to correct for heteroscedasticity.

Table 3 shows the results of the decomposition. We expect the price premium be negatively related to the credit quality and the liquidity level. We find that the Quiscore is consistently negatively related to the price premium, shows that credit risk is negatively related to price premium. The price impact measure is positively related to the price premium, which is consistent to the expectation that low liquidity status increase the price premium. This relation is confirmed by using the turnover and the number of trading days as the liquidity proxy, that we find a negative relation between these two proxies and the price premium. Regress the premium on all the explanation variables does not change much the results. However, we do not find a statistically significant relationship from these regressions.

5.3 Bid-ask spread

5.3.1 Summary of bid-ask spread

Table 4 summarizes the results of estimated bid-ask spread. Panel A presents the results of securities included in price premium estimation. Panel B presents the results of all spread estimation sample. We found that investment grade securities have slightly higher bid-ask spread than the non-investment grade securities. It may be caused by the slightly higher average trading volume in non-investment grade securities.

Bid-ask spread can be affected by many factors. The inventory theory suggests that dealers set the bid-ask spread to offset inventory risk. So the risks of the security will affect the bid-ask spread. For corporate bonds, the usually considered risks are credit risk and interest rate risk. However, as a proxy for liquidity, bid-ask spread is also affected by other liquidity measures that reflect different aspects of liquidity. To see the determinants of the bid-ask spread, we estimate the following two regressions:

$$y_{ba}^{j} = \alpha + \beta_1 D_j + \beta_2(\alpha * Credit_j) + \varepsilon_j \qquad (2)$$

$$y_{ba}^{j} = \alpha + \beta_1 D_j + \beta_2(\alpha * Credit_j) + \beta_3(\beta * L_j) + \varepsilon_j \qquad (3)$$

where y_{ba} is the bid-ask spread of bond j, D_j the duration for bond j, $Credit_j$ is the Quiscore that proxy for the credit risk for bond j, and α is the corresponding coefficient of Quiscore from equation (1). L_j is the ith liquidity measurements for bond j. We use the following liquidity measurements: price impact, turnover, and the number of trading days. The liquidity measures are timed by the absolute value of the corresponding coefficient β obtained from equation (1). All the measures are standardized except for the price impact measure. To correct for heteroscedasticity, we use the White's correction for the standard error of estimators.

The first regression tells us how bid-ask spread is affected by the risk that are related to the future cash flow, the second regression tells how do liquidity risk add explanation to the bid-ask spread, and also compares the effects of different liquidity proxies.

Table 5 summarizes the regression results.

The bid-ask spread should increase with the risk a security has. Without the liquidity risk proxies, the bid-ask spread is positively related to interest risk but negatively related with the credit risk (the higher the Quiscore, the better the credit of a security). The results are not statistically significant. It shows that there should be other factors that affect the bid-ask spread.

After adding the liquidity proxy, we find that when using turnover as the liquidity proxy, it significantly explains the bid-ask spread. At the same time the interest rate risk is also a significant factor of the bid-ask spread. The other two liquidity proxies, the price impact measure and the trading days, although have the expected relation with the bid-ask spread, do not have significant relation with the bid-ask spread.

When using the duration, Quiscore and all the liquidity proxies as the explanation variables, we find that the turnover still has the most significant effect on the bid-ask spread.

Overall, our results may suggest that interest rate risk and liquidity risk play important role in determining the bid-ask spread of the fixed income securities. Credit risk may be a factor that is less important than liquidity risk, which is best proxied by the turnover of a security.

5.4 Trading revenue

5.4.1 Summary of dealer's trading revenue on individual securities

Table 6 gives the summary of trading revenue margins for the whole market-making industry and for different security categories. Securities are grouped by their credit status and time to maturity (TTM).

We consider all securities that have been traded by dealers as principals, and consider only the transactions that are principal trading. This restricted sample contains 574 securities, which account for 40% of securities traded in the market but account for 63.76% of total market turnover over the sample period. We identify 152 investment-grade bonds that account for 22.4% of total sample turnover, 76 non-investment grade bonds that account for 13.6% of total sample turnover, and the rest 346 bonds with unknown credit status that account for 64% of total sample turnover. 61 out of 91 dealers made market on these securities. So this sample well represents dealer's market making behavior.

The trading revenue varies from security category from loss of £1.13 million in the short bonds with unknown credit status to gain of £1.36 million in the long bonds of investment grade. The market making industry as a whole earns positive trading revenue of £1.05 million.

For the whole industry, market making appears profitable. The overall revenue margin is 3.02 basis points. Dealers make profit in the investment grade bond but in general lose in the non-investment grade bonds. We do not find time to maturity of the security have any significant effect on the trading revenue.

We also identify the percentage of losers in security categories. It shows that for each security categories, the percentage of losers seldom exceeds 50%.

5.4.2. Rank correlation between trading revenue and order flow on individual security

The above results shows that revenue margins are different across dealers and securities, and turnover may be an important factor that determines dealer's revenue.

As an initial test, we perform a rank correlation test on dealer's trading revenue and his trading volume. The hypothesis is that dealers who observe more order flow or trades gain information from these order flow, which they can use to gain profit.

We did two sets of rank correlation test. The first test is the rank correlation between dealer's total trading revenue and his turnover on a security. The second test is between dealer's trading revenue margin and his turnover margin on a security. The turnover margin is measured by the proportion of dealer's turnover on the security's total turnover executed by all principals.

Table 7 summarizes the results. We sorted the securities by numbers of the dealers who act as principals to control for the competition on the security. Whatever the level of competition, we expect to see that the dealers with higher turnover, or those who observe high order flow gain accordingly. R1 is the correlation coefficient between each dealer's ranked revenue and ranked turnover on a security, and t1 is the corresponding t statistics. R2 is the correlation coefficient between each dealer's ranked revenue margin and ranked turnover margin on a security, and t2 is the corresponding t statistics.

We define a security with or less than 3 market makers as the security with less competition, and securities with more than 3 market makers as the security with high competition. There are 430 securities that each has less than 3 dealers making markets and 144 securities that each has more than 3 market makers. Except for the R2 for the highly competitive securities, all the correlation coefficients are significantly positive. It shows that trading revenue does increase with dealer's turnover. When we look at the correlation between dealer's revenue margin and his turnover margin, it still gives the same positive relationship. It shows that dealer's revenue does increase with his competitive advantage on order flow, perhaps in a nonlinear way[8]. Take the sample as a whole, both correlation coefficients are significantly positive.

The finding shows that generally, the more turnover the dealer has, the higher revenue and revenue margin he will get. But it's also interesting to notice that this rule does not apply to every dealer. We will address the issue of heterogeneity of dealers in later section.

5.5 Decomposition of trading revenue

Trading revenue has two components, the spread component and the position component. According to microstructure theories, dealers may earn positive spread revenue, but will make negative position revenue. However, if dealers have an information advantage that is significant enough for him to make money, they may be able to earn positive position revenue.

5.5.1 the components of trading revenue margin

Table 8 summarizes the components of the trading revenue based on security credit status and time to maturity. We decompose dealer's trading revenue into spread revenue and

[8] We have preformed the test using finer definition of competition to stratify bond category. The correlation coefficients are always positive, but not always significant across categories. The results may be affected by our sample size. But it also shows that when the competition is stronger, the relation between revenue and order flow advantage is more apparent. This is especially the case for a few securities where there are more than 10 market makers. The R1 are all significantly positive and exceed 0.5.

position revenue. The position revenue margin of dealer j on security i is calculated as the difference between dealer's revenue margin (based on his own turnover on this security) and the security's bid-ask spread.

We restrict the sample to securities where dealer make positive revenue. We have 300 securities with 47 dealers making markets in these securities. The bid-ask spreads of these securities are generally large, which on average exceed 100 basis points. Although dealers make positive revenue on these securities, it is mostly come from the bid-ask spread revenue. Based on security's time to maturities, we find that dealers only make positive position revenues on securities at the long end, but make losses on securities at the short end. Overall, dealers make a position loss of 11.25 basis points.

The results show that in general, market-making industry of the fixed income market has tight profit margin. This result is consistent to the theory predictions that dealers set the bid-ask spread to compensate the possible lose to the informed traders.

5.5.2. The determinants of position revenue

Position revenue reflects dealer's ability to profit using his information. The above section shows that dealers make position revenue in some securities but lose in others. It may be interesting to explore the issue a bit further to understand the possible determinants of the position revenue. Especially, we examine whether order flow information plays an important role in determining the position revenue. We estimate the following regression:

$$Pos_{i,j} = \beta_1 D_i + \beta_2 Credit_i + \beta_3 Tov_{i,j} + \beta_4 Bas_i + \varepsilon_i \qquad (4)$$

Where $Pos_{i,j}$ is the position revenue margin for dealer *j* on security *i*; D_i is the duration of security *i*; $Credit_i$ is the credit proxy of security *i*—here we use Quiscore as the credit proxy; $Tov_{i,j}$ is the turnover margin of dealer *j* on security *i*; and Bas_i is the average bid-ask spread of security *i*. We use the White's correction to adjust for heteroscedasticity.

Table 9 summarizes the results. Not surprisingly, the bid-ask spread has the most significant negative relation with the position revenue. As expected, liquidity does contribute to the position revenue. The position revenue is increasing with dealer's turnover margin and decreasing with the bid-ask spread. Credit risk and interest risk of the security have positive relation with dealer's position revenue margin. However, except that the bid-ask spread has significant effect on the position revenue, none of the other factors statistically significantly affect the position revenue.

5.6. The heterogeneity of dealers

Until now we have treated all the dealers as a group. In fact, dealers are different of their dealing capacity and so may have different levels of order flow advantage. This is especially true in a dealership market, where normally few dealers take the majority trading of a security. Those dealers observe more order flows and have contact with more customers, so they may obtain better liquidity information than other minor dealers in this security.

We test the heterogeneity of dealers by identifying the top dealer on a security, then comparing his revenue and position revenue margin with other dealers on this security. We define a top dealer as the dealer who has the highest principal trade turnover on a security. All the other dealers who trade on this security are non-top dealers.

Table 10 summarizes the revenue margin for top and non-top dealers. We restrict the sample to the securities that have bid-ask spread estimation, and also have at least two principal dealers. We are left with 110 securities. But we have over 47 dealers making markets on these securities, so it should to a good extend reflect dealer's trading results. To make direct comparison between dealers, here the revenue margin is calculated as a dealer's trading revenue on a security divided by the total turnover a security has in the sample period.

It is clear that top dealer earn much higher revenue than the non-top dealers. Top dealers earn positive revenue in every bond categories, while non-top dealers make loss on non-investment grade bonds. Overall, the top dealers make revenue margin of 33.79 basis points, and non-top dealers only make revenue margin of 1.65 basis points. The results show that dealers are heterogeneous, and order flow information advantage does make a difference in profit earning.

6. Conclusion

In this paper, we examine whether liquidity information advantage leads to profit by examining the trading revenue of dealers in London fixed income market over the period from August 1994 to October 1994. In such a market with opaque transaction information and little private fundamental information, dealers have more information advantage on market liquidity than the public investors. Does this non-fundamental information transferable to profit? We examine whether market making in this market is profitable and whether dealers with higher level of liquidity information outperform dealers with lower level of liquidity information.

The analysis is conducted in four steps:

First, we estimate the transaction cost of the corporate bonds. Using different liquidity proxies, we find that liquidity proxies do affect our bid-ask spread measure as expected. Therefore, liquidity does affect dealer's spread revenue.

Second, we estimate dealer's total trading revenue. The whole market making industry makes positive total revenue, but negative revenue margin. It shows there is heterogeneity in individual dealer's profit ability. Our rank correlation test shows that, after controlling for competitions on a security, dealer's revenue and turnover are positively correlated. So in general dealers who observe more order flow make more gain. Our regression result for determinants of trading revenue also shows that trading revenue is positively related to dealer’s turnover and the liquidity status of the security.

Third, we decompose the trading revenue into spread revenue and position revenue. In general, dealers do not make position profit. The result is consistent with the theory prediction, that dealers charge the bid-ask spread to balance his loss to the informed trader. However, we still find position revenue is positively correlated with dealer’s trading activity—his turnover comparing to other dealers. This finding again suggest that dealers may be different in profit earning, based on the level of liquidity information they have.

Finally we examine how do dealers differ from each other by separating them into top-dealer group and non-top dealer group. We find that on average top dealer earn higher revenue margin than the non-top dealers. As the spread revenue is the same for the same security, top dealers do earn higher position revenue than the non-top dealers. This result lends further support to the hypothesis that dealer who observes more liquidity (proxies by order flow) earn more than the others. Therefore, liquidity information does matter to the dealers.

To sum up, in this paper we anatomize dealer’s revenue in fixed income market. We find evidence consistent with theory predictions that trading revenue for the market making industry as a whole is not significantly different from zero. However, we also find evidence that dealer’s liquidity information advantage positively contribute to trading revenue, and the relation may be non-linear. Furthermore, our findings support that since dealers are heterogeneous on liquidity information, dealers with higher level of liquid information can gain higher profit than other dealers do. So, liquidity information is valuable.

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Table 1 Descriptive Statistics

This table summarizes the market activities of London fixed income market over the period of August 1994 to October 1994. Panel A gives the summary statistics of the total trade activity, and Panel B summarize the market activities based on transaction types. # Trade is the number of trade. # Security is the number of securities. # Market maker is the number of dealers.

Panel A													
	Investment grade				Non-investment grade				Unknown grade				Total
	Short	Medium	Long	Undated	Short	Medium	Long	Undated	Short	Medium	Long	Undated	
Turnover($m)	42.59	130.21	600.64	104.95	96.83	244.82	58.64	152.24	703.64	835.09	835.96	1,648.82	5,454.42
# Trade	2633	672	936	2391	345	682	275	2010	3371	2925	942	14821	32,003
# Security	71	49	76	156	38	27	17	66	280	182	100	390	1,452
# Market maker	22	21	21	27	17	18	13	31	49	45	22	72	91
	Trade size($1,000)												
Mean	16.17	193.76	641.71	43.89	280.66	358.98	213.22	75.74	208.73	285.50	887.43	111.25	170.44
Median	1.15	9.85	144.19	5.04	45.34	45.82	20.24	11.01	60.24	18.40	303.75	14.85	13.65
Max	2,157.10	6,027.63	9,174.69	2,775.00	7,553.54	5,868.75	2,826.56	13,682.50	7,371.00	20,869.92	9,395.31	101,400.00	101,400.00
Panel B													
	# Trade												
Principal-Institution	2,554	597	828	2,288	272	586	258	1,819	2,881	2,384	757	13,416	28,640
Principal-Interdealer	0	2	46	2	0	6	0	0	6	18	89	17	186
Principal-Principal	31	6	50	64	0	11	11	96	3	63	49	359	743
Other	45	64	7	25	67	77	6	91	462	447	38	1,009	2,338
	Turnover($m)												
Principal-Institution	39.83	125.65	527.52	91.22	92.10	229.79	56.38	130.38	630.93	660.09	703.62	1,440.92	4,728.43
Principal-Interdealer	0.00	0.60	38.40	1.14	0.00	3.81	0.00	0.00	3.58	16.85	84.38	8.23	157
Principal-Principal	0.38	0.12	34.45	11.74	0.00	7.22	2.00	11.99	0.45	58.02	40.83	41.03	208
Other	2.38	3.83	0.28	0.83	4.73	3.99	0.25	9.87	68.68	100.13	7.12	158.57	361
	Mean Size($1,000)												
Principal-Institution	15.59	210.47	637.10	39.87	338.61	392.14	218.54	71.68	219.00	276.89	929.49	107.40	165.10
Principal-Interdealer	0.00	298.86	834.72	568.00	0.00	635.29	0.00	0.00	597.00	935.90	948.12	484.30	844.01
Principal-Principal	12.20	20.54	689.05	183.45	0.00	656.52	181.77	124.91	150.03	920.99	833.33	114.30	280.28
Other	52.96	59.90	39.69	33.38	70.54	51.87	42.46	108.45	148.65	224.00	187.36	157.16	154.26

Table 2 Summary of Price Premium estimation

This table summarizes the price premium estimation. Price premium is defined as the price difference between a risky security and a theoretic security with same structure but without credit risk or liquidity risk.

#Sec is the number of the risky security included. Turnover is the securities' total trading value in million pounds. Premium is the average price premium estimated presented in pence. Also presented are the standard deviation, minimal value and maximal value of the price premium.

Credit status	#Sec	Turnover (£m)	Premium (pence)	Std	Min (pence)	Max (pence)
Investment grade	66	6.11	10.86	9.27	0.01	51.88
Non-investment grade	35	3.43	15.26	15.44	1.26	83.26

Table 3

This table summarizes the results of this regression:

$$Premium_i = \alpha * Credit_i + \beta * liq_i + \varepsilon$$

Where $Premium_i$ is the average daily price premium for bond i. *Credit* is the Quiscore for bond i and *liq* is the following liquidity measures for bond *i*: the price impact measure PI, total turnover, and total number of trading days. All explanation variables have been standardized. Figures in the brackets are the t values.

	Quiscore	PI	Turnover	#day
1	−2.80	1.19		
	(−1.56)	(0.84)		
2	−2.57		−1.12	
	(−1.44)		(−0.66)	
3	−2.60			−0.07
	(−1.45)			(−0.03)
4	−2.75	1.12	−1.06	0.12
	(−1.31)	(0.53)	(−0.51)	(0.06)

Table 4 Summary of Bid-ask Spread estimation

This table summarizes the bid-ask spread estimation. #Sec is the number of security included. Turnover is the securities' total trading value in million pounds. Spread is the average bid-ask spread estimated presented in basis points. Also presented are the standard deviation, minimal value and maximal value of the bid-ask spread.

Panel A presents the results of securities included in price premium estimation. Panel B presents the results of all spread estimation sample.

Credit status	#Sec	Turnover (£m)	Spread (bp)	Std	Min (bp)	Max (bp)
Panel A						
Investment grade	66	6. 11	126. 43	79. 31	12. 50	440. 00
Non-investment grade	35	3. 43	100. 57	95. 26	6. 25	483. 33
Panel B						
Investment grade	85	7. 17	132. 98	92. 92	12. 50	460. 00
Non-investment grade	46	4. 42	94. 94	97. 93	2. 63	483. 33
Other	213	20. 13	96. 95	86. 98	0. 75	462. 12

Table 5 The Determinants of Bid-ask Spread

This table summarizes the results of bid-ask spread determinants. We estimate regressions that take the following general form:

$$y_{ba}^{j} = \alpha + \beta_1 D_j + \beta_2(\alpha * Credit_j) + \beta_3(\beta * L_j) + \varepsilon_j$$

Where y_{ba} is the bid-ask spread of bond j, C_j is the credit risk proxy for bond j, D_j the duration for bond j, and L_j is the liquidity measurement for bond j. We use duration as the interest risk proxy, Quiscore as the credit risk proxy, and the following liquidity measurements: price impact, turnover, and the number of trading days.

Panel A gives results including all sample, and panel B presents results excluding securities with negative bid-ask spread. Figures in the brackets are t-statistics.

	Duration	Qscore	PI	Turnover	#day
1	0.13	0.06			
	1.29	1.96			
2	0.13	0.07	-0.24		
	1.30	2.18*	-1.41		
3	0.20	0.06		-0.29	
	2.01*	1.93		-3.61**	
4	0.16	0.05			-2.48
	1.48	1.54			-1.76
5	0.22	0.02	-0.17	-0.28	-1.03
	1.89	1.32	-0.75	-2.69**	-1.10

Note: * Significant at 5% level
** Significant at 1% level

Table 6 Summary of trading revenue

This table summarizes the aggregated trading revenue of dealers on individual securities. Securities are grouped by their credit status and time to maturity (TTM). Turnover is presented in million pounds. #sec is the number of security. #mm is the number of dealers make market on the group of securities. Revenue is the aggregated trading revenue of dealers in the security group. M is the average revenue margin in basis points. The revenue margin is calculated as the weighted average of dealer's trading revenue, where the weight is the dealer's total turnover on a security. The %loser is the percentage of dealers who made negative revenue on the category.

Credit status	TTM	Turnover (£m)	# sec	#mm	Revenue (£m)	M(bp)	% loser
Investment grade	Short	35.97	31	20	0.06	15.69	0.31
	Medium	112.57	28	20	0.13	11.74	0.46
	Long	552.03	44	19	1.36	24.64	0.50
	Undated	78.64	49	16	-0.47	-59.24	0.43
	Total	779.22	152	34	1.08	13.86	0.44
Non-investment	Short	74.80	21	8	0.06	8.09	0.24
	Medium	238.30	21	17	-0.23	-9.69	0.52
	Long	52.29	10	13	-0.14	-25.94	0.47
	Undated	107.23	24	21	-0.20	-18.91	0.23
	Total	472.62	76	32	-0.51	-10.79	0.35
Other	Short	482.75	120	33	-1.13	-23.42	0.35
	Medium	688.24	96	38	0.28	4.09	0.41
	Long	785.48	55	20	1.34	16.75	0.41
	Undated	269.27	75	29	-0.01	-0.21	0.36
	Total	2,225.74	346	56	0.48	2.16	0.39
Total		3,477.58	574	61	1.05	3.02	0.39

Table 7

Rank correlation test between dealer's revenue and turnover

Table 7 summarizes the rank correlation tests between dealer's revenue and his turnover on individual securities. #dealer is the number of dealer for each security, #sec is the total number of securities in this category. R1 is the correlation coefficient between each dealer's ranked revenue and ranked turnover on a security, and t1 is the corresponding *t* statistics. R2 is the correlation coefficient between each dealer's ranked revenue margin and ranked turnover margin on a security, and t2 is the corresponding t statistics. The turnover margin is measured by the proportion of dealer's turnover on the security's total turnover executed by all principals.

#dealer	#sec	R1	t1	R2	t2
<=3	430	0.22	6.33**	0.08	2.34*
>3	144	0.18	5.39**	0.04	1.18
Total	574	0.20	8.17**	0.07	2.72**

Note: * significant at 1% level
** significant at 5% level

Table 8 Decomposition of trading revenue

This table shows the results of trading revenue decomposition based on security credit status and time to maturity. Tover is the total turnover of the securities in million pounds; #sec is the number of the security in the category; #fc is the number of the firms in the category; SP is the average bid-ask spread of the securities and PM is the average position revenue margin of the securities. SP and PM are presented in basis points. Panel A gives the results of all sample including securities having negative spread, and Panel B reports the results for the sample excluding securities with negative spread and negative trading revenue.

Credit Status	TTM	Tover(£m)	#sec	#fc	SP (bp)	PM (bp)
Investment grade	Short	32.58	16	12	115.32	−51.73
	Medium	97.25	17	15	120.84	−70.81
	Long	492.34	24	14	106.36	52.80
	Undated	76.18	20	12	153.81	−43.49
Non-investment grade	Short	59.55	8	7	58.59	−54.67
	Medium	215.95	11	9	81.13	−59.15
	Long	45.42	8	10	73.78	26.60
	Undated	96.16	12	17	141.57	−46.81
Other	Short	307.96	58	23	100.72	−17.23
	Medium	568.44	52	27	106.04	−16.41
	Long	706.70	35	18	88.73	−13.53
	Undated	251.60	39	21	160.39	23.22
Total		2950.10	300	47	108.67	−11.25

Table 9 Determinants of position revenue

This table summarizes the results for the following regression:

$$Pos_{i,j} = \beta_1 D_i + \beta_2 Credit_i + \beta_3 Tov_{i,j} + \beta_4 Bas_i + \varepsilon_i$$

where $Pos_{i,j}$ is the position revenue margin for dealer *j* on security *i*; D_i is the duration of security *i*; $Credit_i$ is the credit proxy of security *i*—here we use Quiscore as the credit proxy; Tov_i is the turnover margin of dealer *j* on security *i*; and Bas_i is the average bid-ask spread of security *i*.

	Estimation	t-value
Duration	43.49	1.07
Quiscore	10.40	0.43
Turnover margin	10.94	0.71
Bid-ask spread	-77.08	-3.00**
#observation	200	

Note: ** significant at 1% level.

Table 10 Comparison of top dealers and non-top dealers

This table summarizes top dealer's revenue margin and non-top dealer's revenue margin. To make direct comparison between dealers, here the revenue margin is calculated by the dealer's trading revenue on a security divided by the total turnover a security has in the sample period.

Credit status	Dealer	#Sec	#Dealer	Revenue margin (bp)
Investment grade	Top	31	13	36.40
	Non-top	31	29	5.79
Non-investment grade	Top	11	7	29.06
	Non-top	11	25	−1.26
Others	Top	69	13	33.56
	Non-top	69	41	0.81
All	Top	110	20	33.79
	Non-top	110	47	1.65