ELECTRONIC TRADING SYSTEMS: STRATEGIC IMPLICATIONS OF MARKET DESIGN CHOICES

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Abstract

Modern financial markets compete aggressively for trading activity and investor interest. Information technology, once a crucial element in streamlining paper flows and operations, is now a strategic resource used in attracting or retaining market liquidity. Established exchanges introduce technology to enhance their markets. New market venues challenge the status quo and rely on technology to offer diverse services to increasingly sophisticated investors. In this paper, we examine the strategic design decisions embedded in these new electronic trading systems. Design decisions are critical, as they determine the market microstructure which influences investing strategies, patterns of trade, liquidity and volatility. We propose a taxonomy of design alternatives based on six major dimensions: market structure, type of orders, order execution priority rules, price discovery rules, time stamping, and transparency. Using examples of existing systems, we discuss the potential impact of the various alternatives on the eventual attractiveness of the market to the investors.

1 - Introduction

Modern financial markets have become heavily dependent on technology. The New York Stock Exchange (NYSE) has invested $1 billion in information technology since 1978 to increase capacity and support trading[1]. From information dissemination to clearing and settlement, every major market function can potentially be supported by electronic devices. Market structure choices become embedded in an electronic system and design decisions are now strategic choices that will shape a market environment in an increasingly competitive industry. Successful markets must accommodate investors' needs, and all design options, from the type of market structure to the level of trade

[1] Edward A. Kwalwasser, Executive Vice President, Regulatory group, NYSE. Testimony before the Subcommittee on Telecommunications and Finance, May 26, 1993.

information dissemination, have to be carefully examined and their implications analyzed. Indeed, the choice of trading strategies by investors, the sequencing of trades, disruptions in the pattern of trade, and the rate of change in prices are determined by the form of market organization. In this paper, we analyze the strategic design alternatives available in modern financial markets and propose a taxonomy of market systems. We find that the general principles of strategic information systems do not provide unambiguous guidance in structuring market information systems.

The growth of automation in financial markets worldwide has been explosive over the last few years. Exchanges, independent of their size, are adopting technology to automate trading (Grody and Levecq 1995). Competitive pressures force existing markets to introduce technology to retain the order flow captured by more sophisticated exchanges offering lower trading costs and better efficiency. For example, the Paris Stock Exchange introduced the CAC system in 1988 in response to the threat posed by London's new SEAQ International screen based quotation system (1985) which offered a level of liquidity and immediacy of trade execution[2] not available in France. Along with its electronic system, Paris Stock Exchange also shifted from a periodic call to a continuous auction market structure, more adapted to investor's need for immediate liquidity. More recently, the Amsterdam Stock Exchange implemented a set of reforms including a new screen-based wholesale market. This electronic market was created "*to confirm [the Amsterdam SE's] role as the price leader in Dutch equities*[3]", a role which was jeopardized by SEAQ International. Smaller exchanges and new exchanges are counting on technology to support their operations. With hopes of a rapidly developing economy, the newly opened Brastislava Stock Exchange in Slovakia operates an electronic trading system designed to allow on-line trading regardless of the brokers' location.

The implication of the various design decisions on market quality proxies like liquidity, depth or fragmentation are not well understood (Domowitz 1993). With the growing diversity and sophistication of market systems, market participants are seeking to understand the role of technology

[2] Immediacy of trade execution refer to the ability for investors to buy or sell without searching or waiting for counterparties to be assembled.
[3] Quote by Baron Boudewijn van Ittersum, Chairman of the Amsterdam Stock Exchange, **Financial Times**, September 30, 1994

in different financial market structures. Market providers such as Exchanges and vendors like Reuters are looking for ways to offer an improved trading environment to market participants.

In this paper, we examine the principal design dimensions of an electronic trading system. We propose a taxonomy to evaluate design decisions and their potential impact on the market. Section two is a sketch of the evolution of technology in financial markets. In section three, we discuss the applicability of general strategic information systems principles to financial markets. In section four, we present the important issues that must be addressed in the design of an electronic trading system; using examples of existing systems, we discuss differences between various options and their potential consequences on fairness, liquidity and volatility. We conclude with some research directions to further our knowledge in the area of electronic markets.

2 - Evolution of Technology in Financial Markets

The application of technology to financial markets began in the early nineteenth century with pigeons flying stock prices between exchanges. Pigeons turned obsolete when the telegraph (1836) and the Morse code ticker (1867) became the electronic mainstay of market price dissemination. In the beginning of the twentieth century, technology appeared in more familiar forms with the development of telephonic communications and the introduction of automation to support information display.

At first, technology was introduced to integrate markets. Market places trading similar financial instruments are scattered around the world. Before the development of information links, prices on similar securities varied widely across exchanges. Fragmentation led to inefficient markets in which price discovery was imperfect and prices reflected only locally available information. The situation resulted in lower liquidity and higher volatility. Thus, technology was needed to support market mechanisms, and in particular, to allow rapid dissemination of information both within and across financial places. The first electronic system for real time price information dissemination was the moving electronic display board introduced in 1925 by the Translux Corporation. This system was a remarkable improvement over the existing slow electro-mechanical technology. However, the information remained locally available, and was not automatically dispatched outside the exchange. In 1959, the Scantlin Electronics Corporation, a predecessor firm to Quotron Systems, introduced the electronic quote terminal, which made information readily available to remotely located market participants. The development of technology and telecommunications, as well as regulatory pressures, led to more intermarket linkages. For example, in the US, price and quote information for the NYSE and the regional stock exchanges is available on a single system known as the Consolidated Quote System and the Consolidated Tape Service. Interconnections between markets are not limited to price dissemination, and also include order routing systems, such as the Intermarket Trading System introduced in the US in 1978 as part of the National Market System. Order routing systems provide market participants with the possibility to send their orders electronically to the exchange for execution. All these market linkages have led to more integrated market places (Hamilton 1989), for the benefit of investors who receive better transaction prices, and can therefore trade at lower costs.

Once related financial markets were linked via systems, increasing trading volumes led to another technology push in financial markets. Without automation, markets were clogged with volumes of paper, and in 1968-69, U.S. Exchanges were forced to close one day a week to process the backlog of trades from the previous days. Technology was needed to introduce automation into the very manual clearing and settlement system, and to offer robust storage medium for stock ownership information. Technology also became essential to support a growing financial community, and allow for larger trading volumes without compromising markets' operational integrity and efficiency. In today's highly integrated and competitive markets, technology has become a strategic tool to attract and retain order flow.

Technology is facilitating innovation and trading efficiency in the securities industry, and has now become such a critical part of financial markets that it is starting to shape these markets. This was illustrated by the London Stock Exchange's Big Bang in 1986: the introduction of the screen-based dealing system SEAQ led to the unexpectedly rapid abandonment of floor trading (Clemons and Weber 1990). The improved access to information allowed by the new computer system along with new rules and regulations provided a superior trading environment in upstairs dealing rooms. Floor trading became an aside to screen-based trading, and eventually disappeared.

While information technology improves the efficiency of market operations, it creates other, often unanticipated problems. In the eyes of some market participants, it has brought undesirable changes and limitations to markets. One major change is the creation of opportunities for new electronic markets and matching systems, which disturb the industry's status quo and challenges existing vested interests. For example, the dealers of the London Stock Exchange see the introduction of a disintermediated electronic order matching system which will allow investors to trade without SEAQ market makers as a serious threat to their ability to remain profitable (Clemons and Weber 1995). The dealers will certainly be hurt by this off-exchange system, but is it a mere reallocation of excess profits, or will it reduce their profits to the point where they are not properly rewarded for their risk, and hence, may no longer assume their role of market makers? Neither situation is satisfying for the dealers. However, in the latter case, the market may become less efficient, which is likely to result in more volatility and higher costs to the investors. The dealers are fast to use this worst case scenario to denounce certain trading technology innovations as undesirable.

Among the limitations introduced by technology is the loss of behavioral and social cues that are considered a valuable source of information to the traders on the floor (Baker 1984). As electronic trading systems develop, face to face communication that has prevailed on markets for many years is replaced by electronic communication. Electronic communication provides traders with a wealth of information on what is happening on other markets, other securities, and related products. Computers can process this information to further assist traders. However, electronic communication is not able to convey behavioral and social information. Postures and the pace of activity, which can hint at a market participant's or a trader's position, or rumors, a mix of information and noise which traders can use to their advantage if they can recognize real information, are not available on electronic trading systems. Floor traders argue that this type of information is essential to market efficiency, as it allows them to develop a feel for the market, and make trading decisions based on their own assessment of the current market situation. However, technology provides traders with a different set of information, thereby changing the trading function. While floor trading requires social and feigning[4] types of skills, screen-

[4] Feigning refers to "gaming" tactics used by traders to avoid giving away plans to other market participants.

based trading emphasizes analytical skills. Whether electronic trading systems' inability to provide the social information available on the floor is outweighed by the benefits they provide is widely debated.

It is possible that technology eventually makes some market structures obsolete. By allowing higher trading volumes and more complex financial instruments, technology could ultimately dictate partial or total elimination of human traders, to replace them with electronic systems (Hakansson et al. 1985). While this view appears consistent with the current rapid development of technology and the proliferation of new electronic trading systems, it is important to realize that most of today's trading relies on crucial manual intervention at the time of pricing and executing the order. It is not clear whether technology can replace some manual and behavioral features of the trading function that appear to be essential to markets.

Given the uncertain impact of fully automated trading, many established exchanges have used information technology to upgrade and enhance their existing trading mechanisms, strengthening or preserving the status quo. Existing markets face increasing competition, and they are introducing more technology to retain order flow. For example, in June 1991, the NYSE introduced two after-hours trading sessions supported by technology in order to retain customers attracted by crossing networks. New markets, on the other hand, apply information technology in ways that more radically change the market's structure. New markets, especially those meant to compete with existing markets by providing different types of services to the investors, are commonly based on technology and highly automated; they are generically called electronic markets. Hence, this paper focuses on electronic trading systems; we discuss the alternative design decisions and how they ultimately affect the desirability of the market to the investors.

3 - Financial Markets and their Uses of Strategic Information Systems

The rapid development and widespread availability of technology have led to dramatic changes in the way organizations are doing business. Managers are required to be aware of and understand the effects of technology on their industry to adapt and possibly use technology to gain competitive advantage. Research and literature on strategic information systems offers a variety of frameworks and case studies designed to help managers assess the evolution of their environment, and better take advantage of the changes induced by technology (Porter and Millar 1985, Clemons and Row 1990, Copeland and McKenney 1988).

Financial markets are highly dependent on technology, and some major changes in financial markets have been the result of the introduction of information technology. Financial markets are also very competitive, and managers in market provider organizations as well as regulators need to anticipate the impact of technology on their industry and recognize the opportunities it creates in order to make the appropriate strategic decisions.

3.1 - Characteristics of Financial Markets

Financial markets differ fundamentally from more traditional forms of industries, which limits the potential guidance provided by the precepts of strategic IS. In particular, regulation, the existence of important network externalities, and the effects of competition on market quality create unique characteristics that tend confine strategic opportunities to the level of market design.

Regulation - Regulatory organizations such as the Securities Exchange Commission (SEC) for securities markets and the Commodity Futures Trading Commission (CFTC) for derivatives markets have been created to guarantee efficiency and fairness of financial markets, which are essential to a capitalistic economy. Regulators, motivated by issues of performance more than competition, closely monitor changes in the industry and evaluate the potential improvement that technology can provide. In order to ensure market efficiency, they introduce requirements that indirectly force existing market providers to take advantage of technological advances to comply with new rules. Hence, regulatory organizations can be major drivers of change, as illustrated by the new requirement imposed by the SEC on securities markets to settle trades within the three days following execution by June 1995[5]. As a result, all markets have to provide the high level of operational efficiency mandated by regulators. This situation, combined with the fact that overhead expenses are only a small part of the overall cost

[5] The current requirement is 5 days after the trade.

of a trade, makes it almost impossible for a market to distinguish itself on the basis on operational efficiency.

Network externalities - There is a strong incentive for market participants to be present in the in the most active markets: on condition that the operational structure of the market can handle large volumes, the concentration of orders improves price discovery, maximizes liquidity, and limits volatility induced by persistent order imbalances. Consequently, competition between two markets offering similar trading services is likely to turn to the advantage of the market which was able to create initial liquidity. For example, the trading of a successful futures contract has never been taken away from the exchange which initially introduced it[6]. Exchanges which try to offer futures contracts with similar characteristics to those already traded elsewhere are unlikely to succeed and generate liquidity, as order flow remains concentrated in the original market place. Hence, appropriate strategies should not be based on imitation and lower cost leadership. The cost of illiquidity will outweigh cost savings from efficient operations. Differentiation and innovation are required in presence of liquidity externalities. Investors constitute an heterogeneous population with various trading needs which may not been adequately serviced by the established market place. Technology creates opportunities to design markets to satisfy the special needs of the market participants. These alternative markets must be attractive enough to the targeted class of investors to offset the cost induced by the loss of positive externalities, and generate sufficient order flow. Therefore, market providers ought not be overly concerned if their market is mimicked by others, but should instead focus on assessing how technology is changing the nature of financial markets, thereby creating opportunities for potential competitors. For instance, the NYSE overlooked investors interest in options and futures contracts on its listed stocks and Chicago markets[7] developed and attracted trading activity for these derivative instruments.

Competitive effects on market quality - The product offered by exchanges and other market providers is a *market*. A market is a physical or virtual location where price is determined and buy and sell orders are matched to create trades according to a set of rules which governs the processing of

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[6] The only exception is the Chicago Mercantile Exchange (CME) taking away stock option futures from Kansas City (Private interview with Adam Graves 1994).

[7] The Chicago Mercantile Exchange (CME) introduce the S&P 500 futures contract in 1982. The Chicago Board of Options Exchange (CBOE) introduced trading on individual stock options in 1973.

these orders. The value of a market to an investor is a function of the availability of matching orders at desired prices. In other words, the whole value of a market is a function of network externalities: there is no value to a market in which nobody participates. Therefore, competition can not only reduce order flow, it also undermines the value of the market services. Consequently, managers of market provider organizations need to evaluate the impact of their strategic decisions on the relative desirability of their market to the investors, as well as the opportunities their market design decisions create for competitors to offer alternative products. This does not imply that competition reduces the overall welfare of market participants, which, as an aggregate, should benefit from competitive diversity. But from the stand point of market providers, competition may both reduce their customer base and alter the value of their product.

3.2 - Strategic roles for IT In financial markets

Technology is omnipresent in the financial industry. The various market functions that can be performed by technology include quote display, order entry, order routing, trade execution, trade reporting, information dissemination, clearing and settlement, and surveillance. We will leave clearing and settlement and surveillance out of the following discussion to concentrate on electronic trading systems, which generally include some combination of automation of the first six functions. Indeed, we observe today a proliferation of electronic markets. These systems vary widely in the type of functionalities they offer to serve the financial community. For example, the proprietary systems developed by brokers often lack price discovery mechanisms, and borrow prices[8] from external sources, usually the New York Stock Exchange. Some systems introduced by exchanges match buy and sell order continuously during the trading day, while others match them only once a day at a given time. All these characteristics of electronic systems reflect the specific segment of trading needs these systems are trying to satisfy. The development and the introduction of an electronic trading system requires the developer to carefully identify, evaluate, and understand the possible impact of the various design alternatives, as they determine the market microstructure which in turns, influences investing strategies, patterns of trade, liquidity and volatility. The variety in market designs also creates competitive diversity which should be beneficial to traders and investors.

[8] The electronic trading systems which do not offer price discovery mechanisms have to rely on an other exchange to provide the price at which they match buy and sell orders.

In the remainder of this paper, we introduce a taxonomy to evaluate the major design decisions that specify an electronic trading system based on six major dimensions: market structure, type of orders, order execution priority rules, price discover rules, time stamping, and transparency. For each dimension, we discuss the impact of the various alternative on fairness, liquidity, and volatility.

4 - Design Considerations in Electronic Trading Systems

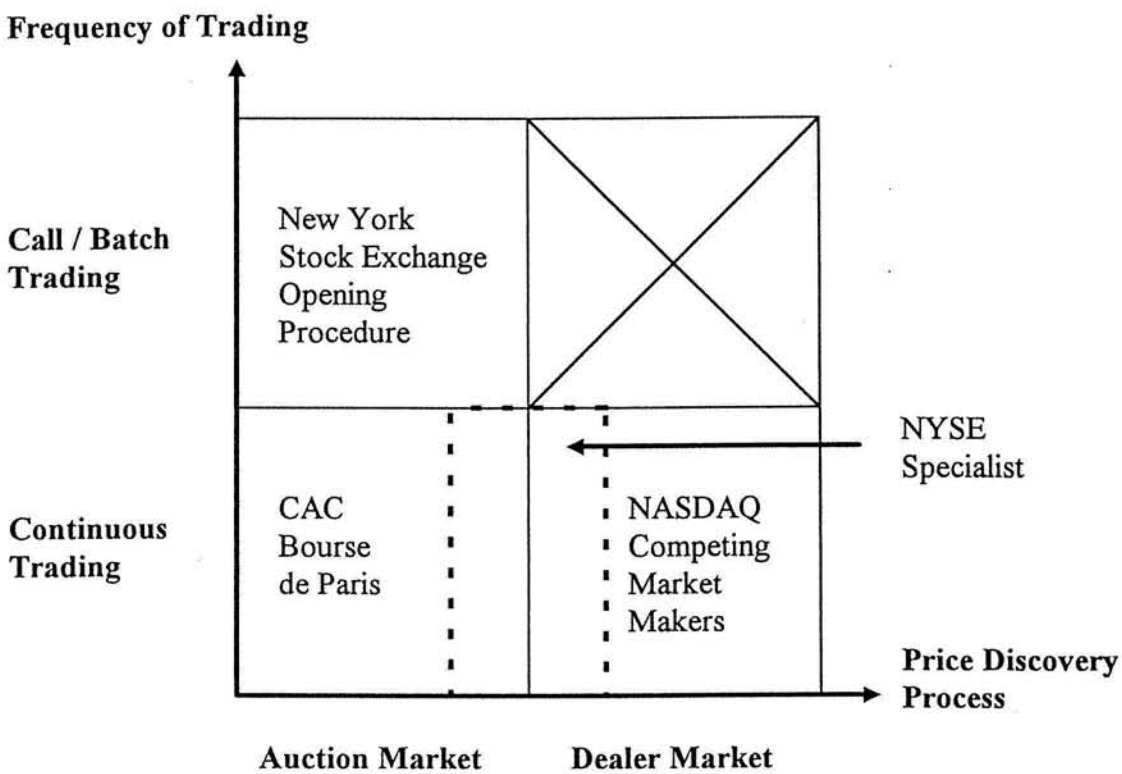
While the important options available in the system's architecture are technological in nature, We find that the design of the electronic trading system software reflects traditional market preferences, business decisions, and business pressures (Grody et al. 1994). Longer term issues of efficiency, fairness, changing customer needs, and regulatory constraints have to be addressed. If technology is introduced to *support an existing market*, the level of automation supported by the system is generally chosen to ensure its coexistence with the traditional market structure. If the system accompanies the *creation of a new market*, a wider range of options is available, but careful attention must be given to the system start-up and the initial development of liquidity. In both cases, however, many facets of the market structure will be embedded in the system's design.

4.1 - Market Structures

Financial markets around the world exhibit a variety of different market structures. Despite this diversity, market structures can be classified along two fundamental dimensions: the frequency of trading, and the type of price discovery process. Frequency of trading refers to the distinction between a continuous and a call market. In a continuous market, the securities or contracts traded are continuously priced. This means that a trade can occur at any time, providing that the incoming order matches the current price. Prices in a continuous market are characterized by the existence of a spread, the difference between the quoted bid and ask prices. In a call market, orders are batched over a predetermined period of time. They are then matched at a single price at a given time of the day. The most commonly used matching algorithms determine the trading price as the price that minimizes imbalances between buy and sell orders, or as the price that maximizes the number of trades.

The second dimension is the price discovery process. It can be accomplished in an auction market or a dealer market. In the auction market, buy and sell orders are matched continuously at a price that satisfies both parties. Such markets are also called order-driven. Toronto's CATS system, the proposed Swiss Stock Exchange's automated system and Instinet are examples of order-driven markets. In a dealer market, a market maker exposes quotes, a bid price and an ask price[9]. The quote are prices at which trades execute. Such markets are also called quote-driven. NASDAQ and London Stock Exchange's SEAQ are quote-driven markets. Figure 1 summarizes the principal market structures.

Figure 1 - Principal Market Structures



[9] The market maker's <u>bid</u> price is the price at which an investor can <u>sell</u> a financial instrument. The market maker's <u>ask</u> price is the price at which an investor can <u>buy</u> a financial instrument.

There are benefits and disadvantages associated with each market structure. In a call market, for example, investors enjoy lower trading costs because they do not bear the bid-ask spread cost. However, they may suffer from the lack of immediate liquidity provided by dealers. The emergence of new investment management strategies has created a demand for a more diverse, more refined set of trading services. This is illustrated by the development of indexation, an investment management technique which requires the fund manager to match a given index, such as the S&P 500. Indexation is a strategy which demands low trading costs in order to follow the index more closely, but does not benefit from immediate execution of orders. Hence, fund managers whose objective is to perform like the index are likely to favor a call market over a dealer market. The market structure is a strategic decision which depends on the type of customers the system is targeting. Moreover, these market structures need not be mutually exclusive, and can coexist as hybrids to serve a wider range of investor needs: an electronic call market, for example, can complement a continuous auction floor market.

The largest financial markets in the world operate on a continuous trading basis (Stoll 1992). Continuous pricing of securities and the immediacy it provides appears to be an important feature to investors who need to be able to take a position on the market quickly. However, some observers argue for the economic superiority of the call market structure (Cohen and Schwartz 1989, Schwartz 1991). The core proposition of call market proponents is that it allows for better price discovery, and is more likely to price an instrument at or near its equilibrium price. Improved market efficiency and absence of spread costs would result in lower costs to the investor. The drawback of this structure is the periodic executions which may lock investors into unwanted positions. For example, an investor who owns some stock of a company which has just published disappointing results may want to sell the shares quickly and invest the proceeds in another industry. However, this is impossible in a periodic market, and the investor will have to wait until the next price is called for that given stock. The upside, and one benefit of a call market, is that by the time that stock is called, all the market participants will have had time to evaluate the real impact of the news on the value of the stock, and the price variation may not be too severe. Indeed, it is not unusual in a continuous market to observe a stock price drop sharply after a bad news announcement, and then rise again during the same trading day, after investors have digested the news. In this case, the call market could acts as a buffer against overshooting and smooth out price variations.

Another limitation of periodic markets is that they cannot support contingent trading. A contingent order is an order which execution depends on an external parameter or event (we discuss contingent orders in more details in the next section). For example, *"sell Exxon and then use proceeds to buy Anheuser-Busch"*. This is *one* instruction: the execution of the buy and sell orders must be nearly simultaneous. This not possible in a call market, because trading is sequential and ordered. Although the trader may want to remain fully invested, he or she would not know how many Anheuser-Busch shares to buy until the sell order was executed.

In line with the recommendation of some researchers (Amihud and Mendelson 1988, Cohen and Schwartz 1989), an electronic trading system could offer the best of both worlds. A continuous market which satisfies investors' need for immediacy could co-exist with a single price auction that would offer the benefits of the call market, including lower trading costs and a single price execution for all orders. Technology allows for such systems, and its possible that new hybrid market structures will arise from the extensive use of computers.

To inform decision makers on how to automate trading, a number of studies have been undertaken to evaluate the various manual or electronic market micro-structures, and their coexistence in highly interconnected market places. Research in this area concentrates on individual markets to evaluate their respective merits with respect to a number of market quality proxies. The existence of intermarket linkages brings additional complexity to this research, as a market cannot be studied in isolation, but the respective impact of interconnected markets has to be accounted for (Garbade and Silber 1979, Hamilton 1989). In a recent study of futures markets, Pirrong (1994) compared the German electronic trading system Deutsche Terminbörse (DTB) to the manual pit trading of the London International Financial Futures Exchange (LIFFE). He found that the electronic system, DTB, offered at least similar liquidity, and more depth than the London market. However, his study does not take into account the existing interconnections between these two markets, and how their coexistence affect their respective attractiveness and efficiency. Such an analysis would have shown that trading on

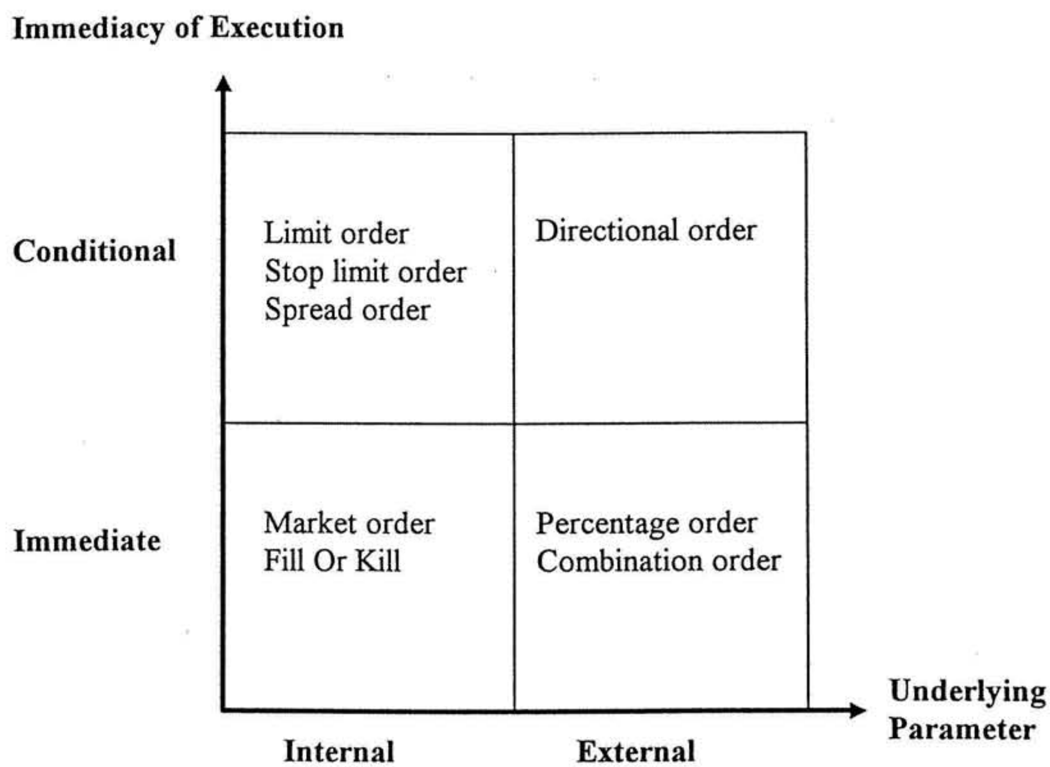
DTB does not exhibit a clear trend until trading begins in London and that the real price discovery seems to happen on LIFFE. While DTB satisfies some trading needs, it seems to be dependent on the London market for price discovery. That is, it appears to be a satellite market. The understanding of how markets coexist, compete and complement one another is essential to design the market structure that will be implemented in any new system.

5.2 - Type of Orders Allowed

There is a wide range of order instructions used in financial markets. As with market structures, orders can be classified along two dimensions: the underlying parameters upon which the order depends, and degree of immediacy of the execution. The execution of the order is either immediate or conditional. In the case of immediate execution, the order will be filled at the current price when the order is exposed to the market. If it is a conditional execution, the order will be filled only if a specific condition is met. That condition can either depend on the price of the security of interest, on the value of an external parameter, or on the occurrence of a given event. The underlying parameter is the other dimension. It divides the orders into two broad categories: simple orders and contingent orders. Simple orders only depend on the security or contract of interest: the underlying parameter is internal to the order. Simple orders include market orders, limit orders, day orders, good till cancel (GTC) orders, stop limit orders, market on opening orders, market on closing orders. Contingent orders rely on the value of an external parameter to be executed. An example is an order where execution is contingent upon the value of an underlying instrument, such as an option priced versus an underlying stock, or a parameter, such as volatility. Contingent orders include: percentage orders, which are orders to buy or sell a percentage of the volume of the book, or of the volume of the last transaction; directional orders, which are dependent on market direction, as in the example that an uptick must occur before a short sell order will be accepted; combination or spread orders, which imply simultaneous executions like buying a futures contract in one month and selling the same contract in another month, or buying one security and selling another at a stated price difference. Figure 2 illustrates this framework, and classifies some of these orders in terms of the two dimensions, immediacy of execution and underlying parameter.

Contingent orders are more complex to handle than simple orders. It is often difficult to execute these orders electronically because they rely on information which may be external to the system. Some systems, including the NYSE's Specialist Order Book system and the Belgian Futures and Options Exchange system allow contingent orders. However, they have been left out of the systems design, and are handled manually by specially designated brokers. NYMEX Access, LIFFE APT and DTB allow spread orders, the simultaneous buy and sell of a contract at different expirations based on the price difference on the two contracts. Other exchanges support electronic contingent orders viewing this capability as a new product. An example is GLOBEX's trading of volatility contracts. Finally, contingent orders may be forced into the system by existing rules or regulation. For example, NASDAQ International, a screen based quotation system that operates a European trading session for American stocks, is subject to the uptick rule that requires that the previous price of a stock be unchanged or an uptick for a short sale to be allowed[10].

Figure 2 - Types of Orders



[10] The uptick rule is in effect for the stocks that are traded on both NASDAQ and either the New York Stock Exchange (NYSE) or the American Stock Exchange (AMEX).

The choice of orders that are allowed into the system impacts attractiveness and efficiency of the market. This can be illustrated by the call market, in which orders are batched over a period of time, and then matched at a set price. To find the matching price, supply and demand curves are generated from sell and buy orders. It is therefore important that each order be accompanied by a reservation price. Market orders, which are not priced and do not contribute to the price discovery process, may alter price discovery if they are numerous relative to the number of priced orders. Hence, restricting the system to priced orders can be a way to guarantee better prices in a call market. However, restrictions designed to improve the quality of the market may also discourage market participants from participating in the market. For example, NASDAQ International's short sale rule discussed earlier was introduced to restrain traders and dealers from accelerating the price decline of a stock. However, foreign market makers are reluctant to participate in a market for securities already traded in foreign markets not subject to the same restriction[11]. As a result, NASDAQ International has failed to attract foreign dealers to the market for US securities listed on the NYSE or the AMEX (Michaels 1992).

Systems designers may be constrained by the complexity of contingent orders, as well as by the development of elaborate trading strategies designed to control investor's risk exposure which remain a challenge to electronic systems. Moreover, the current trend is to the creation of more, often complex, financial instruments. While existing systems handle them poorly, rapid technological progress will certainly allow trading systems to handle a wider range of contingent orders and trading strategies. Will this result in even more complexity, or instead, will it reduce variety and foster integration? Tentative answer to this question requires a good understanding of how technology can be used both at the strategic level to offer unique and better trading services to market participants, and at an operational level to improve market efficiency, and cope with increasing demand posed upon market providers.

5.3 - Priority Rules - Order Execution Algorithm

The priority rules determine the sequence in which orders are processed once they have been entered into the system. Priority rules are based on the identity of the parties, the type of order, the

[11] The uptick rule does not exist in the U.K. for example.

quantity, the price, the submission time, and the transparency of the order. Table 1 presents a listing of priority levels found in electronic trading systems (Domowitz 1992).

Table 1 - Priority Levels in Electronic Trading Systems

Price	priority is given to better prices
Price with improvement	the order is briefly exposed to the market maker to allow for possible quote improvement
Time	first come, first served
Order Type	priority is a function of the order type: market orders, limit orders, cross orders
Order Allocation	the order is routed to a dealer or market maker, independent of price
Quantity/Size precedence	priority given to larger or smaller orders
Quantity Allocation	similarly priced orders are equally allocated or pro rated according to the order size
Quantity Identified	priority given to orders revealing the order size
Trader Identified	priority given to orders that reveal the identity of the trader
Trader Class	priority is given to the public investors over specialists, market makers, or agency brokers
Direct Execution	direct action of accepting the bid or taking the offer

Contrasting GLOBEX with the Automated Pit Trading (APT) system of the London International Financial Futures Exchange provides a good illustration of the implementation of various priority rules. GLOBEX uses a simple price/time matching algorithm: for similarly priced orders, older orders will be executed first. APT does not use the time rule: the algorithm allocates executions among all identically priced orders, without any consideration for the time of arrival.

In most systems, however, price is the highest priority, followed by time (Domowitz 1992, Grody et al. 1994): if two orders are identically priced, the one submitted first will be executed first. It is also important to recognize that the order execution algorithm may not be unique for a given electronic trading system: different market structures may have been implemented, each with a specific order execution algorithm. For example, the NYSE uses a call market procedure at the opening, while the regular trading session is a continuous auction market.

The choice of priority rules implemented in the system can affect both efficiency and liquidity. For example, order priority rules that favor those who submit early limit orders increase the incentive of agents to reveal their private information -e.g. the price, and perhaps the quantity they are willing to do business at-. The rationale for providing traders higher priority for limit orders submitted earlier is that the early revelation of private information provides better efficiency. Early submission of limit orders will also enhance liquidity. This is especially true in auction markets.

The selection of priority rules must also be considered in light of other market attributes. For example, if the price variation allowed in the market is very small -e.g. 1 tenth of a cent-, the value of time priority for limit orders would be limited. An investor could always get precedence over old limit orders by simply pricing the newly submitted order one tenth of a cent higher for a buy order or one tenth of a cent lower for a sell order.

5.4 - Price Discovery Rules

The price discovery process determines the efficiency of the market. It is directly linked to the order matching algorithm. For example, the Instinet Crossing Network executes trades against the closing price from the NYSE, or the mid-spread of the closing bid-ask quotes from NASDAQ. The absence of price discovery here is a direct consequence of the execution algorithm implemented in the system. The level of price discovery facilitated in the system is important, because financial markets are relied on to determine the true price of the security or contract. We find that many of today's electronic systems depend on the ability of other markets to discover prices.

Table 2 presents an ordered classification of price discovery rules, from the lowest to the highest level (Domowitz 1992). At the lowest level, there is no price discovery. The system simply matches orders at a price which was discovered on another market. At the next level of price discovery, it is possible to improve upon the imported price by trying to execute the transaction at a price better than the current the bid-ask spread, or by adding some negotiation capabilities between traders in the system. Systems with such restricted price discovery mechanisms remain rather simple, but cannot exist independent from the market which provides the price. While liquidity remains a concern, volatility is generally assumed to be exogenous to these systems.

Table 2 - A Classification of Price Discovery Rules

Price from another market	in this situation, there is no price discovery
Price from another market with improvement	potential price improvement depends on the bid ask spread and on market conditions. It can be determined electronically by a trading algorithm
Price negotiation	some level of negotiation is allowed is the system between potential buyers and sellers
Electronic quote execution	executable quotes and quantities based on the best quotes entered into the system.
Matched auction	transaction occurs when the price of the offer to buy matches the price of the offer to sell. The price is: - determined by the system using a matching algorithm - affected by specialist / market maker interaction
Single-price auction	bids and offers are submitted over a period of time, and executed at a single price at a given time. The price is: - determined by system using a balancing algorithm - affected by specialist / market maker interaction

The remaining three price discovery rules, electronic quote execution, matched auction, and single-price auction allow for full price discovery. The electronic quote execution corresponds to a dealer market, where a bid price and an offer price are available. The matched auction corresponds to the continuous auction market, where only one price is available at any time, but this price can potentially vary for each trade. The single-price auction is equivalent to the call market, in which all orders are crossed at a single price.

There are a number of systems that borrow prices from other markets. POSIT, the NYSE's after-hours crossing services, Instinet's Crossing Network, and the Arizona Stock Exchange borrow prices from the primary markets for equities in the US. There is an immediate benefit to use prices from other markets: it avoids the processing and infrastructure costs associated with the price discovery process. This results in lower transaction costs to the investor. However, if a system which relies on prices from other markets draws heavy volumes, fewer trading orders will be available to discover prices on the original market. Prices will become less accurate, thereby generating more volatility. And in more fragmented markets, orders will have a lower probability of getting executed (Weber 1995), which means less liquidity. Overall, investors may have to bear higher trading costs. The "free rider" aspect of systems borrowing prices from other markets is naturally of concern to regulators.

5.5 - Time Stamping Issues

Time stamping of orders is an important issue, especially in the context of electronic trading, as market participants can be geographically far from the actual electronic system and response time can vary with transaction load. We have seen that most trading systems use time priority to sequence orders identically priced. If two competing orders reach the market, the one with the oldest time stamp will be executed before the other. In order to respect the fairness of the market, it is important that the order which gets priority be the order that was sent to the system first. Time stamping is the mechanism used to enforce this time priority rule. The possible time stamping strategies are presented in table 3.

The time required for transmission is one reason why an order sent before a competing order can hit the market after that order. A trader located in Australia who wants to place an order on a system in New York may suffer some delays due to the time necessary to transmit the order. These delays can be significantly more than a few milliseconds if satellites, for example, are used in the transmission. More likely to be critical are network problems such as overloads or momentary unavailability. In this situation, an order may take a few seconds to reach the market. A delay in the magnitude of seconds or millisecond may not be dramatic in normal market conditions, when trading volume is within expectations. However, when tensions on the market lead to unusual activity and possibly higher volatility, the timeliness of orders becomes essential. A trader who is penalized by transmission delays might not be able to get any transaction done just because orders are slow going through the network, and the market moves before the orders can get executed. Unfortunately, a busy market also means busy networks, likely routing delays, and poor response time. Therefore, these are times when time stamps becomes essential to preserve a fair and orderly market.

Table 3 - Time Stamping Rules

Terminal entry	The order is time stamped locally when send from the trader's workstation. It requires every workstation connected to the system to be synchronized
Receipt at the host site	The order is time stamped when it is received in the system
Entry in the book	The order is time stamped when it is entered in the limit order book

Time stamping at time of terminal entry appears to be the best technique in terms of fairness. It requires that the system maintains the time on all the terminals connected to the market. The system must also provide a mechanism for reordering the messages if they are not received in the sequence that their time stamp would suggest. This is not a trivial feature as it may delay the execution of transactions to wait for possible lagging orders.

The difference between time stamping at time of receipt at the host site and at time of entry in the book is more subtle, but can still lead to similar problems if processing delays are significant.

Market makers are very sensitive to this problem: they need to react quickly to changes in market conditions. If response time is bad, they may get an unwanted execution at the old price between the time they have entered their new quotes on the terminal and the time these quotes are updated on the book[12]. Poor response time is more likely when the processing capabilities of the technology which supports the electronic system are stretched to its limits. Here again, this will happen when the market becomes very busy, that is when the ability to get the order or transaction processed promptly becomes essential.

The time stamping strategy must be identified at the design stage. The various alternatives should be evaluated in conjunction with the technology that will be used. and the potential users of the system. If time stamping issues are not properly addressed at the design stage, it may not affect the efficiency of the electronic market until it has to face a crisis situation, in which case it may not operate properly as a market anymore.

Similarly to order entries, order executions can be recognized as time stamped at time of execution, at time of order book removal, at time of acceptance on an outbound queue, or at time of release from the outbound queue. Time stamping issues are not as visible to market participants as the other design attributes discussed earlier. However, they are important to the system designer, especially in situation where market participants are remotely located, which is most often the case with electronic trading systems. A poor handling of time stamping could discourage market participants from using the electronic market.

5.6 - Transparency - Information Dissemination

The last important design consideration for an electronic trading system concerns transparency and information dissemination. Access to information by market participants appears to be both

[12] INTEX is an example of an electronic trading system which suffered from the mismanagement of time stamping rules. INTEX began operation in 1985, offering a loosely regulated market to trade futures contracts. Despite low volumes, inadequacies between the hardware and software selection led to delays in response time. As a result, traders were regularly picked off: orders were executed between the time they had wanted to cancel them and the time the system had processed their cancel transaction. INTEX ceased operation in 1988 after failing to attract sufficient liquidity (Private interview with Adam Graves 1994).

desirable and fair. Desirable information access should be evaluated in the context of the "efficient markets hypothesis", which claims that equilibrium prices should fully reveal all available information. Information access is fair because private information allows its owner to make profits at the expense of less informed investors. However, the world is not so simple, and decisions such as who should see specific pieces of information impact the efficiency and fairness of the market. The major categories of market participants that should be considered are market makers, who make two-sided markets, dealers who operate as principals on either side of the market, order book managers, agency brokers, and institutional and retail customers. The types of relevant information that can be seen by market participants are shown in Table 4.

Table 4 - Information Types Observable by Market Participants

Last trade information	volume, price, identification of the dealer, identification of the counterparty
Trading session information (for a given instrument)	high price, low price
Best Bid/Ask quotes (for a given instrument)	bid/ask quote, quantity, dealer identification, number of dealers
Book information	quotes, quantities, dealer identification, counterparty identification
Analytic information (for a given instrument)	sales history, volume history, data from other markets
News and research information	

The transparency of the system, along with the order execution algorithm, are important issues from a regulatory perspective (Corcoran and Lawton 1993). In the US, the Securities and Exchange Commission has a number of rules that govern the dissemination of information in the American markets. For example, Rule 11Aa3-1 requires all US securities exchanges, including NASDAQ, to report last sale information as promptly as possible, and no later than 90 seconds after the trade is made, to the Consolidated Tape System

One major advantage of electronic trading systems is that trade information is readily available in the system, and can be disclosed immediately to market participants. Rapid information dissemination allows investors to judge the fairness of their own transactions and the momentum of stock prices. While the SEC obeys this principle and imposes real-time publication of price and volume information on all executed equity transactions, the London Stock Exchange allows a 90-minute delay on trade information disclosure for large trades. This divergence of views on this fairness issue illustrates the impact that information dissemination decisions can have on the market attractiveness. The 90 minutes shield from reporting obligations was granted to dealers in the London Stock Exchange on large trades to protect them from speculative trading against their inventories. To complete large trades, dealers have to commit their own capital to the purchase of securities. At the completion of the trade, they find themselves with a strong imbalance in their inventory position. They need time to unwind their position, and restore a balanced inventory. Price and volume information disclosure immediately after the trade is made may encourage other dealers to take advantage of these imbalances. Before the application of the 90 minutes delay, *"market makers were unwilling to commit their capital. They quoted firm prices for only small quantities of stock. With their capital commitments removed, liquidity fell. Market efficiency suffered, especially for major institutional investors who consider liquidity the most attractive characteristic of a market place. The result was a rise in the cost of capital*[13]*."*

This brief discussion illustrates the potential impact of information dissemination decisions not only on fairness, but also on liquidity and efficiency of the market. Despite the availability of information provided by electronic trading systems and the claim that immediate information disclosure is only fair to market participants, the system designers must carefully consider which information to disseminate, to whom, and within which time frame.

[13] Unpublished speech by Sir Andrew Hugh Smith, chairman of the London Stock Exchange, to the Workshop of the International Federation of Stock Exchanges, Toronto, June 22, 1992

6 - Conclusion

While technology has led to increased speed and reduced costs in the operations of financial markets, it has also produced significant changes in trading procedures. It has affected trading rules, trading patterns and traditions, as well as market transparency and the value of information. Technology as also made possible more refinements in market structures, thereby transforming financial markets in an increasingly competitive environment. One outcome of competition is diversity which, by allowing traders and investors to select the market that best satisfies their trading demand, should globally benefit market participants. However, too much diversity may also threaten fairness, and generate fragmentation and an overall degradation of market quality.

The design decisions presented here are not independent from one another, and their simultaneous impact must be considered. The financial markets literature provides insights on market behavior and the interaction between some of the major market design dimensions we discussed. However, with technological advances, the number of types of possible market structures has dramatically increased, and imagination is the only limit to the variety of potential market designs. Further research on market structure should provide market developers with performance measures and knowledge to make the appropriate market design decisions, decisions which eventually determine market efficiency, adoption by the financial community, and approval by regulatory organizations.

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