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ABSTRACT

Two alternative trading mechanisms for securities markets are compared using laboratory experimentation and computer simulation. One mechanism is the floor-based specialist auction in place in most U.S. stock exchanges today, and the other is an electronic alternative employing automatic order matching. We conclude that transition from the established floor-based exchanges to potentially superior electronic alternatives is possible, despite the inertia resulting from the experience of benefits investors trading in active markets, and that current proposals for electronic markets are not demonstrably superior on generally accepted criteria used to assess market quality.

This has clear implications for established stock exchanges, market regulators, and vendors of electronic trading systems.

1. INTRODUCTION

1.1 Overview of the Paper

There is considerable confusion concerning the potential impact of electronic alternatives to traditional, established, floor-based stock markets, such as the New York Stock Exchange (NYSE). There are unresolved research issues in finance about which market mechanism is superior (Beja and Hakansson 1979; Cohen et al. 1986).[1] Information technology creates a range of new possibilities for the organization of securities trading (Garbade and Silber 1978; Schwartz 1988), yet research techniques are not fully developed for identifying the consequences of implementing such major information systems. A worrisome possibility exists that a new electronic market may be preferable and socially desirable, but that no feasible transition path exists from the entrenched market to this alternative; in this case, regulation may be needed to effect a transition from one trading arena to another. These are issues with considerable significance to regulators, securities markets, and financial services firms. Through experimental economics and detailed computer simulation, we resolve some of these research issues. Equally important, the techniques developed are applicable to evaluating a wide range of strategic systems, with uncertain adoption, and thus uncertain benefits.

1.2 The Problem

There has been an ongoing debate for over a decade concerning the relative merits of floor-based exchanges compared to high technology disintermediated order matching systems. The principal proponent of the traditional trading floor has been the US, where the best known example is the NYSE. Electronic enhancements to existing markets were pioneered in the United States in the over-the-counter market's NASDAQ system. The most prevalent form of electronic trading, automatic order matching (described below), was pioneered in the Toronto Stock Exchange, in their CATS (Computer Assisted Trading System), and variants are currently employed in the Tokyo Stock Exchange, the Paris Bourse, and numerous exchanges and bourses throughout Europe.

Customers may submit either ***limit orders***, requests to buy or sell a specified quantity at a specified price, or ***market orders***, requests to buy or sell a specified quantity immediately at the best price currently available in the market. Limit orders are placed in a ***limit order book*** in price and time priority – the higher the ***bid price*** the customer is willing to pay to buy, the higher the order's priority in the book, and the lower the ***ask price*** the customer demands for his shares, the higher the order's priority; equal bids and equal asks are put in FIFO order. Market orders to buy will execute against the best ask in the book; market orders to sell will execute against the best bid in the book. Limit orders will attempt to match orders already in the book: if an investor is willing to bid at a price equal to or higher than the best ask, the two orders will execute at the ask price, and if an investor is asking a price lower than or equal to the best bid, the orders will execute at the bid price; otherwise the new limit order is added to the book.

Specialist Markets: US style stock exchanges feature a ***specialist***, a market-maker on the floor of the exchange charged with making a fair and orderly market in an individual stock. The specialist provides his own quotes at all times, which may or may not be the best bid and offer on the book; at times there may be no customer bids or offers, but the specialist must always have his own quotes in the book. A key aspect of the specialist's role is ***affirmative obligation***; that is, the specialist ***must buy*** stocks when there are no customer orders to buy and ***must sell*** when there are no customer orders to sell. When doing so, the specialist both stabilizes price changes in the market and provides ***immediacy*** to customers; market order customers are assured that they will be able to buy or sell without waiting for other customers' orders to arrive.

Automatic Order Matching Systems: A market based on fully automatic order matching has no specialists, and no party with affirmative obligation. Securities firms, trading for customers and for their own accounts, enter orders into an electronic dealing system, where they are usually displayed on trading screens; orders to buy or sell at an attractive price may well be expected to attract additional offers to trade against them. Orders to buy and sell match if they are for the same price, and in these systems orders transact only against other orders. Despite the prevalence of manual trading in major stock markets, there appear to be several advantages to automated trading. Screen-based trading systems can become 24-hour global markets. There is no specialist acting as intermediary, buying customers' shares to resell to other customers, and thus no need for investors to pay specialist commissions or to bear the difference between the specialists' buying and selling prices. Systems such as Instinet charge one cent per share commission, compared to about ten cents per share for trades executed on the NYSE. In addition, there are surveillance and regulatory advantages to trading systems that provide an electronic audit trail.

The question of whether to move from specialist markets to automatic trading systems is hotly debated.[2] There is an emotional issue of *privilege and fairness* – the specialist has preferred access to information about orders in the book, which enables him to trade more intelligently; since the specialist sees the entire book, and traders off the floor do not, the specialist can sense when buy or sell pressure is building, and can exploit this information when setting his quotes. This preferred access is a form of compensation for his affirmative obligation. Some parties have seen preferred access to order flow information as providing an unjustified trading advantage. Of more fundamental importance than the emotional issue should be a matter of *economic efficiency* or *social welfare*: is the specialist worth his cost? Is the service provided sufficiently valuable to justify the specialists' trading profits and commissions?

1.3 The Research Issues

Our research has addressed two hypotheses:

H1: A transition from a floor-based specialist market to an automatic order matching system is *feasible*.

H2: Automatic order matching systems are *preferable* to specialist markets.

Traders who take their orders to a new, less active, and less ***liquid***[3] market face economic penalties. The first is uncertain execution: in the absence of significant order flow, it is uncertain when their orders will actually execute. Additionally, they face a ***liquidity penalty***: attempts to sell in an inactive market will naturally create an imbalance, depressing the price and damaging the attempted seller, and attempts to buy will create an imbalance and raise the price. This advantage of established markets is called the ***liquidity trap*** or ***central market defense***, and explains why, in general, order flow attracts order flow (Cohen et al. 1986). Liquidity is the single most important criterion market professionals cite when selecting among alternative markets for an instrument (Cohen and Schwartz 1988). Traders thus face a coordination game: even if the trading mechanism of the new market is more attractive than the established market, it may be difficult to induce enough traders to switch. The reduction in service cost in the new market may not be sufficient to compensate early adopters for the penalties of inferior execution caused by the liquidity penalty.

Independent of whether transition is possible, it remains to be established whether automatic order matching systems truly offer customers superior execution. This will enable us to consider whether adoption of these systems is desirable. Standard measures of market quality employed in the finance literature will be used (e.g., Cohen and Schwartz 1988).[4]

1.4 Significance of the Research

This work is significant to various stakeholders, including exchanges regulators, and trading systems developers. It suggests strategies that developers can use to capture market share from established exchanges, and defenses with which these exchanges can counter.

The relative merits of traditional markets and electronic alternatives remains a complex unresolved issue in finance. There have been numerous suggestions for disintermediated electronic markets (Amihud and Mendelson 1988; Amihud, Ho and Schwartz 1985; Black 1971; Peake, Mendelson and Williams 1989). Since the desirability of these markets has not been established analytically, there have been suggestions for parallel operation, allowing investors to decide through their selection of markets for their orders which market will become more liquid (Amihud and Mendelson 1988; Amihud, Ho and Schwartz 1985; Black 1971). Questions of transition among markets, involving dynamic behavior rather than equilibrium analysis, have proven quite intractable to traditional analytical tools of finance research.

It is the contribution to MIS research, especially to evaluating the potential impact of proposed strategic systems, that originally attracted us to this research. There is evidence that executives struggle to make technology investment decisions, particularly when the evaluation requires determining the impact of an innovative and potentially strategic application of information technology (Clemons 1991; Clemons and Weber 1990b; Pool 1983). It is difficult to estimate the future benefits of strategic systems, when there is great uncertainty in marketplace response, and when the benefits are largely determined by this response. There are natural extensions to evaluating impact of, and marketplace response to, more complex systems operating in less stylized markets.

2. EXPERIMENTAL METHODOLOGIES

Recently, laboratory experiments have become recognized as a useful, valid way to test economic behavior and theories (Smith 1982). Data from real markets may be influenced by a range of seen and unseen factors that do not allow the direct testing of traders' choices among markets for their orders. Analytic models of trader choice, when there are transactions costs and multiple markets are available, do not lead to a unique prediction of traders' behavior. Multiple outcomes may each represent stable equilibria (Economides and Siow 1988; Pagano 1989). We can determine experimentally which of the available equilibria is most likely to occur, and can thereby gain insight into the dynamics of trading volume transitions among competing markets.

We use simulation to extend analytical work done by Demsetz (1968), Ho and Macris (1985), Mendelson (1987), and others, examining the relative performance of different market structures. In previous analytical research, derivations of market differences are kept tractable by making several restrictive assumptions. The results provide significant insight into the determinants of market quality for the market structures examined, but often abstract away the specific details that we are attempting to examine. For example, in actual markets the specialist faces competition from the limit orders of public investors, and a simulation that examines the performance of market-makers without competition from investors will not enable us to determine the actual cost to investors implicit in this competition. Simulation has yielded useful results in market microstructure research, in particular for examining phenomena for which tractable analytical modeling is not yet possible. We use simulation modeling to accommodate a wide range of assumptions and to retain details of actual market mechanisms that may strongly influence their transactional characteristics and performance.

3. AN EXPERIMENTAL TEST OF MARKET TRANSITIONS

The principal question we address in the experiments is *can the cost advantages of an alternative trading mechanism be sufficient to overcome the strategic uncertainty about liquidity in a new market?* Unless a computerized trading mechanism can attract sufficient trading volume, it will remain unattractive to traders. This appears to have been a problem with many automated trading mechanisms. As Schwartz (1988) noted, "major traders in the equity markets are reluctant to enter orders in a computerized market system." Ariel, Autex, NSTS/Cincinnati, and Intex are examples of computerized trading systems that failed to have the expected impact[5] (Schwartz 1988). In other cases, transitions to a new trading market have succeeded: Eurobonds moved from NYC to London in 1963 and Swedish share trading moved to London after 1986.[6]

Because the greatest uncertainty in evaluating the adoption of electronic trading alternatives comes from attempting to predict the responses of market participants, we create a laboratory experiment to examine their choices of markets for their orders. In these experiments, subjects' trading decisions determine the liquidity of two alternative markets and hence the prices at which trades occur. Initially, one market is made more attractive than the other, allowing it to capture a majority of trading volume. At the experiment's mid-point, the less liquid market is given cost advantages similar to those evident for electronic trading. Development of liquidity in the new, now advantageous market, if it occurs, will be the result of traders' choices, which will in turn depend on traders expectations for the liquidity of the new trading alternative.

3.1 Experimental Design

The reward structure for experimental subjects reflects gains from coordination and the possibility of lower profits, or even losses, from adverse order imbalances and market illiquidity.[7] In the two markets, supply and demand are created endogenously, based on the subjects' submission of orders. Subjects have either an order to buy or an order to sell a certain number of shares in each period. Subjects divide orders across the two markets as he or she feels is best. After orders have been submitted, traders' earnings are based on the balance of buying and selling interest in each market, and on the size of each market.[8] The best outcome is for all traders to direct their orders to same market, and when the trading costs differ in the two markets, to trade in the market with the lower cost.

The experiment had two parts. In Part 1, traders divided their orders across two markets with the same earnings functions. Orders submitted to Market X were assured execution and had profits and losses determined, based on orders actually submitted, according to the function given below. Market Y, however, was characterized by uncertain execution similar to that encountered in a direct search market, in which buyers and sellers must attempt to locate each other. In Part 1, after subjects made their trading choices, a stochastic element was introduced. The results of a random event determined whether or not trading occurred in Market Y. If trading occurred, then profits were calculated normally; if trading did not occur, then subjects earned no profits on orders submitted to Market Y. In all experiments, by the end of Part 1, Market X emerged as the dominant, more liquid market.

In Part 2 of the experiment, advantageous technological improvements were ascribed to Market Y, which as a result was now able to offer assured execution and to impose lower transactions costs. Traders were still permitted to divide their orders among markets.

Payoffs for market participants are determined as follows: First D is calculated for each market, where D is the absolute value of the share imbalance, the difference between orders submitted to buy and orders submitted to sell in each market. Traders on the stronger side of the market (i.e., buyers when there are more buy orders than sell orders in the market, or sellers when there are more sell orders than buys) are rewarded according to the following payoff function:

Strong-Side Profit per Share =
10¢ - (K_{strong} * D) / Total Share Orders Submitted

Traders on the weaker side of the market instead receive:

Weak-Side Profit per Share =
10¢ + (K_{weak} * D) / Total Share Orders Submitted

K_{strong} and K_{weak} are coefficients (in units of cents) that relate profits to the ratio of market imbalance divided by the size of the market. In the experiment, K_{strong} was set higher than K_{weak}. That is, the penalty for trading in the illiquid market, when there were few orders against which your order could trade, was greater than the rewards for trading in the illiquid market when there were few orders to compete with yours.[9] To compute the payoff in the technologically improved Market Y in Part 2 it is necessary only to add a small amount to the payoff function defined for Part 1, reflecting the reduced transactions costs of the improved market. In some replications of the experiment, four cents were added, increasing expected earning by 40% for equivalent order submissions, to see how traders responded to a large relative cost savings; in other replications, 1¢ was added, increasing expected earnings by 10%.

3.2 Experimental Procedures

Experimental participants were volunteers recruited from undergraduate classes in management, decision science, and finance at the University of Pennsylvania. Eight subjects were assigned in equal numbers to be buyers or sellers. Instructions were read aloud and subjects worked through two trading examples that demonstrated their understanding of the choices open to them and of their payoff functions. Profits per round ranged from a fifty cent loss to a $1.50 gain, and experimental subjects each earned between $12.00 and $24.00 during the two hour experiment. An additional experiment was conducted using senior traders from New York Stock Exchange specialist firms, one morning before the Open, to determine if the behavior of our student experimental subjects was consistent with that of experienced market professionals. The experimental outcomes were similar.

There are three competing predictions of the outcome of the trader choices among different competing markets. First, if trades attract trades, we expect the established market to remain dominant. Second, symmetric rational expectations[10] predict immediate transition to the more advantageous market (Muth 1961). Third, adaptive learning (Camerer 1990; Lucas 1986) implies that with sufficient incentive traders will be persistent in their use of the new market, even when initial use is not always rewarded financially; other traders will observe this and reduce their uncertainty concerning market liquidity; and there will be a gradual trend toward the market now offering superior transactions costs. Ultimately, this market will capture sufficient order flow to offer superior execution as well, and the dominance of the new trading systems will emerge as a stable new equilibrium.

Our results consistently supported this third prediction. There is a significant trend toward the lower-cost market after its introduction of technological improvements. An illustrative graph, demonstrating the division of orders among competing markets during both phases of a single experiment, is provided in Figure 1. In Part 1 of the experiment, the market share of X varied but was usually greater than 50%. In Part 2 of the experiment, there was a persistent decline in X's share, leading to its eventual extinction; superimposed over the graph of X's actual share is a smoothed curve fitted to this data.

We use a model of market adoption based on exponential decay of the established market:

$$\text{MarketShare}_{MktY} = Ae^{-Bt}$$

Models are derived in ordinary least squares regression of the form

$$\text{Log}(\text{MarketShare}_{MktY}) = \log A + (-Bt)$$

The actual supporting data are shown in Table 1.

The model is significant at the .01 level in all four of the cases when the new market offered the larger advantage, and at the .10 level in 2 of the 3 cases when the relative advantage was smaller. Also, when the smaller advantage was offered, transition was considerably slower.

We find transitions appear *feasible* and are best explained by traders' adaptation to feedback from the prior period's outcome. In addition, comparing transitions observed with differing transactions costs improvements allows us to determine that the size of the new market's advantage influences the transition likelihood and speed.

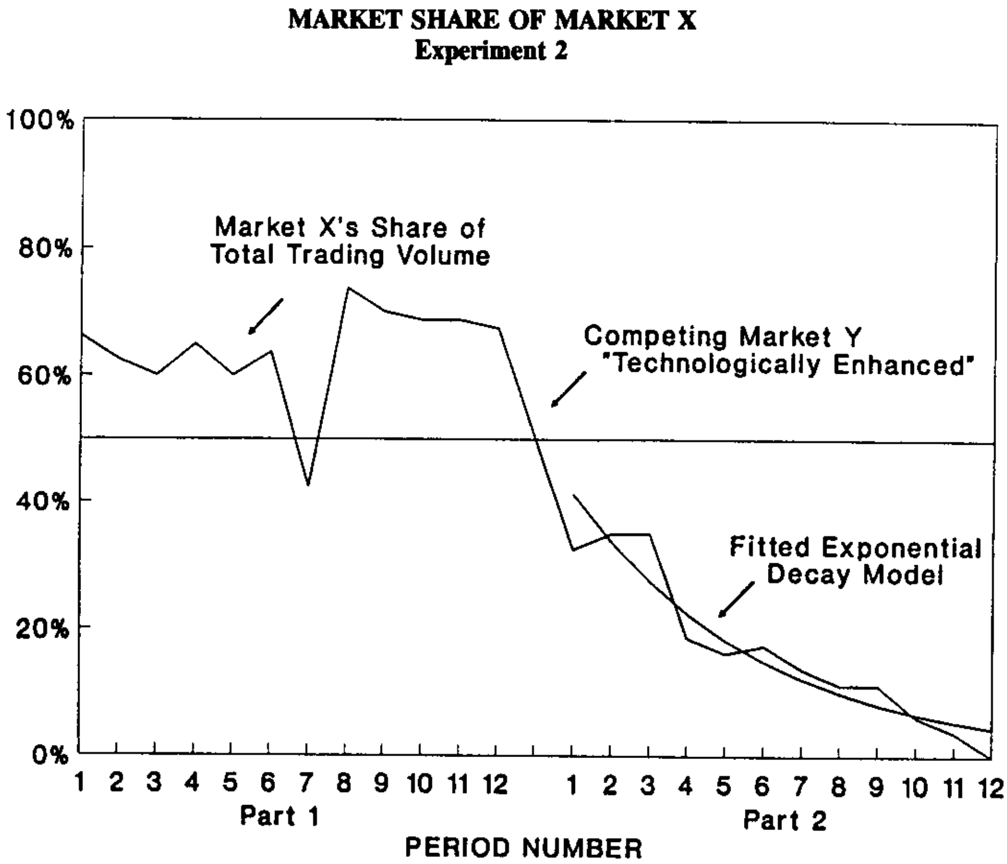

Figure 1. Market Share of Market X in Typical Experiment

Market share of Market X varies in Part 1 of the experiment, as subjects vary the portion of their orders that they direct toward each market. Market X generally has the dominant market share. In Part 2, when Market Y is given a significant cost advantage, Market X's share begins a steady exponential decline.

Table 1. Time Series Analysis: Transitions of Trading Activity

The data on transitions from dominant Market X to technologically superior Market Y are fit to an exponential decay curve for the market share of Market X. All four experiments with a large cost advantage are statistically significant at the .01 level. Transitions with a smaller cost advantage are more problematic, but do occur. Dominant market share is considered to be 85% or greater.

Experiment	Cost Advantage of Alternative Market	Coefficients A	Coefficients B	R^2	t-Statistic	Durbin-Watson Statistic	No. Periods until Alternative Market is Dominant
1	40%	.373	.086	52.4%	2.97#	.964[&1]	11
2	40%	.506	.203	90.7%	9.38#	1.75[@]	6
3	40%	.384	.077	66.5%	4.46#	2.08[@]	13
4	40%	.408	.044	52.2%	3.30#	1.55[@]	23
5	10%	Not Significant		2.7%	.052	–	–
6	10%	.500	.047	56.2%	3.58#	3.08[&2]	26
7	10%	.504	.030	24.0%	1.78*	1.80[@]	41
T	40%	.491	.081	22.6%	0.94**	–	15

\# = Significant at .01 level
* = Significant at .10 level
** = Significant at .20 level
@ = Cannot reject null hypothesis of nonautocorrelated residuals at .05 significance level
&1 = Reject null hypothesis of nonautocorrelated residuals in favor of positive first-order autocorrelation
&2 = Reject null hypothesis of nonautocorrelated residuals in favor of negative first-order autocorrelation

4. SIMULATIONS TO COMPARE ALTERNATIVE MARKET DESIGNS

4.1 Design of the Simulation

The simulations compared two different designs for equities markets. The first design is a disintermediated order matching market similar to the CATS trading system in use at the Toronto Stock Exchange and several other stock markets. The second is based on the dominant structure for securities trading in the US, a specialist-led floor auction market.

In simulation models of these two designs, common assumptions are made about the arrival process of investors' orders, order placement strategy, price volatility, and the proportions of market and limit orders. Differences in the two market structures lead to performance characteristics that are compared under controlled trading conditions. A factorial experimental design permits controlled comparisons of the two market architectures using three levels of order arrival rates, four levels of equilibrium price volatility, and three levels of ratio of market to limit orders. Based on six measures of market quality, we assess the relative attractiveness of the alternative designs for each of twenty-four sets of conditions. Because of space limitations, only two critical measures will be addressed here; a more complete treatment can be found in Weber (1991).

Both markets were simulated with the following conditions in common:

- Trading is continuous in time – that is, can occur at any point in time during the hours the market is open – and price and time priority are strictly followed.[11]
- An underlying equilibrium price for the security is initially set to $33.00, and is assumed to follow a random walk; this implicit equilibrium price is of course not directly observable by market participants.
- Orders arrive based on a Poisson arrival process that is dependent upon equilibrium price; at prices above the equilibrium price, sell orders become more likely, and below it, buy orders are more likely.

Essential market differences were also incorporated in the simulation:

- The floor-based market utilizes a specialist, who buys and sells for inventory. The specialist makes continuous quotes for both buying and selling, and adjusts these quotes to reflect current positions and trading conditions.
- The specialist has no advantageous information about equilibrium price, and responds only to inventory and order flow.
  - When the specialist acquires a position more than six units long of the security, the specialist's bid and offer quotes are lowered by an eighth; a short position of more than six units leads the specialist to raise bid and offer quotes by an eighth.
  - When the arrival of investors' limit orders makes the book measurably "thick" on the bid side (and thus more competitive with the specialist), the specialist will raise his bid quote by an eighth; when the book on the ask side is thick, the specialist's ask is lowered by an eighth. A "thin" book leads the specialist either to lower his bid or raise his ask.
- The specialist's trading policies result in positive trading profits for the simulation period; this entails:
  - adjusting bid and ask quotes as described and
  - setting the initial spread between their bid and ask quotes depending on trading conditions: a wider spread for higher price volatility and a higher proportion of limit orders, and a narrower spread for more frequent order arrivals.

4.2 Simulation Results

Three predictions are available to assess the output of the simulations. First, electronic order matching systems enhance market quality by eliminating the specialist's role and returning specialists' profits to the investor community. Second, specialists enhance market quality and provide liquidity services that have value in excess of their cost to investors. Third, the value of the specialist role is contingent on market conditions such as price volatility and investors' use of limit orders.

We will focus here on two closely related measures of market quality: market bid-ask spread and the round-trip cost of execution using market orders. The bid-ask spread is the measure most widely used in the finance community and is easy to assess analytically; our results are consistent with those derived in closed form (Stoll 1985). Round-trip execution cost using market orders is the measure that most accurately reflects the costs an individual retail customer incurs in trading in the market. The two measures of market quality yield very similar quality comparisons. Sample graphs of both quality measures, comparing both markets for varying levels of limit order percentages, are shown in Figures 2 and 3. Under all market activity conditions examined – high, average, and low – the specialist market had superior performance.

The presence of a specialist is shown to reduce market bid-ask spreads; it could hardly be otherwise, since the specialist is not permitted to make the spread worse, and

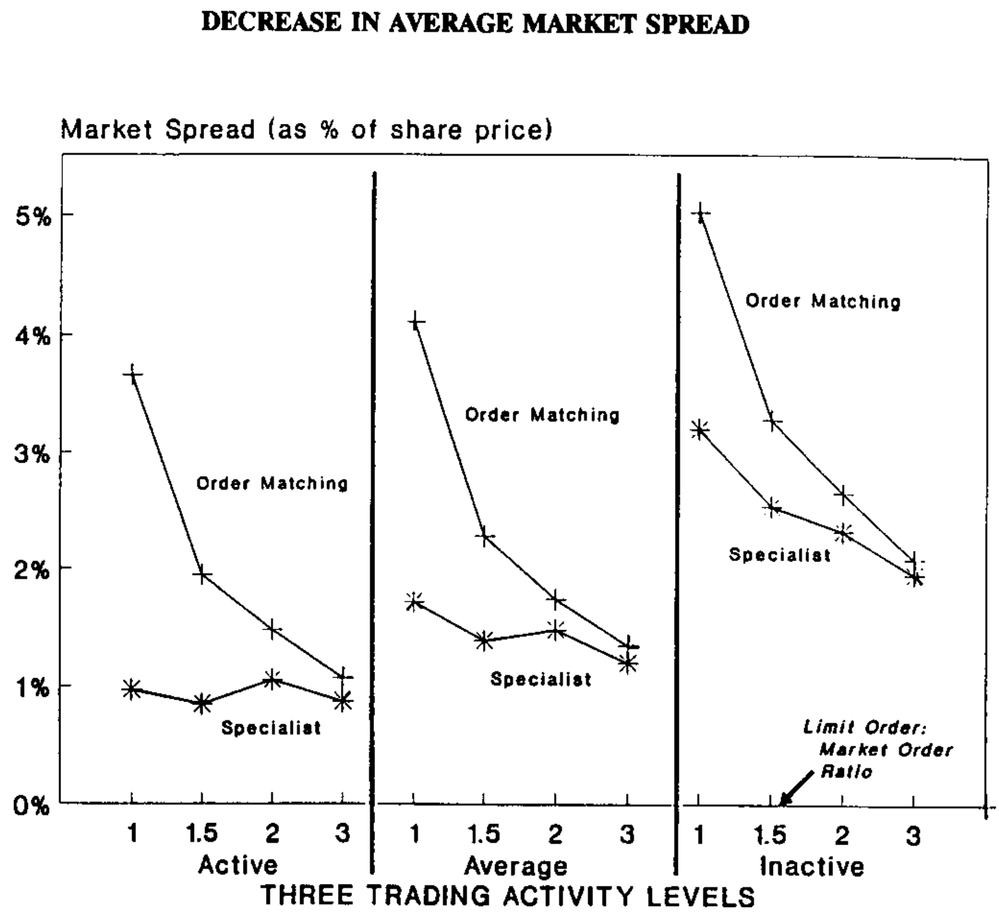

Figure 2. Decrease in Average Market Spread for Three Trading Activity Levels as a Function of the Ratio of Market Orders to Limit Orders

Market spreads, for markets with and without a specialist, are compared for four different ratios of market orders to limit orders, using three different sets of trading conditions that represent stocks that trade very actively, with average activity, and inactively. Under all conditions, the presence of a specialist reduces spreads. The specialist's contribution to reducing spreads is greatest when the fraction of limit orders is lowest, and decreases as use of limit orders increases.

if his quotes do not improve upon existing customer limit orders he will not trade and will earn no profits. Perhaps more importantly, we showed that the cost of a round-trip trade using market orders is lower even when the dealer makes positive average profits, and average transaction-to-transaction price change is less. Thus, a profitable dealer operation is consistent with improved market quality. Electronic market designs that "disintermediate" trading may not be in best interest of market participants. We find that we can accept the second and third predictions. A non-parametric Mann-Whitney two-sample rank test indicates that the difference in the two markets' average spreads are significant at the .01 level for twenty-three of the twenty-four trading conditions studied. Differences in the cost of a round-trip transaction are significantly lower for seventeen of the twenty-four trading conditions. The specialist was not significantly more beneficial for inactive trading when limit orders accounted for two-thirds or more of arriving orders, or when volatility was highest.

Advocates of electronic disintermediated markets suggest that the widespread availability of information on all available orders will attract additional use of limit orders by both opportunistic and patient investors. Our evidence suggests that a dramatic increase in use of limit orders would be required to replicate the benefits provided by the specialists' profitable behavior. Depending upon price volatility and order arrival rates, an increase in limit order utilization, ranging from an increase of 20% up to an increase of 50%, would be required (Weber 1991); in the absence of the transactions costs advantage and access to order flow information resulting from specialists' privileges, it is uncertain that this additional use of limit orders will materialize.

DECREASE IN ROUND TRIP TRADING COSTS

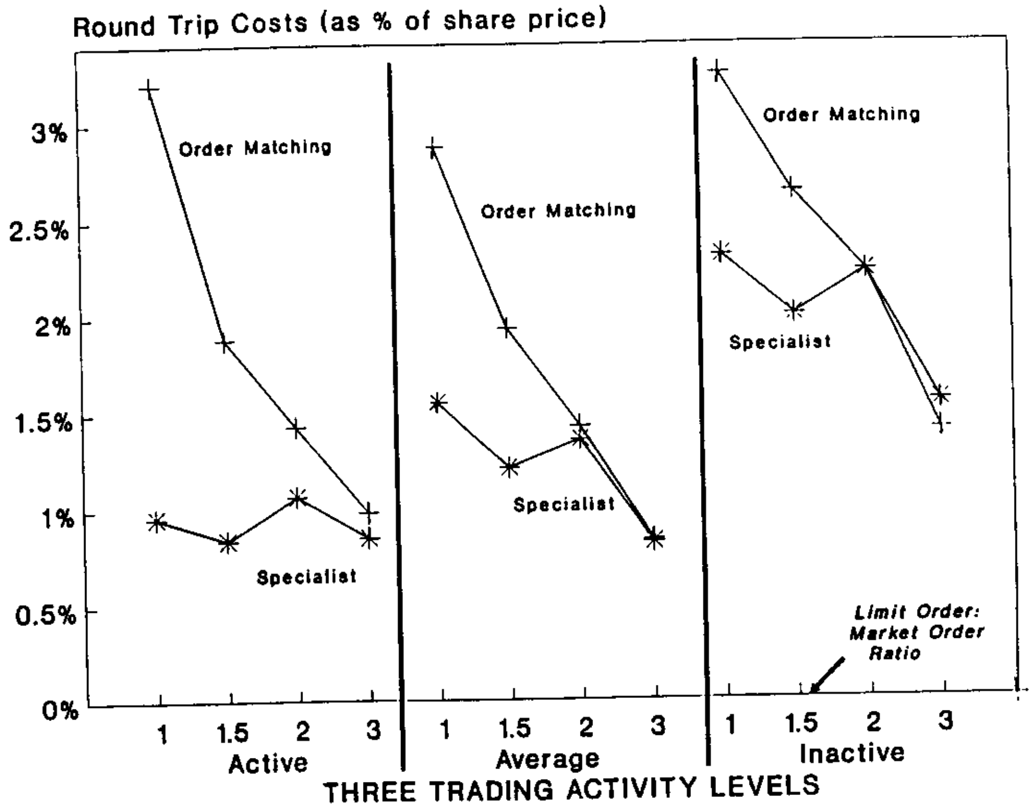

Figure 3. Decrease in the Average Cost of a Round-Trip Trade Using Market Orders for Three Trading Activity Levels as a Function of the Ratio of Market Orders to Limit Orders

Average cost of a round-trip trade, using market orders, in markets with and without a specialist, is compared for four different ratios of market orders to limit orders, using three different sets of trading conditions that represent stocks that trade very actively, with average activity, and inactively. Under all conditions, the presence of a specialist reduces the cost of a round trip using market orders. The specialist's contribution to reducing this cost is greatest when the fraction of limit orders is lowest, and decreases as use of limit orders increases.

4.3 Validation

Considerable effort was made to validate assumptions used in the simulation model. Actual exchange data on order arrivals were used to validate our assumption of Poisson arrivals, using a Kolmogorov-Smirnov test. Similarly, data from the NYSE were used to set the ratio of limit and market orders and the prices of these orders, and specialists from the NYSE validated our model of specialist behavior. Additionally, our results are derived under conservative assumptions: in reality, the specialist does not always make a profit, and he no longer has exclusive access to information in the order book. If specialists add value under these conditions, they will add value under more competitive conditions. Validation of the simulation is treated in greater detail in Weber (1991).

5. CONCLUSIONS AND CONTRIBUTION

5.1 Implications for Stakeholders

This research has implications for three major classes of stakeholders affected by the prospects of electronic trading systems: regulators, established exchanges, and developers of alternative trading systems.

The principal implication for regulators is that there is no need for them to take a proactive stance on market mechanism. We have confidence that the investor community is capable of coordinated transition and will adopt alternative trading mechanisms when they are demonstrably superior.

The principal implication for established securities markets is that the central market defense cannot be relied upon forever or under all circumstances. Again, when electronic alternatives are financially preferable to investors, evidence suggests that they will be adopted, and that liquidity will leave the established market. When the balance has tipped sufficiently for the previously dominant market to perceive this as a problem it may already be too late to respond, as the alternative will now offer both a transactions costs advantage and superior liquidity. This new equilibrium should be stable, and attempts by the previously dominant market to recover share by matching the cost reductions of the upstart will probably be unsuccessful.

Developers of alternative trading systems should take comfort in the demonstration that the central market defense is not insurmountable. However, significant benefits will need to be offered to attract the liquidity needed to move trading volume and regulatory relief for failed systems ventures is unlikely.

5.2 Implications for Strategic Systems Research

We have demonstrated here that for a class of strategic systems investments it is possible to model marketplace adoption experimentally. Since the benefits to systems innovators will frequently be dependent upon adoption, and since adoption of strategic innovations is frequently dependent upon the decisions of a group of potential users acting without external coordination, valuing such systems innovations has been extremely difficult and uncertain. We have presented here a set of experimental techniques – through simulation and work with experimental subjects – that can be employed to estimate *a priori* the potential value of a strategic innovation.

Our plans for future work include the following:

- A more complete publication of experimental methodology and results, including data sources, statistical analyses, and a discussion of external validity.
- A more detailed presentation of results of interest to the finance research community.
- Extensions to model additional forms of securities exchanges and additional trading mechanisms.

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7. REFERENCES

Amihud, Y., and Mendelson H. "Liquidity, Volatility and Exchange Automation." *Journal of Accounting, Auditing and Finance*, Fall 1988, pp. 369-395.

Amihud, Y.; Ho, T.; and Schwartz, R. "Overview of the Changing Securities Markets." In Y. Amihud, T. Ho, and R. Schwartz (Eds.), *Market Making and the Changing Structure of the Securities Industry*, Lexington, Massachusetts: Lexington Books, 1985, pp. 1-14.

Beja, A., and Hakansson, N. "From Orders to Trades: Some Alternative Market Mechanisms." In E. Bloch and R. Schwartz (Eds.), *Impending Changes for Securities Markets – What Role for the Exchanges?* Greenwich, Connecticut: JAI Press, 1979, pp. 144-161.

Black, F. "Toward a Fully Automated Exchange." *Financial Analysts Journal*, July-August 1971, pp. 29-44, continued November-December 1971, pp. 25.29.

Camerer, C. "Behavioral Game Theory." Chapter 13 in R. Hogarth (Ed.), *Insights in Decision Making*, Chicago: University of Chicago Press, 1990.

Clemons, E. "Evaluating Strategic Investments in Information Technology." *Communications of the ACM*, Volume 34, Number 1, January 1991, pp. 22-36.

Clemons, E., and Adams, J. "Global Competition in Corporate Capital Markets." In H. Lucas, Jr. and R. Schwartz (Eds.), *The Challenge of Information Technology for the Securities Markets: Liquidity, Volatility, and Global Trading*, Homewood, Illinois: Dow Jones-Irwin, 1989.

Clemons, E., and Weber, B. "London's Big Bang: A Case Study of Information Technology, Competitive Impact, and Organizational Change." *Journal of Management Information Systems*, Volume 6, Number 4, Spring 1990, pp. 41-60.

Clemons, E., and Weber, B. "Strategic Information Technology Investments: Guidelines for Decision Making." *Journal of Management Information Systems*, Volume 7, Number 2, Fall 1990, pp. 9-28.

Cohen, K.; Maier, S.,; Schwartz R.; and Whitcomb, D. *The Microstructure of Securities Markets*, Englewood Cliffs, New Jersey: Prentice-Hall, 1986.

Cohen, K., and Schwartz, R. "Realizing the Potential of an Electronic Trading System." *Proceedings: Conference on Information Technology and Securities Markets under Stress*, New York University, May 1988, pp. 7-44.

Demsetz, H. "The Cost of Transacting." *Quarterly Journal of Economics*, Volume 82, 1968, pp. 33-55.

Economides, N., and Siow A. "The Division of Markets is Limited by the Extent of Liquidity (Spatial Competition with Externalities)." *American Economic Review*, March 1988, pp. 108-121.

Garbade, K., and Silber, W. "Technology, Communication and the Performance of Financial Markets: 1840-1975." *Journal of Finance*, Volume 33, Number 3, June 1978, pp. 819-831.

Ho, T., and Macris, R. "Dealer Market Structure and Performance." In Y. Amihud, T. Ho, and R. Schwartz (Eds.), *Market Making and the Changing Structure of the Securities Industry*, Lexington, Massachusetts: Lexington Books, 1985, pp. 41-66.

Ho, T., and Stoll, H.R. "The Dynamics of Dealer Markets under Competition." *Journal of Finance*, Volume 38, September 1983, pp. 1053-1072

Lucas, R. Jr. "Adaptive Behavior and Economic Theory." *Journal of Business*, Volume 59, Number 4, Part 2, 1986, pp. S401-S425.

Mendelson, H. "Consolidation, Fragmentation, and Market Performance." *Journal of Financial and Quantitative Analysis*, Volume 22, June 1987, pp. 189-207.

Muth, J. "Rational Expectations as a Theory of Price Movement." *Econometrica*, July 1961, pp. 315-329.

Pagano, M. "Trading Volume and Asset Liquidity." *Quarterly Journal of Economics*, May 1989, pp. 255-274.

Peake, J.; Mendelson, M.; and Williams, R. Jr. "Black Monday: Market Structure and Market Making." In H. Lucas, Jr. and R. Schwartz (Eds.), *The Challenge of Information Technology for the Securities Markets: Liquidity, Volatility, and Global Trading*, Homewood, Illinois: Dow Jones-Irwin, 1989.

Pool, I. D. *Forecasting the Telephone: A Retrospective Technology Assessment*. Cambridge, Massachusetts: MIT Press, 1983.

Schwartz, R. *Equity Markets*. New York: Harper & Row, 1988.

Smith, V. "Microeconomic Systems as an Experimental Science." *American Economic Review Proceedings*, December 1982, pp. 923-955.

Stoll, H. "Alternative Views of Market Making." In Y. Amihud, T. Ho, and R. Schwartz (Eds.), *Market Making and the Changing Structure of the Securities Industry*, Lexington, Massachusetts: Lexington Books, 1985, pp. 67-91.

Weber, B. *Information Technology and Securities Markets: Feasibility and Desirability of Alternative Electronic Trading Systems*. Unpublished Ph.D. dissertation, University of Pennsylvania, 1991.

8. ENDNOTES

1. A ***market mechanism*** is the means by which orders submitted to a market are converted into completed trades. Numerous mechanisms are possible, and many are in use in major markets today (Beja and Hakansson 1979). For example, some markets permit customer orders to interact with each other, while others require all customer orders to interact with intermediaries called ***market-makers***, who buy shares that customers are selling or sell shares that customers wish to buy; some have continuous trading, while others use periodic clearing of a batch of submitted orders. Each will convert the same sequence of orders into a different set of trades.

2. Our research was inspired by our experience working on a Congressional Office of Technology Assessment Advisory Panel, examining electronic markets. The OTA staff began the study with strong presumptions: that electronic disintermediated markets would be better, since investors would no longer be providing profits for intermediaries with their trades, and that only venal self-interest of established power structures at exchanges preserved roles of intermediaries. These led to the belief of OTA staffers that investors were trapped in archaic and expensive markets. These initial assumptions require examination.

3. Liquidity measures the ability to convert a security readily into cash, or to convert cash into a security, without excessive delay, and without undue price impact. In a liquid market, it will be easy to buy or sell a security, quickly, and at the current price. In an

illiquid market, attempts to buy or sell will incur significant delay; moreover, attempts to buy will increase the price that must be paid, and attempts to sell will decrease the price received.

4. These include ***market spread*** between the best bid and ask, probability that a limit order executes, average time until a limit order executes, average price change between consecutive transactions, average cost of a market round-trip using market orders (average cost to buy and then sell using market orders), and average gain of a round-trip using limit orders.

5. Ariel, a computerized block trading system started in London in 1974, was closed due to lack of activity. The Cincinnati Stock Exchange's National Securities Trading System (NSTS) was expected to become the basis for an automated national stock exchange. Autex is a system in the US that enables block traders to indicate their trading interests. Intex is a Bermuda-based automated futures exchange. None is widely used.

6. Shortly after London introduced improved trading technology in its October 1986 ***Big Bang*** deregulation of the stock exchange, Sweden doubled the trading tax imposed on securities transactions. The result was a rapid movement of as much as 85% of the trading in key Swedish stocks off the Stockholm Stock Exchange and onto London's International Stock Exchange (Clemons and Weber 1990a).

7. The experiment uses market size as a proxy for liquidity, since liquidity is an elusive concept and difficult to measure notion. In general, thinly traded securities are considered less liquid, and larger and more active markets are considered more liquid; we adopt this convention.

8. In a typical market experiment, prices are determined in an oral or computerized double auction in which subjects place and accept bids and offers. To save time and permit a greater number of replications to be performed, the auction mechanism is not included in our experiment. The factors that influence auction price formation are instead included in the experiment's earnings functions. There is little reason to expect trader earnings arrived at through an auction to diverge from those that result from our experimental earnings functions. (Smith [1982] notes that auctions converge to competitive equilibrium prices in three to four trading periods.) The liquidity externality in the market should be more prominent if the level of earnings from traders' quantity submissions is not confounded with their success in an auction.

9. This is quite plausible, given the reward structure of many traders, especially fund managers. A fund manager who outperforms the market receives a bonus; a fund manager who under-performs the market is frequently terminated.

10. In other words, traders know that it is beneficial if they all move to the new market, they all know that all other traders know, and they all know therefore that moving to the new market will maximize their expected earnings. Moreover, this move will be stable and self-reinforcing, since all know that a trader who defects will incur both higher transactions costs and the penalty of trading in a less liquid market.

11. Trades are executed in sequence, with the highest "bit" price to buy and lowest "ask" price to sell having priority. Among competing orders at the same price, the earliest order has priority.