STATEMENT

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by

Ian Domowitz
Mary Jean and Frank P. Smeal Chaired Professor of Finance
Smeal College of Business Administration
Pennsylvania State University

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Summary
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My testimony deals with one of the most important developments in the trading services industry today: the impact of advances in computer and telecommunications technology on the cost of trading and the development of market structure. These issues are addressed by focusing on the characteristics of exchange trading products, rather than concentrating on the characteristics of traders.

Exchanges operating in a competitive environment are firms offering trading products which embody particular technologies, regardless of precise governance structure. The "liquidity effect," to which is commonly ascribed the durability of the dominant national exchanges, derives from the salience of network externalities in the securities trading industry. Issues of trading technology adoption require analysis in the framework of network models of industrial organization. Such models serve to illuminate increasingly prominent features of exchange competition and market structure development.

Assuming roughly equivalent product quality as between incumbent (floor auctions) and entrant (computerized auctions), an assumption whose applicability is documented, new technology adoption in the face of network externalities requires clear cost advantages for the entrant. Cost therefore features as the centerpiece of a quantitative study of electronic versus intermediated trading. Yet the diffusion of new trading technology involves more complex processes. A review of recent competitive developments in the trading industry appears to reinforce the fundamental role of the network effects postulated by this branch of industrial organization theory. First-mover advantages exist, but are being eroded by relative cost movements and strategic pricing behavior. The role of technology "sponsorship," strategic investment in the technology of automated trade execution, appears to be important in abetting successful entry. We observe sudden and rapid adoption of the entrant's trading technology once apparently small advantages have been

achieved. The spread of external "adapter" systems, such as Instinet, that integrate incompatible networks, is further predicted by the theory. The emergence of mergers and "cartels" among automated system operators also would be predicted by theory, a development documented here, and which may be socially optimal given the underlying tenets of network economics.

Several factors bring the market for trading services much more closely into line with the assumptions of perfect contestability, implying a competitive market for such services. These include a massive decline in automated system development costs, the elimination of "distance costs" in the provision of cross-border electronic trading services, and the expansion of securitized products. As cross subsidization of products is inconsistent with sustainability of prices in a contestable market, this has important implications for the way in which exchanges price different types of trading. Among US and European exchanges, salient examples of such cross subsidization include large trades by small trades, "on-exchange" trades by "off-exchange" trades, and retail trades by institutional trades. The automation of the trading process facilitates specialization of service provision and, as a consequence, serves to arbitrage away cross subsidies. This trend may be reasonably expected to intensify.

The behavior of exchanges is conditioned not merely by the competitive environment, but by the incentive structure deriving from their internal governance arrangements. The traditional mutual structure of an exchange is a remnant of the pre-automation era, when the space limitations inherent to trading floors necessitated the rationing of direct access to members. As members then became intermediaries for all non-member order flow, exchange behavior came to be partly directed by the interests of members in maintaining intermediation profits. As trading automation has facilitated unlimited direct access, it is logical that new automated entrants have chosen not to be governed as intermediary cooperatives, but rather as for-profit joint-stock companies selling execution services on a transaction basis. Member-based exchanges are increasingly trying to replicate the incentive structures of such companies by demutualizing, or divorcing ownership from membership. The historical record of such initiatives is short, but the Stockholm experience in particular would appear to indicate that innovations such as foreign remote membership and direct investor access are more easily implemented when intermediaries are minority owners, and that demutualization may therefore serve to improve the performance of the exchange as a commercial enterprise.

As commercial enterprises, exchanges compete on the basis of the "market quality" which they offer as well as the cost of their trading services. In this regard, the focus of academic research has long been on measures of market quality. A true understanding of trading technology adoption and market structure development can now be achieved only by moving the focus to cost, however. This conclusion stems from an examination of extant empirical evidence comparing traditional trading venues to automated price-discovery systems. Market quality is assessed using a combination of information relating to liquidity, informational efficiency, and volatility characteristics. Overall, the evidence suggests that automated markets and traditional trading floors may differ in subtle and complex ways, but that market quality is equalized across market structures.

If this is the case, measuring the actual cost of trading across traditional intermediated markets and automated non-intermediated markets becomes an important exercise. Despite the many recent transformations from floor and dealer markets to automated auction markets which we have documented, the structures still coexist in many parts of the world. Lower development and operational costs for automated structures will undoubtedly influence competitive developments, but it is the explicit and implicit (execution) costs borne by traders in each type of market which is ultimately likely to be determinant. Explicit and implicit costs have been evaluated using a unique sample of five-year trading data from a large institutional user of proprietary electronic trading systems.

Both categories of cost are lower for electronic systems than for traditional brokers across OTC (Nasdaq) and US exchange-listed stocks. Analysis of execution costs, net of commissions, suggests that trades on the electronic systems are easier trades, with lower expected cost. However, we also find that electronic markets are generally less costly than traditional brokers for more difficult trades.

For OTC stocks, electronic markets dominate traditional brokers across the board. For listed stocks, our conclusions are similar but more nuanced. An examination of total trading costs, inclusive of commissions, reveals electronic trading to be superior to traditional brokerage by any measure of trade difficulty for buy trades, and comparable for sells. We therefore conclude that electronic trading generally yields considerable cost savings over traditional trade intermediation.

The implications of advances in computer and telecommunications technology are far-reaching in terms of trading market structure development and effective public policy. In particular, exchanges are now compelled to compete in an increasingly international market for trading services, and can no longer be seen as static repositories for rules governing the transfer of ownership of securities.

Members of the Subcommittee on Capital Markets, Securities, and Government-Sponsored Enterprises:

The following written testimony is taken from the paper, "Automation, Trading Costs, and the Structure of the Trading Services Industry," which is co-authored with Benn Steil of the Council on Foreign Relations. The paper was drafted in November, 1998, and will be published this year in full in the *Brookings-Wharton Papers on Financial Services*, edited by Robert E. Litan and Anthony M. Santomero. The opinions expressed here should nevertheless be considered only to be my own, and not those of Dr. Steil nor of his organization.

1. Introduction

The effects of advances in automated trade execution on the cost of trading and the structure of the trading services industry have been fundamental: the cost of providing exchange trading services has declined significantly, the means by which they can be delivered to investors has changed radically, and the natural industrial structure of the trading services industry has been transformed in consequence. All classes of market participants – exchanges, broker-dealers, investors, and regulators – are affected by these developments.

The discussion is organized as follows. At the outset, we provide an analytical description of recent industry developments in the context of the spread of technologies enabling automated trade execution. Theoretical paradigms are then suggested to explain observed changes, and to assist in anticipating future changes, in trading market structure. Specific implications for the competitive behavior of industry incumbents and entrants are drawn out, and compared to current and planned developments in exchange and industry structure. We then look to isolate those inputs into the theories which govern their predictions, in order to guide empirical investigations of their significance in the development of the trading industry. Finally, we examine trading data corresponding to such inputs in order to evaluate the trajectory of market structure development.

Existing analyses of automated trading operations focus on the explicit trading rules of systems, the mechanics of trading under those rules, and how the trading mechanism affects the price formation process. This description of the work matches precisely the objectives of the various paradigms in classical financial market microstructure (e.g., O'Hara, 1995:1). Aside from clear statements of the mechanics of trading, the concentration is on the characteristics of traders. This emphasis persists even in papers purporting to describe competition between exchanges.[1]

[1] See, for example, Ramanlal, Hargis, and McDonald (1997), in which competition depends only on the ratio of informed to uninformed traders and the degree of information revelation by market makers. Information asymmetries, for example, are not linked to trading mechanisms

In contrast, our objective is to explain changes in the structure of the trading services industry. Our maintained hypothesis is that industrial structure cannot be explained by focusing on the demand side alone – that is, the traders – and that insufficient attention has been paid to the supply side. We shall not ignore trader behavior in the analysis, but the emphasis is decidedly on the provision of alternative technologies for trading services.

Exchanges operating in a competitive environment can be analyzed as firms.[2] Firms offer different technologies for trading, including traditional floors and computerized auctions embodying automated trade execution.[3] Through these alternative technologies, transaction services are produced. Traders are consumers of trading services. They choose technologies and associated transaction-services bundles, taking explicit costs, implicit trading costs, and liquidity effects into account. Through the interaction of technology choice and trader behavior, prices are produced.

A combination of network economics and contestability theory is used to unify developments. In section 2, we analyze the rapid entry of computerized exchanges as competitors in the world market for exchange services within a network theory paradigm. We focus in particular on the interaction of development costs, operating costs, and the direct cost of delivering trading services to customers. We examine liquidity effects, which are commonly held to account for the durability of the dominant national exchanges, as a form of network externality. The rise of automated exchange systems, in the face of such externalities enjoyed by incumbent floor exchanges, is examined in terms of significant shifts in relative costs, strategic penetration pricing, and competitive efforts to achieve compatibility among electronic systems, and thus to expand new networks.

The impact of trading automation on the pricing behavior of exchanges is addressed through the framework of contestability theory in section 3. We argue that automation has significantly increased market contestability, in particular via its role in reducing sunk cost barriers to entry and exit. The effect is to reduce dramatically the ability of exchanges to cross subsidize

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[2] See also Arnold, Hersch, Mulherin, and Netter (1998) for a similar perspective.

different types of trading activity, as such behavior is incompatible with the sustainability of prices in a contestable market. We illustrate this effect by reference to the competitive erosion of long-standing exchange cross subsidization regimes: in particular, large trades by small trades, "on-exchange" by "off-exchange" trades, and retail trades by institutional trades.

The incentive structure under which an exchange operates is heavily influenced by its governance structure, which is itself a logical product of the trading technology employed. In section 4 we discuss the role of automation in the determination of exchange governance structure, focusing on the motivations for and effects of exchange demutualization, and the emergence of non-member based proprietary trading systems.

In the context of trading technology adoption, the determination of market structure depends upon the relative quality of the technologies and cost. Debates over the viability and future of computerized auctions traditionally focus on performance across a number of standard measures of "market quality" relative to the floor trading alternative. In contrast, we suggest that consideration of trading technology adoption and subsequent market structure development needs to move from issues of market quality to cost. This conclusion stems from an examination of extant empirical evidence which we carry out in section 5, comparing traditional trading venues to automated price-discovery systems. Overall, the evidence suggests that automated markets and traditional trading floors may differ in subtle and complex ways, but that market quality is equalized across market structures.

Assessment of relative costs is a complex undertaking. Beyond the problems of valuing fixed cost components and calculating marginal cost, trading entails a variety of implicit costs faced by the investor. In section 6, we evaluate explicit and implicit (execution) costs using a unique sample of five-year trading data from a large institutional user of proprietary electronic trading systems. Electronic markets dominate traditional brokers across the board for trading in OTC stocks. An analysis of total cost, including commissions, suggests that commissions are high enough to outweigh possible gains in

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[3] There may, of course, be product differentiation within a given technological class (such as automated continuous auctions and periodic call auctions).

execution cost by going to a traditional broker for trading of listed issues. These conclusions are reinforced by an examination of costs sorted by a variety of trade characteristics.

2. Automation and Network Effects

Securities exchanges operating in a competitive environment can be analyzed, regardless of their actual governance structure, as firms offering trading products which embody particular technologies. The way in which the structure of the trading industry develops might then profitably be studied within the framework of industrial economics. Given the nature of the trading products offered in the marketplace, we argue that issues of technology adoption must be approached using industry models where network externalities feature prominently.

An exchange or trading system is analogous to a communications network, with sets of rules defining what messages can be sent over the network and who can send them, as well as delineating how these messages translate into trades. This is more readily apparent for an automated system than for a floor-based one, but the principle applies equally for both models.

In the securities trading industry, there are two important effects relating specifically to the network nature of the product. First, the benefit to an individual market participant of a specific trading system increases in the number of locations from which the system may be accessed. As in the operation of telephone and retail distribution systems, consumer benefit increases in the number of outlets at which a good or service is available.[4] Second, the benefit to an individual market participant increases in the number of other participants on the system. As the value to one trader of transacting on a given trading system increases when another trader chooses to transact there as well, such a system is said to exhibit "network effects" or "network externalities." We believe that such network externalities are the source of the

[4] In the case of trading systems, this benefit can assume an additional dimension: as the number of locations increases, the variety of instruments available for trading may rise as well

"liquidity effect" to which is commonly ascribed the durability of the dominant national trading markets.

The salient presence of network effects in the securities trading industry makes the process of technology adoption a complex one. The cost of trading over a given system is a function of the operator's market entry timing *vis-à-vis* incumbents, and not merely the marginal production costs of the system operator. Trading network users derive significant positive external consumption benefits from the presence of other users and from the complementarity of the network with other systems designed to generate and process trades. Each of these factors has a major influence over technology adoption.

Network models yield some important implications for the development of market structure. Clearly, traders have enormous incentives to coalesce around the system which minimizes trading costs. Yet the actual process of standardization of trading on a given system is far from straightforward. First, standardization may not occur even where it is optimal (Katz and Shapiro, 1986).[5] Individual traders may disagree with respect to which trading technology is the more desirable, and traders take no account of negative liquidity effects on other traders when choosing a given trading platform in preference to standardization on another. Second, when standardization does occur the optimal technology may not be selected. The existence of a network externality can confer a significant first-mover advantage on the technology which is available earlier, or which is cheaper at the outset, that is not overcome even when it is socially optimal to standardize on a newer alternative technology.

Given such a first-mover advantage, a potential entrant utilizing a technology of quality equivalent to that of the incumbent's would have, at the least, to face a lower marginal cost of production. In the face of a significant network externality enjoyed by the incumbent, this may not, however, be sufficient. The entrant may have to engage in penetration pricing in order to establish its own viable network. Sub-marginal cost pricing to first-period

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[5] Optimality is social optimality or efficiency here, defined in terms of maximization of total economic surplus.

traders can be optimal where their participation on the system raises the value of the system to second-period traders.

In order for such strategic pricing to be a viable competitive option, the entrant must control property rights to some significant component of the underlying technology, or other entry barriers into the supply of that technology must exist. Otherwise pricing above marginal cost in future periods, necessary to recoup initial losses, will not be possible. Katz and Shapiro (1986) refer to such firms as "sponsors" of a given technology. By engaging in below-cost pricing early in the technology's life, the sponsor can internalize the external benefits generated when first-period traders adopt its technology.

Models of sponsorship are complex, and yield markedly different welfare outcomes depending on the cost structures, entry timing and sponsorship powers of the competitors (see Katz and Shapiro, 1986). In the context of trading system competition, strategic pricing capability in network markets can yield results which are not only important for understanding and predicting market structure developments, but for guiding public policy towards the industry. In particular, trading system operators will often face strong incentives to construct cartels among themselves in order to facilitate strategic pricing, and such cartels may actually be socially desirable. To the extent that cartels enable future period pricing above marginal cost, they generate incentives to invest in new trading technology in the presence of liquidity effects. This line of reasoning is pursued in Domowitz (1995), who notes that "implicit mergers" between providers is enabled in large part by the advent of automated trading system technology. Trading services providers may actually move to automated systems specifically in order to facilitate such cartel activity.

2.1. Networks in the Context of Automated Trading and Market Structure Development

2.1.1. Entry and Cost

In the early days of automated systems development, a quarter century ago, hardware and software development costs were much higher than they are today: $100 million developments were the norm at a time when listings were much fewer and turnover much lower. Given that traditional trading floors already possessed functioning liquidity pools, or "networks," the cost of trading automation had to fall considerably before it would be widely adopted. This is likely even if automated trading would have been superior at existing levels of floor turnover, owing to the network externalities enjoyed by the established floor-based markets.

Development costs for computerized auction markets have declined dramatically over the past decade. Against a backdrop of static or rising costs for floor-based systems, we witness automated systems emerging as the model of choice in almost all new market development efforts. Across Western and Eastern Europe, virtually every stock exchange has now implemented an electronic auction system. It is only where the network power of floor-based and dealership markets was substantial in the 1980s that resistance to full automation has been significant. The world's five largest stock exchanges - New York, Nasdaq, London, Tokyo and Frankfurt - have been the slowest in dismantling obligatory human trade intermediation.

It is exceptionally difficult to compare the costs involved in operating automated as opposed to floor-based trading structures on the basis of cross-market expenditure comparisons. Trading volumes, ancillary services, and regulatory obligations vary markedly across exchanges. In terms of up-front construction costs, recent European automated and floor system development plans indicate that the latter are at least three to four times more costly.[6] The best we may be able to do in estimating the annual operating cost savings in switching from floor to automated trading is to rely on the proprietary estimates of exchanges which have undergone, or are undergoing, the transition. The most recent such published estimate comes from the Sydney Futures

[6] The London Stock Exchange and Deutsche Borse each spent over $100 million implementing their new automated auction systems, Sets and Xetra, yet Tradepoint's system was developed for under $10 million. Relative volumes cannot account for the difference, as Tradepoint could match the capacity of either with a further technology investment of around $5 million. Yet the cost of building and technologically equipping a floor is clearly much higher. Liffe's floor development plan, abandoned in the spring of 1998, was priced at over $400 million. A smaller bond futures trading floor project at the Chicago Mercantile Exchange was completed in 1997 at a cost of approximately $200 million.

Exchange, which expects savings in human resources and ancillary services of at least 40 percent.

Cost is undoubtedly the most significant factor which has driven the rapid expansion of automated trading in the past several years. Expansion often proceeds in the face of direct competition from well established floor based exchanges. It is not merely the decline in development and operating costs which has driven this process, however, but also a steep decline in the direct cost of delivering automated services to customers.

"Distance costs"[7] in the provision of automated trading services are small or non-existent, whereas the cost of access to floor systems generally increases with distance from the customer. This derives from the requirement for the customer either to be physically present on the floor itself, or to employ an agent to intermediate transactions on the floor. The removal of important legal barriers to direct cross-border electronic trading since 1996, both within the EU and between the EU and the US, has allowed automated markets to expand their networks dramatically, attracting foreign traders whose cost of access to local floor markets was much higher.

Article 15.4 of the EU Investment Services Directive gives "regulated markets" within the EU the right to solicit "remote members" in foreign EU member states without having to secure any authorization from the foreign market regulator. Most EU screen-based equity and derivatives exchanges have now implemented remote membership. In 1997, the US Commodity Futures Trading Commission (CFTC) granted the Frankfurt-based DTB derivatives exchange the right to solicit remote members in the US for trading in 10-year bund futures contracts - making DTB the first non-US exchange to be granted direct access authorization by a US authority. They have since attracted about 20 new members based in Chicago and New York. Prior to the launch of US trading, DTB's market share was about 35-40 percent for many years. The speed with which DTB moved to a 70 percent share by the spring of 1998, and a near-100 percent share by the summer, is testimony to the power of "tipping"

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[7] The shift from open outcry to electronic trading at the Sydney Futures Exchange was specifically motivated, according to the chief executive, by the competitive need to overcome the "tyranny of distance" (*Financial Times*, 1998:VI), representing the cost of providing trading services to traders based at great distance from the Exchange.

effects in network markets. Strong positive-feedback elements in network markets generate a tendency for one system to achieve complete dominance rapidly once it has achieved an initial advantage. In dynamic network models, tipping is reflected in equilibria where new placements of the losing system dry up once a rival system becomes accepted in the marketplace (Farrell and Saloner, 1986; Katz and Shapiro, 1992). This was clearly the case for Liffe once DTB had surpassed the 50 percent market share barrier.

Furthermore, locally established EU automated exchange members have increasingly been transferring or expanding their screen access across national borders, even where explicit legal authorization has been lacking.[8] This has allowed them to reduce trading and support costs in automated markets by creating access points where they can be most efficiently exploited.

Table 2-1 lists transformations from existing floor-based or dealership trading systems to automated auction systems, which were either implemented or initiated in 1997 and 1998.[9] Rapidly falling seat prices on floor-based exchanges – particularly derivatives exchanges, which have been most directly affected by cross-border automated competition – have accelerated the process.[10] The most dramatic cases of transformation involved Liffe and Matif in the spring of 1998. Liffe abruptly abandoned a $400 million floor development plan in favor of accelerated development of an electronic system in the wake of the loss of the 10-year bund futures market to DTB. Matif had long resisted moving to screen-based trading as a precondition for a strategic alliance with DTB, yet moved quickly to adopt it after DTB was merged with the Zurich-based SOFFEX to create a new electronic Eurex exchange. Matif's move created a fascinating case study of hybrid trading, as the floor was initially maintained in parallel with the new electronic system. The plan was formally

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[8] Instinet and Lattice Trading direct electronic access from the US into European automated exchange systems has never been formally authorized by the SEC. The SEC has decided not to challenge it, however, despite the fact that the European exchanges of which they are members are explicitly forbidden from placing *their own* screens in the US. There is no logic to this disparity of treatment between exchange screens and exchange member screens: orders entered through either screen go directly to the exchange's electronic order book.

[9] Floor and dealership trading remains for some products on some of these exchanges.

[10] Sydney Futures Exchange seat prices halved in the two years to April 1998. Chicago Board of Trade seat prices halved in the first half of 1998 alone.

abandoned within 30 trading days, after the electronic system rapidly achieved a 99 percent market share.[11]

2.1.2. Entry and Strategic Pricing

Automated exchanges have also applied strategic penetration pricing to undercut incumbents with established networks. DTB offered cut-price memberships and fee holidays on the 10-year bund contracts in 1997, when then-floor-based Liffe still controlled about two-thirds of the market. After abandoning the floor for screen-trading in 1998, Matif began offering 5- and 10-year UK government bond contracts at £0.17 per trade, 40 percent less than Liffe was charging.[12] The start-up Cantor Financial Futures Exchange (CFFE), a joint venture for electronic trading of US Treasury futures launched by brokerage firm Cantor Fitzgerald and the New York Board of Trade (NYBOT), went live in September 1998 charging 50 percent less than the incumbent floor-based Chicago Board of Trade (CBOT). Tradepoint undercut the London Stock Exchange (LSE) by 75 percent in the processing of pre-matched interdealer broker (IDB) trades in the run-up to the LSE's launch of automated auction trading in 1997.

2.1.3. Adapters and Incompatible Networks

The proliferation of incompatible automated auction systems has encouraged the growth of enterprises which aim to reduce investor access costs by providing a standardized interface across different networks. These electronic brokerage firms correspond to the role of "adapters" in the network economics literature (see Katz and Shapiro, 1994). They become members of different automated exchanges, constructing electronic interfaces into each from their own proprietary order-entry systems. These systems are marketed to institutional investors, who use them to access multiple exchange order books directly via a single electronic entry point. Instinet, owned by Reuters, operates

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[11] Automated auction trading is also rapidly expanding in US derivatives exchanges. For example, the CBOT recently cancelled evening floor trading in bond contracts in favor of trading on its electronic Project A system. More recently, the exchange has petitioned the CFTC to allow Project A trading in bond contracts during daytime floor trading hours

[12] Liffe's fee of £0.28 per trade was already a 33 percent reduction from its £0.42 charge earlier in the year.

the largest such system, providing direct cross-border institutional access into US, European, and Asian stock exchange order books. Other cross-border adapters include Lattice Trading, owned by State Street Brokerage, and CSFB's PrimeTrade system for listed derivatives.

2.1.4. Remote Cross-Border Trading

Examples of automated exchange systems offering remote cross-border access from the US include the Chicago Mercantile Exchange's (CME) Globex (access in the UK, Hong Kong, Japan, France, and Bermuda), NYMEX's Access (Australia, Hong Kong, and the UK), and the CBOT's Project A (UK). Most European exchanges now accommodate remote cross-border access, but some, such as the Madrid Stock Exchange, still do not allow remote *membership*. The latter does not require members to maintain an office in the exchange's home country, and is frequently resisted by local members concerned with losing cross-border brokerage business to foreign intermediaries. As the example of DTB's US expansion illustrated, remote membership can be a powerful tool for expanding networks and, hence, liquidity traceable to network effects. The fact that local members controlling an exchange will often resist remote membership to protect their existing brokerage franchises raises important questions regarding exchange governance, which we discuss in section 4.

2.1.5. Mergers and Alliances

Exchanges have begun to cooperate in the construction of their own adapters in order to enable compatibility between their networks, or in some cases to merge their networks outright. As investors expand their holdings of foreign securities and intermediaries expand the geographic scope of their activities in consequence, the externalities resulting from cross-border networking increase. The cost advantage in operating a cross-border system over multiple incompatible national systems thereby increases.

Concern has recently been spreading rapidly among exchanges in Europe and the US that failure to participate in a major cross-border trading network will lead traders to abandon domestic systems in favor of single entry point access to a much wider international grouping of traders and products. This is particularly true in the wake of the July 1998 agreement between the London Stock Exchange (LSE) and Deutsche Börse to develop a common trading platform for UK, German, and other leading European shares. The perception of first-mover advantages in network markets lends a sense of urgency to exchanges considering a competitive response to such initiatives.

Table 2-2 documents US and European automated exchange linkage strategies launched or implemented between January 1997 and September 1998. These are classified into four broad categories: strategic alliances / joint ventures, common access systems, common trading systems, and mergers.

An example of the strategic alliance strategy is that agreed by the CME and Matif. The CME will adopt the Matif NSC-VF trading technology as the basis for its own electronic trading system, and Matif will adopt the CME's clearing system. A deeper form of alliance is exemplified by the creation of a common electronic system to access two or more different exchange systems, a strategy being pursued by the three "Benelux" exchanges. The Norex alliance between Stockholm Exchanges and the Copenhagen Stock Exchange goes a step further, producing a single trading system, based on the Stockholm SAX technology, to trade both Swedish and Danish stocks. Although the exchanges will remain separate legal entities, members of one are offered free membership of the other. The CBOT and Eurex have adopted a similar strategy, deepening an earlier one based on a common access system model. The most notable example of an actual exchange merger during this period is Eurex, which combined Deutsche Börse's DTB derivatives arm with the Swiss Exchange's SOFFEX derivatives arm into a single corporate entity, utilizing a common trading system. Matif, which had launched electronic trading specifically to accommodate networking with Eurex, has agreed the outlines of a common membership scheme with the new entity, and the two are continuing discussions regarding the construction of an adapter system to link the trading systems - an initiative named "Euro Alliance." Eurex is also in discussions with the derivatives arms of the Borsa Italiana, Amsterdam Exchanges, and several Scandinavian exchanges regarding possible linkages or mergers.

3. Automation and Cross Subsidization of Trading

State-owned or protected public utilities frequently engage in cross subsidization of products and services, pricing above marginal cost in one area to keep prices below it in others. Such cross subsidization is usually defended on the grounds of distributive concerns, although it clearly distorts market incentives and generates deadweight efficiency losses. Increased automation is now leading to the disappearance of cross subsidization in the trading services industry. The argument is based on a link between automation of trading and market contestability.

In markets which are contestable, cross subsidization is inconsistent with sustainability of prices: it always invites profitable entry into the subsidizing portion of the business, thus ensuring it cannot persist (Baumol, Panzar and Willig, 1988). The trading services industry is showing clear signs of increasing contestability. Sunk cost barriers to entry have declined rapidly over the past decade, owing in particular to the following factors:

1. System development costs have plummeted, as basic auction market technology has become commoditized and computer processing power has expanded dramatically.
2. The significance of geographic location has declined tremendously in tandem with the steep decline in the cost of constructing wide-area cross-border computer networks.
3. Automated systems can now be tailored quickly and inexpensively to accommodate trading in a growing number of securitized products, such as equities, bonds, currencies, financial derivatives, pooled mortgages, agricultural commodities, electricity, pollution emission permits, and hospital bed allocations. This facilitates rapid and low-cost entry into different sectors of an expanding market for securitized products.

Perfect contestability requires not only the absence of sunk cost barriers to entry and exit, but also that entrants face no disadvantage vis-à-vis incumbents and that they be capable of undercutting incumbents before the latter can react. The proliferation of open architecture trading services systems has greatly facilitated the integration of new trading systems with existing information and support systems, thus reducing entrant disadvantage, and there is considerable evidence of price undercutting by entrants (see section 2.1.2). If the trading services market does now sufficiently approximate a contestable one, then we would expect to see evidence of the erosion of cross subsidies employed by incumbent national exchanges.

In fact, the expansion of automated trading structures does appear to be imposing increasing external discipline on the way in which exchanges can price different types of trading. The cross subsidy regimes which have traditionally been imposed by exchanges fall into three general categories: cross subsidization of large trades by small trades, "on-exchange" by "off-exchange" trades, and retail by institutional trades. Although these issues clearly are not independent, this categorization offers different perspectives on the cross subsidy issue. The general message is easy to summarize, however. As automation significantly reduces the cost to system operators of focusing their competitive strategies on well-defined types of trading and traders, and of extending their competitive reach across wide geographic areas, it enables automated competitors to avoid an incumbent's subsidized market segment and to focus instead on the profitable subsidizing segment. We discuss examples of this effect below.

3.1. Cross Subsidization of Large Trades by Small Trades

Data from the LSE in the early 1990s documented high market maker profits on small transactions, where dealer intermediation was rarely necessary. These profits subsidized losses on mid-size blocks,[13] where institutional clients appeared to have strong knowledge of market order flow. The continental European automated auction systems, many of which were implemented in the period 1989-1991, had the effect of undermining this structure. Small transactions in continental shares rapidly migrated from SEAQ-I back to the home markets, wiping out a major source of market maker subsidy and exposing many of them to large losses at the hands of well-informed

[13] 6-10 times Normal Market Size (NMS), NMS being equivalent to approximately 2.5 percent of average daily trading volume.

institutional clients. SEAQ-I quoted spreads more than doubled between 1991 and 1994, as dealers abandoned formal "market making" in continental stocks (Pagano and Steil, 1996).

Given the experience of SEAQ-I, we would suggest that Nasdaq's experience in the face of Instinet's rapid rise to a 20 percent market share is also explicable in the context of conventional industrial economics. In particular, the "excessively wide" quoted spreads identified by Christie and Schultz (1994) do not necessarily require an explanation based on widespread collusion, and frequent reports of Nasdaq market makers dropping stocks in the midst of a bull market are not puzzling, as is sometimes claimed.[14] Both effects would represent logical responses to the erosion of cross subsidies in the dealer market.

3.2. Cross Subsidization of "On-Exchange" by "Off-Exchange" Trades

Many auction market operators impose "interaction" rules on members, obliging block traders transacting away from the central limit order book to satisfy all orders on the book at equivalent or better prices. This is commonly presented as an issue of "fairness" regarding order book users: yet, whatever the merits of this position, interaction rules represent a clear subsidy by off-exchange for on-exchange traders.[15]

Paris Bourse interaction rules, created in 1989 after members were permitted to trade for their own account, were significantly relaxed in 1994 owing to the effect of "regulatory arbitrage" in favor of London. Block traders in Paris routinely executed their block trades in London in order to avoid having to expend capital or leak information by obeying the Bourse's interaction rules. Even under the current Paris regime, which requires only that block trading take place within a "weighted average" measure of the order book inside spread,

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[14] The Wall Street Journal ran a story focused on this phenomenon in 1996. One observer's reaction was quoted as follows: "What you are seeing is [that] even in a huge bull market, you still have market makers cutting back on stocks when logic tells you they should be increasing (Robert Flaherty, editor of *Equities* magazine)."

[15] A counter-argument that traders must price their off-exchange deals based on order book prices, and are therefore "free riding" on price discovery, are only valid where the price and quotation data provided by the exchange to data dissemination systems (such as Reuters and Bloomberg) are not themselves priced at competitively determined

blocks trades are still often executed in London via SEAQ-I screens in Paris in order to avoid the market impact risk that a dealer might take on in trading within the Paris spread limits.[16]

The OptiMark call auction system, which is scheduled to begin trading in the autumn of 1998, has been heavily marketed as a mechanism for accommodating anonymous block trading. As a facility of the Pacific Stock Exchange (PCX), OptiMark does not subject traders to the interaction rules of the New York Stock Exchange (NYSE). Thus, if the system is in fact successful in transacting blocks, the cross subsidy enjoyed by NYSE specialists from member-firm block traders also faces erosion in the face of regulatory arbitrage towards the PCX. It is our sense that OptiMark is not alone. Anecdotal evidence suggests that a primary goal in new automated system design is the more efficient handling of large transactions, and a number of firms are working on the problems involved.

3.3. Cross Subsidization of Retail Trades by Institutional Trades

NYSE and Nasdaq rules intended to accommodate small retail-sized trades on uneconomical terms are being exploited by proprietary trading systems focusing entirely on executing institutional orders. For example, Nasdaq market makers are subject to the requirements of the "Small Order Execution System" (SOES), which allows small orders (up to a thousand shares) to be executed electronically against market maker quotes. Whereas the system was set up to ensure that retail investors could achieve timely executions, SOES is exploited by firms known widely as "SOES bandits," which fire rapid streams of one thousand share orders at market makers before they are able to adjust their quotes to news or trading activity. Non-exchange systems such as Instinet can "cherry pick" profitable institutional order flow, leaving unprofitable executions to the traditional exchange systems.

rates. Given that data dissemination represents approximately 17 percent of European exchange revenues (Baggiolini, 1996), this argument would not appear to us to have merit.

[16] See Pagano and Steil (1996) for details.

4. Automation and Exchange Governance

Exchanges have traditionally been organized as mutual associations, operated by member-firm brokers and dealers, under varying degrees of state control. The member firms often are the legal owners of the exchange, and in some cases actually own shares in the exchange as a corporate entity.[17] In other cases, the exchange is legally a government entity.[18]

This mutual structure is a remnant of the pre-automation era, when exchanges were of necessity floor-based. Inherent limitations of trading floor space required access limitations. Access was rationed through the sale of a fixed number of memberships (or "seats"). Since a non-automated trading floor itself has little more than commercial real estate value, it is logical that the members themselves should operate the floor as a cooperative. These members necessarily become intermediaries for all others wishing to trade the exchange's contracts, and a portion of their profits derives from barriers to entry.

In an automated auction market, there is no technological barrier to providing virtually unlimited direct access. There is, therefore, no longer an economic logic to exchanges being organized as intermediary cooperatives. An automated system operator can sell access direct to all who wish to trade, and charge for this service on a transaction basis. Thus we would expect the operator to select its governance structure on the same basis as a normal commercial enterprise.

Whereas an automated exchange *can* be organized along traditional mutual lines, it is questionable whether such a structure is optimal in the type of competitive environment which we have heretofore described. The optimality issue is beyond the scope of this paper, however. We make a set of more limited observations here. First, as already described, trading market automation permits demutualization, defined as separating ownership of the exchange from membership. Second, the incentive problems inhibiting demutualization are similar to some of those inhibiting technology adoption,

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[17] Transference of such shares is generally strictly limited. In the case of Deutsche Börse AG, for example, the sale of shares must be approved by the supervisory board.

[18] This was the case with the Italian Consiglio Di Borsa, the predecessor to the privatized Borsa Italiana.

namely vested financial interests. Third, demutualization is now rapidly being adopted in practice, and all such examples begin with a conversion from traditional floor trading technology to automated trade execution. Finally, for trading services enterprises without a prior history of mutual governance structure, the mutual structure is routinely avoided in favor of a for-profit joint-stock corporation structure. As automation initiatives continue to proliferate, a revealed preference argument may indeed suggest the optimality of a demutualized exchange structure relative to its mutual counterpart.

It is clear that the incentive structure under which a mutualized exchange operates is different from that under which a demutualized one does. As exchange members are the conduit to the trading system, they derive profits from intermediating non-member transactions. This in turn means that members may resist innovations which reduce demand for their intermediation services, even if such innovations would increase the value of the exchange. If the members are actually *owners* of the exchange, they will logically exercise their powers to block disintermediation where the resulting decline in their brokerage profits would not be at least offset by their share in the increase in exchange value.

A number of European exchanges have in the past several years chosen to demutualize, detaching ownership from membership. This transformation of governance structure has the effect of diluting member firm influence over the commercial activities of the exchange. To the extent that the financial interests of non-member owners differ materially from those of members, such a transformation could have a significant impact on the exchange's behavior.

The first exchange in the world to demutualize was Stockholm, in 1993. The initiative came on the back of major competitive inroads into Swedish equity trading made by London's SEAQ International between 1987 and 1990, a period in which Stockholm's turnover declined by a third and its market share of global reported Swedish equity turnover went as low as 40 percent.

Half of the shares in the new Stockholm corporate structure were retained by the members, and half allocated to listed companies. The shares became freely tradable in 1994, and in 1998 were listed on the Exchange itself.

Following the demutualization, the Exchange became the first in Europe to offer remote cross-border membership (1995) and direct electronic access for institutional investors (1996).[19] Both of these initiatives faced resistance from local Swedish members, but could not be blocked given their minority interest.[20] Non-member owners, on the other hand, had an unambiguous incentive to support these measures. The Exchange as a commercial enterprise appeared to have performed well following the demutualization. Turnover quadrupled in the first two years of demutualized operation,[21] and the Exchange's share price also rose nearly sevenfold.

The Stockholm model has since been widely emulated among other automated exchanges. Table 4-1 documents demutualizations. The biggest difference among them has been in the initial allocation of shares. Helsinki and Copenhagen, for example, applied a 60-40 share split between members and listed companies. Amsterdam allocated 50 percent to the members, and auctioned off 50 percent to both listed companies and institutional investors. Australia allocated all shares to the members, but listed them on the Exchange itself the day following the demutualization.

Member-based exchanges are demutualizing in order to approximate better the incentive structure of a public company with a diversified shareholder base. In contrast, trading system operators in the US and UK, which have entered the market with automated auction products, have avoided the mutual structure entirely. Such companies are widely referred to as "proprietary trading system" operators. Instinet (owned by Reuters), Posit (owned by ITG), and Lattice Trading (owned by State Street) are formally regulated as brokers, but sell order-matching services on a transaction fee basis direct to institutional investor clients. The Arizona Stock Exchange and London-based Tradepoint are classified by their respective national regulatory authorities as "exchanges," but operate in an identical manner. OptiMark has chosen a third route: it is neither legally a "broker" nor an "exchange." The

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[19] Such trades must still be notionally executed via a "sponsoring member."

[20] Anecdotal evidence from Exchange officials suggests that smaller local members did, in fact, suffer financially from a diversion of foreign order flow to the new larger remote intermediaries.

[21] The Exchange itself credits part of this increase to the removal of a 1 percent transaction tax at the end of 1991.

company licenses its trading product to existing bodies which are classified by their regulators as "exchanges."

We argued in section 2 that exchanges operating in a competitive environment can profitably be analyzed as firms offering trading products in a market defined by the salience of network externalities. The degree to which this formulation approximates reality depends upon the level of contestability in the market for trading services and the incentive structure under which exchanges operate. As we have argued in section 3 and here in section 4, trading automation has, in fact, increased significantly both market contestability and the incentives of exchanges to exploit network externalities. These incentives are manifested, *inter alia*, in the transformation of exchange governance structures towards conventional corporate models.

5. Market Quality Comparisons

Network models rely largely on two factors for their explanatory power: the quality or efficiency of the alternative trading technologies and relative cost. Early conceptual arguments over the introduction of computerized markets focus exclusively on the issue of market quality relative to the floor trading alternative.[22] We argue that debates over trading technology adoption and consequent market structure development need to move from considerations of market quality to issues of cost. We offer evidence supporting this position in this section.

A precise definition of market quality is lacking. We focus on liquidity, informational efficiency, and volatility characteristics. Liquidity is a multidimensional factor, which we address through consideration of the size of the bid-ask spread and measures of market depth. We would concede that all aspects of what we call "market quality" can be characterized by the term "cost," born by some party in the trading process. This is most clear in the case of bid-ask spreads. In other cases, the link is not as easily quantifiable.

[22] The earliest mention seems to be in Special Study of Securities Markets, Report of the Special Study of the SEC (1963), in H.R. Doc. No. 95, 88th Congress, 1st Session, pt. 2 at 358 and 678. The Commodity Futures Trading Commission organized a conference around the topic in 1977, summarized in *Proceedings of the CFTC Conference on Automation in the Futures Industry*, CFTC (1977), and Melamed (1977).

Consider informational efficiency, for example. Greater speed of value revelation through the trading mechanism lowers the cost of trading in terms of the formulation and implementation of order submission strategies.

General conclusions, to the extent that they may be obtained, require intraday data and multiple market comparisons. The data requirements are too large for any single research project. We rely, therefore, on a variety of existing studies for our information. The relevant literature is not extensive, and we are able to cover most of it in what follows. Since our treatment proceeds by topic, and not by individual paper, Table 5-1 summarizes the contributions for reference.

Some of these papers provide more direct evidence than others, and the emphasis in individual papers differs. Studies of the Bund futures contract benefit from the overlap of trading times on the automated DTB market and the Liffe floor, as well as the close similarity of contracts traded in the two venues.[23] Comparisons of the automated Osaka Stock Exchange and floor trading in Singapore on SIMEX share these advantages, but there are differences across markets unrelated to automation. Interpretation of a study of Globex and the CME floor is complicated by natural deficiencies in liquidity endemic to an overnight market. Work on India is in the form of a time-series event study of the introduction of automation, as opposed to a comparison of automated and floor auctions operating over the same time period. Analysis of computerized DAX futures trading relies on a comparison of the futures contract with aggregate trading in the underlying index, reflecting different forms of trading activity, as well as variations in market structure.[24] Finally, comparisons of automated auctions with dealer markets have contrasted the Paris CAC and German IBIS auction systems with the London SEAQ International dealer market. The findings of these studies are favorable to computerized markets, but rife with ambiguities. Beyond problems with data interpretation, dealer markets are quite different from auction markets generally, whether the latter be automated or floor-based. Although we include

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[23] Shyy and Lee (1995) also consider the Bund market, but the overlap of emphasis between that work and others considered here is large enough not to merit separate consideration.

[24] A similar contribution is made by Kempf and Korn (1996).

these studies for completeness, we do not consider details of the comparisons.[25]

Whereas tradeoffs may exist between some markets, our reading of the evidence is that market quality is roughly equalized across automated and floor technologies.

Bid-ask spreads are approximately the same across automated and traditional trading venues. Considerations of market design tell us little about the anticipated size of relative spreads. The openness of automated limit order books does, however, suggest higher costs in terms of the adverse selection component of the spread. Available evidence supports such intuition in environments characterized by a high probability of adverse selection effects. Theoretically, the spread is composed of the sum of adverse selection costs, inventory costs, and order processing costs. Given that the inventory component is found to be very small in all studies that attempt to break it out separately, the results therefore suggest that order processing costs are generally lower in automated markets. These conclusions must be tempered by considerations of relative size of processed orders and explicit costs that may or may not enter the spread calculations. It is not generally true that automated systems handle only small orders, however, as exemplified by the Osaka/SIMEX comparison. Larger spreads are a feature of markets, automated or not, that process larger orders on average.

It is often argued that automated markets do not foster good market depth, due to the high visibility of order book information and order cancellation delays. Neither average trading volume nor average volatility in isolation provide good measures of depth, obviating some evidence on this point. Based on parametric estimates, using data on volatility and volume combined, market depth is generally found to be greater in the automated market.

Average volatility is at least as low in computerized markets as in their floor counterparts. It is not clear exactly what dimension of market quality is being measured, however. This confusion may also explain why results on

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[25] See Pagano and Steil (1996) for an overview of results and a detailed critique.

volatility dynamics, and the effect of volatility on market share, are mixed. There are also conflicting interpretations of volatility persistence, in terms of information and market design.

Mild differences in informational efficiency across trading technologies are observed, but these differences disappear once such models are augmented by additional trading information. There is no evidence supporting "price information leadership" across market structures, either in terms of prices or volatility characteristics. Traders do not necessarily migrate to floors in the presence of high volatility, despite anecdotal arguments to the contrary.

One explanation of the equality of market quality across trading structures lies in a peculiar form of what statisticians call "selection bias." The term is commonly reserved for situations in which the sampling information is not random in some dimension. This lack of randomness is exemplified here, since all cross-market comparisons depend on the survival and stability of two markets trading the same securities, usually with heavy overlap in terms of time zone. One might, therefore, reasonably conclude that both floor and automated auctions are serving traders well, even if this may be along different dimensions. Quality of market may differ between competing structures in some aspect, which is offset in another.

This rough equality across auction mechanisms does not imply that dual market structures will continue to exist over the long run. The consumers of trading system services also face a combination of implicit and explicit costs, and we now turn to some new evidence on this point.

6. Transactions Costs, Intermediation, and Market Structure

An important implication of the automation of trading market structure is the potential for direct market access on the part of institutional investors.[26] Access to traditional trading floors requires the use of brokers with exchange membership. Intermediation in dealership markets is built into trading protocols by design. In contrast, an institutional trader can place orders

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[26] Although this may eventually also be true for retail customers, capital requirements typically exclude direct access for non-institutional traders

directly in automated venues such as Instinet, Posit, and the Arizona Stock Exchange (AZX).[27]

Why might this distinction matter in practice? The first answer concerns the choice of trading venue. In an intermediated setting, the broker determines where execution will take place. If the broker is representing the best interests of the trader, choice of trading location would be rationally based on price and execution quality. This hypothesis appears to be refuted in practice. Blume and Goldstein (1996), for example, show that most trades in NYSE issues executed off the NYSE floor happen when the execution venue is posting inferior quotes. This indicates that location is often determined for reasons other than best pricing.[28]

Discussions with institutional investors suggest a second response, pertaining to information. Once an order is placed with a broker, information about the trade is no longer private, and information leakage can occur. If so, some information is reflected in quotes prior to trade execution, adversely influencing execution costs on the part of the original investor. Keim and Madhavan (1996) argue that such leakage is greater for trades in small capitalization stocks, large block transactions, and in high volatility environments.

A simple alternative explanation is that human intermediation services are often unnecessary. The investor is nevertheless obliged to pay for such services when trading through a traditional broker. Automated trading enables institutions to avoid paying for intermediation services they do not require. On simpler trades, the trading expertise of the broker may not be sufficient to compensate for the lower commission charges which automated services invariably levy.

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[27] Technically, an institutional trader cannot place an order directly on AZX. Because the company is legally regulated as an "exchange," the SEC requires registered broker intermediation. However, the broker is merely placing the order, and receives only a small payment for the service.

[28] U.S. law mandates that brokers must provide "best execution," described by the SEC (1996) as "[to] seek the most favorable terms reasonably available under the circumstances for a customer's transaction." Macey and O'Hara (1996), however, note the absence of specific definitions of best execution or of an explicit best execution rule. A variety of studies also show that trades are often executed at prices superior to the posted quotes, suggesting the possibility that trades executed at the inside quote might have received better execution at an alternative venue; see Peterson and Fialkowski (1994), Bessembinder and Kaufman (1996), and Blume and Goldstein (1996).

Common to each explanation is the importance of transaction cost, whether explicit or implicit. We have already stressed the contribution of cost considerations to theoretical predictions concerning market structure. We now examine explicit and implicit costs, concentrating on commissions and fees, realized bid-ask spreads, and price impact.

Excepting the spread analyses in the previous section, work on transactions costs across trading venues has concentrated on comparisons among the NYSE, Nasdaq, and the various regional exchanges in the U.S.[29] Such studies do not compare costs across intermediated versus non-intermediated venues or traditional versus electronic trading arenas.[30]

We compare transaction costs for trades executed through traditional brokers with those incurred through non-intermediated trading in automated markets. Explicit costs in terms of commissions, as well as implicit costs embodied in the prices at which trades are completed, are considered.

There are two possible levels of interpretation for the results to follow. Cost comparisons are most directly interpretable in terms of intermediated versus non-intermediated trading. There is no ambiguity associated with this particular exercise. On the other hand, the vast majority of trades handled through brokers are executed through the Nasdaq market and on the NYSE or regional floors. To the extent that broker order flow, representing institutional orders in particular, is not directed to automated venues, the comparisons may be interpreted as between automated and traditional trading markets.

6.1. The Data

The data consist of information reflecting the trading activity of a US mutual fund managing approximately $44 billion in equity assets. We refer to this institution hereafter simply as "the Fund." The data are averages of cost components and related variables for trades over six-month periods between 1992 and 1996, as reported by their trading cost consultant, SEI. The data are

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[29] A survey of the transactions cost literature, with a brief review of individual contributions, is provided by Keim and Madhavan (1997b).

[30] Bessembinder and Kaufman (1997) discuss the Cincinnati Stock Exchange, however.

available for 35 "traditional brokers" and four "electronic brokers." The latter include Instinet's continuous order matching system, the Instinet Crossing Network, Posit, and the AZX call auction. Thus we have one continuous auction system, two periodic crossing systems, and one call auction in our electronic broker sample.[31]

We have identified as "electronic" only those brokers which specialize in electronic order execution. Those whose electronic services are exclusively order-routing to exchanges are classified as "traditional brokers." The distinction is somewhat arbitrary for listed stocks. For example, Instinet is often used for order-routing on NYSE issues (through the DOT system), making it similar in function to some other brokers, which we have classified as "traditional." Our categories distinguish, as accurately as allowed by the data, between those brokers which intermediate trades and those which allow buyers and sellers to interact directly, without human intermediation.

For each broker and time period, trades are broken down into those in OTC (i.e., Nasdaq) or exchange-listed issues. Trade direction is identified. When we refer to buy trades, for example, we mean that the Fund initiated the trade as a buyer. The number of trades of each type that enter the six-month averages is known. Information is available on shares per trade, market capitalization of the stock traded, market beta of the stock, daily volatility of stock returns, and average stock price. Data on transactions costs are included in the form of explicit costs (fees) and implicit costs, for each broker and time period. We return to the construction of implicit costs below.

Like some other proprietary data bases, the data come from only a single trading entity. There is potential selection bias in the choice of brokers by time period or market conditions, which cannot be effectively corrected with the limited number of observations and variables available. Similarly, variation in investment style cannot be used as an input to transaction cost benchmarks, as in Keim and Madhavan (1998a), for example. The analysis also is conditional on trade execution; i.e., we exploit no information as to execution

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[31] It has been suggested, especially for the early period of our sample, that AZX is effectively a crossing network, as orders entered into the system are almost invariably priced "passively;" that is, the NYSE closing price typically is used for orders that indeed receive execution

delays or whether an order received execution in the particular venue to which it may have originally be sent.

There are characteristics of this single-institution data which make it very appropriate for our analysis, however. First, the Fund has no "soft commission" arrangements with brokers, as a matter of company policy. In effect, funds that pay soft commissions are paying for non-execution-related services via trade execution fees, complicating the task of measuring their true costs of trade execution. The Fund data are relatively immune from this distortion.[32] Second, the Fund is an exceptionally large-scale user of non-intermediated electronic trading services. The Fund accounts for approximately half the total trading volume going through such systems on the full SEI database, which comprises data from 33 institutional clients. It is one of the few funds in the world for which there are sufficient data to allow valid trading cost comparisons between traditional and electronic trading mechanisms.

Finally, most cross-exchange comparisons are made using trade-by-trade data, while our information is restricted to activities across days. The conceptual cost experiment in the former case is one of immediate turnaround on the next trade.[33] In contrast, the data here compare costs embodied in prices against what would happen if turnaround occurred in one or two days, depending on the measure. Regardless of the reader's preferences with regard to this tradeoff, our approach is the only one feasible. Available trade-by-trade information does not allow discrimination between automated and traditional trading venues or between intermediated versus non-intermediated trades.[34]

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[32] Soft commissions represent payments made directly from client funds to brokers for research and other services, which are effectively embedded in the fees which the fund pays for each trade. Generally, funds which pay soft commissions commit in advance to paying a minimum annual level of commissions to the broker in return for services. The Fund does not commit to minimum volume levels with any broker, to obtain research, information, or trading system services. This does not eliminate the possibility that the company is implicitly securing such services by *de facto* maintaining large volumes with a given broker, but it does mitigate the distortionary effects of explicit soft commissions.

[33] More formally, the cost might include the difference between the actual post-trade value and the value if the investor had been instantaneously able to transact the desired quantity at a net price equal to the fair value of the asset.

[34] For example, in the TAQ database available from the NYSE, trades executed on Instinet are reported as NASD trades, and cannot be separately identified. Trade-by-trade data also force the researcher to infer trade direction, introducing estimation error, while trade direction is unambiguously identified here.

6.2. The Definition of Transaction Costs

The appropriate construction of implicit cost measures is often debated. We have access only to the information provided to the Fund by SEI, and not to the underlying database, however. We must use the implicit cost measures provided by the consultant, as opposed to developing our own. Nevertheless, the available measures correspond to commonly used definitions.

Let V_{it} denote the true economic value of security i at time t, for which some observable proxy must be used in applications. Following Huang and Stoll (1994) and Bessembinder and Kaufman (1997), define

$$\textit{effective half-spread} = 100D_{it}(P_{it} - V_{it})/V_{it}$$

and

$$\textit{realized half-spread} = 100D_{it}(P_{it} - V_{it+n})/V_{it}$$

where P is the transaction price of the security, n is a time increment, and D is a binary variable taking on the value of one for buy orders and negative one for sell orders. The effective half-spread is a measure of the proximity of the trade price to the underlying value. This provides an estimate of the percentage execution cost paid by the trader. It has the advantage of reflecting savings due to trading inside the quoted spread. The realized half-spread is the difference between the effective spread and decreases in asset value following sells and increases in asset value following buys. The latter measure, sometimes called price impact, reflects the market's assessment of private information conveyed by the trade (Bessembinder and Kaufman, 1997). The realized spread may also be interpreted as a measure of the reversal from the trade price to post-trade economic value.

The cost measure supplied by the Fund represents an interpretable combination of these concepts, as well as proxies for the underlying true value of the security. Specifically, setting n=1 day in the definitions above, we define

$$\textit{execution cost} = D^{*}[(\textit{effective half-spread})(\textit{realized half-spread}) - \textit{index return}]$$

where the index return is calculated for the day after the trade, based on a specific industry index appropriate for the particular security under consideration. Effective and realized half-spreads typically are analyzed separately. This permits, for example, the isolation of price impact effects directly through the difference between the two measures. In our case, for small movements in index returns within days, the cost measure is approximately the square of the geometric average of effective and realized spreads.

SEI uses the trading day closing price as a proxy for V_{it}, and the next day closing price as a proxy for V_{it+n}. The product of the two half-spreads is then modified by a measure of the index performance of the relevant industry group with which the stock is associated from trade day until close of the next day. On the buy side, a positive value of the term within the brackets represents favorable execution cost, while the opposite is true on the sell side. For example, suppose this cost is computed for a buy trade as 99 basis points. The impact is favorable: it may be a result of the stock price moving up on trade day and down by more the next, yet not by as much as the composite of stocks in the same industry group. In other words, the stock price performed well after the trade relative to the industry group performance, even though the investor actually lost money on the transaction. Thus, D^{*} now takes on the value of negative one for buy orders and positive one for sell orders. The example above represents a savings of 99 basis points. Finally, we define *total trading cost* to be the sum of execution cost and fees for the trade.

6.3. Average Trading Costs

Cost is reported as percentage of value traded in Table 6-1. Data means are disaggregated into trading categories, differentiating between OTC and exchange-listed shares, and buy versus sell activity. The percentage of dollar volume for all market categories and individual electronic markets is also provided.

On the basis of unconditional average total trading costs, the automated systems outperform the traditional brokers across the board. For listed buys, traditional brokers generate costs 429 percent higher than electronic venues, while for OTC buys the gap is 217 percent. For listed sells, traditional broker costs are only 6.7 percent higher than in the electronic markets, while for OTC sells the difference is 26 percent.

One might reasonably expect cost savings to be larger when disintermediation potential is larger, as it is in the OTC market. The evidence is consistent on the sell side, but not for buy trades here. This intuition is better supported once trading characteristics are taken into account below. The volume data also reflect differences in potential cost savings. Dollar volume directed to electronic markets for OTC trades is over five times that of electronic brokerage in listed issues. Interestingly, most of this variation is for trades using Instinet's continuous market. Relative dollar volumes on the periodic markets differ little and unsystematically between listed and OTC stocks.

Keim and Madhavan (1998b) suggest that crossing systems offer substantially lower fees than commissions charged by traditional brokers, and mention a figure of one to two cents a share. We also observe large differences between traditional brokers and periodic automated systems in terms of fees calculated in percentage terms. Fees for Instinet continuous trading, even in OTC issues, are also substantially lower than those charged by traditional brokers for listed trades. Traditional brokers charge about twice as much as the continuous automated auction.

These preliminary results could be due to the special nature of our single-institution data. The range of the results is generally in accordance with other studies, however. Keim and Madhavan (1998b) report average commissions of approximately 0.20 percent over the 1991-1993 period, which is close to that calculated by Stoll (1995) for 1992. Our data represent trading over more recent periods, and commissions have been falling. For listed stocks traded through traditional brokers, commissions are in the range of 0.13 to 0.17 percent. The ratio of traditional broker commissions to crossing fees should be on the order of 3.73 based on other studies.[35] For listed stocks, we find the ratio to be 3.75 on average. It is more difficult to compare our numbers for execution cost to the half-spreads in the literature, given the different methods of computation. Our geometric average of half-spreads for traditional

[35] This rough calculation is based on Edwards and Wagner (1993), who find average commissions in dollar terms to be about 5.6 cents. Compare this number with 1.5 cents per trade on a crossing network, as suggested by Keim and Madhavan (1997b).

broker trading activity is very close, however, to the effective spreads reported by Bessembinder and Kaufman (1997), for example.

The data also exhibit striking absolute and relative variation in performance across buys and sells. On average, trading cost is much higher for sells than for buys, and the difference is particularly marked for OTC stocks. Keim and Madhavan (1998b) note similar results in other studies. The finding is apparently unrelated to automation effects, and we simply continue to condition our subsequent analysis on buy and sell initiations separately.

6.4. A Benchmark Correction for Trade Difficulty

Execution costs differ with respect to the relative difficulty of making the trade. Trade characteristics matter in assessing costs, making unconditional comparisons less than fully informative. In this section, we construct a benchmark against which other costs may be measured. Although our variables and technique differ somewhat, the exercise follows the regression approach suggested by Keim and Madhavan (1998a). The goal is to judge whether trading costs vary systematically between traditional brokers and electronic markets, controlling jointly for variation in a set of economic characteristics. The general approach is analogous to risk-adjusted return measures in the performance evaluation field.

We estimate a panel data model of the form

$$C_{it} = \alpha_i + \beta' x_{it} + \varepsilon_{it}$$

in which the i's index variation over traditional brokers and electronic markets, and t denotes time. We take C_{it} to be execution cost, and use the full sample to estimate the slope coefficients.[36] The vector of trade characteristics, x_{it}, includes shares per trade (*sh/tr*), market capitalization of the stock (*mktcap*), the market beta of the stock, annualized daily standard deviation of returns for the traded issue (*vol*), and the inverse of the share price (*p*). This list is similar to that used by Bessembinder and Kaufman (1997) and others in the calculation of economic characteristics of trading costs. Execution costs may diminish with firm size, owing to relatively better liquidity and reduced informational asymmetries. Larger trades should be more difficult, hence more costly, possibly due to larger inventory costs in intermediated settings or because of information content. Costs rise with volatility, especially in intermediated venues, given some degree of risk aversion. Trading costs are related to price levels, and the use of the inverse follows Harris (1994).

There are some specific estimation issues to be addressed. The α_i represent individual broker effects. They are treated as fixed, as opposed to random, given potential correlation of the effects with other variables in the model. Our data are unbalanced; i.e., we have different numbers of time series observations for each broker and electronic market. The fixed effects estimator for unbalanced panels discussed in Domowitz, Glen, and Madhavan (1997) is used, with one modification. The estimator is adapted to generalized least squares, given that all data are averages. The number of trades for each broker and for each time period is used in the weighting scheme, an otherwise standard correction for averaged data.

Estimation is based on a cross-section of 39 traditional brokers and electronic markets, and an average of 17 time periods per broker. The cost measure is calculated from the regression estimates as

$$\tilde{C}_{it} = 0.003(sh/tr)_{it} - 0.013(mktcap)_{it} + 0.001(beta)_{it} + 0.009(vol)_{it} + 0.061(p)_{it}.$$

We will refer to $\tilde{C}_{it}$ as *benchmark cost*.[37] Unlike Bessembinder and Kaufman (1997), we do not use estimated fixed effects as a measure of cost differences after adjusting for economic heterogeneity in trades.[38] Instead, we compare the benchmark to actual execution cost. Realized cost embodies any broker-specific attributes which may increase or decrease cost relative to that predicted by trade characteristics alone.

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[36] Qualitative results using total cost measures are very similar and not reported. One could also use different regressions for different categories of trades, e.g., for OTC versus exchange listed issues and/or buys versus sells. Sample size and selection considerations make such estimates unstable, however.

[37] Since we are not interested in inference with respect to coefficient estimates, standard errors are omitted. They are generally small, with the exception of the coefficient on inverse price, and the regression R-square is 0.09.

6.5. Execution Costs Relative to Benchmark Costs

Median execution costs (i.e., excluding commissions) and benchmark costs for overall market activity are reported in Panel A of Table 6-2. The electronic systems are handling easier trades at lower cost. Execution cost is 20 percent higher for traditional brokers relative to their electronic counterparts. On the other hand, benchmark costs in the electronic venue are about 22 percent less than those predicted for traditional brokers, indicating less difficult trades.

We differentiate between OTC and listed trades in Panel B. For OTC stocks, differences in trade difficulty, as measured by the benchmark, are small, but the transactions are done much more cheaply electronically. Execution cost for traditional brokers in OTC transactions is 89 percent higher than for electronic systems, while the benchmark cost difference is only 29 percent.

For listed stocks, the situation is reversed: trades done electronically look extremely easy according to the benchmark, but trading costs are only slightly less than those incurred by traditional brokers. Realized costs are only 13 percent higher for traditional brokers, while the benchmark is 173 percent larger, relative to electronic venues.

Benchmark costs are higher for sell trades than for buys. This observation provides one explanation for the cost asymmetry between buy and sell transactions. Sells appear to be done under more difficult conditions, on average.[39] On the other hand, percentage differences between the realized costs of buy and sell transactions, holding type of broker constant, exceed those observed for the benchmark costs. Thus, market conditions alone cannot explain the disparity between costs on the two sides of the market, regardless of type of broker.

In Table 6-3, we report the median ratio of execution costs to the benchmark by type of trade. We interpret this measure as cost relative to the difficulty of the trade. A ratio greater than one indicates costs in excess of those expected based on trade characteristics. Conversely, ratios less than one

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[38] The conditioning set is incorrect for this interpretation, given our econometric method. Bessembinder and Kaufman (1997) transform their variables somewhat differently.

suggest that the trades are done more cheaply than would have been suggested by their relative difficulty.

For OTC stocks, the electronic systems are handling easier trades, but much more cheaply than traditional brokers, relative to trade difficulty. The traditional brokers' ratio is 50 percent larger than that observed for electronic systems. A breakdown of OTC trades into buy and sell transactions reveals superior performance of electronic systems in both cases, but much of the relative advantage is on the buy side.

For listed issues, however, it appears that traditional brokers outperform the electronic systems. Traditional brokers exhibit a cost ratio close to one, while the figure for electronic systems is just over two. Relatively lower cost compared to the benchmark characterizes traditional brokers' operations, regardless of whether the transaction is on the buy or sell side.

The contrast between the results for trades in OTC and listed shares might not be surprising. The potential for cost savings through disintermediation via the electronic systems is greater for OTC trades than for those in listed shares that already take place in an auction environment. The complete reversal of results based on the ratio of execution costs to the benchmark for listed trades is more surprising, given the remainder of the evidence. We investigate this point further in the context of individual trade characteristics.

6.6. Trade Characteristics and Total Trading Costs

As we have discussed, trades executed through traditional brokers appear in the aggregate to be more costly than trades done electronically. Transactions on electronic systems are easier trades with lower expected cost. Differences in trade difficulty account for some, but not all, of the electronic markets' cost advantage, however.

Excluding commission costs from our analysis, the superior performance of electronic markets is only evident for OTC stocks. For OTC trades,

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[39] This is consistent with Keim and Madhavan (1997b), who attribute larger costs to larger sizes on the sell side.

traditional brokers incur costs that are 34 percent higher than expected, given market conditions, while trades on the electronic systems are over 10 percent less than would be predicted. Benchmark costs for OTC trades are over double those for listed issues, suggesting that electronic markets do well for more difficult trades. For listed trades, however, electronic markets appear to fare much less well vis-à-vis traditional brokers. Based on the ratio of execution cost to the benchmark, electronic markets do poorly relative to expectations, and relative to the performance of traditional brokers. We now attempt to shed some further light on these results by extending our analysis to total trading costs (i.e., including commissions) and more disaggregated comparison data.

In Tables 6-4 through 6-6, total costs are sorted by values of several trade characteristics, including benchmark execution cost. The figures are constructed in the following manner. For a trading category (listed or OTC), the median value of a trade characteristic (e.g., shares/trade) is calculated. Observations for a type of broker (traditional or electronic) are classified as being above or below this median value. For observations on either side of the median, average total trading cost is calculated.[40]

Costs by trade characteristic for OTC trades are contained in Table 6-4. Electronic OTC trading costs are lower than those for traditional brokers, regardless of the size of the trade, market capitalization, or average share price. Electronic trade execution is also less costly for trades with volatility and expected cost above median values. These results support findings based on execution cost: in the OTC market, and for relatively more difficult trades, the electronic markets outperform the traditional brokers. Figures reported in Table 6-5, disaggregating OTC trades into buy and sell activity, yield the same basic conclusion. Electronic brokers tend to dominate across all categories on the sell side, which we have documented as representing more difficult market conditions in this sample.

In the case of listed issues, our results suggest that large savings in explicit trading costs from electronic executions outweigh possible gains in

[40] In Table 4-4, for example, average total cost for traditional brokers doing OTC trades in stocks whose market capitalization is below the median for all OTC trades in the sample is 0.919. The corresponding value for trades in stocks with above-median capitalization is 0.558 for traditional brokers, and 0.546 for electronic venues.

implicit costs from trading via traditional brokers. We earlier reported an execution cost to benchmark ratio for traditional brokers that is 55 percent below that for the electronic markets. On the other hand, for benchmark execution costs above the median, *total* costs for traditional brokers are 62 percent above those in electronic markets. The difference between findings stems from commissions charged by traditional brokers, that are over 100 percent more than fees charged by electronic markets.

We also note that for listed stocks, the electronic brokers exhibit lower total costs for high volatility trades, for small sizes, all price ranges, and low market capitalization. Given such results, the apparent superiority of traditional brokers based specifically on the ratio of execution cost to the benchmark stands out as an exception. We now suggest that there are simply some ambiguities in the data that obscure the basic finding that electronic systems constitute the less costly trading technology.

We disaggregate listed activity into buys and sells in Table 6-6, and several significant findings emerge. First, all electronic trading in this sample of listed stocks is done for trade sizes below the overall median (conditional on whether the trade is a buy or a sell). This implies that benchmark execution cost is lower relative to sample averages for electronic systems, raising the ratio of execution costs to the benchmark for electronic markets.[41] Second, average costs for traditional brokers fall for large trades relative to small trades. The expected relation between price impact and order size may be reversed by upstairs-facilitated block trades in listed stocks.[42] Yet, the benchmark cost regression indicates that for the full sample - including electronic markets, traditional brokers, and OTC as well as listed stocks - cost increases with size. Benchmark costs for traditional brokers in listed issues rise as size increases; actual execution costs fall due to block facilitation; and the ratio of execution cost to the benchmark declines.

Thus, the execution cost results for listed stocks, favorable to traditional brokers, are due to a combination of sample selection problems and a bias in

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[41] This is another way of expressing a result of the potential sample selection bias noted earlier.

[42] See Madhavan and Cheng (1995), Leinweber (1995), and Keim and Madhavan (1996), who also document similar findings to our own in this respect.

the benchmark calculations due to unobserved upstairs activity. This conclusion is supported by other information in Table 6-6. Consider buy transactions in particular. Total trading costs are lower for automated systems for small trade sizes, and all levels of market capitalization, volatility, price level, and benchmark cost.

Owing to the complications involved in handling the listed trade data, we would state our conclusions as follows. In the US OTC markets, trading via electronic systems would appear to offer significant cost savings over trading via traditional brokers, even after adjusting for trade difficulty. Whereas considerably more ambiguities are present in the listed stock trading data, the results of the extension of our analysis to encompass total trading costs and more informative disaggregated data would justify a similar conclusion in that market.

7. Summary and Conclusions

The classical financial market microstructure literature models exchanges as hierarchies of trading rules which determine the parameters within which heterogeneously endowed traders strategically interact. The explicit transaction costs which traders bear are presumed to be unaffected by the technology, operating costs, or organizational structure of the exchange. Even such issues as competition between exchanges are assumed to be governed by trader behavior and composition. As such, the literature has little to say about the most important developments in the trading services industry today; namely, the impact of advances in computer and telecommunications technology on the cost of trading and the development of market structure. In this paper, we address these issues directly by focusing on the characteristics of exchange trading products, rather than concentrating on the characteristics of traders.

We argue that exchanges operating in a competitive environment should be analyzed as firms offering trading products which embody particular technologies. The "liquidity effect," to which is commonly ascribed the durability of the dominant national exchanges, derives from the salience of network externalities in the securities trading industry. Issues of trading technology adoption require analysis in the framework of network models of industrial organization. Such models serve to illuminate increasingly prominent features of exchange competition and market structure development.

Assuming roughly equivalent product quality as between incumbent (floor auctions) and entrant (computerized auctions), an assumption whose applicability we document, new technology adoption in the face of network externalities requires clear cost advantages for the entrant. Cost therefore features as the centerpiece of our quantitative study of electronic versus intermediated trading. Yet the diffusion of new trading technology involves more complex processes. Our review of recent competitive developments in the trading industry appears to reinforce the fundamental role of the network effects postulated by this branch of industrial organization theory. First-mover advantages exist, but are being eroded by relative cost movements and strategic pricing behavior. The role of technology "sponsorship" appears to be important in abetting successful entry. We observe sudden and rapid adoption of the entrant's trading technology once apparently small advantages have been achieved ("tipping"). The spread of external "adapter" systems, such as Instinet, that integrate incompatible networks, is further predicted by the theory. Finally, we examine the emergence of mergers and "cartels" among automated system operators, a development which may be socially optimal given the underlying tenets of network economics.

We discuss the role of cost in the pricing of exchange trading services in the context of increasing market contestability. Several factors bring the market for trading services much more closely into line with the assumptions of perfect contestability. These include a massive decline in automated system development costs, the elimination of "distance costs" in the provision of cross-border electronic trading services, and the expansion of securitized products. As cross subsidization of products is inconsistent with sustainability of prices in a contestable market, this has important implications for the way in which exchanges price different types of trading. Among US and European exchanges, we document salient examples of such cross subsidization, such as large trades by small trades, "on-exchange" trades by "off-exchange" trades, and retail trades by institutional trades. We demonstrate how trading automation greatly facilitates specialization of service provision and, as a consequence, serves to arbitrage away cross subsidies. We expect this trend to intensify. For example, limit order traders benefit from exchange "interaction rules" obliging block traders to execute their orders. As automation increasingly facilitates the incursion of competitor block trading services, and thereby eliminates this subsidy for limit order traders, exchanges may be compelled not merely to eliminate fees for such traders (as Tradepoint has already done) but actually to *pay* them.

The behavior of exchanges is conditioned not merely by the competitive environment, but by the incentive structure deriving from their internal governance arrangements. The traditional mutual structure of an exchange is a remnant of the pre-automation era, when the space limitations inherent to trading floors necessitated the rationing of direct access to members. As members then became intermediaries for all non-member order flow, exchange behavior came to be partly directed by the interests of members in maintaining intermediation profits. As trading automation has facilitated unlimited direct access, it is logical that new automated entrants have chosen not to be governed as intermediary cooperatives, but rather as for-profit joint-stock companies selling execution services on a transaction basis. Member-based exchanges are increasingly trying to replicate the incentive structures of such companies by demutualizing, or divorcing ownership from membership. The historical record of such initiatives is short, but the Stockholm experience in particular would appear to indicate that innovations such as foreign remote membership and direct investor access are more easily implemented when intermediaries are minority owners, and that demutualization may therefore serve to improve the performance of the exchange as a commercial enterprise.

As commercial enterprises, exchanges compete on the basis of the "market quality" which they offer as well as the cost of their trading services. In this regard, the focus of academic research has long been on measures of market quality, whereas it is our contention that a true understanding of trading technology adoption and market structure development can now be achieved only by moving the focus to cost. This conclusion stems from an examination of extant empirical evidence comparing traditional trading venues to automated price-discovery systems. Market quality is assessed using a combination of information relating to liquidity, informational efficiency, and volatility characteristics. Overall, the evidence suggests that automated markets and traditional trading floors may differ in subtle and complex ways, but that market quality is equalized across market structures.

If this is the case, measuring the actual cost of trading across traditional intermediated markets and automated non-intermediated markets becomes an important exercise. Despite the many recent transformations from floor and dealer markets to automated auction markets which we have documented, the structures still coexist in many parts of the world. Lower development and operational costs for automated structures will undoubtedly influence competitive developments, but it is the explicit and implicit (execution) costs borne by traders in each type of market which is ultimately likely to be determinant. We evaluate explicit and implicit costs using a unique sample of five-year trading data from a large institutional user of proprietary electronic trading systems.

Both categories of cost are lower for electronic systems than for traditional brokers across OTC (Nasdaq) and US exchange-listed stocks. To account for differences in trade difficulty across electronic markets and traditional brokers, we construct a benchmark measure of execution cost, based on trade characteristics. Analysis of execution costs, net of commissions, suggests that trades on the electronic systems are easier trades, with lower expected cost. However, we also find that electronic markets are generally less costly than traditional brokers for more difficult trades.

For OTC stocks, electronic markets dominate traditional brokers across the board. For listed stocks, our conclusions are similar but more nuanced. The ratio of execution cost to benchmark cost is generally superior for traditionals, but this statistic is not informative for listeds, owing to a number of features of the data which we detail in the text. An examination of total trading costs, inclusive of commissions, reveals electronic trading to be superior to traditional brokerage by any measure of trade difficulty for buy trades, and comparable for sells. We therefore conclude that electronic trading generally yields considerable cost savings over traditional trade intermediation.

We have tried to demonstrate in this paper the enormous impact that advances in computer and telecommunications technology have had both on trading costs and on the natural industrial structure of the securities trading industry. The implications are far-reaching in terms of market structure development and effective public policy. In particular, exchanges are now compelled to compete in an increasingly international market for trading services, and can no longer be seen as static repositories for rules governing the transfer of ownership of securities. In our view, researchers, regulators, and traders would benefit from taking an industrial economics approach in trying to understand and react to this new market environment.

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Table 2-1

Transformations to Automated Auction Trading: 1997-1998

Athens Stock Exchange

Chicago Board of Trade

Chicago Mercantile Exchange

International Securities Market Association

Liffe

London Stock Exchange

Matif

Monep

NASD (OptiMark equity trading)

Osaka Securities Exchange

Pacific Stock Exchange (OptiMark equity trading)

SIMEX

Sydney Futures Exchange

Tokyo Stock Exchange

Toronto Futures Exchange

Toronto Stock Exchange

Table 2-2

Automated Exchange Mergers and Alliances: 1997-1998

Exchange Mergers	
AEX: Amsterdam Stock Exchange-EOE	I
HEX: Helsinki Stock Exchange-SOM	I
BEX: Brussels Stock Exchange-BELFOX	I
Stockholm Exchanges: Stockholm-OM	I
Vienna-OTOB	I
Paris-Monep	I
Paris-Matif	I
Eurex: DTB-SOFFEX	I
NYBOT: NY coffee & cotton exchanges	I
Matif-MEFF	N
Common Trading System	
Oslo-OM	I
Deutsche Börse-Vienna	A
IPE-Nord Pool	A
Norex: Stockholm-Copenhagen	A
Eurex-CBOT	A
Eurex-HEX	A
Norex-Helsinki/Oslo/Reykjavik	N
LSE-Deutsche Börse	N
Common Access System	
Euro NM	A
Euro Alliance: Eurex-Matif	A
Matif-MEFF	A
Benelux	N
Strategic Alliance / Joint Venture	
CFFE: Cantor Fitzgerald-NYBOT	I
CBB: CBOT-Prebon Yamane	A
CME-Matif	A
CME-Cantor Fitzgerald	N
IPE-NYMEX	N

Key: I = implemented A = agreed N = being negotiated

Table 4-1

Exchange Demutualizations

Stockholm Stock Exchange (1993)
Helsinki Stock Exchange (1995)
Copenhagen Stock Exchange (1996)
Amsterdam Exchanges (1997)
Borsa Italiana (1997)
Australian Stock Exchange (1998)

Table 5-1

Implicit Trading Cost Studies for Automated Markets

Study	*Automated Market*	*Traditional Market*	*Instruments*
Coppejans and Domowitz (1997)	Globex	CME floor	futures
de Jong, *et al* (1995)	Paris CAC	SEAQ-I	stocks
Franke and Hess (1995)	DTB	LIFFE	Bund future
Grunbichler *et al* (1994)	DTB	FSE	Dax future
Kaufman and Moser (1995)	DTB	LIFFE	Bund future
Pagano and Roell (1990)	Paris CAC	SEAQ-I	stocks
Pirrong (1995)	DTB	LIFFE	Bund future
Sandmann and Vila (1996)	Osaka SE	SIMEX	Nikkei future
Schmidt and Iversen (1992)	IBIS II	SEAQ-I	stocks
Shah and Thomas (1996)	BOLT/NSE	Bombay SE	stocks
Vila and Sandmann (1996)	Osaka SE	SIMEX	Nikkei future

Table 6-1

Average Total Trading Costs

Panel A: *OTC Buy Trades*

	Total cost	Fees	Percentage of $ volume
All brokers	0.22	0.04	100
Traditional	0.38	0.00	38.5
All Electronic	0.12	0.06	61.5
Crossing/call	0.15	0.05	6.08
Instinet	-0.23	0.03	1.98
Posit	0.25	0.06	3.52
AZX	0.83	0.04	0.58
Instinet cts.	0.11	0.07	55.4

Panel B: *OTC Sell Trades*

	Total cost	Fees	Percentage of $ volume
All brokers	1.37	0.05	100
Traditional	1.60	0.00	30.9
All Electronic	1.27	0.07	69.1
Crossing/call	0.73	0.06	7.68
Instinet	0.61	0.04	2.47
Posit	0.83	0.07	4.45
AZX	0.52	0.04	0.76
Instinet cts.	1.33	0.08	61.5

Panel C: *Listed Buy Trades*

	Total cost	Fees	Percentage of $ volume
All brokers	0.33	0.12	100
Traditional	0.37	0.13	88.6
All Electronic	0.07	0.05	11.4
Crossing/call	0.09	0.04	7.38
Instinet	0.21	0.03	2.55
Posit	-0.04	0.05	3.93
AZX	0.25	0.03	0.90
Instinet cts.	0.05	0.07	3.99

Panel D: *Listed Sell Trades*

	Total cost	Fees	Percentage of $ volume
All brokers	0.47	0.16	100
Traditional	0.48	0.17	88.3
All Electronic	0.45	0.06	11.7
Crossing/call	0.33	0.04	6.63
Instinet	0.20	0.04	2.50
Posit	0.42	0.05	2.86
AZX	0.39	0.03	1.27
Instinet cts.	0.61	0.08	5.10

Table 6-2

Realized and Benchmark Median Execution Costs

Panel A: *Overall Market Activity*

		All Brokers	Traditional	Electronic
Execution cost		0.310	0.325	0.270
Benchmark cost		0.349	0.355	0.278

Panel B: *OTC versus Listed*

		All Brokers	Traditional	Electronic
Execution cost				
	OTC	0.520	0.660	0.350
	Listed	0.220	0.220	0.195
Benchmark cost				
	OTC	0.502	0.528	0.409
	Listed	0.241	0.270	0.099

Panel C: *Buy versus Sell*

		All Brokers	Traditional	Electronic
Execution cost				
	Buy	0.175	0.220	0.105
	Sell	0.520	0.480	0.555
Benchmark cost				
	Buy	0.331	0.335	0.264
	Sell	0.363	0.370	0.323

Table 6-3

Median Ratio of Realized to Benchmark Execution Cost by Category

	Traditional	Electronic
OTC	1.343	0.895
Listed	0.913	2.066
Buy	0.654	0.171
Sell	1.548	2.158
OTC Buys	0.531	0.043
Listed Buys	0.807	1.085
OTC Sells	2.558	1.864
Listed Sells	1.086	3.027

Table 6-4

Trading Costs Sorted by Market Conditions

Panel A: *Trading Costs for OTC Shares*

	Below median		Above median	
	traditional	electronic	traditional	electronic
Shares/trade	0.543	0.452	0.967	0.825
Market cap	0.919	0.150	0.558	0.546
Beta	0.381	0.459	1.292	0.598
Volatility	0.324	0.508	1.181	0.595
Inverse price	0.502	0.461	1.016	0.714
Benchmark cost	0.386	0.524	1.053	0.649

Panel B: *Trading Costs for Listed Shares*

	Below median		Above median	
	traditional	electronic	traditional	electronic
Shares/trade	0.475	0.255	0.307	0.815
Market cap	0.506	0.291	0.231	0.263
Beta	0.241	0.179	0.522	0.341
Volatility	0.232	0.286	0.529	0.262
Inverse price	0.364	0.210	0.391	0.312
Benchmark cost	0.239	0.271	0.478	0.295

Table 6-5

OTC Trading Costs Sorted by Market Conditions

Panel A: *Trading Costs for Buys*

	Below median		Above median	
	traditional	electronic	traditional	electronic
Shares/trade	0.255	0.293	0.017	0.051
Market cap	0.285	0.005	-0.137	0.254
Beta	-0.264	0.511	0.587	0.041
Volatility	-0.102	0.351	0.330	0.082
Inverse price	0.193	0.268	0.059	0.176
Benchmark cost	0.060	0.253	0.165	0.158

Panel B: *Trading Costs for Sells*

	Below median		Above median	
	traditional	electronic	traditional	electronic
Shares/trade	1.156	0.622	1.689	1.452
Market cap	1.399	-------	1.558	0.823
Beta	1.104	0.700	1.984	0.893
Volatility	0.834	0.660	1.970	1.198
Inverse price	0.996	0.894	1.824	0.633
Benchmark cost	0.877	0.832	1.849	0.755

Table 6-6

Listed Trading Costs Sorted by Market Conditions

Panel A: *Trading Costs for Buys*

	Below median		Above median	
	traditional	electronic	traditional	electronic
Shares/trade	0.401	0.125	0.260	-------[a]
Market cap	0.472	0.106	0.149	0.137
Beta	0.061	0.018	0.601	0.207
Volatility	0.235	0.202	0.400	0.031
Inverse price	0.431	0.141	0.203	0.109
Benchmark cost	0.267	0.163	0.357	-0.227

[a] no observations within cell

Panel B: *Trading Costs for Sells*

	Below median		Above median	
	traditional	electronic	traditional	electronic
Shares/trade	0.494	0.396	0.391	------[a]
Market cap	0.537	0.445	0.315	0.396
Beta	0.419	0.337	0.451	0.459
Volatility	0.235	0.375	0.649	0.435
Inverse price	0.336	0.530	0.531	0.285
Benchmark cost	0.184	0.392	0.614	0.715

[a] no observations within cell