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When It's Not The Only Game in Town: The Effect of Bilateral Search on the Quality of a Dealer Market

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ABSTRACT

We report results from experimental asset markets with liquidity traders and an insider where we allow bilateral trade to take place, in addition to public trade with dealers. In the absence of the search alternative, dealer profits are large—unlike in models with risk-neutral, competitive dealers. However, when we allow traders to participate in the search market, dealer profits are close to zero. Dealers compete more aggressively with the alternative trading avenue than with each other. There is no evidence that price discovery is less efficient when the specialists are not the only game in town.

IN RECENT YEARS, THE volume of equity trading has grown; the variety of trading mechanisms available to traders has grown as well. Trading is becoming less centralized as third and fourth market activity has expanded greatly. A recent article in *Investment Dealers' Digest*[1] notes that the growth in the fourth market has been exponential over the last four years. This article reports that, "Among the largest institutions—those who paid out more than $5 million in commissions last year (1993)—nine percent of their total commission flow was through . . . the . . . fourth market . . .— . . . up from three percent in 1992 and less than one percent in 1991. . . . Mostly OTC stocks trade through the systems" (p. 19). A market for order flow has developed, whereby intermediaries purchase trades from brokers and redirect them to regional exchanges. Additionally, the Nasdaq system has grown, both in terms of the number of traded companies as well as the number of shares traded. The modern marketplace affords an investor many options in terms of how, when, and where to trade.

This growth opens the issue of whether the fragmentation of centralized markets may have undesirable social consequences. For instance, Ashenfelter

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[1] "Rising Tide Lifts All Boats in Institutional Equities," *Investment Dealers' Digest,* March 28, 1994, pp. 16–20.

(1989, esp. pp. 31–32) notes that the price discovery function performed by a public auction is a form of public good. Two parties who have no connection to the auction can use the auction price to reduce research and bargaining costs. Ashenfelter believes that this externality may lead to the underproduction of price discovery and advocates nationalizing auction houses, as is done in some parts of Europe. This analysis applies directly to centralized asset markets. The New York Stock Exchange (NYSE) has rules to limit the ability of member firms to eschew the "trading floor." Furthermore, Rule 410B (effective November, 1992) requires member firms to *report* all trades in NYSE-listed stocks. In fact, U.S. law has recognized the price discovery performed by a centralized market as private property (see Mulherin, Netter, and Overdahl (1991, esp. pp. 627–634)).

Much of the "piggybacking" on centralized markets is an attempt to unbundle the functions of price discovery and liquidity provision that an exchange provides. An excellent example is provided by the following anecdote from a recent *The Wall Street Journal* article on the growth of Instinet.[2] "When Nasdaq went down because of power outages earlier this year, Instinet volume dropped off precipitously until Nasdaq was brought back on line." An Instinet official is quoted as saying, "(Instinet) is not a substitute for Nasdaq. (Instinet's) customers rely on Nasdaq's prices." The article notes that Instinet, which preserves trader anonymity and generally involves trades within posted spreads, may account for as much as 20 percent of Nasdaq volume.

Of course, traders migrate from dealer markets because they do not demand immediacy. Early theoretical work on dealer markets assumes that liquidity traders have an inelastic demand for immediacy (e.g., Kyle (1985)). While subsequent theoretical analysis has relaxed this assumption, the question of *where* patient liquidity traders would opt to trade is not pursued. In fact, theoretical microstructure models tend to be highly stylized and the conclusions are not robust to the relaxation of seemingly minor assumptions.

Recent evidence suggests that trading mechanism design has important implications for market outcomes. Christie and Schultz (1994) compare quotes on Nasdaq to the NYSE for very large, actively traded firms and find that Nasdaq posted bid-ask spreads are wider than those on the NYSE. Huang and Stoll (1995) also do a matched comparison of trading costs and find them to be roughly twice as high on Nasdaq as on the NYSE for similar stocks. One possible explanation for such spread differentials is the different mechanisms. In large NYSE-listed stocks, the specialist's post is essentially a meeting place for buyers and sellers. The computerized Nasdaq system affords no such direct meeting between buyers and sellers. The system routes all trades through the competing dealers.

There are no theoretical models with asymmetric information, risk-averse dealers, and trader options with respect to the timing of trades and the choice of trading mechanism. This article uses the experimental laboratory to exam-

[2] "Reuter's Instinet is Biting Off Chunks of Nasdaq's Territory," by Warren Getler, *The Wall Street Journal*, p. C1, October 4, 1994.

ine the effect that the possibility of trader migration from a centralized dealer market has on the quality of that market. Specifically, we compare a market where all trade is channeled through competing dealers to a market where traders may also trade with one another in a bilateral search setting. The market with the search alternative is operationalized by shutting down the dealer market, allowing a period of bilateral trading that bypasses (and is hidden from) the centralized dealer market, and then reopening the centralized dealer market. We find that dealers compete more aggressively against the search alternative than they do against one another. Thus, dealer profits are large when the dealer industry is the only game in town, whereas dealer profits are virtually nil when traders may use the search alternative to dealers. In addition, we find evidence of the piggybacking of searchers: search trades are benchmarked to the dealer spread prior to search. Nevertheless, trades in the market where search is available are more efficient in the sense that transaction prices are closer to the asset's true value than is the case in the market where the dealers are the only game in town.

The remainder of this article is organized as follows. We review the literature on price discovery and trader migration in Section I. Section II provides details of the laboratory environment used to examine the effect that possible trader migration has on dealer behavior and market quality. The data produced in the lab are analyzed in Section III. Section IV concludes.

I. Literature Review

There is a large body of literature that explores the dealer's problem, both when some traders possess better information than a risk-neutral dealer, and in cases where a risk-averse dealer faces no informational asymmetry. Bagehot (pseudonym for Jack Treynor) (1971) introduces liquidity traders who are captive locally by the dealers, and hence have inelastic demand to trade with the dealers. Kyle (1985) and Glosten and Milgrom (1985) formally model the environment characterized by Treynor. In these models, trading times are exogenously determined, and the dealers are the only game in town. Ho and Stoll (1983) examine risk-averse dealers competing for order flow in a market with no asymmetric information, and hence, no role for price discovery. In the context of their model, Ho and Stoll compare a dealer market like Nasdaq with a specialist market such as the NYSE. They conclude that the specialist is more flexible than competing dealers, and can therefore post a narrower spread than competing dealers since the dealer market offers greater liquidity at each spread.

Dennert (1993) allows for asymmetric information assuming risk-neutral market makers. In Dennert's model, trade with competing market makers takes place simultaneously. Since the insider can "pick off" each market maker individually, market makers provide negative externalities for one another—if there is only one dealer, he sees the entire order flow, and his signal extraction problem collapses to that in Kyle (1985) (assuming that traders are playing linear strategies). With multiple dealers, the insider trades more in aggregate, but the signal extraction breaks down. Similarly, Pagano and Röell (1996) develop a model where increased transparency results in tighter spreads. In Pagano and Röell, the risk-neutral dealer protects himself against losses to insiders by widening his spread relative to the case of the more transparent auction market.

Admati and Pfleiderer (1988) relax the restriction on liquidity trader behavior made in Kyle (1985) that their trades must take place the instant the shock occurs; or in Glosten and Milgrom (1985) that trading times are exogenous. Giving liquidity traders flexibility in terms of the timing of trade gives rise to an equilibrium where the liquidity traders cluster temporally. Although some of Admati and Pfleiderer's liquidity traders do not have an inelastic demand for immediacy, they must still trade with the dealer on his terms—the question of trader migration from the centralized market is not addressed.

Pagano (1989) has a model where there are two markets operating simultaneously in a single risky asset. There is no asymmetric information with respect to the asset's terminal value. Unless traders must precommit to trade in one market or the other, arbitrage arguments force the two markets to merge into a single market. In this model, traders have quadratic utility and random endowments. The market is imperfectly competitive in that traders take into account the effect that their trades will have on prices. Enlarging a market has two effects in this model. As more traders enter a market, its absorptive capacity increases. This increase makes agents better off by mitigating the effect of a large endowment shock. On the other hand, agents also benefit from price volatility that raises the probability that one will be able to buy low and sell high (for example an agent with a small endowment shock may be rewarded by supplying liquidity to those with large endowment shocks).

Models of pure search have also been developed theoretically. Assuming symmetrically informed agents, Rubinstein and Wolinsky (1987) examine the role of dealers and consignees in improving trade prospects for buyers and sellers seeking (known) gains to trade. With asymmetrically informed agents, Wolinsky (1990) examines the informational efficiency of transaction prices in a bilateral search market. Campbell, LaMaster, Smith, and Van Boening (1991) conduct a laboratory experiment where agents choose between trading on an organized exchange or bilateral search. Their experiment has symmetrically informed agents, and as such indicates the effect that the cost of search has on the level of search activity.

Finally, a recent article by Bulow and Klemperer (1994) is related to this study. (See also Gul and Lundholm (1995).) Bulow and Klemperer (BK) do not focus on market structure; in fact, their model posits an ad hoc quote adjustment rule. Nevertheless, Bulow and Klemperer explore the implications of traders' options as to when to trade. In an environment of asymmetric information, BK note that the prices at which traders are willing to trade are fragile (as opposed to traders' reservation values). For example, a liquidity trader may be willing to buy at 110, but if no one else is buying and the dealers are in a disequilibrium adjustment mode, it behooves him to wait and allow the inside ask to fall. Once he observes a buy order, it becomes more urgent to trade and he revises his willingness to pay. An implication of the BK model is that trading activity will tend to cluster in calendar time.

II. Experimental Design, Subjects, and Procedures

Trading in the experimental markets is conducted under two different market mechanisms, with each mechanism distinguished by the rules governing the trading of a risky asset. Since we are interested in studying the effect of trading mechanism design on market outcomes, the information structures and the distributions of all random variables are identical under both mechanisms. In addition, to facilitate comparison, the draws from these distributions are also held constant: all differences in the data generated by these two mechanisms are due directly to differences in the trading mechanisms we examine.[3] We explain below the features that are common to both settings, and then explain in detail the rules governing exchange under each trading mechanism.

There are three types of agents; a single insider who learns the end-of-period value of a single risky asset, three competing market makers or dealers, and four liquidity traders who trade to satisfy an exogenously determined liquidity motive. The framework is similar to Kyle (1985), but with an important difference. Although the liquidity traders have an exogenously determined liquidity demand, their arrivals to the market are not determined by an exogenous process; each liquidity trader (as well as the insider) in the experimental markets chooses the timing of his/her trades.

A. Communications and Computer Displays

All interactions among subjects are conducted on a series of networked personal computers with custom software. The computer screen in front of each dealer and trader contains continuously updated market information, including a record of each trader's own trading activity and cash balances, and the time remaining in the current trading interval. We provide writing materials to all subjects so they can track any additional information that they feel is relevant.

B. Agents, Trading Profits, Parameter Values, and Variable Distributions

Endowments, Payments, and Monetary Units: The monetary unit employed in the experiment is the laboratory dollar (henceforth, L$). To convert a L$ to a US$ dollar (the currency in which payments are made to subjects), multiply

[3] In the experimental design, we chose to maintain cohorts of eight subjects over the five sessions under each mechanism. The highly experienced subjects that this approach affords is desirable because of our interest in examining *equilibrium* behavior. This did not allow for the control of possible cohort-specific differences. In our judgement, randomly assigning roles at the beginning of each session and the relatively large size of the cohorts minimizes the possible importance of such differences.

by 0.05. All agents begin the first market period with a cash balance of L$520 ($26). Trading profits (losses) are carried forward to subsequent periods. At the end of the final market period, the current cash balances are converted to US$, and each subject is privately paid his earnings for the session in cash. Given the zero-sum nature of the trading game, cash payments (net of any penalties incurred by traders) average L$520 ($26) per subject.

Risky Asset Value: The asset value each market period is known to be drawn from an approximate normal distribution with mean of L$100, standard deviation of L$8.7, and support on the whole L$s between L$70 and L$130, both inclusive. A riskless asset (cash) is included offering an interest rate of zero.

Insider: At the beginning of each market period, one of the five traders is chosen randomly to be the insider. The insider learns the end-of-period asset value prior to the start of trade, and is free to engage in trades over the course of the market period in pursuit of trading profits. There are no constraints on insider activity. Trading profits are carried forward to subsequent periods.

Traders' Required Positions: Each of the four remaining traders will be required to buy or sell a randomly determined number of assets in net. Each trader's required position is determined by an independent draw from a uniform distribution with support on the nonzero integers between -5 and 5 (endpoints included). If a trader does not meet this requirement, a penalty is assessed at the end of the period equal to L$100 times the absolute value of the deviation between the required position and the actual end-of-period position. The magnitude of the penalty ensures that demand is inelastic at the required position. Each period, the trading profits or losses of each trader are added to starting cash balances and carried forward to the next period, so traders have an incentive to minimize trading costs.

Dealers: Each of the three dealers is free to engage in trades in pursuit of profits. At the beginning of each market period, dealers neither learn the end-of-period asset value, nor receive required positions. Each period, trading profits or losses of each dealer are added to starting cash balances and carried forward to the next period.

Trading Profits: Trades represent a zero-sum game, with the profitability of each trade determined on the basis of the relation between the trading price and the end-of-period asset value. Trading profits on a trade are equal to the signed trade ($+1$ for a buy, -1 for a sell) times the end-of-period asset value less the transaction price. All transactions are for a single unit of the single risky asset.

Information Sets: Prior to the start of trade, only the insider learns the asset liquidation value, and the insider is not identified to the other agents. Each of the other four traders observes his liquidity shock privately. At the end of each market period, all agents learn the asset liquidation value. All information pertaining to distributions, parameters, payments, and the rules governing trade is common knowledge.

C. Subjects and Procedures

The 24 subjects who participated in the experimental markets were recruited from a preliminary training round. The training round consisted of training in the information structure, variable distributions, and parameter values, and two market periods of trade under each of the three trading mechanisms.[4] The training round lasted, on average, slightly more than 3.5 hours. There were eight subjects in each of five identical training sessions. Of the forty subjects who participated, eight were undergraduates recruited from a senior level finance class, 28 were MBA students recruited from a second year finance class, and four were business Ph.D. students.

We used performance in the training session as a criterion to select 24 subjects for the actual experimental markets. Of the 24 students (from the training sessions) initially invited to participate in the experimental markets, 23 accepted. From the pool of 24 subjects, we randomly formed three cohorts of eight subjects (each of the three classes of students was represented in each of the three cohorts). We then assigned each of the cohorts to a single mechanism. The experimental data we report below is drawn from five additional two-hour trading sessions under each trading mechanism.

Each session was preceded by a review of trading rules, parameter values, and distributions. Since the five sessions were completed in a maximum of eleven days, the review became progressively shorter as the subjects became more experienced, and averaged one half hour prior to the first session under each mechanism, and five minutes prior to the fifth session. In the first session, subjects were randomly assigned to roles. In the second and third sessions, random role assignment was maintained with the exception that there was one dealer in each session with previous experience as a dealer. In the fourth and fifth sessions, role assignments were purely random. At the end of each session, each subject was paid in private. None of the subjects ever went bankrupt—all left the session with a cash payment; none had any interim adjustments to their cash balances.

In each of the experimental sessions, we set the number of market periods to the number that could be completed in a two-hour session after preliminary instructions. We thus have a laboratory database consisting of five experimental sessions under each trading mechanism, each of which includes from seven to ten market periods. The random draws that define each market period are constant across mechanisms.

D. Trading Mechanisms

The trading rules pertaining to each trading mechanism are summarized below. As explained above, all probability distributions, as well as the specific draws, and other procedures not specific to trading mechanisms were held constant.

[4] In addition to the two mechanisms described in this article, a pure search mechanism was also run. Attributes of that market are reported in a separate article.

D.1. Pure Dealer Mechanism

Before the trading interval can begin, each dealer (D1, D2, D3) must submit a bid and an ask. These represent the prices at which he/she is willing to sell a single unit of the risky asset (ask), and a price at which he/she is willing to buy the asset (bid). After each dealer has entered one price on each side of the market, the market opens and the trading interval clock begins a 120-second countdown. Each dealer does not observe the other dealers' quotes until the market opens. When the market is open, traders are free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. The quotes are displayed on each trader's and dealer's computer screen so that bids are in ascending order and asks are in descending order, with the inside quotes highlighted. A dealer can move to the "inside" on either side of the spread by matching or improving on the current inside quote. When a trader initiates a trade at the inside bid or ask, all traders and dealers observe the occurrence of the transaction and the price, but they do not learn which trader initiated the trade, nor which dealer took the other side. The trading interval clock is stopped while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval that is conducted exactly as the first. The trading halt is included for control purposes, since the dealer-cum-search mechanism, discussed below, by its nature requires a closing and reopening of the centralized (quote-driven) market.

Over the trading interval, no restrictions hold on the number of trades that a trader may initiate, or that a dealer may undertake. There are also no restrictions on (or costs to) quote revisions, and no costs or inducements to trading activity other than the pursuit of trading profits, and the incentive to meet required positions. Historical information is maintained on each trader's and dealer's screen. This record includes, in addition to the history of trading activity (trading prices and times) and remaining time in the trading interval, the net market order imbalance (buyer initiated trades less seller initiated trades), and private information such as cash balances, current positions, and in the case of the insider, the asset value.

D.2. Dealer-cum-Search Mechanism

The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval, there is an eight minute bilateral search market. During this period, dealer screens continue to reflect the history of trades in the centralized, quote-driven market, but show no information about the search market. (Dealers are prohibited from participating because of our interest in studying the implications of fourth market activity for the quality of a centralized market.) During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal from his computer. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. If not accepted, all trade proposals expire (and disappear from the sender's and recipient's screens) after 25 seconds. Additionally, trade proposals may be revised at any time by the sender, or countered with different terms by the recipient. Trade proposals may be made to any combination of potential counterparties simultaneously, and there is no limit to the number of trade proposals that may be sent over the trading interval. There are no costs or subsidies associated with proposing or accepting trades.

If a trade proposal is accepted, each participant's screen reflects current positions and trading prices, along with who initiated the trade. A trade completed in the search market is observed only by the two traders who participated in the transaction. No general market activity is reported. Thus, all trades that take place in the search market are unobserved by the dealers.

The search market is followed by a second 120-second pure dealer market. Trading activity tracked on computer screens includes all transactions completed during the dealer portions of the market period. In addition to the dealer market activity (which all traders and dealers observe), those traders who completed transactions during the search portion of the market period continue to observe a record of their search market activities.

III. Results

We analyze below the results from the five sessions under each trading mechanism. We discard the first four market periods from the first session, and the first market period from subsequent sessions to allow for refamiliarization with the market process. This leaves a total of 27 market periods for each mechanism. Since the random draws which define each market period are constant across mechanisms, the first market period under the pure dealer mechanism is directly comparable with the first dealer-cum-search market period. The statistical tests exploit this feature of the experimental design. The net liquidity trade (the sum of the liquidity demands of the four liquidity traders) and the asset value for each of the 27 market periods are reported in Table I.

A. Liquidity Trader Losses

When all trades are funnelled through competing dealers, liquidity traders' losses are large. Summed over the four liquidity traders, per period losses average L$73.36 in the pure dealer market. Average per period losses are reduced to L$48.40 in the presence of the search alternative (Table I). A matched-pairs t-test indicates a significant difference ($p < 0.03$). In the markets where traders were free to migrate from the dealers to seek better terms,

Table I

Profitability and Trading Activity By Trader Type Under the Pure Dealer and Dealer-cum-Search Mechanisms

This table reports profits by trader type for each of the 27 market periods under the two trading mechanisms. Under the pure dealer mechanism, before trading begins each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval that is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval, there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. The monetary unit in all tables is laboratory dollars (L$ in the text). To convert to US$, multiply the laboratory dollars by 0.05. Net Liquidity Trade is the sum of the liquidity demands for the liquidity traders, each of whom makes an independent draw from a uniform density from −5 to 5, excluding 0. The asset value is the realized draw from the distribution governing asset value (Gaussian, with unconditional expectation of 100, and standard deviation of 8.66). Trading activity in the search portion of the dealer-cum-search market is detailed by trader type. Liq-Liq means a trade between two liquidity traders and Liq-Ins means a trade between a liquidity trader and the insider. Dealer industry profits (the sum of the profits of the three competing dealers) are significantly higher in the pure dealer mechanism. Liquidity trader losses are significantly lower in the presence of the search alternative.

	Pure Dealer Only Mechanism							Dealer-cum-Search Mechanism			Dealer-cum-Search: Dealer Portion Only				Dealer-cum-Search: Search Portion Only			
Market Period	Net Liquidity Trade	Asset Value	Dealer Industry Profits	Liquidity Traders' Profits	Insider Profits	Liquidity Trades	Insider Trades	Dealer Industry Profits	Liquidity Traders' Profits	Insider Profits	Liquidity Traders' Profits	Insider Profits	Liquidity Trades	Insider Trades	Liquidity Traders' Profits	Insider Profits	Trades Liq-Liq	Trades Liq-Ins
1	−7	81	−40.5	45.5	−5.0	11	3	−11.9	−35.3	47.7	−3.1	15.0	9	2	−32.2	32.2	2	2
2	1	108	111.5	−114.5	3.0	17	3	11.3	−68.7	57.4	−34.8	23.5	9	11	−33.9	33.9	3	6
3	3	98	−2.5	−31.0	33.5	9	8	−13.5	−26.5	40.0	−19.5	33.0	3	5	−7.0	7.0	3	2
4	3	105	116.0	−102.0	−14.0	11	5	42.0	−66.6	24.6	−47.0	5.0	9	2	−19.6	19.6	3	4
5	1	84	−0.5	−44.5	45.0	9	4	−47.0	−48.0	95.0	−1.0	48.0	6	6	−47.0	47.0	1	3
6	5	95	88.5	−94.0	5.5	13	4	3.0	−30.8	27.8	−6.0	3.0	2	1	−24.8	24.8	5	5
7	11	111	133.7	−165.7	32.0	19	6	74.0	−92.0	18.0	−92.0	18.0	15	4	0.0	0.0	4	0
8	9	87	123.8	−249.0	125.2	19	9	31.5	−214.5	183.0	−61.5	30.0	9	5	−153.0	153.0	0	12
9	6	95	−28.0	−69.1	97.1	14	13	16.2	−45.8	29.6	−20.3	4.1	10	2	−25.5	25.5	2	6
10	−3	120	−48.5	−192.5	241.0	11	17	−140.3	−10.6	150.9	54.3	86.0	5	12	−64.9	64.9	4	10
11	5	93	44.4	−88.4	44.0	15	12	20.1	−37.9	17.8	−25.8	5.7	6	3	−12.1	12.1	1	4
12	0	107	14.4	−16.0	1.6	8	8	−4.7	−1.3	6.0	3.7	1.0	4	1	−5.0	5.0	1	2
13	12	99	81.0	−130.0	49.0	12	14	40.0	−49.6	9.6	−43.6	3.6	5	3	−6.0	6.0	0	7
14	−1	113	15.1	−49.1	34.0	7	8	−22.9	−61.2	84.1	−53.2	76.1	10	11	−8.0	8.0	0	1
15	6	97	52.6	−59.2	6.6	10	7	7.1	−19.1	12.0	−19.1	12.0	10	7	0.0	0.0	0	0
16	9	98	68.6	−89.3	20.7	15	10	−21.5	−81.2	102.7	−81.2	102.7	15	15	0.0	0.0	0	0
17	−4	106	45.9	−74.0	28.1	12	11	22.8	−53.5	30.7	−40.5	17.7	15	12	−13.0	13.0	0	3
18	−1	98	25.4	−20.4	−5.0	9	4	0.5	−9.4	8.9	−8.5	8.0	7	6	−0.9	0.9	0	2
19	7	119	−42.1	−6.9	49.0	13	4	−57.2	19.9	37.3	23.9	33.3	14	11	−4.0	4.0	1	1
20	−4	101	20.9	−31.0	10.1	6	7	−5.0	−3.2	8.2	3.0	2.0	5	2	−6.2	6.2	0	7
21	−1	100	49.0	−51.0	2.0	11	2	17.0	−16.2	−0.8	−15.0	−2.0	3	1	−1.2	1.2	3	2
22	−8	117	6.0	−139.5	133.5	8	14	−37.2	−115.3	152.5	10.5	26.7	4	4	−125.8	125.8	1	10
23	10	110	20.0	−20.0	0	10	0	114.5	−146.0	31.5	−137.0	22.5	13	8	−9.0	9.0	0	3
24	5	98	44.0	−46.0	2.0	15	1	22.9	−50.9	28.0	−26.7	3.8	7	1	−24.2	24.2	2	6
25	−9	97	66.0	−77.0	11.0	13	7	17.1	−19.1	2.0	−17.1	0.0	8	0	−2.0	2.0	1	5
26	−2	104	37.0	−41.0	4.0	10	2	10.0	−13.2	3.2	−11.0	1.0	4	1	−2.2	2.2	2	2
27	−1	92	27.0	−25.0	−2.0	7	4	−0.4	−10.9	11.3	−10.9	11.3	5	2	0.0	0.0	1	0
Mean	1.93	101.22	38.1	−73.36	35.26	11.6	7.7	3.27	−48.4	45.1	−25.6	21.89	7.85	5.11	−23.24	23.24	1.48	3.89
Std. Error (Dev)	(5.7)	(9.8)	9.45	11.82	10.56			8.7	9.78	9.51	7.16	5.14			7.04	7.04		

liquidity traders traded on average 7.85 times with dealers, as compared to 11.6 trades with dealers when dealers were the only game in town (Table I).

Liquidity traders fare better in the dealer-cum-search mechanism for two reasons. First, spreads (and hence trading costs) are significantly lower in the presearch dealer market than in the dealer market when there is no search alternative. (This propensity of dealers to compete more aggressively against the search alternative than they do against each other is a characteristic feature of these markets, and is considered below in the context of dealer profits.) Second, liquidity traders were able to offset roughly 25 percent of their liquidity needs by trading with each other. Such trades are a zero-sum game for the participants and the sector of liquidity traders.

B. Insider Profits

Insider profits by market period are reported in Table I. The insider does best when there is an extreme asset value draw *and* when the liquidity traders tend to trade in the opposite direction. For example, in market period 10, the asset value is L$120, and liquidity traders are net sellers. Here insider profits are very large relative to average levels under both trading mechanisms.

Insider profits are higher in the presence of the search alternative. They average L$45.10 per market period, falling to L$35.26 in the pure dealer market, although this difference is not statistically significant. The insider is also more active in the presence of the search alternative. Here the insider averages 5.11 trades in the dealer market and 3.89 trades in the search market (Table I). In the pure dealer market, the insider averages 7.7 trades per market period.

C. Dealer Profitability

When dealers are the only game in town, dealer profits are large. Here dealer industry profits average L$38.10 per market period, and are larger than those of the insider. In the presence of the search alternative, dealer profits average L$3.27 per period (Table I). This difference is statistically significant ($p < 0.01$). Table II reports the composition of dealer industry profits across the three dealers in each session. Here there is evidence of significant heterogeneity across the dealers in virtually every session under both mechanisms. Agents' roles changed from one session to the next, and the agents did not know how they would be assigned in any session prior to sitting in front of the computer.

The large dealer profits in the absence of overt collusion under the pure dealer mechanism deserve attention. In Table III, we report average posted spreads, which represent all spreads at which traders could have traded. We also report average realized spreads, which were the spreads prevailing at the time of trades. Here results are aggregated across the 27 market periods. The 240-second market periods are divided into 16 consecutive 15 second subintervals. Note that in the first 15 second subinterval, 51 trades took place, and there were 115 posted inside quotes: traders passed on 64 quotes. By compar-

Table II

Dealer Profits per Session

Dealer profits for each of the five sessions under each trading mechanism are reported below. Under the pure dealer mechanism, before trading begins, each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval that is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. The monetary unit in all tables is laboratory dollars (L$ in the text). To convert to $US, multiply the laboratory dollars by 0.05. Different subjects assume the roles of dealers in different sessions. This table therefore illustrates the considerable variability in the profits of individual dealers by sessions, and the impact of providing a search alternative on the profitability of the dealership industry. All random draws are held constant across mechanisms; thus individual sessions are directly comparable across mechanisms.

	Pure Dealer Only Mechanism				Dealer-cum-Search Mechanism			
Session	Dealer 1	Dealer 2	Dealer 3	Dealer Industry Profits	Dealer 1	Dealer 2	Dealer 3	Dealer Industry Profits
1	32.0	24.5	12.0	68.5	15.0	−9.2	−19.9	−14.1
2	169.0	10.0	282.5	461.5	−10.0	4.0	109.5	103.5
3	48.0	9.3	6.0	63.3	−4.3	−27.3	−37.1	−68.7
4	24.6	44.5	117.3	186.4	0.4	−5.3	−71.3	−76.2
5	102.0	47.0	100.0	249.0	28.5	100.0	15.4	143.9

ing the average posted spreads with the average realized spreads, it seems that dealers compete with one another to attract order flow. This phenomenon is also depicted in Figure 1. Here we have selected period 14 as a prototype. The figure shows the time series of inside quotes and transaction prices under the two mechanisms. Note that spread is revised several times prior to a trade taking place in the pure dealer market. After the third trade, there is a quiet period of some 40 seconds, where dealers also narrow the spread to attract trade. This quote adjustment process is not a part of any model—presumably quotes that are revised prior to trades reflect disequilibria. This behavior is roughly consistent with the ad-hoc price adjustment rule suggested by Bulow and Klemperer (1994). For illustrative purposes, Bulow and Klemperer envi-

Table III

Spreads, Efficiency, Volume, and Time Under the Pure Dealer and the Dealer Portion of the Dealer-cum-Search Mechanisms

Under the pure dealer mechanism, before trading begins each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval which is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. Each 240-second pure dealer market period, and 240-second dealer portion of the dealer-cum-search market period is divided into 16 equally spaced intervals of 15 seconds each. Data are aggregated from the 27 sessions and reported by time subinterval. The average spread is the average inside spread posted throughout the subinterval. Spreads are expressed in relative percentage terms: {(lowest ask minus highest bid)/(highest bid plus lowest ask)/2} $*$ 100. The average realized spread is the average relative spread which prevailed when transactions occurred. RMSE (Price) is the root-mean-square-error of transaction prices relative to the asset value. RMSE (mid-pt) is the root-mean-square-error of spread midpoints relative to the asset value. Quote Revisions is the number of times the inside spread is revised. Insider Trades is the number of trades initiated by the insider. Unprofitable Insider Trades is the number of trades by the insider that are putatively unprofitable, causing the insider to incur an immediate loss. Liquidity Trades is the number of trades, by subinterval, initiated by liquidity traders. Transaction prices are significantly more efficient relative to intrinsic value under the dealer-cum-search mechanism. In the pure dealer mechanism, the comparison of average posted spreads with average realized spreads seems to indicate that dealers compete with one another to attract order flow. This disequilibrium adjustment is itself materially affected by the mechanism. Under the dealer-cum-search mechanism, average posted and realized spreads are significantly less prior to search than in the corresponding pure dealer subintervals. Post-search these differences are not significant.

Subinterval	Average Posted Spread	Average Realized Spread	RMSE (Price)	RMSE (mid-pt)	Quote Revisions	Insider Trades	Unprofitable Insider Trades	Liquidity Trades
			Panel A: Pure Dealer Mechanism					
1	14.95	8.81	12.48	11.98	115	11	2	40
2	10.63	7.86	16.98	17.69	74	16	3	16
3	14.40	8.16	10.35	11.33	61	8	3	14
4	11.05	10.16	9.92	10.94	52	7	1	9
5	10.21	8.49	8.80	7.87	59	5	0	9
6	10.42	8.79	10.45	12.17	64	6	0	12
7	12.59	10.34	7.91	7.16	78	10	2	17
8	11.57	8.82	6.02	8.63	76	9	0	7
9	11.41	9.24	9.70	9.83	116	18	1	33
10	9.15	8.16	6.52	7.09	61	12	1	15

Table III—*Continued*

Subinterval	Average Posted Spread	Average Realized Spread	RMSE (Price)	RMSE (mid-pt)	Quote Revisions	Insider Trades	Unprofitable Insider Trades	Liquidity Trades
Panel A:—*Continued*								
11	12.07	8.31	8.64	8.37	81	12	1	20
12	12.49	10.05	10.75	10.24	77	6	1	12
13	11.12	10.35	7.40	8.49	65	7	2	13
14	13.16	8.90	9.33	8.29	73	15	1	22
15	11.41	10.94	10.78	10.15	95	14	0	31
16	14.07	13.79	9.58	8.10	115	31	1	44
Mean	10.66	9.43	9.88	9.72	78.88	11.69	1.19	19.63
Std. Error	0.22	0.22	0.49	0.48				
Panel B: Dealer-cum-Search Mechanism: Dealer Portion Only								
1	7.95	4.44	11.06	11.99	96	10	0	22
2	9.22	3.56	6.07	6.23	73	8	1	10
3	5.72	2.70	7.76	7.07	65	5	0	14
4	6.78	4.07	4.28	3.65	56	3	0	9
5	5.39	4.28	6.32	7.73	56	1	0	6
6	5.12	4.70	8.62	8.03	68	2	0	9
7	5.32	4.37	8.77	9.09	73	6	2	13
8	8.04	5.37	9.28	9.96	87	16	1	15
9	12.00	10.57	5.97	8.53	110	10	0	38
10	11.54	10.68	3.80	3.99	62	4	1	3
11	11.63	9.90	5.60	9.48	64	7	0	12
12	11.19	14.54	3.92	3.57	57	0	0	3
13	11.02	13.26	11.94	5.14	61	0	0	3
14	8.22	5.09	9.02	7.76	80	14	2	14
15	8.28	7.52	8.49	7.36	80	24	0	20
16	10.68	8.48	6.90	7.01	102	28	1	21
Mean	8.21	7.10	7.36	7.29	74.38	8.6	0.5	13.25
Std. Error	0.62	0.89	0.59	0.57				

sion a dealer running a Dutch auction—starting with unreasonably high quotes and lowering them to attract volume.

To further isolate the disequilibrium adjustment in the pure dealer market, we characterize the behavior of dealers (across the 27 market periods) *before the first trade*. The ask was lowered 21 times and the bid raised 42 times. Thus across the 27 market periods, the spread was improved 63 times prior to the first trade.[5] Of these, the inside dealer bettered his quote (on either side of the market) 20 times, and a new dealer posted a more attractive bid (on either side of the market) 43 times. A dealer on the inside worsened his quote five times while still remaining on the inside on that side of the market.

[5] In an empirical study of NASDAQ dealer behavior, Chan, Christie, and Schultz (1995) observe a similar asymmetry in the dynamics of dealer competition. Over the trading day, spreads decline due primarily to increased competition on the *bid* side of the market.

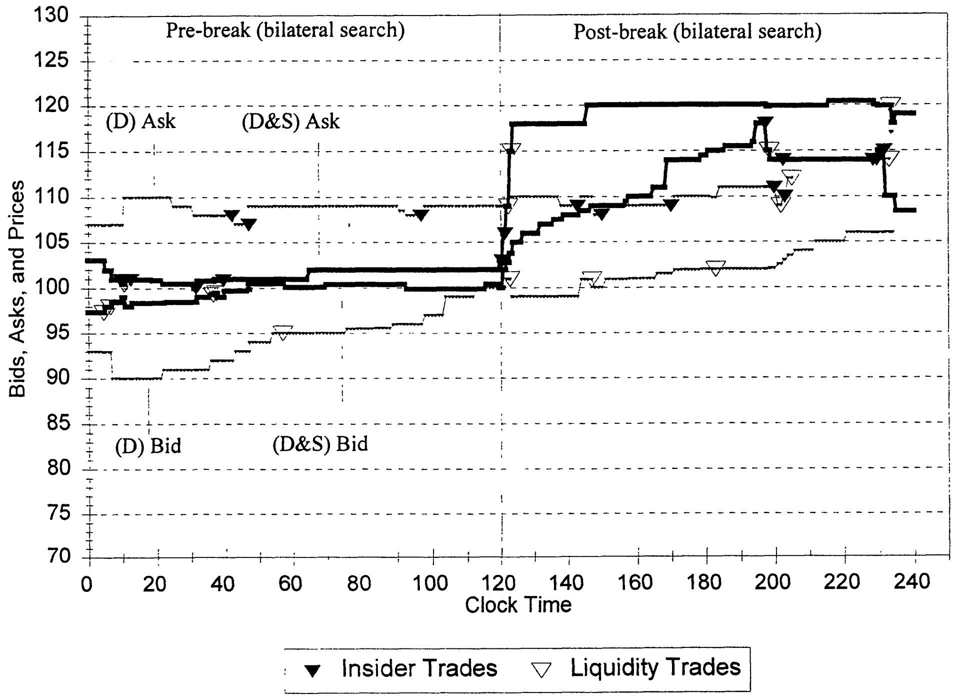

Figure 1. Pure dealer and dealer-cum-search market period 14. The figure depicts the time series of bids, asks, and transactions prices in market period 14 under the pure dealer mechanism (D), and the dealer portion of the mechanism which also allows bilateral search and trade (D&S). Under the pure dealer mechanism, before trading begins each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval which is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. This figure is constructed using all of the inside bids, asks, and transactions prices from market period 14 under the pure dealer mechanism, and the dealer portion only of the dealer-cum-search mechanism. (During the search portion of this market period, there was a single trade at a price of 105.) The large spreads in the pure dealer market are typical of the market periods under this mechanism. Features of this market period that are characteristic of the dealer-cum-search market periods are the tight spreads in the presearch dealer subperiod, the significantly wider spreads postsearch, and the heightened sensitivity of price to order flow postsearch. The end-of-period asset value is 113.

The average across the 27 market periods of the average subinterval spreads at the time when trades occur in the pure dealer mechanism is reported in Table III. Here, the relative bid-ask spread at which transactions occur averages 9.4 percent prior to the break, and 9.8 percent after the break when each transaction is equally weighted. The standard errors of these means are around 0.7 percent, so there is no indication of any difference in pre- and post-the midpoint break spreads. In the dealer market with search (Table III), the mean spread in the postbreak period is 8.7 percent, with a 1 percent standard error, so this is indistinguishable from the spread in the pure dealer markets. In the prebreak period, however, the average spread at which trades occur is 4.5 percent, with a standard error of 0.5 percent. Unlike in the pure dealer markets, or postsearch, dealer profits are insignificantly different from zero, presearch. Per transaction, dealers lose an average of L$1.8 ($0.009) in these periods.

By examining the temporal convergence of spreads to the points at which transactions occur, we note that the competition with the alternative mechanism affects dealer behavior as soon as the market opens. The disequilibrium adjustment itself is materially affected by the mechanism. The average posted spread (at which transactions could have taken place) is 14.95 percent in the first 15 seconds of the pure dealer market, and 7.95 percent in the same interval in the dealer-cum-search market (Table III). The average posted spread over the first 8 subintervals in the pure dealer markets is 11.98 percent. The corresponding average in the dealer-cum-search market is 6.69 percent. The average posted spread in the last 8 subintervals in the pure quote market is 11.86 percent. It is 10.57 percent in the dealer-cum-search market. The fact that the search alternative beckons affects dealer competition: traders in the dealer-cum-search mechanism can afford to be more patient in the dealer market prior to search.

We see the effect of the reduced spreads prior to search in the trading activity in this period. Tables III and IV provide information as to the timing of trades in the dealer-cum-search mechanism. Liquidity traders made 98 trades with dealers prior to search, and 40 trades with each other in the bilateral search market (the equivalent of 80 trades with dealers). From Table IV, we see that liquidity traders engaged in 105 bilateral search trades with the insider. The insider engaged in 138 trades with dealers in this mechanism. Liquidity traders engaged in 114 trades with dealers following the search period.[6]

Thus dealers compete more aggressively against the search mechanism than they do with one another. The most compelling reason for this is that while the

[6] Table IV provides evidence to suggest that the insider attempts to manipulate the price in the pure dealer mechanism. The insider engages in 168 profitable trades (58 in the last 45 seconds). The insider engages in 19 putatively unprofitable trades (8 of these in the first 45 seconds). In the dealer-cum-search markets the insider engages in 138 trades with the dealers, eight of which are, on face-value, unprofitable. Of the 105 trades that involve the insider in the search portion of the dealer-cum-search, five of them were putatively unprofitable—and none of these were trades that the insider proposed.

Table IV

Price Efficiency, Trading Activity, and Time Under the Search Portion of the Dealer-cum-Search Mechanism

During the search portion of the dealer-cum-search mechanism, each of the five traders (one insider and four liquidity-motivated traders) may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed only by the two traders who participated in the transaction. Thus, all trades which take place in the search market are unobserved by the dealers. The 480-second search portion of the dealer-cum-search market period is divided into 16 equally spaced intervals of 30 seconds each. Data are aggregated from the 27 sessions and reported by time subinterval. RMSE (Value) is the root-mean-square-error of transaction prices relative to the asset value. RMSE (100) is the root-mean-square-error of transaction prices relative to 100, the unconditional expectation of the asset value. RMSE (spread) is the root-mean-square-error of transaction prices relative to the midpoint of the inside spread at the end of the first 120-second dealer portion of the market period. RMSE's are reported for all trades, for trades between liquidity traders (Liq-Liq), and for trades between an insider and a liquidity trader (w/Ins). The number of trades by time subinterval is also reported for all trades, trades between liquidity traders, and trades involving the insider. Trades during search tend to be benchmarked to the midpoint of the standing spread at the end of the first dealer market rather than the unconditional expected asset value. Prices also become significantly more efficient relative to intrinsic value over the course of the search market.

Subinterval	Total Trades	RMSE (Value) All	RMSE (100) All	RMSE (spread) All	Trades w/Insider	RMSE (Value) w/Ins	RMSE (100) w/Ins	RMSE (spread) w/Ins	Trades Liq-Liq	RMSE (Value) Liq-Liq	RMSE (100) Liq-Liq	RMSE (spread) Liq-Liq
1	8	14.11	3.94	5.78	4	18.81	3.62	4.51	4	6.63	1.41	2.41
2	12	12.49	2.20	2.66	9	17.89	1.80	2.59	3	12.14	3.11	1.03
3	16	11.38	3.12	2.35	12	22.13	4.06	2.49	4	5.29	1.53	1.84
4	19	9.18	6.19	2.64	13	18.17	6.14	2.02	6	8.36	11.38	4.57
5	11	9.07	5.98	4.16	5	9.92	3.09	1.71	6	11.31	10.13	6.23
6	7	7.43	6.09	4.06	5	8.99	1.12	0.92	2	3.98	9.09	5.13
7	7	5.17	3.09	1.44	4	3.44	0.21	0.77	3	5.91	4.71	1.37
8	13	5.59	4.77	3.64	10	9.00	4.47	3.04	3	4.52	6.21	3.93
9	8	4.75	5.48	3.38	7	6.33	4.69	2.51	1	2.25	3.75	2.00
10	9	4.26	4.37	3.71	7	6.16	4.33	3.08	2	1.72	1.13	1.57
11	8	5.59	6.18	4.34	7	7.84	5.59	3.36	1	1.05	2.83	1.95
12	6	4.90	3.05	2.64	4	4.05	2.34	1.55	2	4.43	1.47	1.80
13	5	9.48	6.12	4.09	3	4.47	4.23	2.19	2	9.60	2.94	2.55
14	5	3.88	7.42	6.65	4	4.30	3.82	3.30	1	0.50	6.93	4.75
15	6	4.06	5.17	4.43	6	4.97	4.22	3.13	0	N/A	N/A	N/A
16	5	6.61	8.48	6.94	5	7.39	6.32	4.48	0	N/A	N/A	N/A
Mean	9.06	7.37	5.10	3.93	6.56	9.62	3.75	2.60	2.50	5.55	4.76	2.94
Std Error		1.87	0.54	0.41		6.74	0.53	0.21		0.69	0.64	0.31

liquidity demand is exogenous in the pure dealer market and post search in the dealer-cum-search market, it is endogenous prior to search in the dealer-cum-search markets. As Huang and Stoll (1995) note in a study of relative spreads on NASDAQ and the New York Stock Exchange, "In summary, spreads are wide on NASDAQ because there is little incentive to narrow them." This is not the case in the presearch portions of the dealer-cum-search market periods. In order to attract order flow from liquidity traders, the spread must be small, and dealers here compete aggressively.[7]

D. Price Discovery and Market Efficiency

The NYSE has argued that alternative mechanisms can actually lead to a drop in social welfare, since price discovery occurs as a result of public trading in a centralized market.[8] As alternative mechanisms attract profitable trades from the exchange, the rewards of market making are reduced, which may

[7] The dynamics of dealer competition change when the liquidity demand is exogenous. Contributing factors here are that the number of dealers is small relative to the expected order flow, and that dealers attempt to maintain a flat inventory. Evidence of dealer inventory management was garnered through a randomization study of dealer inventories. Let $I_{j,t}$ be the inventory (number of shares) of dealer j, after trade t. In each period the following statistic is computed:

$$d = \frac{1}{N}\sum_{t=1}^{N}\frac{1}{3}\sum_{j=1}^{3}(I_{j,t} - \bar{I}_t)^2, \qquad \text{where} \quad \bar{I}_t \equiv \frac{1}{3}\sum_{j=1}^{3} I_{j,t}$$

and N is the number of trades in the period. In general, if dealers manage their inventories, this statistic (d) will be small. The distribution of the test statistic under the null is constructed by simulating an order flow identical to that in each market period. Then the trade is randomly assigned to one of the three dealers. This procedure is repeated 10,000 times for each trade, in each market period. In 16 of the 27 market periods, the actual statistic is less than the 1 percent critical value from the simulations. Only in market periods 5 and 23 are the tabulated statistics higher than the median simulated statistic.

Further evidence in support of dealer inventory management is contained in the regression results of Table VII. These regressions show that the response of the spread midpoint to a trade depends on the dealer industry net inventory in the pure dealer market periods and the presearch dealer-cum-search subperiod. Note that post search in the dealer-cum-search markets, lagged inventory is not related to the midpoint of quote revisions. This is not surprising since the remaining liquidity demand post search would be expected to be correlated with the insider's demand. The intuition here is that if the asset value is high, during search the insider can profitably provide liquidity to traders that need to sell. Liquidity traders that need to buy will prefer to wait for the second dealer market, rather than accept unfavorable terms offered by the insider. Dealers protect themselves post search by moving prices aggressively in response to order flow. This can be seen in Table VIII where price changes in response to order flow are examined, controlling for the size of the spread. The price response to order flow is highest in the dealer market subperiod following search. A possible explanation for dealer inventory management is dealer risk aversion. Ho and Stoll (1983), for example, develop a model in which dealer risk aversion implies inventory management, which in turn, is shown to have implications for the competitive dynamic. Cox, Smith, and Walker (1988) report experimental evidence of risk aversion in first-price private-value auctions.

[8] This is a tenet of a recent article by Hasbrouck (1995) that takes as given that price discovery and volume should be proportional across markets.

Table V

Price Efficiency Under the Pure Dealer and Dealer-cum-Search Mechanisms

This table reports root-mean squared price errors for each of the 27 market periods under each trading mechanism. Under the pure dealer mechanism, before trading begins, each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval which is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. RMSE (Price) is the root-mean squared error of transaction prices from the asset value during the market period, while RMSE (mid-pt) bases the same calculation on the spread mid-point when the transaction takes place. In the search portion of the Dealer-cum-search mechanism, transaction prices are compared to three different values; Value (the asset value), 100 (the unconditional expectation of the asset value), and spread (the midpoint of the bid-ask spread when the first dealer market closed and the search market opened). Trades are also isolated by counterparties. All means all search trades, Liq-Liq means a trade between two liquidity traders, and w/Ins means a trade between a liquidity trader and the insider. In the dealer portion of the dealer-cum-search markets, transaction prices are significantly more efficient relative to intrinsic value than in the pure dealer mechanism. The pricing errors in the search portion of the dealer-cum-search markets are lower than in the dealer portions of these markets, but this difference is not significant.

	Pure Dealer Only Mechanism		Dealer-cum-Search Mechanism (Dealer Portion Only)		Dealer-cum-Search Mechanism (Search Portion Only)								
Market Period	RMSE (Price)	RMSE (mid-pt)	RMSE (Price)	RMSE (mid-pt)	RMSE (Value) All	RMSE (100) All	RMSE (spread) All	RMSE (Value) w/Ins	RMSE (100) w/Ins	RMSE (spread) w/Ins	RMSE (Value) Liq-Liq	RMSE (100) Liq-Liq	RMSE (spread) Liq-Liq
1	16.42	17.36	6.59	8.18	17.21	3.07	2.37	16.36	4.10	3.04	18.03	1.41	1.41
2	7.99	5.09	4.32	6.02	7.13	3.04	2.70	6.27	3.60	2.86	8.59	1.32	2.35
3	7.57	6.47	9.02	7.93	2.80	3.14	3.14	3.81	4.95	3.54	1.85	0.29	2.84
4	11.88	9.03	6.30	5.01	5.12	1.28	1.28	5.05	1.21	1.21	5.22	1.37	1.37
5	11.79	11.97	10.82	14.54	15.51	0.71	0.71	15.67	0.58	0.58	15.00	1.00	1.00
6	8.73	7.21	3.42	4.87	5.19	1.03	1.10	4.97	0.32	0.62	5.41	1.42	1.43
7	12.03	9.71	9.71	8.73	4.37	8.01	5.72	N/A	N/A	N/A	4.37	8.01	5.72
8	18.84	18.89	9.04	10.03	13.83	5.36	5.45	13.83	5.36	5.45	N/A	N/A	N/A
9	9.33	9.48	4.72	4.73	5.14	1.81	2.72	4.59	1.88	3.12	6.52	1.58	0.61
10	17.23	17.71	9.88	12.60	13.27	10.24	6.90	14.01	9.84	6.83	11.18	11.18	7.07
11	8.26	8.84	5.56	5.56	4.16	3.95	2.78	3.55	4.39	3.09	6.00	1.00	0.50
12	6.65	6.99	3.28	5.65	2.41	4.66	3.66	2.55	4.53	3.54	2.10	4.90	3.90
13	8.91	9.83	7.30	6.20	0.93	0.38	2.07	0.93	0.38	2.07	N/A	N/A	N/A
14	7.79	8.74	9.45	9.66	8.00	5.00	3.80	8.00	5.00	3.80	N/A	N/A	N/A
15	5.19	5.00	2.22	2.43	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16	5.69	4.72	7.71	7.81	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	6.27	5.87	6.43	6.19	4.51	2.08	3.56	4.51	2.08	3.56	N/A	N/A	N/A
18	2.64	2.05	1.74	2.41	0.47	2.45	0.96	0.47	2.45	0.96	N/A	N/A	N/A
19	13.27	14.77	11.64	12.07	2.83	17.12	6.32	4.00	15.00	4.00	0.00	19.00	8.00
20	4.7	4.87	1.00	1.77	0.96	0.39	0.72	0.96	0.39	0.72	N/A	N/A	N/A
21	4.84	2.59	4.94	1.10	1.12	1.12	2.26	0.72	0.72	1.25	1.32	1.32	2.74
22	13.29	14.55	10.27	13.08	12.70	4.93	4.93	12.77	4.93	4.93	12.00	5.00	5.00
23	6.2	5.51	12.16	10.06	3.11	7.05	4.08	3.11	7.05	4.08	N/A	N/A	N/A
24	4.39	2.86	4.50	3.73	5.65	3.95	3.23	4.46	2.79	2.17	8.25	6.25	5.26
25	6.13	5.97	3.31	2.54	2.48	4.71	2.57	1.55	3.71	2.58	5.00	8.00	2.50
26	5.95	4.91	3.52	3.35	2.37	4.61	3.41	1.10	2.90	1.40	3.16	5.83	4.61
27	6.87	6.68	5.10	6.40	8.50	0.50	0.50	N/A	N/A	N/A	8.50	0.50	0.50
Mean	8.85	8.43	6.64	6.44	5.99	4.02	3.08	5.79	3.83	2.84	6.80	4.41	3.16
Std Error	0.79	0.88	0.66	0.60	0.92	0.70	0.33	0.96	0.64	0.31	0.90	0.91	0.43

result in underproduction of price discovery. It is clear that the rewards to being a dealer are reduced by the presence of alternative mechanisms, as shown in the previous subsection.

Price efficiency is measured by the root mean square error (RMSE) of prices relative to the true asset value (Table V). This statistic is reported for each of the 27 market periods using both the transaction price (one side of the spread), and the midpoint of the spread when the transaction takes place. In the dealer-cum-search market periods, RMSEs are reported for both the dealer portion and the search portion of each market period. In the search portion, the statistic is reported relative to the true asset value, the unconditional expectation of the asset (100), and the midpoint of the inside spread at the end of the first dealer market subperiod. These RMSEs are also broken out to isolate trades that did and did not involve the insider.

In the pure dealer market, the average RMSE of transaction prices across markets is 8.85, which is roughly equal to one standard deviation of the asset value's distribution. The standard error is 0.79. Looking at the 15 second subintervals in Table III, we see a slight tendency for the RMSE to decline as trading proceeds, but the average RMSE in the last 15 seconds of trading is 9.58. The maximum RMSE is 17.0 in the second 15 second interval of trading.

By comparison, note that the RMSE of trades with dealers in the quote driven portion of the dealer-cum-search markets is 6.64, with a standard error of 0.66. This difference is significant ($p < 0.01$). Looking at the results by 15 second subintervals in Table III, we note a decline in the RMSE of both transaction prices and the spread midpoint following the first 15 seconds of trading. After that however, the RMSE with respect to the transaction price is fairly flat over the remaining periods, and it is highest in the fifth subinterval *following* the break.

There were 145 trades in search (as noted above, liquidity traders traded with each other 40 times). The cross-market averages in Table V suggest that traders use the posted spread to benchmark their trades in search. The overall RMSE with respect to the standing spread midpoint is 3.08 (3.93 when averaged over subintervals, in Table IV), whereas the RMSE relative to the asset's *unconditional* expected price is 4.02 (5.10 when averaged over subintervals). Note that the RMSE of transaction prices relative to the asset's value in the search portion of the dealer-cum-search market is 5.99 (standard error of 0.92) which is lower than the same RMSE of all trades which take place in the quote-driven portion of this mechanism (6.44) and all trades that take place in the pure dealer mechanism (8.85) (Table V). In the latter comparison this difference is significant ($p < 0.01$), while in the former it is not. From Table IV we observe the patterns by which liquidity traders trade with each other in the search portion of the dealer-cum-search mechanism. These trades tend to occur early in the interval, and we see that they tend to be benchmarked by the posted spread.[9]

[9] The finding that the transaction prices are closer to the true values in the dealer-cum-search markets than in the pure dealer markets appears contradictory to the prediction of Pagano and

Whereas the search market uses the price discovery in the preceding dealer market as a benchmark, price discovery continues to occur in the search period. Over the first four 30-second intervals, the RMSE of all transactions, relative to the asset's value declines from 14.11 to 9.18. It is clear from Table IV that this is because of the behavior of the insider. There is a dramatic drop in the RMSE of his transactions over the first two minutes of the search period.

Table VI provides results from regressions of the absolute value of the "price error" (i.e., the difference between the transaction price and the asset's value) on time and value, as well as a dummy variable to indicate whether the insider is trading (recall that the value is *known* only by the insider, although the dealers are attempting to infer it from the order flow). We also run the same regressions, using the midpoint of the bid-ask spread at the time of the transaction as the dependent variable. These regressions are reported for both the pure dealer mechanism and the dealer-cum-search mechanism, and also prior to and subsequent to the break in the dealer market (which is the search portion of the dealer-cum-search mechanism, and a break in the pure quote mechanism). In this regression, time is measured as the number of seconds into the trading interval, so prices become more efficient with the passage of time, when price is measured by the spread midpoint. However, when transaction prices are used, time does not increase informational efficiency in the dealer-cum-search market overall, or in the postbreak subinterval of the pure quote mechanism. Since the insider will generally trade on the side of the spread closer to the asset value, it is not surprising that when efficiency is measured using the transaction price, efficiency is higher when the insider accepts the quote. Similarly, since the insider is less likely to trade when the spread surrounds the value, we also see in Table VI that when price is defined as the midpoint of the bid-ask spread, prices are less efficient when the insider trades. One difference between the pure quote-driven and the dealer-cum-search mechanisms that is apparent from Table VI is that postsearch in the dealer-cum-search markets, value is *not* related to the pricing error, using either the transaction price or the midpoint of the spread as the dependent variable. In all other settings, value is positively related to the pricing error. Once again, this reflects the heightened elasticity of quotes to trades following the search portion of the dealer-cum-search mechanism.

We ran a similar regression for the search portion of the dealer-cum-search markets. Specifically, the dependent variable is the absolute value of the deviation between the transaction price and the asset's true value, and the independent variables are: time, an insider dummy variable, an interaction term between time and the insider dummy variable, and the difference be-

Röell (1996), (cited above), that increased transparency results in tighter spreads. In the lab markets, the search markets are less transparent, but they are a source of competition to dealers. In Pagano and Röell, the opaqueness of the market allows the insider to "pick off" all of the dealers without revealing his presence through the order flow. Thus, dealers widen their spreads in self defense. Here, (most likely) dealers tighten their spreads prior to the search period to attempt to attract trades from the opaque search market. The traders are also more patient when they see spreads that appear unfavorable relative to terms of trade anticipated in the search market.

Table VI

Price Efficiency and Time Under the Pure Dealer Mechanism and the Dealer-cum-Search Mechanism

In order to examine the convergence of price to efficient values over time we estimate the following model with Ordinary Least Squares:

$$\text{PRICE ERROR} = b_0 + b_1\text{TIME} + b_2\text{INSIDER} + b_3\text{VALUE} + \varepsilon$$

Variable definitions are as follows. PRICE ERROR is the difference between the trading price and the end-of-period liquidation value in absolute value, TIME is the clock time of the transaction counting up from zero, INSIDER is an indicator variable that takes on the value of 1 when a trade is initiated by the insider and 0 otherwise, and VALUE is the absolute value of the deviation of the asset value from its unconditional expectation (t-values are reported in parentheses). Under the pure dealer mechanism, before trading begins each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval which is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. The clock time variable (TIME) is set to 0 at the start of the first 120-second centralized market period, and 120 at the start of the second centralized market period. The model was also estimated with the PRICE ERROR calculation based on the differential between the asset value and the midpoint of the spread. Results are provided for aggregated results under each treatment, and for the two 120-second subperiods. Results from the bilateral (search) periods in the dealer-cum-search market periods are not included. In general, intrinsic value is positively related to the pricing error. The exception is post search under the dealer-cum-search mechanism. This reflects the heightened sensitivity of quotes to trades following the search market.

Session	$\hat{b}_0$	$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$	Trades	Adj R^2
	Panel A: PRICE ERROR = abs(P − Asset Value)					
Pure dealer	6.62	−0.01	−2.53	0.51	501	0.30
(Global)	(10.98)	(−4.11)	(−5.12)	(13.15)		
Pure dealer	4.22	−0.02	−2.19	0.80	196	0.54
TIME $\leq$ 120	(5.34)	(−2.29)	(−2.95)	(13.96)		
Pure dealer	8.13	−0.01	−3.70	0.28	305	0.19
TIME $>$ 120	(5.45)	(−1.07)	(−5.85)	(5.44)		
Dealer-cum-search	4.38	−0.00	−1.44	0.30	350	0.15
(Global)	(7.27)	(−0.67)	(−2.85)	(7.71)		
Dealer-cum-search	1.72	−0.004	−0.93	0.75	153	0.74
TIME $\leq$ 120	(3.57)	(−2.49)	(−1.97)	(20.97)		
Dealer-cum-search	3.99	0.02	−2.39	−0.00	197	0.06
Time $>$ 120	(2.26)	(1.89)	(−3.65)	(−0.03)		

Table VI—*Continued*

Session	$\hat{b}_0$	$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$	Trades	Adj R^2
Panel B: PRICE ERROR = abs((bid + ask)/2 − Asset Value)						
Pure dealer	4.23	−0.01	3.35	0.59	501	0.49
(Global)	(8.75)	(−5.75)	(8.44)	(18.66)		
Pure dealer	1.97	−0.01	1.92	0.88	196	0.70
TIME ≤ 120	(3.01)	(−1.82)	(3.13)	(18.53)		
Pure dealer	5.77	−0.01	3.29	0.40	305	0.29
TIME > 120	(4.97)	(−2.33)	(6.68)	(9.83)		
Dealer-cum-search	3.47	−0.01	2.22	0.40	350	0.34
(Global)	(6.80)	(−2.85)	(5.16)	(11.94)		
Dealer-cum-search	1.11	−0.01	1.13	0.80	153	0.85
TIME ≤ 120	(2.97)	(−3.40)	(3.04)	(28.63)		
Dealer-cum-search	7.71	−0.02	2.89	0.07	197	0.13
TIME > 120	(5.09)	(−2.27)	(5.13)	(1.36)		

tween the asset value and its unconditional expectation in absolute value. The coefficient (t-statistic) on time is −0.007 (−1.44); the insider dummy variable, 2.26 (1.94), the interaction between time and the insider dummy, −0.009 (−1.56), and value, 0.59 (13.70). As in the dealer market trades, efficiency tends to improve with the passage of time, and value is the most important determinant of efficiency. Since during the dealer market *prior* to the search portion of the market period value discovery may occur, we repeated the regressions adding a new variable, the difference in absolute value between the asset value and the midpoint of the spread prior to search (at the end of the first dealer market subperiod). The coefficient on this variable is significant: 0.96 (7.39). Its inclusion also reverses the sign and reduces to insignificance the coefficient on the asset value variable, and increases the adjusted R^2 of the regression by 15 percent to 0.75. The superior price efficiency of the search portion of the dealer-cum-search mechanism can therefore be explained as follows. First, liquidity traders tend to split the gains due to avoiding the bid-ask spread when trading with each other, while benchmarking trades on prices established in the preceding dealer market. Second, the insider does not in general initiate trades at prices which would lie outside the spread expected to prevail in the subsequent dealer market since the liquidity traders have the option to wait and trade in this market. Prices therefore incorporate information from the first dealer market, while avoiding the inefficiency of a large bid-ask spread.

Table VII examines the dealer's responsiveness to order flow and net order imbalance in the two quote driven markets. The change in the midpoint of the spread, from one transaction to the next, is regressed on +1 if the previous trade was a buy or −1 if it was a sell, and the net order imbalance at the time the trade was made (i.e., the sum of all previous order flow variables). Note that this simple model explains more than half of the spread midpoint revisions in the presearch dealer-cum-search market, and approximately one-third

Table VII

The Responsiveness of Quotes to Order Flow

In order to measure the responsiveness of dealers' price setting behavior to order flow we estimate the following model with Ordinary Least Squares:

$$\Delta \text{MIDPOINT}_t = b_0 + b_1 Q_{t-1} + b_2 \text{NETQ}_{t-1} + \varepsilon.$$

Variable definitions are as follows. The dependent variable (ΔMIDPOINT$_t$) is the change in the midpoint of the spread $(\text{ask}_t + \text{bid}_t)/2 - (\text{ask}_{t-1} + \text{bid}_{t-1})/2$, Q_{t-1} is the order preceding the quote revision, and NETQ$_{t-1}$ is the net order imbalance prior to the quote revision. Results are provided for aggregated outcomes under each mechanism, as well as for the two 120-second subperiods. Under the pure dealer mechanism, before trading begins each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval which is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. In the first dealer market under both mechanisms, the impact of the net order imbalance on price setting behavior indicates dealer inventory management. Post search under the dealer-cum-search mechanism, dealers cease to manage inventories in the usual way.

Session	$\hat{b}_0$	$\hat{b}_1$	$\hat{b}_2$	Trades	Adj R^2
Pure dealer	−0.06	1.43	0.15	474	0.30
(Global)	(−0.58)	(13.53)	(3.93)		
Pure dealer	−0.06	1.06	0.36	170	0.32
TIME ≤ 120	(−0.41)	(7.83)	(5.05)		
Pure dealer	−0.08	1.66	0.09	305	0.32
TIME > 120	(−0.54)	(11.54)	(2.14)		
Dealer-cum-search	0.08	1.35	0.06	323	0.32
(Global)	(0.62)	(11.83)	(2.01)		
Dealer-cum-search	−0.10	1.06	0.27	129	0.55
TIME ≤ 120	(−1.00)	(11.55)	(5.10)		
Dealer-cum-search	0.25	1.61	0.02	194	0.31
TIME > 120	(1.26)	(8.05)	(0.47)		

in the other three cases. We note that the effect of net order imbalance declines significantly in the second dealer market. Under both mechanisms, in the first dealer market, both regressors are statistically significant. As noted, post-search, we expect the remaining liquidity demand to be correlated with the insider's demand, limiting opportunities for inventory management. In this context, dealers cease to manage inventory in the usual way.

Table VIII uses the method of Glosten and Harris (1988) to decompose the spread into a fixed component and a component due to order flow. Here the change in the transaction price from one transaction to the next in the dealer markets is regressed on a variable relating this transaction to the previous transaction and signed volume. The coefficient on the first variable is posited to be unrelated to the information in the trade (fixed component) whereas the coefficient on the second variable is the permanent effect of the trade (adverse selection component). The adverse selection component of the spread is defined as the ratio of the latter to the sum of the two components. Although the percentage of the spread due to adverse selection in the dealer-cum-search market is more than twice the percentage in the pure dealer market both pre- and postsearch, the reasons are different in each period. In the dealer only market, the coefficient estimates for the fixed and adverse selection components of the spread are not significantly different before and after the trading halt. Under the dealer-cum-search mechanism, the estimate of the fixed component of the spread prior to search is less than half the postsearch estimate. This is due to the effect of the impending search market on the nature of dealer competition. Postsearch, price is also significantly more responsive to order flow because of the heightened adverse selection resulting from the search market.

IV. Conclusions

Motivated by the dramatic growth rates in off-floor trading mechanisms, such as POSIT, this article examines the economic effects of a competitive market mechanism on a dealer market. The experimental lab is exploited to address questions that are beyond the reach of existing theoretical models. We find that an alternative bilateral search mechanism (with no publication of trades) has a profound impact on trading activity in the centralized market. Spreads are much lower in the period preceding the search market than in the subsequent period, or in markets with no search. Dealer profits are greatly reduced when the search market is introduced. This phenomenon is attributed to the endogeneity of the order flow when traders have alternatives. Introducing many new dealers would greatly reduce dealer profits; we see here that the same effect can be obtained by allowing traders to engage in fourth market type transactions.

Market efficiency is not attenuated by hidden trades that take place in the bilateral search context. As a matter of fact, the root mean square error of transaction prices relative to the asset's true value is lowest in the search portion of the dealer-cum-search market, where no trades are public knowledge. The root mean square error is also lower in the dealer portion of the dealer-cum-search market than in the pure quote-driven market.

The implications of this study for regulation of securities markets depend on allocative issues outside our analysis. In the experiment, all markets were

Table VIII

Decomposing the Spread

In order to decompose the spread into a fixed component and a portion due to adverse selection, we estimate the following model with Ordinary Least Squares:

$$\Delta P_t = b_0(I_t - I_{t-1}) + b_1 Q_t + e_t.$$

Variable definitions are as follows: ΔP_t is the transaction price change $(P_t - P_{t-1})$, I_t is an indicator $(+1, -1)$ of a buyer or seller initiated trade, and Q_t is signed volume (t-values in parentheses). The column labeled adverse selection % gives the estimate of the proportion of the spread due to adverse selection, following the Glosten-Harris method (1988). Results are provided for aggregated outcomes under each mechanism, as well as for the two 120-second subperiods. Under the pure dealer mechanism, before trading begins each of the three dealers must submit a bid and an ask for a single unit of the risky asset. The market then opens and the trading interval clock begins a 120-second countdown. There are five traders (one insider and four liquidity-motivated traders). When the market is open, each of the five traders is free to hit inside quotes, and each dealer is free to revise his/her outstanding quotes at any time. When a trader initiates a trade, all traders and dealers observe the transaction price, but they do not learn which trader initiated the trade. The trading interval clock is paused while the dealers go through the process of resubmitting quotes, so the actual trading interval requires considerably more than two minutes. After the completion of the 120-second (in potential trading time) trading interval, there is a 30-second pause in trading activity that has no effect on market activity. At the end of the trading halt, there is a second 120-second trading interval which is conducted exactly as the first. The dealer-cum-search market opens exactly as the pure dealer mechanism. After the first 120-second trading interval there is an eight-minute bilateral search market. During the search market, each trader may attempt to initiate a trade with any other trader by sending a trade proposal. A trade proposal indicates the type of trade desired (buy or sell), the trader to whom the proposed trade is directed, and the proposed trading price. Upon receiving the trade proposal, the recipient may accept the proposal or allow it to expire. A trade completed in the search market is observed *only* by the two traders who participated in the transaction. The percentage of the spread due to adverse selection under the dealer-cum-search mechanism is more than twice the percentage in the pure dealer markets. Under the pure dealer mechanism, the estimates of the fixed and adverse selection components do not differ significantly in the first (TIME $\leq$ 120) and second (TIME $>$ 120) dealer markets. This is not the case in the presence of the search alternative. Here, both component estimates are significantly larger postsearch.

Session	$\hat{b}_0$	$\hat{b}_1$	Adverse Selection %	Trades	Adj R^2
Pure dealer	3.46	0.93	0.12	474	0.63
(Global)	(19.06)	(3.96)			
Pure dealer	3.04	0.77	0.11	170	0.61
TIME $\leq$ 120	(11.29)	(2.28)			
Pure dealer	3.66	1.03	0.12	304	0.65
TIME $>$ 120	(15.40)	(3.28)			
Dealer-cum-search	1.27	1.31	0.34	323	0.42
(Global)	(7.53)	(6.83)			
Dealer-cum-search	0.81	0.82	0.34	129	0.45
TIME $\leq$ 120	(4.79)	(3.70)			
Dealer-cum-search	2.00	1.55	0.28	194	0.49
TIME $>$ 120	(7.67)	(6.03)			

zero-sum games. Much of the economic value attributed to centralized markets concerns the fact that prices are publicly available (Ashenfelter 1989). Fears of underproduction of price discovery because of trades taking place in decentralized markets seem unfounded, however. In fact, in this experiment, dealer profitability and market efficiency are inversely correlated.

This study does not explore the effect of limit orders. The search mechanism used in this experiment is not directly analogous to limit orders. Specifically, when a trader posts a limit order, he generally gives a free option to the market. Because public information continues to come out after the limit order is placed, the trader who places a limit order is also subject to a winner's curse problem. Here, no public information is released or processed when traders engage in search activity. Also, here a trader who submits a desire to trade in search chooses to whom to direct that desire; he does not post a limit order that is observed by dealers and all other traders. It remains a subject for future research to compare the fourth market bilateral search trades in this study with limit orders.

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