Crossing Network Trading and the Liquidity of a Dealer Market: Cream-Skimming or Risk Sharing?[♣]

Carole Gresse
Université de Paris-Nanterre
CEREG, Université de Paris-Dauphine
e-mail: carolegresse@hotmail.com

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Abstract

When a crossing network (CN) operates within a dealer market (DM), investors as well as dealers have the choice between two different trading venues: they can either trade on the central market, pay the bid-ask spread and obtain immediate execution, or submit hidden anonymous orders to the CN where execution is not guaranteed but executed orders are crossed at mid-quote. According to previous theoretical works, the trading activity in the CN may positively or negatively affect the quality of the DM, but the net effect remains ambiguous. This article investigates the impact of CN-trading on the liquidity of a DM by comparing trade and quote data from the quote-driven segment of the London Stock Exchange (LSE) and internal data from the POSIT crossing network over two 6-months' period.

The empirical study consists of a cross-sectional analysis on a sample of UK mid-cap stocks listed on the SEAQ dealer market, and examines in which way the submitted, executed and unexecuted CN order flow affect closing-price volatility, spreads, quote revisions and the total cost of trading on the market. The findings support that CN-trading does not significantly increase adverse selection and inventory risk on the central market. The CN activity appears to strengthen the competition between market makers and to give them a risk sharing opportunity that leads them to improve quotes.

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1. Introduction

During the last decades, competition for order flow has intensified between major market centres as well as between established exchanges and new trading systems. First, progress in communication technology has reduced the cost of establishing proprietary trading systems. Second, some investors have expressed the need for alternative markets providing low-cost execution. As a result, new electronic trading systems appeared in the US in the late 70s and have emerged all around the world ever since. European stock markets have made no exception to the rule.

New electronic systems, when not registered as exchanges, have been regulated by the SEC and designated as *Alternative Trading Systems* (ATS).[1] They include Electronic Communication Networks (ECN) and Crossing Networks (CN). The former are defined by the SEC as electronic systems that widely disseminate to third parties orders entered by an exchange market maker or OTC market maker, and permit such orders to be executed against in whole or in part. Though, the term ECN does not include any system that crosses multiple orders at specified times at a single price. Conversely, the latter are defined by the SEC as systems that allows participants to enter unpriced orders to buy and sell securities and that crosses orders at specified times at a price derived from another market.

In the United States, the first ECN to open was Instinet[2] in the 70s. At its start, the success of Instinet came from the need expressed by institutional investors as well as broker-dealers for alternative systems, where they could trade after the traditional exchanges had closed and that would help reducing the cost of trading. Following Instinet, other ECNs have emerged in the US, such as Island, Redi-Book, Archipelago, B-Trade, Brut, NexTrade, Attain,

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[1] The SEC defines ATSs as automated systems that centralise, display, match, cross or otherwise execute trading interest but that are not registered with the Commission as national securities exchanges or separated by a registered securities association. In Europe, the FESCO, now renamed CESR, published in June 2001 a set of standards proposed for application on ATSs, where ATSs are defined as entities "which, without being regulated as an exchange, operates an automated system that brings together buying and selling interests – in the system and according to rules set by the system's operator – in a way that forms, or results in, an irrevocable contract."

[2] The Instinet system allows subscribers to anonymously enter limit orders into a book where all subscribers may view the existing orders. If a buyer meet a seller willing to trade at what they deem a favourable price, the trades executes on Instinet electronically and the system takes care of all the necessary paper work involved in completing the trade.

MarketXT. They accounted for 37% of NASDAQ trading volume in September 2001. This success has been mainly related to the inefficiencies of the NASDAQ, notably denounced by Christie and Schultz (1994): institutional investors were missing confidentiality on trades transmitted to dealers and spreads remunerating market makers were deemed to high. Also, "opening" to the market a decision to buy or sell a less liquid stock would often result in a major shift in the share price of that stock, with little or no turnover having taken place. This led to reluctance from institutional investors to even pass orders to the market in such stocks.
In response to the dealing inefficiencies in the US equity market, primarily with respect to smaller, less traded, stocks and in particular in response to the issues of market impact, another form of ATS has emerged with technological improvement: the crossing network (CN). The main difference with an ECN is that participants do not enter the prices at which they wish to trade, so that no price discovery takes place in a CN. Instead, at designated cross times, interested buyers and sellers are matched and the price at which the trades execute is taken from an exchange. The largest CN currently operating in North America are the ITG's CN, POSIT[3], and the Instinet's Crossing Network. As ECNs, these systems usually provide significant discounts on commissions.

The competition coming from these new trading facilities have changed the structure of financial markets, and probably also the role of intermediaries on these markets. The implications for liquidity are of much interest for academics, regulators and investors. In order to bring answers on the actual advantages or drawbacks of crossing networks, this paper focuses on the consequences of trading through a crossing network, by testing market data from the London Stock Exchange dealer market segment and private data from the POSIT crossing network.

1.1. The development of CNs in Europe

Up to now, ECNs have developed significantly in the US.[4] However, this is still not the case in Europe, where only CNs have emerged.

These crossing networks match buy and sell orders periodically, at specified times of the trading day. At the hour of a match, buy and sell orders are matched in order to maximise the trading volume but without calculating any transaction price. Executed orders are

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[3] POSIT stands for *Portfolio System for Institutional Traders*. This system was created in 1987, as a joint venture between ITG Inc. and BARRA Inc., the California based quantitative house.

[4] According to Barclay, Hendershott and McCormick (2001), "ECNs are involved in more than a third of total NASDAQ trading volume and are now attempting to build market share in NYSE-listed issues".

crossed at the central market mid-quote, or, in some cases, at the preceding closing price or the volume-weighted average price over some period.

CNs generally promise anonymity and lower transaction costs, but do not guarantee execution. In such, they address the needs of a certain type of traders, ready to sacrifice immediacy and execution guarantees so as to obtain low-cost execution. This led to the development of the Reuters' Instinet Crossing Network, ITG's POSIT and the New York Stock Exchange's after-hours Crossing Network in the US, the largest of these CNs being POSIT. POSIT developed quickly in the United States. 35 millions of shares are presently traded daily on this system, which is still no more than 2,5% of volumes.

In Europe, the very first attempt to create crossing facilities took place in the UK, in the 80s, with the crossing system ARIEL, which, at that time, failed in attracting and executing substantial order flow. Ever since, two London-based crossing networks[5] have emerged on European stock markets. First, after being already operating in the North-American and Australian markets, POSIT was adapted to Europe and launched there on the 18th of November 1998 by ITG Europe.[6] It is now working for ten European countries: UK, Germany, Switzerland, France, Belgium, Netherlands, Italy, Spain, Sweden and Finland. A second CN followed in 1999. A team of institutional investors, led by Barclays Global Investors and Merrill Lynch Investments Managers, created E-crossnet. E-crossnet is an automated matching system where orders can be entered either via a Bloomberg interface or via direct connection.[7] It is available for 14 countries[8] in Europe and runs 4 crosses a day. Matched orders are passed to Merrill Lynch for execution at mid-price, reporting to the appropriate exchanges and settlement, and are charged 10 basis points. Up to now, E-crossnet has not really succeeded in reaching a critical mass and the rate of execution in its system has kept quite low from its start, so that POSIT has remained the biggest CN on the European market. At the current date, the main part of the POSIT order flow is related to UK midcaps. The FTSE 100, which is 80% of the market capitalisation, represents only 40% of

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[5] Let us note that an other brokerage firm, Garban, has also began to run some crosses on the UK market.

[6] the American ITG Inc. and Société Générale created ITG Europe in 1998, each partner owning 50% of the European subsidiary. Then, in May 2001, Société Générale sold its participation, ITG Inc. becoming the unique shareholder. ITG Europe is an Irish company with a branch in London and acts as a pure agency classical broker. It is a member of the London Stock Exchange, Deutsche Börse and Euronext.

[7] Like in POSIT, submissions are anonymous and no information about awaiting orders is disseminated outside the system.

[8] Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom.

ITG crossing business, mainly because crossing is more interesting for less liquid stocks. However, crossing business is almost zero for most illiquid stocks.

As a consequence, since 1998, institutional investors and broker dealers have several venues to trade within the UK stock market: they can either submit an order to the central market of the London Stock Exchange (LSE) or submit it to a CN. In the former case, they incur the bid-ask spread but get higher execution guarantee. In the latter case, their probability of execution is little but they are provided anonymity, they incur no adverse selection cost as their orders are not visible from the rest of the market and if executed, they trade at the mid-quote with no market impact.

1.2. Objective and general organisation of the paper

The objective of this paper is to analyse the effects of crossing on a dealership market, by using both private data from a CN and public market data. To this goal, the UK domestic mid-cap stock market is a particularly well-adapted case, as it is a nearly pure quote-driven market where the POSIT crossing network attracts the major part of multilateral crossing.

In fact, the London Stock Exchange (LSE) administers three stock markets: the Alternative Investment Market (AIM) for domestic small and growing companies, the Domestic Equity Market (DEM) for ordinary shares of UK, Channel Islands and Isle of Man companies and other companies with primary UK listing (principally Irish companies), and the International Equity Market (IEM) for non-UK stocks. Three trading platforms are operating for the DEM and the AIM: the continuous electronic order book SETS[9] for most liquid stocks of the DEM, the mixed system SEATS PLUS[10] for less liquid domestic stocks (SEATS securities) and AIM securities, and the almost pure competitive dealership system SEAQ for non SETS domestic equity market securities.

This paper focuses on SEAQ stocks and analyses the effect on the liquidity of the central market of orders submitted and crossed into POSIT, over a 6 months' period, and is organised as follows. Section 2 sets the theoretical framework of the study and derives a series of testable hypotheses about the impact of CN trading activity on the liquidity of a DM. Section 3 provides information on the organisation of the SEAQ market segment and the workings of the POSIT crossing network. After describing the data and the samples in Section 4, stylised facts about market activity, CN order flow and CN-traded stocks are

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[9] SETS (*Stock Exchange Electronic Trading Service*) is opened from 8:00 am to 4:30 pm. It replaced the quote-driven competing market maker system for blue chips in 1997.

[10] SEATS PLUS (*Stock Exchange Alternative Trading Service*) supports the entry of both market makers' quotes and orders.

reported in Section 5. Finally, the testable hypotheses developed in section 2 are tested: methodology and results are presented in section 6. Section 7 concludes.

2. Theoretical findings on market competition with a CN

2.1. The debate on multi-market trading

The emergence of ATSs has given rise to a stream of research around the trade-off between the benefits of competition and the potential costs of order flow fragmentation that ATSs may cause. The debate began in 1979, with Hamilton, who pointed out the two opposite effects of multi-market trading and the deviation of a part of the order flow from the central market. Either multi-system trading increases competition among liquidity providers and thus reduces bid-ask spreads, or, conversely, the fragmentation of the order flow between several locations lowers economies of scale and probabilities of execution, resulting in higher volatility and spreads.

2.1.1. The potential benefits of multi-system trading

A common argument in favour of multi-system trading is that increased competition could reduce the market power of price-setting agents and thus result in better execution conditions, as mentioned by Easley, Kiefer and O'Hara (1996). In particular, examining the transaction costs on dealership markets such as NASDAQ or SEAQ, the bid-ask spread can be substantial for a certain category of stocks. If market makers actually provide the insurance of immediate execution, the costs may be prohibitive for some investors. The existence of an ECN or a CN then provides investors with the opportunity to obtain better prices but without a guarantee of execution. For instance, giving the opportunity to trade at mid-quote, CNs such as POSIT, contribute to reduce the average cost of trading, increase the competition between liquidity providers, as market makers or limit order traders, resulting in lower bid-ask spreads, and finally, if they bring informed traders to trade higher volumes, the higher proportion of informed transactions could well enhance efficiency. Such positive effects will be referred to as the *competition effect*.

However, multiple trading systems may also harm the market in its whole because of the *fragmentation* of the order flow.

2.1.2. The potential costs of multi-system trading

Trading in a security market possesses, as demonstrated in Mendelson (1987), a network externality, which means that a security market is more valuable to customers as more customers engage in trading at that location. According to Mendelson (1987), the dispersal of orders between several trading locations lowers the probability of execution at each location and therefore reduces liquidity. If the market remains very fragmented, each trading system will only have a few people willing to trade, making it more difficult to find a counterparty. Under information asymmetry, Chowdry and Nanda (1991) show that informed trading increases with the number of markets listing the asset: spreads widen because market makers incur higher adverse selection costs but trade prices are more efficient.

Yet, Chowdry and Nanda's model cannot fully apply to the case of a CN competing with another market. In Chowdry and Nanda (1991), price discovery is active at all trading locations and trades have market impact on every market. Hence, no price discovery is taking place in a CN, where transaction prices are derived from another market without producing market impact. Because of this specific feature of CNs, potential competition or fragmentation effects induced by a CN may slightly differ from those caused by trading systems with pricing mechanisms.

To address this particular case of CNs, Hendershott and Mendelson (2000) model the intermarket competition between a CN and a competitive dealership market (DM). Their theoretical predictions are widely discussed in the next paragraphs and will serve as a basis to the testable hypotheses settled in section 5.

2.2. Theoretical findings on multi-market competition involving a CN

Several papers have already addressed the question of the viability of diverse competing market structures for the same asset. Pagano (1989), Gehrig (1993), Glosten (1994), Parlour and Seppi (1998), Hendershott and Mendelson (2000), and Dönges and Heinemann (2001) analyse liquidity-based competition between markets with different structures. Market liquidity arises as a result of traders' trading venue choice. A common line to these works is the idea that multiple markets with different trading mechanisms may co-exist when the population of traders is heterogeneous, each market then addressing the need of a particular class of investors.[11] In other words, the order flow fragments because traders cluster together according to their typical characteristics such as order size, liquidity preferences, impatience for execution etc.

Among the works mentioned above, Hendershott and Mendelson (2000) and Dönges and Heinemann (2001) specifically focus on the case here-studied, that is a CN operating next to a DM.

[11] For more details on these articles, the reader may refer to section 1 in Dönges and Heinemann (2001).

2.2.1. Why can a CN reasonably co-exist with a DM?

In Dönges and Heinemann (2001), N_b potential buyers and N_s potential sellers randomly enter the market, following a geometric distribution, and choose between two trading venues. They may trade with dealers on the DM: their orders are then surely executed and they pay the half-spread t_{dm}. Or, they can submit their orders to a CN where submission is free but execution is not guaranteed. In case of execution, the due fee is $t_{cn} < t_{dm}$. Besides, unexecuted orders leave the traders with some disutility θ.

In a first game, designated as the "common knowledge game", all trades face the same disutility θ, and θ is a common knowledge. The game results in several Nash equilibria according to the level of θ: a pure CN-equilibrium where all traders go to the CN, a pure DM-equilibrium where all traders submit orders to dealers, and a mixed equilibrium in which expected payoffs are the same on both markets and the CN market share is $\tilde{\alpha}(\theta)$. Exactly as in Pagano (1989), the mixed equilibrium is very weak: any coalition with at least one trader on each side of the market switching from the DM to the CN can improve their payoffs. Once the CN has a market share of $\tilde{\alpha}(\theta)$, one should expect that it takes over the whole market. Under a threshold level of θ, the CN-equilibrium is stronger; the DM-equilibrium becomes stronger as θ rises.

In a second game, referred to as the "private information game", noisy private information about the value of trading θ is introduced. If the noise in private information about θ is sufficiently small, there exists a unique equilibrium with a threshold value x^*: agents with signals below x^* place orders at the CN, those with signal above x^* trade at the DM.[12]

Finally, in a third game, qualified as the "private value game", the disutility of unexecuted orders θ, in other terms the value of trading, differ across individuals. The DM and the CN co-exist: all traders with lower disutilities ($\theta < \theta^*$) submit orders to the CN, while traders with higher disutilities ($\theta > \theta^*$) trade at the DM.

As a conclusion, when traders assign the same value to trading, it is very unlikely that both markets co-exist. Conversely, when the value assigned to order execution differs across investors, the CN and the DM should co-exist: traders with high trading value cluster on the the DM while traders with low trading value choose the CN.

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[12] x^* increases in the DM bid-ask spread $2t_{dm}$, rises with market thickness, that is the expected number of traders on the market, and decreases in trading costs at the CN, t_{cn}.

However, Dönges and Heinemann's model does not enlighten the impact of the CN activity on the DM market, an issue that is widely discussed in Hendershott and Mendelson (2000).

2.2.2. The effects of CN trading on a DM market

Reading the article of Hendershott and Mendelson (2000), one figures out how complex is the answer to this question. According to their findings, the effects of CN trading on a DM are ambiguous. On the one hand, traders who exclusively use the CN can provide a counterbalancing effect that reduces adverse selection and inventory costs for market makers on the central market. On the other hand, traders who use the DM as a "market of last resort", i.e. submit orders to the CN first and then go to the DM if not executed, can induce dealers to widen their spread but also can lead to more efficient subsequent prices on the DM.

Their model considers a random geometrically distributed number of informed and liquidity traders, each one buying or selling one unit of asset. They have two trading venues: a DM and a CN, and the order submission cost is assumed to be fixed and equal to c_o on each market. The realisation of $\tilde{v}$, the final value of the asset, is known to the informed traders. The volatility of $\tilde{v}$, $\sigma_{\tilde{v}}$, is equal to the value of the insiders' information. All insiders are either *momentum* traders with probability γ or *fundamental* traders with probability $1-\gamma$. To benefit from their inside information, momentum traders must trade before the CN crosses, whereas fundamental traders may wait until after the CN crosses. A high value of γ means that private information is short-lived, while a low level of γ implies that information is long-lived. Liquidity preferences differ across uninformed traders. Each liquidity trader has a random liquidity preference u with a continuous distribution function $F(u)$. The higher u, the higher the value of trading for the liquidity trader.

The DM is modelled in the following way. Risk-averse dealers freely enter the market, they engage in a Bertrand competition and post bid and ask prices . They receive multiple single-unit orders and cannot distinguish between the informed and the liquidity traders. In equilibrium, the bid-ask spread correspond to each order market impact and compensate for adverse selection, inventory and operating fixed costs. Paying the half spread to dealers, traders have their orders executed with certainty.

At the same time, a CN provides a pure transactional service with no price discovery. Orders are aggregated and passively matched. In case of imbalance, orders on the excess side are randomly selected. If executed, orders are charged a fixed commission c_e. Furthermore, when trading in the CN, a liquidity trader is assumed to receive only a fraction δ of his trading value. δ may be considered as an impatience factor standing for the fact that trading at the CN is not continuous and that participants have to wait till the match time. Based on the expected quantity of orders going to the CN, each trader can infer his probability of execution, so that the decision to submit an order there depends on the relationship between this probability, the impatience factor δ and the costs c_o and c_e.

Given the DM and the CN structures, traders have four possible strategies:

- do not trade,
- trade exclusively on the CN and do nothing if the order fails to execute,
- trade opportunistically on the CN, in other words, submit his order to the CN and if it fails to execute, trade in the DM,
- trade only on the DM without first attempting to trade on the CN.

The game results in multiple equilibria, all characterised by the following structure.

1. By hypothesis, the informed traders' decisions are driven by the longevity of their information:
   - short-lived information forces trading in the DM exclusively;
   - long-lived information leads to opportunistic trading on the CN.
2. Any liquidity trader with trading value u will choose from the following strategies:
   - liquidity traders belonging to segment I, with $u \leq \hat{u}_1$, do not trade at all;
   - liquidity traders belonging to segment II, with $\hat{u}_1 \leq u \leq \hat{u}_2$, trade exclusively on the CN;
   - liquidity traders belonging to segment III, with $\hat{u}_2 \leq u \leq \hat{u}_3$, use the CN opportunistically;
   - liquidity traders belonging to segment IV, with $u \geq \hat{u}_3$, trade immediately in the DM.

Some segments may be empty according to the parameters of the model. The fraction of liquidity traders potentially trading in the CN is $F(\hat{u}_1) - F(\hat{u}_3)$ and is referred to as the fraction of low-preference liquidity traders. The cut-off values $\hat{u}_1$, $\hat{u}_2$ and $\hat{u}_3$ obviously depends on the DM bid-ask spread. The insiders trade on the CN with probability $(1-\gamma)$.

From there, the global effect of CN trading on the DM in equilibrium is unclear.

In a first stage, Hendershott and Mendelson (2000) consider the baseline case where the cut-off values $\hat{u}_1$, $\hat{u}_2$ and $\hat{u}_3$ are taken as given without taking into account changes in liquidity traders' decisions. They find two positive effects of the introduction of the CN:

1. the dealers' inventory risk is reduced by CN trading due to risk sharing on non exclusive-CN trading with exclusive–CN orders, this effect being stronger with long-lived information;
2. CN trading let the dealers' expected adverse selection costs unchanged when information is short-lived but lowers them when the information is long-lived, with the difference increasing in the amount of exclusive-CN trading.

These positive risk-sharing effects are counterbalanced by a negative one: the expected order flow coming to dealers is reduced increasingly with the amount of opportunistic-CN trading, the net effect remaining ambiguous.

In a second stage, Hendershott and Mendelson (2000) condition the double-market equilibrium on liquidity traders' strategies and still, the global effect of CN-trading can be unclear. On the one hand, additional liquidity trading in the CN produces positive risk-sharing effects. On the other hand, opportunistic-CN trading induces negative cream-skimming effects. Finally, as the introduction of the CN makes long-lived information more valuable, this result suggests that the presence of the CN could well increase volume trading based on fundamental information.

Positive risk-sharing effects on the dealers' spread

1. The linear inventory cost is reduced because the expected dealer imbalance is decreased due to long-lived information trading in the CN.
2. The CN attracts both new low-liquidity-preference traders who would not otherwise trade and liquidity traders who would otherwise go directly to the DM: in case of long-lived private information, a part of the adverse selection risk is then born by these CN liquidity traders.

Negative cream-skimming effects on the dealers' spread

1. Allowing liquidity traders to use the CN opportunistically rather than go directly to the DM tends to widen dealers spreads. The CN is then skimming off a part of the uninformed trades, which cannot be used anymore by dealers to compensate their losses on informed trades. Actually, the traders that strategically use the DM as a "market of last resort", either informed or uninformed, make the DM riskier and force dealers to quote larger spreads.
2. If CN trading leads to higher dealer spreads, then the lower-liquidity-preference traders, many of whom would not trade with the DM as the only option, are made better off because they get a lower-cost trading opportunity. However, the higher-liquidity-preference traders are more worse off because they still trade in the DM, but now at higher cost. In whole, the CN can either improve or harm social welfare.

2.3. Dealer trading in the CN

Hendershott and Mendelson (2000) clearly demonstrate that the CN may create an interesting risk-sharing benefit for dealers. This benefit comes from pooling orders on the CN without requiring inter-dealer trading. Yet, the CN structure can also be viewed as an ideal mechanism for facilitating inter-dealer trading or dealer principal trading. Hence, as shown in Reiss and Werner (1998), inter-dealer trading, by producing risk-sharing benefits, reduces dealers' costs and consequently allow them to improve their spreads.

Therefore, another role of the CN, that has not been modelled in previous literature, might consist of providing dealers with a mean to trade at low cost after executing customers' demand. If the CN actually plays the role of a risk-sharing tool, its activity could then result in lower spreads on the DM.

A series of testable hypotheses ensuing from all these theoretical predictions about the implications of CN trading for market quality, are now developed in the next subsection and will be investigated in section 6.

2.4. Testable hypotheses

Four groups of testable hypotheses are derived from the theoretical literature, and more specifically from Hendershott and Mendelson's model. The first group of hypotheses concerns the consequences of CN opportunistic trading with respect to the harmful impact of CN unexecuted order flow. Then, follows two categories of hypotheses on the risk-sharing effects: the first one focusing on the trade-off between the so-called cream-skimming effect and the potential risk sharing effect due to new liquidity trading in the CN, the second one addressing the issue of dealer trading in the CN. Finally, the last set of hypotheses aims at defining tests of the net global effect of CN trading on the cost of transacting and the competitiveness of prices.

2.4.1. The cream-skimming effect due to opportunistic trading in the CN

As pointed out by Hendershott and Mendelson (2000), when patient liquidity traders and fundamental informed traders are present in the market, they will use the CN opportunistically: they will first submit orders to the CN, and use the DM as a "market of last resort", if CN orders get no execution. As a result, the CN first skims off liquidity trades from the central market; secondly, the unexecuted opportunistic CN order flow makes the DM riskier when coming back to the dealers after crossing hours, and increases market making costs at the end of the trading session.

This is the reason why hypotheses H1 and H2, related to the cream-skimming effect, are based upon the impact of the POSIT unexecuted order flow.

Hypotheses H1 and H2

H1. *Crossing activity makes the DM riskier at the end of the trading day because unexecuted opportunistic CN orders come back to dealers after the crosses.*

If H1 holds, the volatility of closing prices per unit of traded volume would increase with the CN unexecuted order flow.

H2. *Unexecuted order flow coming back from the CN to the central market for execution, creates temporary tension on liquidity, either because it increases adverse selection, as demonstrated in Hendershott and Mendelson (2000), or because it suddenly generates abnormal inventory costs for market makers.*

Provided H2, spreads would widen with the amount of unexecuted CN order flow.

2.4.2. Risk-sharing effect due to new liquidity trading in the CN vs cream-skimming effect

Nevertheless, the cream-skimming effect may also be offset by a positive risk sharing effect induced by new liquidity trading attracted into the CN.

On the one hand, the CN may skim off uninformed trading from the DM, and thus increase adverse selection costs on the central market; but, on the other hand, it can also attract new liquidity traders, who would not trade out of the CN because of the cost of trading. These new liquidity-motivated orders help to absorb long-lived information-based orders in the CN, which reduces market making costs on the DM and creates a risk sharing effect.

Hypotheses H3a and H3b focus on this issue.

Hypotheses H3

H3a. *The fragmentation of the order flow between the central market and the CN creates additional adverse selection costs on the DM, because the CN skims off opportunistic liquidity trading from the DM, where the proportion of informed trading gets higher.*

Under H3a, spreads would increase with the share of order flow submitted to POSIT.

H3b. *The fragmentation of the order flow between the central market and the CN lowers adverse selection and inventory risk on the DM because the CN attracts new liquidity traders whose orders help absorb the opportunistic informed order flow.*

If spreads decrease in the share of order flow submitted to POSIT, H3b is accepted and H3a is rejected: the risk-sharing effect can then be considered dominant over the cream-skimming effect.

2.4.3. The risk-sharing effect due to dealer trading in the CN

One major specific of the POSIT crossing network lies in that it is open to the sell side. This specific feature allows me to test H4.

Hypothesis H4

H4. *The CN gives an opportunity to market makers to reallocate their positions with no implicit trading cost and thus lowers inventory costs.*

Under H4, spreads should be negatively related to the share of volume traded by market makers through the CN.

2.4.4. Global effect on implicit transaction costs and price competitiveness

Finally, the last hypotheses all relate to the general question: ***does the competition effect dominate the fragmentation effect when a CN operates within a DM?***

If so, the competition between price-setting agents would intensify with crossing (cf. H5), resulting in lower temporary market impact of trades (H6) and less expensive effective cost of trading (H7).

Hypotheses H5, H6 and H7

H5. *CN-trading intensifies the competition in price-setting between market makers.*

If H5 holds, then the number of quote revisions per day would increase with the share of order flow going to the CN.

H6. *Crossing activity reduces temporary market impact.*

The higher the temporary market impact of trades, the more sell prices differ from buy prices, the difference increasing in the associated quantities. Trade prices are then more volatile around the daily average transaction price, i.e. the so-called VWAP (volume-weighted average price). Provided H6, that is provided crossing globally helps to reduce the market impact of transactions, intra-day volatility around VWAP would be negatively related to the share of traded volume executed in the CN.

H7. *CN-trading helps reduce the effective cost of trading.*

Under H7, spreads should be negatively related to the share of traded volume executed in the CN (positively otherwise).

To test these hypotheses, the SEAQ market segment and the POSIT crossing network form an ideal investigation for the two following reasons:

- SEAQ operates as an almost pure quote-driven market;
- CNs are the only ATSs to operate within this market segment, POSIT being the major one and the only one to accept dealer orders, at the time of the study.

Before presenting the data and the characteristics of the sample, I first describe market mechanisms.

3. The DM organisation and the CN trading mechanisms

3.1. SEAQ

SEAQ is the screen based competitive market making segment of the Exchange trading system for non order book domestic equity securities. A SEAQ security is a domestic equity market security for which a minimum of two market makers register with the Exchange. Each market maker is obliged to display firm two-way prices on SEAQ in the NMS,[13] or reduced NMS in the case of reduced size market makers[14], during the Mandatory Quote Period (MQP), which lasts from 8:00 am to 4:30 am. From 7:30 am to 8:00 am, quotes may be opened but prices are regarded as being indicative only. From 4:30 pm to 5:15 pm, market makers may continue to display firm quotes but are not obliged to do so and the trading system remains open for trading reporting.

During the trading day, the best bid and best offer prices quoted by market makers on SEAQ are commonly referred to as the yellow strip. In the event that quotations by or more market makers are identical in terms of price, the best quote will be the one that was entered first.

The LSE offers crossing facilities three times a day for SEAQ securities that are part of the FTSE 250 Share Index. Three crosses[15] are run during the trading day, taking place at 11:00 am, 3:00 pm and 4:45 pm. Up to the current date, they have failed in attracting sufficient order flow and no substantial volume has been transacted through these crosses.

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[13] The NMS classification of SEAQ securities are reviewed quarterly using the following formula: (value of customer turnover in previous 12 months in £)/(closing mid-price on last day of quarter×10000). NMS's are then rounded up or down to one of the following bands: 100, 200, 500, 1000, 2000, 3000, 5000, 10000, 15000, 25000, 50000, 75000, 100000, 150000, 200000.

[14] Some market makers are granted special permission to display prices in smaller quantities than NMS. The reduced NMS is half the NMS rounded down to the nearest NMS band.

[15] Prior to April 2001, these crosses use to be batch auctions where only limit orders could be entered.

3.2. The POSIT crossing network

Run in Europe by the agency stockbroker ITG Europe, POSIT is an intra-day electronic trading system, which matches buy and sell orders at predetermined times in the day and uses mid-market pricing for execution.

3.2.1. The crossing technology

Users have at their disposal a simple system that may be accessed from a PC, for processing their trades. Single or portfolio orders can be submitted to POSIT continuously, at any time of the trading day. Anonymity is protected and order details are never divulged externally or disclosed to the market. Submissions are free of charge.

The matching algorithm within POSIT is run at designated times each day. In order not to allow gaming and manipulating strategies, at the designated time of a match, a random execution time within a seven minute window is generated from the POSIT computer so that no one is aware of the exact match time. Any order received before the designated match time will be included in the match pool, but any order received after the start of the match window will be taken on a best endeavour basis up to the time the match is run. Any order subsequently received would be for the next scheduled match.

The POSIT algorithm compares all submitted orders confidentially and is set to maximise the total value of shares traded, given the constraints[16] associated with submitted orders. Matching orders are crossed at the ruling mid-price taken from the lead market quote for each stock,[17] and reported to the relevant authority after execution. Only executed orders are charges a 10 basis point brokerage commission.

3.2.2. The matching times

The match timetable (in UK time) consists of six intra-day matching times as follows: 9:00 am, 10:00 am, 11:00 am, 12:00 am, 2:00 pm, 3:00 pm.

This current timetable results from several changes summarised in table 1. When ITG Europe launched POSIT for UK equities in November 1998, only two daily matches were run at 11:00 am and at 3:00 pm. A third match was introduced at 9:30 am in September 1999, and a further one, at midday, was added in January 2000. Then, a new 8:30 am was added in

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[16] Clients can associate different types of constraints on the orders they submit to POSIT, so as to avoid unfavourable match executions. These constraints are detailed in the appendix.

[17] POSIT technology also offers clients the ability to generate trades that require market prints (e.g. internal crosses across different underlying clients) by means of "directed crosses". These bespoke matches may take place at any time during the trading day, outside of the normal scheduled match times and may use the standard POSIT mid-point pricing or some other benchmark pricing, e.g. VWAP. These directed crosses are excluded from our dataset.

November 2000 and moved to 8:45 am in January 2001. Finally, the match times were moved to the current hourly timetable in March 2001.[18]

Table 1
POSIT match times (UK time)

Period	**Match times**
18 nov 1998 – 19 sep 1999	11:00 am, 15:00 pm
20 sep 1999 – 9 jan 2000	9:30 am, 11:00 am, 3:00 pm
10 jan 2000 – 29 nov 2000	9:30 am, 11:00 am, 12:00 am, 3:00 pm
30 nov 2000 – 15 jan 2001	8:30 am, 9:30 am, 11:00 am, 12:00 am, 3:00 pm
16 jan 2001 – 18 mar 2001	8:45 am, 9:30 am, 11:00 am, 12:00 am, 3:00 pm
From 19 mar 2001	9:00 am, 10:00 am, 11:00 am, 12:00 am, 2:00 am, 3:00 pm

The considered observation period only covers the second semester of 2000 and the first semester of 2001, when POSIT match times were those indicated at lines 3 and 4 of Table 1. SEAQ and POSIT data available over the selected period are presented in the next section.

4. Data, empirical measures and sample description

The theoretical hypotheses presented in section 3 are tested on high frequency market data from the LSE and POSIT order data provided by ITG Europe, for SEAQ UK and Irish stocks, over a first period of six months from the 1st of July 2001 to the 31st of December 2001 (Period 1). Then, to appreciate the stability of the results, a second observation period is considered from the 1st of January to the 30th of June 2001.

4.1. Market and POSIT data

On the one hand, tick by tick market data from the London stock market include trade and best prices data. Best prices correspond to the best bid and offer market makers' quotes at any time a new quote is posted or a quote is revised. Quantities associated to best prices are not available so that the NMS is used as a proxy.

On the other hand, POSIT data consist of two series of files. One series includes the characteristics of the orders submitted to the CN, such as the sedol code identifying the stock, the size of the order in number of shares, the type of the initiator, that is "institutional investor" or "broker-dealer", the date and time of the match to which the order is being

[18] On the 28th of March 2000, an unofficial 4:00 pm match was introduced: it is only run some days according to trading activity.

submitted. The second series includes the characteristics of the orders executed in the CN: the stock sedol code, the executed quantity, the type of initiator, the mid-price used for execution and the date and time of the corresponding match.

Before running any empirical tests, this raw data has been rearranged for the purpose of the research in a few ways. The submission files were merged with the execution files, so as to allow to exhibit for each submission whether it is totally or partially executed, or not executed at all. Then, a procedure was set up to determine whether a submission to POSIT was made for the first time or whether it was an order resubmitted after remaining unexecuted in the previous match. In the end, a single table was built up, containing for each submission to POSIT: the stock sedol code, the date and time of the match, the type of the initiator, the submitted quantity, the executed quantity, the price of execution if any and a flag indicating whether the order is newly submitted or resubmitted after total or partial non execution at the previous match.

Both categories of data are available for 1663 SEAQ UK domestic stocks over Period 1 and for 1612 stocks over Period 2. However, only a subset of them are selected for the study: for test feasibility, very low traded stocks are abandoned. In order to select and characterise sample stocks, their risk and liquidity are evaluated through a set of empirical measures such as the volatility of daily close returns, the average NMS in number of shares and in GBP, the average size of trade, the average spreads, the average number of quote revisions throughout the MQP, the average trade number per day, the average daily traded volume as a multiple of the NMS and the average market imbalance between sales and purchases.

4.2. Risk and liquidity measures

Let us note:

- T_i the number of trading days for stock i within a given observation period,
- NMS_{it} the NMS, in number of shares, of stock i on day t,
- CA_{it} the closing ask price, that is the last ask quote of the MQP, for stock i on day t,
- CB_{it} the closing bid price, that is the last bid quote of the MQP, for stock i on day t,
- CM_{it} the closing quote, that is the last mid-quote of the MQP, for stock i on day t,
- $r_{it} = ln\left(\frac{CM_{it}}{CM_{it-1}}\right)$ the return of stock i on day t, computed in logarithm on closing mid-quotes,

- V_{it} the volume in number of shares, traded for stock i within the trading day t,[19]
- BV_{it} the sum of buying volumes in stock i on day t, and SV_{it}, the sum of selling volumes in stock i on day t,[20]
- A_{in} the ask price for stock i at time n,
- B_{in} the bid price for stock i at time n,
- M_{in} the mid price for stock i at time n,
- d_{in} the duration of market quotes posted on stock i at time n,
- N_i the total number of different market spreads quoted for stock i throughout a given observation period,
- P_{ik} the trade price for stock i on trade k,
- Q_{ik} the size of transaction k on stock i, in number of shares,
- μ_{ik} the current mid quote at the time of trade k on stock i,
- K_i the total number of trades for stock i over the considered period.

Volatility and liquidity measures are computed as follows.

1. Volatility

For each stock i, the volatility σ_i is measured by the unbiased estimator of the close return standard deviation:

$$\sigma_i = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}\left(r_{it} - \frac{1}{T}\sum_{t=1}^{T} r_{it}\right)^2} \quad (1).$$

2. Depth

Let us recall that the NMS is the minimum quantity for which market makers are due to quote firm prices. For that reason, the average value of the NMS is used as an indicator of depth. For each stock, the average NMS is calculated in number of shares (NMS_i) as show in equation (2), and in GBP ($£NMS_i$), as in equation (3).

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[19] The trading intra-day period I consider lays from 8:00 am to 5:00 pm, as I noticed that trading volumes remained high until 5:00 pm, even if the MQP closes at 4:30 pm.

[20] To determine the side of a trade, I require two conditions: the side officially reported by the market maker who declared the trade and the difference between the transaction price and the current mid-quote at the time of the trade. Following Lee and Ready (1991), a positive difference is supposed to indicate a purchase while a negative difference would indicate a sale. In case of contradiction between both conditions, I consider that the side of the trade is unknown and the transaction is excluded.

$$NMS_i = \frac{1}{T}\sum_{t=1}^{T} NMS_{it} \quad (2).$$

$$£NMS_i = \frac{1}{T}\sum_{t=1}^{T} CM_{it} \times NMS_{it} \quad (3).$$

Besides, the average size of a trade, denoted TS_i, and equal to

$$TS_i = \frac{1}{K_i}\sum_{k=1}^{K_i} Q_{ik} \times P_{ik} \quad (4),$$

may also be considered as related to the depth of the market.

3. Spreads

Three measures of spreads are used to appreciate the liquidity of each stock i:

- QS_i, the average quoted touch or market spread (i.e. the difference between the best offer and the best bid quoted on the market reported to the mid-quote), calculated by weighting each quoted spread with its duration of validity,
- ES_i, the average effective spread, that is the mean of spreads actually applied on trades weighted by trade sizes,[21]
- CS_i, the average closing spread computed as the equally-weighted mean of daily closing market spreads.

Equations (5), (6) and (7) display the explicit formulas of calculation:

$$QS_i = \sum_{n=1}^{N} \frac{d_{in}}{\sum_{n=1}^{N} d_{in}} \times \frac{A_{in} - B_{in}}{M_{in}} \quad (5),$$

$$ES_i = \sum_{k=1}^{K} \frac{Q_{ik} \times P_{ik}}{\sum_{n=1}^{N} Q_{ik} \times P_{ik}} \times \frac{|P_{ik} - \mu_{ik}|}{\mu_{ik}} \quad (6),$$

$$CS_i = \frac{1}{T}\sum_{t=1}^{T} \frac{CA_{in} - CB_{in}}{CM_{in}} \quad (7).$$

4. Quote frequency

Quote frequency can be measured by NQR_i, the average number of market quote changes within a MQP, for stock i. NQR_i, that is N_i/T, increases with the intensity of the

[21] To calculate the effective spread applied to a trade, the side of the trade is first determined following the criteria mentioned in footnote 20. When the side of a transaction cannot be identified, the trade is excluded from the calculation of ES_i.

information flow conveyed on a security and the level of competition between the market makers who quote prices for the stock.

5. Trading frequency

So as to appreciate the level of trading frequency of a given stock i, I do not only look at the average number of trades per day, denoted TN_i and equal to K_i / T_i, but also at the number of times the NMS is traded on average inside a trading session. This variable is denoted TF_i and is estimated in the following way:

$$TF_i = \frac{1}{T} \sum_{t=1}^{T} \frac{V_{it}}{NMS_{it}} \quad (8).$$

For the remainder of the paper, trading frequency shall be referred to as TF_i.

6. Market imbalance

By market imbalance, I mean the disequilibria between buying and selling trades. The market imbalance for stock i on day t is then defined as $\left|BV_{it} - SV_{it}\right| / \left(BV_{it} + SV_{it}\right)$. The average market imbalance IMB_i, calculated as

$$IMB_i = \frac{1}{T} \sum_{t=1}^{T} \frac{\left|BV_{it} - SV_{it}\right|}{BV_{it} + SV_{it}} \quad (7).$$

is an indicator of illiquidity. The higher IMB_i, the higher the cost of making the market for stock i.

Looking at the individual values of these measures, a certain number of stocks with missing data or very low trading activity are dropped from the samples.

4.3. Deletions for missing data and thin trading

The empirical tests conducted hereafter are based on stock-by-stock aggregated measures. In order to obtain individual measures with comparable statistical meaning, they should be estimated on a minimum number of trading days. Therefore, stocks for which market makers' quotes were available for less than 100 trading days of the observation period, were dropped from the samples. However, some very low-priced and illiquid stocks are still included in the remaining set of securities: these equities exhibit surprisingly high spreads and very low trading volumes.

As such extreme values could well bias the results of the test, I have deleted from the samples, any stock with one, at least, of the following features:

- the average quoted spread QS_i exceeded 20%;
- the average volume traded inside a session, TF_i, was less than 2 NMS;
- or the total number of trades throughout the considered six months' observation period, K_i, was less than 20.

Consequently, the sample for Period 1 (Sample 1) is reduced to 1,400 stocks, for which a total amount of 78,850 million GBP were traded in the market. As for Period 2, the final sample (Sample 2) includes 1,378 stocks for which the total traded volume over the period equalled 79,526 million GBP.

4.4. Characteristics of selected stocks

In terms of risk, depth and transaction costs, the selected subset of SEAQ stocks exhibit the typical features of mid cap equities: low prices, high volatility, limited depth and relatively high spreads, with large discrepancies across stocks. Descriptive statistics on volatility, depth, spreads and quote frequency are reported in Table 2.

Table 2

Characteristics of the samples: average depth, volatility, spreads and quote frequency

	Sample 1 – 1400 stocks Period 1 – 2nd sem. 2000			**Sample 2 – 1378 stocks Period 2 – 1st sem. 2001**		
	Weighted mean	**Standard deviation**	**Median**	**Weighted mean**	**Standard deviation**	**Median**
NMS in number of shares	13,079	17,061	2,000	17,589	20,645	2,512
NMS in GBP	38,681	34,297	3,325	46,488	44,549	3,430
Close-to-close return volatility	2.83%	1.81%	2.11%	2.66%	1.77%	2.27%
Average quoted spread	2.38%	1.47%	3.24%	2.28%	1.54%	3.57%
Average effective spread	1.76%	1.73%	3.77%	1.58%	1.55%	2.31%
Average closing spreads	4.01%	2.53%	4.96%	3.91%	2.95%	5.61%
Average number of quotes	12.9	8.5	6	12.7	5.7	6

The cross-sectional means and standard deviations are based on individual stock average measures weighted by total GBP traded volumes over the period.

The stocks of the samples are quite risky: the average close-to-close return volatility across Sample 1 (Sample 2) reaches 2.83% (2.66%), this mean being probably pulled up by most risky stocks, as the median volatility only equals 2.11% (2.27%). The market for these stocks is not very deep, the median NMS being around 2,000 shares or 3,400 GBP on each observation period. Yet, let us notice that the market for the most liquid stocks of the samples is much deeper, as the cross-sectional means of the NMS stand far above the median values. Consistently, average spreads are relatively high compared to what would be observed on a blue chip market segment. The cross-sectional mean of average quoted spreads equals 2.38% for Sample 1 and 2.23% for Sample 2, while the average effective spreads are substantially lower. The cross-sectional mean of effective spreads is no more than 1.76% across Sample 1 and 1.58% across Sample 2. Large discrepancies in spreads can be observed from one stock to another. For a great number of stocks, average spreads are superior to the mean value of the sample: as an illustration, median values of spreads always exceed the mean values.

Finally, market makers do not revise their quotes very frequently on this market segment. On average across each sample, quotes are revised 12 times a day for a stock, with, again, huge differences between stocks. For most stocks in the samples, the daily number of changes in price is even less than that, the median standing at 6 on each observation period.

5. Stylised facts on CN trading activity

By nature, the probability of execution in crossing systems remains low, as it cannot be improved by price adjustments. As mentioned in the introduction, crossing only addresses the needs of a very special type of trader, for which the reduction of market impact prevails over immediacy. Therefore, crossing is unlikely to attract more than a few per cent of the total order flow. As an illustration, 11 billion pounds were crossed through POSIT last year while 12,000 billion pounds were traded on the UK market. Concerning SETS FTSE100 stocks, significant volumes are crossed, but they have represented an extremely low share of the total market turnover (under 1%). In fact, the main part of POSIT order flow is related to mid caps, the potential gain from crossing being superior for these stocks, and the major share of the crossing business concentrates on SEAQ stocks that belong to the FTSE250.

Let us now examine the level of CN-trading for the stocks selected in samples 1 and 2.

5.1. Market activity and CN-trading over the observation periods

Statistics on market activity and POSIT trading, such as volumes, number of trades and trade size, are reported in Tables 3 and 4. Let us keep in mind that the CN does not open out of the trading period, so that overnight trading is irrelevant for the present study. For that reason, all market figures, from now on, only include intra-day activity.[22]

[22] Is considered as an intra-day transaction, any trade with a reported time between 8:00 am and 5:00 pm (cf. note 19).

In brief, the figures indicate that, when only considering intra-day trading, about 77 billion GBP were traded for the stocks of the samples within each 6-months' period. This volume represented more than 2 million trades on each semester, the average size of a trade standing between 33 and 35 thousand GBP. Over Period 1, 1.28% of the total trading volumes (in GBP) were transacted through POSIT. This market share represented only 0.34% of the total number of trades, as POSIT trades are larger than others. The average size of order executed in the CN is more than 3 times the average size of trade on the market. Crossing activity in POSIT rose substantially in Period 2, reaching 2.34% of total traded volumes and 0.67% of the total number of trades. This increase in crossing cannot only be assigned to a rise in the relative amount of submissions in the CN: comparing the first lines of Tables 5.1 and 5.2 to the first line of Table 3, one can see that POSIT-submitted orders in percentage of the total market volume keep around 50% (49% in Period 1 and 51% in Period 2). If accounting for resubmissions, this ratio goes up to 94% in Period 1 and to 104% in Period 2, as many orders are submitted to several consecutive matches in case of non execution. The increase in POSIT market share is then more probably due to a lower imbalance between selling and buying orders (cf. lines 5 and 9 of Tables 5.1 and 5.2) in the CN, resulting in a better rate of execution in the CN: 4.13% of volumes submitted to the CN in Period 2 were executed instead of 2.63% in Period 1.

Table 3
Total trading volumes

Intra-day GBP trading volumes	Over Period 1	Over Period 2
On the market	76,830,009,243	77,676,613,444
In POSIT	985,190,215	1,638,088,558
% in POSIT	1.28%	2.11%

Table 4
Total trade number and trade size

Intra-day trades	Period 1		Period 2	
	Total number	Average size in GBP	Total number	Average size in GBP
On the market	2,269,072	33,860	2,187,505	35,509
In POSIT	7,792	126,436	14,645	110,853
% in POSIT	0.34%	---	0.67%	---

Table 5.1
Trading activity in POSIT over Period 1

	Total over the observation period	From institutional investors	From broker-dealers
Total submitted volume* in GBP	37,398,488,467	19,611,843,971	17,786,644,496
- in % of total submitted volume*	100.00%	52.44%	47.56%
Total number of submitted orders*	107,357	31,261	76,096
Average size of an submitted order*	348,356	627,358	233,740
Total submitted buy volume* in GBP	15,308,836,748	8,915,064,759	6,393,771,989
- in % total submitted volume*	40.93%	23.84%	17.10%
Total number of submitted buy orders*	37,947	12,821	25,126
Average size of an submitted buy order*	403,427	695,349	254,468
Total submitted sell volume* in GBP	22,089,651,719	10,696,779,212	11,392,872,507
- in % of total submitted volume*	59.07%	28.60%	30.46%
Total number of submitted sell orders*	69,410	18,440	50,970
Average size of an submitted sell order*	318,249	580,086	223,521
Total executed volume in GBP	985,190,215	297,656,877	687,533,338
- in % total executed volume	100.00%	30.21%	69.79%
- in % of total market traded volume	1.28%	0.39%	0.89%
Total executed volume over total submitted volume	2.63%	1.52%	3.87%
Total number of executed orders	7,792	1,680	6,112
Average size of an executed order	126,436	177,177	112,489

* Including new submissions only / excluding resubmissions of unexecuted orders

Looking at the breakdown of CN orders between trader types, it is notable that the reduction in the order imbalance is mainly related to market makers strategies. Let us recall that orders submitted to POSIT come from two categories of traders: institutional investors and broker-dealers, in other words market makers. The former account for about 52% or 53% of the total CN-submitted order flow and submit larger orders. Yet, the latter make the major part of crossed volumes (70% in Period 1 and 59% in Period 2) and tend to submit more selling orders than buying orders. Nevertheless, this imbalance in market makers-initiated orders does not seem stable over time and lessens significantly over the 2nd period: market makers placed nearly twice (1.8 times) more sell orders than buy orders in the CN in Period 1, while this ratio is no more than 1.3 over Period 2.

Beyond these global figures, the share of CN trading can highly differ from one stock to another. Over Period 1, orders had been submitted into the CN for 1,251 stocks out of 1,400. 568 stocks had been traded at least once in the CN, the CN market share exceeding 1% for 281 of these stocks and 5% for 20 of them. As for Sample 2, 1,265 out of 1,378 stocks were CN-submitted and 703 were actually crossed in POSIT, 475 with a POSIT market share superior to 1% and 54 with a POSIT market share over 5%.

Table 5.2
Trading activity in POSIT over Period 2

	Total over the observation period	From institutional investors	From broker-dealers
Total submitted volume* in GBP	39,667,866,722	21,098,078,741	18,569,787,981
- in % of total submitted volume*	100.00%	53.19%	46.81%
Total number of submitted orders*	159,960	50,217	109,743
Average size of an submitted order*	247,986	420,138	169,212
Total submitted buy volume* in GBP	19,309,724,530	11,152,698,360	8,157,026,171
- in % total submitted volume*	48.68%	28.12%	20.56%
Total number of submitted buy orders*	59,712	20,416	39,296
Average size of an submitted buy order*	323,381	546,272	207,579
Total submitted sell volume* in GBP	20,358,142,192	9,945,380,382	10,412,761,810
- in % of total submitted volume*	51.32%	25.07%	26.25%
Total number of submitted sell orders*	100,248	29,801	70,447
Average size of an submitted sell order*	203,078	333,726	147,810
Total executed volume in GBP	1,638,088,558	672,852,578	965,235,979
- in % total executed volume	100.00%	41.08%	58.92%
- in % of total market traded volume	2.11%	0.87%	1.24%
Total executed volume over total submitted volume	4.13%	3.19%	5.20%
Total number of executed orders	14,645	4,532	10,113
Average size of an executed order	111,853	148,467	95,445

* Including new submissions only / excluding resubmissions of unexecuted orders

Before examining, in section 6, the impact on market liquidity of these differences in CN-trading, the next subsection highlights the characteristics of CN-traded stocks.

5.2. Characteristics of CN-traded stocks

This subsection focuses on the specificities, if any, of stocks for which some orders are actually submitted into or executed on the CN. To this aim, the following sub-samples are considered on each observation period:

- sub-sample A including stocks for which at least one order was submitted to the CN,
- sub-sample B containing non submitted stocks,
- sub-sample A1 including stocks actually crossed in POSIT,
- sub-sample A2 corresponding to CN-submitted but never executed stocks,

– sub-sample α including CN-traded stocks with a POSIT market share in volumes of less than 1%,
– sub-sample β including CN-traded stocks with a POSIT market share between 1 and 5%,
– and finally, sub-sample γ including CN-traded stocks with a CN market share over 5%.

Measures of spreads, depth, volatility, trading frequency, market imbalance and quote frequency, as defined in subsection 4.2, are computed for each stock and then, equally-weighted means of these measures are computed and compared by pair of sub-samples.

According to the mean values set out in Table 7, stocks for which no order was submitted to POSIT are the less liquid in the samples, with the highest spreads, the smallest NMS and the largest market imbalance. They are very infrequently traded (less than 3 trades a day on average) and have very sticky quotes (less than 5 quote revisions per day on average).

Table 7
Comparison between CN-submitted stocks and non submitted stocks

	Period 1			**Period 2**		
	Sample A	**Sample B**	**Student**	**Sample A**	**Sample B**	**Student**
Number of stocks	1,251	149	---	1,265	113	---
Quoted spreads	3.33%	4.56%	**-8.36**	4.36%	7.01%	**-5.66**
Effective spreads	3.45%	6.47%	**-5.88**	3.42%	8.38%	**-2.31**
Depth	6,719	2,267	**6.00**	7,667	1,884	**10.39**
Trade size	37,966	47,270	-0.91	34,988	83,966	**-3.10**
Volatility	2.69%	2.82%	-0.58	2.44%	2.47%	1.91
Trading frequency	46.2	34.4	**2.49**	43.9	38.9	1.22
Trade number	14.0	2.9	**7.80**	13.8	2.0	**17.53**
Market imbalance	57.4%	78.2%	**-13.23**	54.0%	74.3%	**-11.84**
Quote frequency	7.4	4.2	**16.85**	7.5	4.4	**15.54**

Sub-sample A gathers stocks for which at least one order was submitted to POSIT over the period, while other stocks of the initial sample are put in Sub-sample B. Student statistics give the level of significance of the difference between Sample A and Sample B mean values. When the difference is significant at a 5% level, the t-value is bolded. Cells are grey when t-values are significant for both periods.

Inside the group of CN-submitted stocks, about half of them have effectively been crossed in the alternative trading system. The differences in spreads, depth, risk, trading frequency and quote frequency between crossed stocks and other submitted stocks are all highly significant on both observation periods (cf. Table 8) and show that CN-traded stocks are less risky and more liquid with respect to any dimension of the concept of liquidity: less expensive spreads, deeper market, higher trading volumes and more frequent trades, more competitive quotes. In a way, this finding is rather intuitive and consistent with theory. As demonstrated in Hendershott and Mendelson (2000), a CN needs to achieve critical mass so as to execute order flow, and the ability of reaching such a critical mass will obviously be more probable when the market is active, deep and well-balanced in terms of selling and buying interest, as high market imbalance may generate crowding effects on one side of the market.

Table 8

Comparison between CN-traded stocks and CN-submitted stocks with no execution

	Period 1			**Period 2**		
	Sample A1	**Sample A2**	**Student**	**Sample A1**	**Sample A2**	**Student**
Number of stocks	568	683	---	703	675	---
Quoted spreads	2.61%	5.33%	**-16.57**	2.95%	6.29%	**-19.53**
Effective spreads	2.04%	4.62%	**-13.11**	2.13%	5.59%	**-8.63**
Depth	9,136	4,708	**5.44**	9,561	4,726	**5.67**
Trade size	49,770	28,150	**7.79**	45,583	32,153	**3.66**
Volatility	2.44%	2.90%	**-4.18**	2.75%	3.14%	**-2.93**
Trading frequency	53.5	40.0	**5.03**	51.0	35.6	**8.01**
Trade number	22.4	7.0	**10.14**	20.3	5.0	**15.58**
Market imbalance	46.6%	66.4%	**-24.71**	43.2%	68.6%	**-33.08**
Quote frequency	9.5	5.6	**16.81**	9.3	5.1	**24.55**

Sample A1 is made of CN-submitted stocks with at least one cross executed in the CN over the period. Sample A2 gathers submitted stocks remained unexecuted. Student statistics give the level of significance of the difference between Sample A1 and Sample A2 mean values. When the difference is significant at a 5% level, the t-value is bolded. Cells are grey when t-values are significant for both periods.

Yet, when examining the sub-sample of POSIT-crossed stocks, further comments should be added on this point. In particular, it is interesting to notice that the stocks which have the highest CN market share by volume, are not necessarily the most liquid in Sample A1, in terms of turnover. The results reported in Tables 9.1 and 9.2 indicate that stocks for which the CN market share exceeds 5% of the total traded volume are less frequently traded and quote-revised than others, although their volatility and spreads are inferior to those of less CN-traded stocks.

Apparently, the CN over-performs when the market lacks depth and remains surprisingly inactive in comparison with the level of risk and transaction costs.

After this first glimpse on POSIT trading activity, the next section is dedicated to the main purpose of this study, that is the analysis of the way CN-trading does affect the liquidity of the market, and is based on the testable hypotheses established in Section 2.

Table 9.1

Comparison of α , β and γ stocks – Period 1

	Sample α	**Sample β**	**Sample γ**	**Student α/β**	**Student α/γ**	**Student β/γ**
Number of stocks	20	261	287	---	---	---
Quoted spreads	2.11%	2.24%	2.99%	0.40	**2.51**	**4.86**
Effective spreads	1.10%	1.59%	2.52%	**2.77**	**5.92**	**4.57**
Depth	5,227	9,802	8,802	**2.67**	**2.14**	-0.86
Trade size	48,075	50,086	49,601	0.25	0.18	-0.12
Volatility	1.53%	2.12%	2.80%	**4.01**	**7.66**	**4.69**
Trading frequency	37.7	45.0	62.4	**2.09**	**5.07**	**3.89**
Trade number	9.3	19.6	25.9	**5.09**	**5.37**	**2.20**
Market imbalance	53.5%	46.0%	46.7%	**-2.76**	**-2.50**	0.66
Quote frequency	7.6	9.6	9.6	**2.88**	**2.75**	0.09

Sample α includes stocks for which the POSIT market share in volumes is superior to 5%; Sample β includes stocks for which the POSIT market share stands between 1 and 5%; Sample γ includes stocks with a POSIT market share strictly positive but inferior to 1%. Student statistics give the level of significance of the difference between mean values by pair of sub-samples. When the difference is significant at a 5% level, the t-value is bolded. Cells are grey when t-values are significant for both periods.

Table 9.2

Comparison of α , β and γ stocks – Period 2

	Sample α	**Sample β**	**Sample γ**	**Student α/β**	**Student α/γ**	**Student β/γ**
Number of stocks	54	421	228	---	---	---
Quoted spreads	2.85%	2.68%	3.47%	-0.57	1.89	**4.63**
Effective spreads	2.20%	1.83%	2.65%	-0.87	1.05	**4.87**
Depth	9,581	9,482	9,704	-0.04	0.05	0.17
Trade size	56,865	46,848	40,574	-1.47	**-2.12**	-1.39
Volatility	2.50%	2.51%	3.25%	0.03	1.93	**4.42**
Trading frequency	41.8	50.3	54.5	**2.81**	**3.55**	1.39
Trade number	13.0	20.4	21.8	**3.91**	**3.29**	0.63
Market imbalance	46.3%	41.7%	45.1%	-1.87	-0.49	**3.18**
Quote frequency	8.2	9.7	8.7	**3.47**	1.05	**-3.05**

Sample α includes stocks for which the POSIT market share in volumes is superior to 5%; sample β includes stocks for which the POSIT market share stands between 1 and 5%; sample γ includes stocks with a POSIT market share strictly positive but inferior to 1%. Student statistics give the level of significance of the difference between mean values by pair of samples. When the difference is significant at a 5% level, the t-value is bolded. Cells are grey when t-values are significant for both periods.

6. The impact of CN trading on the dealer market liquidity: methodology and results

The methodology used to test hypotheses H1 to H7 consists of cross-sectional regressions of stock-by-stock market quality measures on variables that measure the trading activity in the CN. Results are homogenous from Period 1 to Period 2. They globally show that the gains from competition dominate the potential costs of fragmentation. The CN might well skim off liquidity trading from the DM. However, the unexecuted CN order flow does not bring additional risk and liquidity costs on to the market. The risk sharing benefits offset the cream-skimming costs, and dealer trading in the CN induces a competition effect.

6.1. Opportunistic CN-trading and unexecuted CN order flow

Hypotheses H1 and H2 address the impact of CN unexecuted order flow on the riskiness and the liquidity of the DM. The level of unexecuted order flow for a stock i, on a given period, is measured by the rate of non execution in the CN, denoted U_i, and equal to the total volume of unexecuted POSIT orders reported to the total volume of orders newly submitted to POSIT during this period. When no orders are submitted to the CN, U_i is set to zero.

According to H1, U_i would increase the risk of the market after the matches. To test this relation, the riskiness of the DM at the end of the trading day will be represented by the close-to-close return volatility per unit of traded volume, that is the ratio σ_i / V_i, where σ_i is the return volatility as estimated in equation (1) and V_i is the average daily traded volume for stock i.

Prior to further investigation, several variables have been identified as potential control variables for σ_i / V_i:

- all measures of spreads defined in section 4.2 (QS_i, ES_i and CS_i), given the well-known relationship between risk and spreads,
- the average trading frequency measured in logarithm, $ln(TF_i)$, and the average number of trades per day TN_i, as a less risky stock is probably more frequently traded,
- the logarithm of the average NMS in number of shares, $ln(NMS_i)$, and in GBP, $ln(£NMS_i)$, as I expect stocks with a deeper market to be less volatile,
- finally, the average imbalance IMB_i, as the volatility per unit of traded volume could be increasing with the disequilibria between selling and buying orders.

When regressing σ_i / V_i on each of the variables, no significant relation is found either with $ln(NMS_i)$ or with TN_i. As expected, σ_i / V_i is positively related to any spread measure, negatively related to trading frequency, negatively related to $ln(£NMS_i)$ and positively related to market imbalance. Interestingly, the most explanatory variable is the average closing spread, CS_i. No additional variable improves the quality of the regression, whatever the considered period.

Consequently, H1 is tested OLS-regressing σ_i / V_i on U_i across each sample and controlling for CS_i. Regression coefficients and associated t-values are reported in Table 10.

Table 10
Test of hypothesis H1
Closing price volatility and CN unexecuted order flow

Dependent variable	Observation period	Control variables		Explaining variable	R^2
		Intercept	CS_i	U_i	
σ_i / V_i	Period 1 (1,400 obs.)	-8.43.10-3** (-4.822)	1.611.10-3** (19.026)	-1.12.10-5 (-0.683)	21.6%
	Period 2 (1,378 obs.)	-1.31.10-2** (-6.412)	1.815.10-3** (20.736)	2.090.10-5 (1.052)	23.8%

U_i coefficients are not significantly different from zero for any period and H1 is rejected.

H2 also focuses on the impact of CN unexecuted order flow. According to H2, opportunistic CN orders, if not executed, would produce additional liquidity costs when coming back to the DM, so that spreads would be positively related to U_i. Any test of H2 then requires to identify the relevant control variables for spreads.

The following range of potential control variables are examined. First of all, several measures of volatility are considered, as spreads are obviously depending on volatility:

- the standard deviation of close-to-close returns σ_i,
- the variance of close-to-close returns σ_i^2,
- the standard deviation of open-to-close returns σ_{oc_i},
- and the variance of open-to-close returns $\sigma_{oc_i}^2$.

Second, spreads are expected to be decreasing in trading volumes, represented by the logarithm of the average GBP daily traded volume $ln(£V_i)$, and in trading frequency again measured by $ln(TF_i)$. Also, they should be positively related to IMB_i and negatively related to NQR_i, as the number of quote revisions is an indicator of competition intensity between market makers. Finally, three other variables are considered: $ln(NMS_i)$, $ln(£NMS_i)$ and BD_i, the average share of daily volume declared as broker-dealer to broker-dealer trades in the data.[23]

In order to choose the most relevant control variables, OLS-regressions are run following a stepwise procedure. The variable having the highest explanatory power is first selected. Then, the variable that most increase the explanatory power of the model is added, and so on until the model cannot be improved. In the end, for each spread measure and for each observation period, three control variables are selected: $ln(£V_i)$, σ_i and $ln(NMS_i)$, all coefficients being negative, except the one for $ln(NMS_i)$. The positive relation between the spreads and the NMS may be interpreted in the following way. If two stocks are identical in terms of risk and liquidity, spreads will be obviously wider for the one that has the largest NMS, as market makers are due to quote firm prices and risk capital on bigger quantities.

Consequently, tests of H2 consist of regressing spreads on the rate of non execution in POSIT, while controlling for trading volumes, closing price volatility and NMS. The results displayed in Table 11 lead to the rejection of H2, as spreads are never positively related to U_i.

To conclude on H1 and H2, both hypotheses are rejected. Any opportunistic trading that is skimmed off from the dealer market to POSIT and comes back to the dealer market in case of non execution, does not significantly impact closing quote risk and liquidity costs.

6.2. The risk-sharing benefits from new liquidity trading in the CN offsets the cream-skimming costs

Although the POSIT unexecuted order flow does not affect spreads and volatility, I cannot conclude yet to the absence of any fragmentation or cream-skimming effect. The answer to this question depends on the way the existence of the CN modifies the liquidity-based demand. Either opportunistic or patient liquidity traders leave the DM to try the CN first, and the DM becomes more costly (H3a); or, the CN attracts new liquidity traders who would not trade otherwise, so that market makers get lower adverse selection and inventory risks

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[23] $BD_i = \frac{1}{T_i}\sum_{t=1}^{T_i}\frac{BD_{it}}{V_{it}}$ where BD_{it} is the amount of trading volume declared as broker-dealer to broker-dealer trades, on day t for stock i and V_{it} is the volume traded on day t for stock i.

(H3b). Under H3a (H3b) spreads widen (narrow) with the share of order flow submitted to the CN.

Table 11

Test of hypothesis H2 – Spreads and CN unexecuted order flow

Dependent variable	Observation period	Control variables				Explaining variable	R^2
		Intercept	$ln(£V_i)$	σ_i	$ln(NMS_i)$	U_i	
QS_i	Period 1 (1,400 obs.)	13.991* (32.362)	-1.278** (-31.714)	0.672** (21.793)	0.541** (8.804)	$-5.60.10^{-3}$** (-2.695)	62.7%
	Period 2 (1,378 obs.)	14.877** (35.864)	-1.343** (-33.349)	0.503** (19.203)	0.607** (10.089)	$-1.19.10^{-2}$** (-5.451)	64%
ES_i	Period 1 (1,400 obs.)	12.450** (21.069)	-1.260** (-22.219)	0.693** (15.973)	0.549** (6.352)	$-3.96.10^{-3}$ (-1.355)	45.6%
	Period 2 (1,378 obs.)	13.915** (24.414)	-1.278** (-23.095))	0.566** (15.745)	0.533** (6.445)	$-1.55.10^{-2}$** (-5.156)	49.1%
CS_i	Period 1 (1,400 obs.)	16.130 (25.327)	-1.776 (-29.057)	1.524 (32.322)	1.024 (10.990)	$-1.08.10^{-2}$** (-3.423)	67.9%
	Period 2 (1,378 obs.)	17.207** (27.276)	-1.862** (-30.396)	1.399** (35.131)	1.158** (12.650)	$-1.94.10^{-2}$** (-5.832)	72%

The validation of either H3a or H3b is thus based upon the relation observed between spreads and the relative amount of order flow submitted into POSIT.

The relative amount of POSIT-submitted order flow over a given period for stock i is denoted NS_i and computed as the total volume submitted to POSIT for stock i divided by the total volume traded on the market for stock i. NS_i includes new submissions only and does not account for resubmissions of unexecuted orders.

The regressions of individual average spreads on NS_i values (cf. Table 12.1) do not allow to assess that one effect is dominant over the other.

H3a is rejected as none of the NS_i coefficients is significantly positive. Yet, H3b cannot be validated either: although most of them negative, coefficients are not significantly different from zero.

As the concern here is liquidity trading, it might be relevant to focus on the POSIT orders submitted by institutional investors. For that reason, similar regressions are run on NSI_i, the component of NS_i that corresponds to institutional investors' orders only. The results, reported in Table 12.2, do not strongly differ from the previous ones.

Table 12.1

Test of hypothesis H3 – Cream skimming vs Risk sharing: Spreads and CN-submitted order flow

Dependent variable	Observation period	Control variables				Explaining variable	R^2
		Intercept	$ln(£V_i)$	σ_i	$ln(NMS_i)$	NS_i	
QS_i	Period 1 (1,400 obs.)	13.504** (31.675)	-1.311** (-33.479)	0.669** (21.650)	0.538** (8.735)	$-3.43.10^{-5}$ (-0.303)	62.5%
	Period 2 (1,378 obs.)	14.408** (35.074)	-1.382** (-33.764)	0.493** (18.690)	0.595** (9.791)	$-2.19.10^{-4}$ (-1.662)	63.3%
ES_i	Period 1 (1,400 obs.)	12.275** (20.508)	-1.275** (-23.199)	0.693** (15.961)	0.547** (6.324)	$1.388.10^{-4}$ (0.873)	45.5%
	Period 2 (1,378 obs.)	13.080** (23.180)	-1.307** (-23.243)	0.555** (15.303)	0.508** (6.083)	$1.299.10^{-4}$ (0.717)	48.1%
CS_i	Period 1 (1,400 obs.)	16.061** (24.817)	-1.846** (-31.050)	1.518** (32.358)	1.018** (10.891)	$-2.09.10^{-4}$ (-1.218)	67.7%
	Period 2 (1,378 obs.)	16.451** (26.298)	-1.926** (-30.894)	1.383** (34.426)	1.139** (12.300)	$-3.68.10^{-4}$ (-1.829)	71.4%

Table 12.2

Test of hypothesis H3 – Cream skimming vs Risk sharing: Spreads and institutional CN-submitted order flow

Dependent variable	Observation period	Control variables				Explaining variable	R^2
		Intercept	$ln(£V_i)$	σ_i	$ln(NMS_i)$	NSI_i	
QS_i	Period 1 (1,400 obs.)	13.448** (31.631)	-1.307** (-33.431)	0.670** (21.683)	0.538** (8.736)	$5.216.10^{-5}$ (0.450)	62.5%
	Period 2 (1,378 obs.)	14.347** (35194)	-1.376** (-33.879)	0.493** (18.690)	0.592** (9.745)	$-1.96.10^{-4}$ (-1.171)	63.4%
ES_i	Period 1 (1,400 obs.)	12.238** (20.510)	-1.273** (-23.195)	0.693** (15.975)	0.547** (6.334)	$2.148.10^{-4}$ (1.320)	45.6%
	Period 2 (1,378 obs.)	13.149** (23.490)	-1.314** (-23.555)	0.554** (15.294)	0.511** (6.121)	$6.936.10^{-6}$ (0.030)	48.1%
CS_i	Period 1 (1,400 obs.)	16.003** (24.788)	-1.841** (-31.021)	1.519** (32.385)	1.018** (10.882)	$-1.41.10^{-4}$ (-0.801)	67.6%
	Period 2 (1,378 obs.)	16.374** (26.385)	-1.918** (-31.019)	1.383** (34.428)	1.134** (12.263)	$-4.19.10^{-4}$ (-1.648)	71.3%

Eventually, submissions into POSIT do not create additional liquidity costs. The CN does not skim off liquidity trading from the DM in a sufficient way so as to significantly increase adverse selection on the central market. If some liquidity traders actually switch from the DM to the CN, the increase in spreads that this might cause would probably be offset by some risk sharing benefit. The next subsection will provide some other evidence on risk sharing benefits.

6.3. The benefits of CN dealer trading

Using unique data from the LSE, Reiss and Werner (1998) have shown that interdealer trading facilitated inventory risk sharing among dealers. The same idea motivates hypothesis H4: CN dealer trading can also be expected to lessen the cost of managing inventories for market makers. Provided H4, market makers would be able to tighten quotes when they trade or expect to trade in the CN, and quoted spreads would narrow with the amount of dealer orders executed in the CN.

So as to validate or invalidate H4, the average quoted, effective and closing spreads are regressed on the relative volume traded by market makers in POSIT over the period. This relative volume, denoted XM_i, is calculated, for each stock i, as the total POSIT volume traded by market makers reported to the total market volume. The results are set out in Table 13. XM_i coefficients are significantly negative at the 1% level for all measures of spreads, and are stable from Period 1 to Period 2, except for effective spreads over Period 2. Consequently, , hypothesis H4, according to which dealer trading in the CN reduces the cost of market making, can be accepted.

Table 13

Test of hypothesis H4 –Spreads and dealer CN-trading

Dependent variable	**Observation period**	**Control variables**				**Explaining variable**	**R²**
		Intercept	$ln(£V_i)$	σ_i	$ln(NMS_i)$	XM_i	
QS_i	Period 1 (1,400 obs.)	13.056** (30.467)	-1.280** (-32.713)	0.645** (20.656)	0.574** (9.290)	-0.286** (-4.200)	63.0%
	Period 2 (1,378 obs.)	13.856** (33.380)	-1.332** (-32.390)	0.485** (18.424)	0.612** (10.092)	-0.239** (-4.223)	63.7%
ES_i	Period 1 (1,400 obs.)	11.996** (19.859)	-1.256** (-22.775)	0.670** (15.208)	0.579** (6.646)	-0.253** (-2.634)	45.8%
	Period 2 (1,378 obs.)	12.936** (22.578)	-1.295** (-22.805)	0.550** (15.144)	0.521** (6.235)	-0.119 (-1.522)	48.2%
CS_i	Period 1 (1,400 obs.)	15.568** (23.813)	-1.812** (-30.344)	1.501** (31.489)	1.048** (11.111)	-0.234* (-2.255)	67.7%
	Period 2 (1,378 obs.)	15.792** (24.894)	-1.866** (-29.682)	1.375** (34.179)	1.153** (12.450)	-0.254** (-2.93)	71.5%

6.4. Competition and the net effect of the CN activity on implicit transaction costs

This last sub-section presents tests of the net effect of the CN activity on the cost of trading. This net effect depends on the trade-off between competition benefits and fragmentation costs. If the existence of the CN strengthens the competition between price-setting agents, as proposed in hypothesis H5, then CN-trading would accelerate quote revisions.

However, the CN might just have the opposite effect by fragmenting the order flow, as an order could remain submitted to the CN awaiting for execution without coming back to the DM, and therefore is not visible from the market. If such a fragmentation harms price formation and slows down, quote revisions will become scarce when the share of order flow submitted and resubmitted to the CN increases, and H5 will not hold.

Therefore, the validation of H5 is based on the relation between NQR_i, the average number of quote changes per day for stock i and the two following CN-related measures:

- S_i, the total volume of POSIT-submitted orders, including new submissions as well as resubmissions, divided by the total market transaction volume;
- X_i, the total POSIT-executed volume reported to the total market trading volume.

Before regressing NQR_i on S_i and X_i, four control variables for NQR_i have been selected among a wide range of potential explaining variables: the number of quote changes appears to be positively related to the average number of trades per day TN_i, positively related to the size in GBP of the NMS $ln(£NMS_i)$, positively related to the share of dealer-to-dealer trading BD_i and negatively related to the market imbalance IMB_i.

Tables 14.1 and 14.2 exhibit estimates and statistic values.

Table 14.1

Test of hypothesis H5 – Quote revisions and CN-submitted order flow

Dependent variable	Observation period	Control variables					Explaining variable	R^2
		Intercept	TN_i	$ln(£NMS_i)$	BD_i	IMB_i	S_i	
NQR_i	Period 1 (1,400 obs.)	4.011** (4.948)	$9.356.10^{-2}$** (33.280)	0.404** (6.131)	0.355** (12.562)	$-3.74.10^{-2}$** (-6.456)	$1.576.10^{-5}$ (0.461)	74.4%
	Period 2 (1,378 obs.)	4.582** (6.402)	$7.346.10^{-2}$** (20.868)	0.427** (6.921)	0.366** (12.579)	$-4.68.10^{-2}$** (-9.212)	$8.098.10^{-5}$ (0.677)	73.2%

Table 14.2
Test of hypothesis H5 – Quote revisions and CN- executed order flow

Dependent variable	Observation period	Control variables					Explaining variable	R^2
		Intercept	TN_i	$ln(£NMS_i)$	BD_i	IMB_i	X_i	
NQR_i	Period 1 (1,400 obs.)	4.057** (5.008)	9.410.10^{-2}** (33.320)	0.387** (5.822)	0.349** (12.300)	-3.65.10^{-2}** (-6.299)	7.640.10^{-2}* (1.967)	74.4%
	Period 2 (1,378 obs.)	4.645** (6.511)	7.495.10^{-2}** (21.116)	0.389** (6.206)	0.363** (12.538)	-4.45.10^{-2}** (-8.690)	0.105** (2.806)	73.4%

S_i coefficients are not significantly positive on any observation period, while X_i coefficients are positive and significant at the 5%-level (1%-level) over Period 1 (Period 2). The fragmentation of the order flow between POSIT and the DM does not seem to harm the competition in prices, whereas POSIT-executions slightly accelerate quote revisions. Let us note that the second effect is more significant on Period 2, when the rate of execution in POSIT was higher. This allow me to accept H5.

If the competition effect dominates the fragmentation effect, then, on average, crossing should reduce the temporary market impact of trades (hypothesis H6). As a proxy for temporary market impact, I took the average daily volatility around VWAP, denoted σ_{vwap_i} for stock i. VWAP is the volume-weighted average price of the stock on a given trading day and is used by operators as a benchmark either to price after-hours transactions or to measure trading performance. The higher the bid-ask bounce and the market impact of trades, the more individual trade prices will deviate from VWAP. For this reason, σ_{vwap_i}, computed as the average of daily standard deviations of transaction prices from VWAP for stock i, measures short-term volatility around the mean level of prices due to implicit transaction costs and market impact of trades. Again, I selected control variables for σ_{vwap_i} following a stepwise procedure. The variables that most explain the variance of σ_{vwap_i} across the samples are consistent with the economic intuition. Unsurprisingly, σ_{vwap_i} increases with the volatility of daily returns σ_i, with quoted spreads QS_i, with the size of the NMS measured by $ln(NMS_i)$ and, of course, with the daily number of trades TN_i.

While controlling for these control variables, σ_{vwap_i} is regressed on X_i. Then, X_i is split between its sell side component XM_i and its buy side component, XI_i, that equals the total institutional CN-volume for stock i in percentage of the total market volume. Results in

Tables 15.1 and 15.2 validate H6. They indicate that crossing reduces temporary market impact, this effect being essentially related to market makers crosses.

Table 15.1

Test of hypothesis H6 – Market impact and CN-executed order flow

Dependent variable	Observation period	Control variables					Explaining variable	R^2
		Intercept	σ_i	QS_i	$ln(NMS_i)$	TN_i	X_i	
σ_{vwap_i}	Period 1 (1,400 obs.)	-1.372** (-12.677)	9.545.10-2** (10.163)	9.710.10-2** (18.185	0.199** (14.038)	3.401.10-3** (4.912)	-3.87.10-2** (-3.27)	50.3%
	Period 2 (1,378 obs.)	-0.969** (-11.150)	8.337.10-2** (13.678)	7.809.10-2** (18.276)	0.153** (13.280)	5.333.10-3 (7.187)	-2.98.10-2** (-3.769)	57.5%

Table 15.2

Test of hypothesis H6 – Market impact, dealer CN-trading and institutional CN-trading

Dependent variable	Observation period	Control variables					Explaining variables		R^2
		Intercept	σ_i	QS_i	$ln(NMS_i)$	TN_i	XM_i	XI_i	
σ_{vwap_i}	Period 1 (1,400 obs.)	-1.395** (-12.881)	9.399.10-2** (10.015)	9.573.10-2** (17.893)	0.204** (14317)	3.358.10-3** (4.860)	-7.76.10-2** (4.242)	5.652.10-3 (0.285)	50.5%
	Period 2 (1,378 obs.)	-0.970** (-11.154)	8.342.10-2** (13.683)	7.797.10-2** (18.234)	0.153** (13.291)	5.340.10-3** (7.195)	-3.70.10-2** (-3.059)	-1.98.10-2 (-1.315)	57.5%

Finally, the net impact of CN-trading on the cost of trading is examined by regressing spreads on X_i. The estimated coefficients (see Table 16) all indicate that spreads decrease with an increase in the CN volume. However, the t-statistics stand beyond the critical values, with the exception of the case of quoted spreads over Period 1.

With respect to my previous findings, the decreasing relationship between spreads and CN volumes can be assigned to POSIT trades coming from market makers, but the weak significance of this relationship means that the rest of the CN-executed order flow, that is the CN volume initiated by institutional investors, has an opposite effect. On the one hand, trading in the CN lessens the cost of market making for dealers, but on the other hand, when institutional investors' orders are executed in POSIT, dealers are probably losing a part of their potential revenues.

All things combined, the positive effect of dealer CN-trading overbalances the negative impact of institutional CN-trading, so that crossing results in a statistically weak decrease of the cost of trading.

Table 16
Test of hypothesis H7 – Spreads and CN-executed order flow

Dependent variable	Observation period	Control variables				Explaining variable	R^2
		Intercept	$ln(£V_i)$	σ_i	$ln(NMS_i)$	X_i	
QS_i	Period 1 (1,400 obs.)	13.267** (30.961)	-1.290** (-32.639)	0.659** (21.172	0.550** (8.913)	-0.106* (-2.294)	62.6%
	Period 2 (1,378 obs.)	14.082** (33.192)	-1.349** (-31.700)	0.491** (18.566)	0.594** (9.775)	$-6.48.10^{-2}$ (-1.618)	63.3%
ES_i	Period 1 (1,400 obs.)	12.121** (20.133)	-1.260** (-22.683)	0.679** (15.521)	0.561** (6.471)	-0.124 (-1.913)	45.6%
	Period 2 (1,378 obs.)	13.130** (22.528)	-1.312** (-22.440)	0.554** (15.257)	0.511** (6.124)	$-6.48.10^{-3}$ (-0.118)	48.1%
CS_i	Period 1 (1,400 obs.)	15.751** (24.169)	-1.821** (-30.281)	1.513** (31.934)	1.027** (10.948)	$-8.19.10^{-2}$ (-1.165)	67.7%
	Period 2 (1,378 obs.)	16.023** (24.785)	-1.882** (-29.035)	1.381** (34.278)	1.134** (12.252)	$-7.14.10^{-2}$ (-1.169)	71.3%

7. Conclusion

Using private order data from the POSIT crossing network and high frequency data from the London Stock Exchange for SEAQ UK and Irish stocks, I investigated the impact of the CN activity on the liquidity of the SEAQ dealer market. Over the observation periods, the crossing network market share reached between 1 and 2% of the total volume traded for the stocks in my samples. Differences from one stock to another reveal that the CN did not attract any orders on very illiquid stocks while it over-performed on stocks that were infrequently traded compared to their level of risk and liquidity.

The empirical tests conducted in the paper fail in detecting a dominant negative fragmentation effect when a CN is competing with a DM, conversely to the theoretical predictions from multi-market models based on information asymmetry. According to my findings, CN-submitted order flow does not worsen adverse selection on the central market and unexecuted CN order flow does not make the after-crosses market riskier. The CN skims off liquidity-motivated orders from the DM, however the risk sharing benefits and the competition effects from crossing overbalance the cream-skimming costs.

The CN activity tends to reduce the oligopolistic power of market makers on the central market. CN trading seems to strengthen the competition between quote-setting operators, as executions through the CN accelerate quote revisions, and reduces temporary market impact. The main explanation for that appears to be the risk-sharing benefit entailed by dealer trading in the CN. Market makers use the CN as a liquidity-providing system, reducing inventory costs and allowing them to improve quote competitiveness.

Appendix: Order constraints available in POSIT

To control unpredictable match outcomes, a range of constraints can be applied to either individual stocks, pairs of stocks or to single or dual direction lists.

Price constraints

Price limits may be attached to an order to protect against adverse price movements in the market between the time the order is sent and the match time. The constraint simply indicates whether your order is available for the match pool, but does not generate any external information. The only price at which a match can occur in POSIT is at the mid-point of the current bid / offer spread. For example, if a price limit on a buy order is 450 and the ruling mid price is 452, then the order does not participate in the match. If the mid price was 448, then the order would be included in the match and executed at 448, but not at 450. This constraint is at individual stock levels and may only be applied in the currency of the primary price quote.

Minimum shares

The ability to set a minimum number of shares to trade out of a total order size per stock or for all stocks in a portfolio or list is available in POSIT. Clients may wish to receive no fills of less than 25,000 across a list for example. For a particularly large order, of say 1 million shares, a minimum fill of 250,000 in that line alone may be required.

Minimum value

Like the minimum share constraint above, it may be appropriate, particularly for a list of stock with varying prices, to set a minimum value, of say £50,000 per stock. This constraint can be set in any currency that is held on the system, such as British Pounds, US Dollars, Euros, etc.

Cash imbalance

For a portfolio, list or pair of orders, a cash imbalance constraint is available relating to the maximum amount that buy orders can exceed sell orders or vice versa, both in absolute value terms and by shares, if appropriate. This constraint is particularly useful for (a) generally in managing the results of unpredictable match outcomes, (b) ensuring that available cash for investment as a result of, say, a restructuring is not compromised but overbuying or (c) ensuring that any necessary cash is raised, where required. For example, the constraint may be that buy orders on a list cannot come into operation until £5m of sales has been achieved.

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