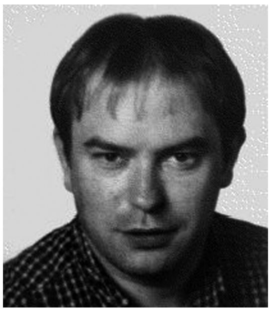
Crossing Networks: Theory and Evidence

The last two decades, alternative trading systems have been competing with traditional exchanges. Our paper focuses on one such system, a crossing network (CN). We present an overview of the theoretical and empirical literature on CNs. Also, we review our own contribution, which presents a dynamic model of the interaction between a dealer market and a CN. We discuss the set-up of the model, our main findings and empirical predictions.



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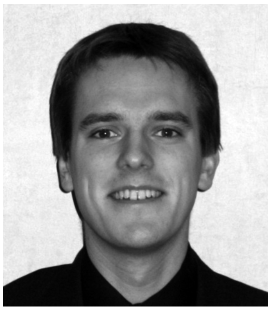

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I. Introduction

Over the past two decades, new technologies as well as deregulatory forces have been leading to the development of alternative trading systems (ATS). These ATS now compete for order flow with traditional markets (for recent reviews see *e.g.* Degryse and Van Achter (2002), Dubreuille and Gillet (2004) or Ludwig (2004)). Our paper focuses on one particular type of ATS, *i.e.* crossing networks (CNs). These are defined by the SEC (1998) as "systems that allow participants to enter unpriced orders to buy and sell securities, these orders are crossed at a specified time[1] at a price derived from another market". Examples of CNs are Instinet Crossing Network, POSIT, E-Crossnet, or Xetra XXL. Data from POSIT show that in 2004 each trading day on average 21.8 million shares were crossed. About 50% stems from stocks in the S&P 500, almost two third from stocks in the Russell 1000. Moreover, a recent survey ordered by E-Crossnet shows that volume sent to crossing networks is set to rise significantly as traders expect to increase their use of crossing networks by 90 percent, on average, over the next two years[2]. As can be gauged from the SEC-definition, CNs do not contribute to price discovery as they typically use the midprice[3] of an existing primary market as their transaction price. Each CN uses a proprietary algorithm for matching buy and sell orders. These specific rules are often opaque. All CNs aim at maximizing trading volume or the value of matched orders. For example, Xetra XXL, a crossing network for block trades at Deutsche Börse, implements a volume/time priority rule. We continue the paper by first highlighting theoretical work concerning the microstructure of CNs. Then, we turn to empirical work on CNs. The last section contains some concluding remarks.

II. Theory about CNs

Theoretical work modelling the CNs market microstructure is a recent area of research. We first review two static models of CNs: Hendershott and Mendelson (2000), the seminal paper in this field, and Dönges and Heinemann (2001). Next, we discuss our own contribution, which presents a dynamic model, see Degryse, Van Achter and Wuyts (2004). Due to the specific nature of CNs (*i.e.* no price discovery, no market impact), the analysis differs from earlier studies on the competi-

1. To avoid price manipulation, the midprice is selected at a random time within a 5- or 7-minute interval immediately following the scheduled cross time.
2. See www.itginc.com/products/posit/ and www.ecrossnet.com for more information.
3. In some cases, however, also the preceding closing price or the volume-weighted average price over some period may be taken.

tion between financial markets (*e.g.* Pagano (1989), Chowdry and Nanda (1991), Glosten (1994), Parlour and Seppi (2003)).

A. Static Models of CNs

Hendershott and Mendelson (2000) model intermarket competition between a CN and a Dealer Market (DM). Their aim is to investigate the tradeoff between the benefits of increasing competition between markets and the potential costs of order flow fragmentation due to the introduction of CNs[4]. They show that the effects of CNs on market performance and investor welfare are subtle and complex. In their model, a random number of informed and liquidity traders simultaneously decide to submit single-unit orders to one of both markets. This choice depends on trader specific characteristics, such as their valuation and impatience to trade, as well as on market parameters (submission and execution costs at the CN, dealer's half spread, CN's probability of execution). Each trader determines his best response given his expectation of all other traders' strategies. Four possible strategies arise: (i) not trading, (ii) exclusive CN trading, (iii) exclusive DM trading and (iv) opportunistic CN trading. The latter reflects the possibility to relay orders to the DM upon non-execution at the CN.

Hendershott and Mendelson show that different trading mechanisms may coexist. This happens when the population of traders is heterogeneous, for instance in the degree of impatience to trade. Each market caters to the needs of particular classes of investors, resulting in order flow fragmentation[5]. DMs are influenced in two opposite ways by competition from the CN. On the one hand, there is risk sharing as dealers' inventory and adverse selection costs are lowered by exclusive CN traders[6], resulting in lower spreads. On the other hand, opportunistic CN trading (this means using the DM as "market of last resort") may widen the spread. In this case, the CN is skimming off part of the uninformed traders. Consequently, this fraction of uninformed traders cannot be "used" anymore by dealers to compensate their losses to informed traders. Within the CN, also two opposite forces are at work. First, a positive liquidity externality exists, as an increase in CN trading volume benefits all CN traders and attracts additional liquidity[7]. Second, when the CN becomes sufficiently liquid, this liquidity externality may be dominated by a negative crowding externality: low-liquidity preference traders compete with the higher-liquidity preference traders on the same market side. Consequently, increasing CN order flow eventually may even reduce overall welfare. Combined with the competition effect, the resulting overall impact remains ambiguous. The emergence of this additional trading venue benefits some traders, while harming others.

Expanding on this paper, Dönges and Heinemann (2001) focus on some game theoretic refinements to reduce the multiplicity of equilibria in the coordination game. In particular, Dönges and Heinemann model intermarket competition as a coordination game among traders and investigate when a DM and a CN can coexist. If the disutility from unexecuted orders sufficiently differs across individuals, both markets coexist and order flow is fragmented. Market shares are determined by the distribution of disutility.

B. Dynamic Model of CN-DM Interaction

In Degryse, Van Achter and Wuyts (2004), we investigate the interaction of a CN and a continuous (one-tick) dealer market (DM). More specifically, we analyze the impact on the composition and dynamics of the order flow on both systems. We contribute to previous work on CNs by explicitly introducing dynamics into the analysis. These dynamics are important: a typical characteristic of a CN is that it "matches" orders at a specified time during the trading day, while the existing primary market simultaneously operates in a continuous fashion. We develop the analysis for three different informational settings: transparency, complete opaqueness, and partial opaqueness. The benchmark transparency case reflects that traders are fully informed about past order flow and hence observe the prevailing state of the CN's order book[8] before deter-

4. According to the literature, two conflicting effects arise. A potential benefit of increasing competition is that bid-ask spreads become narrower. Order flow fragmentation, however, will cause bid-ask spreads to widen and moreover, may increase volatility.
5. For instance, DMs will cater more to traders demanding immediacy (*i.e.* informed traders with short-lived information, high-liquidity value traders,…) while CNs will cater to those traders willing to sacrifice immediacy and certainty of execution in return for lower costs. Hence, when both compete, the CN is able to attract both new low-liquidity-preference traders and liquidity traders that would otherwise go directly to the DM.
6. Inventory costs are reduced because the expected dealer imbalance is decreased due to long-lived information trading in the CN. Adverse selection risk and hence costs in case of long-lived private information are now not only borne by dealers, but also partly by liquidity CN traders. Hence, the CN offers an additional venue for fundamental, value-based trading.
7. Eventually, this also leads to a so-called critical-mass effect, implying that the CN must attract a sufficient trading volume, otherwise it is unable to attract any order flow.
8. This CN order book contains all submitted orders. The assumptions on this book are contained in the discussion below. Note that a CN book differs from a limit order book. In the latter, limit orders disappear when hit by a market order. In the CN, all orders remain in the book until the time of the cross.

mining their strategy. However, in reality CNs are rather opaque. We incorporate this by analyzing two different degrees of opaqueness: partial and complete. While partial opaqueness implies that traders observe previous trades at the DM but not submissions to the CN, complete opaqueness entails that traders are uninformed on both past CN and DM orders.

The general setup of our model is as follows. Traders are assumed to arrive randomly and sequentially. Upon his arrival, a trader knows whether he is a buyer or a seller, observes the bid and ask price of the dealer, the state of the CN's order book (*cf. infra*), and his willingness to trade. Moreover, he knows the time remaining to the cross, the distribution of buyers and sellers and their willingness to trade. Trading at the DM implies a one-tick spread. Trading at the CN implies execution at the midprice, derived from the DM (so CNs do not actively contribute to price discovery). The cross takes place at the end of the trading day. When both trading systems coexist, traders can obtain guaranteed and immediate execution in the DM. They can also opt for cheaper (since they save the half spread), but later and (possibly) uncertain execution on the CN. Order flow to the CN is gathered in an order book where time priority is assumed. This is the case for example in Xetra XXL, where first volume and then time priority is imposed. The implication is that at the cross, the orders submitted last at the excess market side do not obtain execution. Execution is then only certain when, upon arrival, a trader is able to join the shorter queue. In all other cases, the execution probability is lower than one. Finally, a trader can also refrain from trading. We assume opportunistic CN trading to be very costly and therefore exclude it as an equilibrium strategy. Investors trade at most one unit.

We explicitly introduce dynamics into the analysis. In particular, a trader's decision hinges on the state of the CN's order book (when transparent) and his expectation on the behavior of future traders determines his submission strategy. Important to note is that these strategies depend on time; in other words, they are non-stationary. The number of periods left until the time of the cross is one important aspect. The crucial element in the choice between a CN order and a DM trade, though, is the execution probability at the CN, since this determines expected profits. When an arriving trader submits a CN order, she changes the imbalance in the CN. This affects the execution probabilities of future CN orders and hence also the strategies chosen by future traders. When determining his optimal strategy, he must take these effects of his order into account.

Our findings can be summarized as follows. First, in common to the three informational settings, we find that an increase in the DM's relative spread[9] augments the CN's order flow. Therefore, we expect that CNs will be more attractive in markets where spreads are substantial. At the same time price discovery should be sufficiently informative as the CN is "free riding" on price information from the DM. Second, a CN and a DM cater to different types of traders. Investors with a high willingness to trade are more likely to opt for immediacy and trade at a DM. The existence of a CN results in "order creation": investors with a low willingness to trade submit orders to a CN whereas they would never trade at a DM. Third, we also show that the execution probability at a CN is endogenous. The execution probability depends on the state of the CN's order book (if transparent), the observed order flow, and the expectations regarding future orders. Hence, although we start from dealers willing to provide liquidity at exogenously given bid and ask prices, we partly endogenize liquidity supply and demand by looking at traders submitting orders for potential execution at a CN. Fourth, the transparency and partial opaqueness settings produce systematic patterns in order flow. In particular, for the transparency case, we find that the probability of observing a CN order at the same side of the market is smaller after such an order than if it was not. Also, the probability of observing a sell at the DM decreases and the probability of a buyer trading on the DM increases when the previous order was a CN buy. Fifth, our results highlight that it is important to take into account the interaction between trading systems when measuring "normal" order flow. For example, when looking separately at an individual trading system, some trade flow sequences could wrongly be interpreted as being driven by information events. These sequences, however, could stem from the interaction of trading systems.

III. Empirical Evidence on CNs

As for theoretical models, the empirical literature analyzing CNs is also still in its infancy. The main reason is that these proprietary systems often do not reveal detailed information. In this section, we summarize the results of five empirical studies we are aware of.

9. The relative spread is defined as the bid-ask spread divided by the midquote.

Gresse (2002) studies the impact of the POSIT CN on the liquidity of the DM segment of the London Stock Exchange (SEAQ) for two 6-months periods during 2001 for a cross-section of UK and Irish mid-cap stocks. She finds that POSIT has a market share of total trading volume in these stocks of about one to two percent. Its probability of execution, though, is still low (2-4%). Furthermore, she reports that activity at POSIT does not have a detrimental effect on liquidity in the considered DM: there is no significant increase in adverse selection or inventory risk on the DM. Hence, empirically, no dominating negative fragmentation effect is detected. Instead, spreads decrease due to increased competition and to risk sharing.

Conrad, Johnson and Wahal (2003) use proprietary data for a total of $ 1.6 trillion in equity trades from 1996:1 to 1998:1 by 59 institutional investors in the US who are able to choose between three trading platforms: CNs, Electronic Communication Networks and traditional brokers. They distinguish orders that are entirely filled by one trading system (single-mechanism orders) and orders that use more than one trading system (multiple-mechanism orders). While controlling for variation in order and security characteristics as well as for endogeneity in the choice of trading venue, they find that crosses have substantially lower realized execution costs as compared to brokers (the average cost differential ranges from 14 to 30 basis points). Most of these economically significant differences could be attributed to the lower commissions on CNs, but also to the absence of a spread. However, the cost differential is expected to decrease in the future, due to additional competition. For the multiple-mechanism orders, Conrad *et al.* (2003) indeed find that most traders opt for brokers as last method of execution ("market of last resort" as in Hendershott and Mendelson (2000)).

Næs and Ødegaard (2004) examine the trades of the Norwegian Petroleum Fund for a 6-month period: 4,200 orders that are sent first to CNs and, in case of non-execution, subsequently to brokers (*i.e.* an opportunistic trading strategy). Their results show that although the Conrad *et al.* (2003) cost differential is confirmed, it is not clear that when accounting for the presence of private information (which may affect the probability of crossing) this cost differential persists[10]. Hence, lower trading costs in CNs may be fully offset by costs of non-trading due to adverse selection in the CNs.

Næs and Skjeltorp (2003) extend this analysis using the same data set. They investigate the nature of competition between a principal exchange and a CN with respect to the primary market's liquidity. Past empirical evidence shows that CNs primarily compete in the most liquid stocks. Næs ans Skjeltorp argue that if stocks that are not supplied in CNs are less liquid in general, then these stocks need a higher return to induce investors to hold them. Consequently, the abnormal performance of the non-crossed stocks found in Næs en Ødegaard (2004) may be explained by a liquidity premium[11]. They find significant differences in liquidity between stocks that are on CNs and stocks that have to be bought in the market,. This potentially indicates the presence of informed trading in the non-executed CN stocks (*cf.* Næs en Ødegaard). However, they also find that there are systemic differences in liquidity between the two groups of stocks on other dates than the trading dates of the actual crossing strategy, suggesting that there are systematic differences in the characteristics of the two groups of stocks that are unrelated to private information.

Finally, Fong, Madhavan and Swan (2004) focus on the price impact of block trades on different trading venues, *i.e.* a limit order book, a CN and an upstairs market for data from the Australian Stock Exchange. They find that competition from the two latter markets imposes no adverse effect on the liquidity of the limit order book. Hence, there is no evidence of a liquidity drain from the downstairs market. Moreover, they argue that the migration of trades to the upstairs market is not responsible for the high asymmetric information problems in downstairs markets. As compared to Gresse (2002), they argue that this benefit is caused by an improvement of counterparty search, rather than by the cream-skimming of informed traders or by the risk-sharing explanations.

IV. Concluding Remarks

Recently, a number of crossing networks (CNs) have become active in securities trading. Examples are Instinet Crossing Network, POSIT, E-Crossnet, or Xetra XXL. Investors face a number of tradeoffs when considering a CN relative to existing primary markets. On the one hand, CNs minimize price impact, allow for saving the half-spread, have lower submission and execution costs and offer completely anonymous trading. On the other

10. Note that standard methods of measuring trading costs do not account for this adverse selection component.
11. Note that the liquidity and the information story need not be mutually exclusive.

hand, they offer low execution probabilities and no immediacy. Non-execution of an order at the CN implies that the investor needs to relay his order to an existing primary financial market. This opportunistic CN trading introduces some risks as the market may move against the investor, or spreads on financial markets may have widened. Furthermore, CN trades are executed at prices that are derived from an existing primary market. This "parasite pricing" requires a sufficiently informative and well-functioning existing primary market.

CNs also have an impact on other financial markets. Two opposite forces appear. First, CNs introduce additional risk sharing benefits as liquidity providers' inventory and adverse selection costs are lowered by exclusive CN traders. This force leads to lower spreads. Second, spreads may widen due to opportunistic CN trading, where the existing primary market is being used as "market of last resort". In this case, the CN is skimming off part of the uninformed traders.

The existing empirical evidence reveals that, although CNs offer lower trading costs, trading volumes and execution probabilities are rather low. This raises several open issues. Is this evidence valid for all stocks and all CNs? Should traditional markets integrate a crossing facility into their trading venues? Should CNs become more transparent in order to increase execution probabilities and attract more order flow? These are issues for further research.

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