The Organization of Financial Exchange Markets: Theory and Evidence

Craig Pirrong
John M. Olin School of Business
Washington University

November 19, 1998

Abstract. This article presents theory and evidence regarding the organization of financial exchange markets. It derives conditions under which (1) a member-owned exchange has a monopoly over the trade of a particular financial contract and its close substitutes, and (2) exchange members earn economic rents. Specifically, if the identified conditions hold, low cost suppliers of financial services can form an exchange which is large enough to deter entry by competing exchanges but which is smaller than optimal. However, exchanges trading differentiated products may not merge to exploit all scope economies; maintaining separate exchanges reduces competition between suppliers of trading services. Furthermore, exchanges that offer a variety of products may allow some members to trade only a subset of these products in order to preserve member rents. The evidence is broadly consistent with these predictions. Exchanges typically monopolize trade in a particular financial contract. Exchange q ratios are well above 1, indicating economic rents. Exchanges limit the number of members, and frequently create membership classes with limited trading rights. The analysis has implications for the optimal regulation of financial exchanges.

1 Introduction

A vast literature analyzes the prices determined on financial exchanges, but far less attention has been paid to the economics of exchanges themselves. This is unfortunate because exchanges such as the New York Stock Exchange and the Chicago Board of Trade are distinctive organizations that wield great influence over the financial transactions that determine the allocation of risk and capital. A better understanding of the functioning of securities and derivatives markets requires a more complete knowledge of the operation of the exchanges on which a large fraction of financial transactions take place.

To further this understanding, this article presents a theory of the organization of financial exchange markets and some empirical evidence bearing on the predictions of this theory. It derives implications from the feature that distinguishes financial exchanges from the traditional firms that economists typically analyze; the fact that traditional financial exchanges are non-profit cooperative membership organizations which provide semi-private goods to their members, who in turn supply financial services (e.g., brokerage) to those who desire to trade financial assets. These semi-private goods include the erection and operation of physical trading facilities and the creation and enforcement of rules and procedures that reduce default and measurement costs (Pirrong, 1995a).

Although the reduction of transactions costs provides the impetus for the formation of exchanges, strategic considerations influence their organization and operation. I demonstrate that if (1) the creation or operation of an exchange requires the payment of fixed costs and inter-exchange arbitrage is costless, or (2) atomistic investors/hedgers choose where to trade non-cooperatively, the suppliers of trading services can behave strategically when forming exchanges. Specifically, the number of members permitted to join an exchange is limited to reduce competition in the supply of trading services and thereby generate economic rents. Under plausible conditions, exchanges have enough members to make it uneconomic for competing exchanges to form, but fewer members than is socially optimal. That is, under these conditions all trading in a particular financial instrument is concentrated on a single exchange with a suboptimally small membership. However, multiple exchanges trading differentiated products may survive. This occurs because member-intermediaries may face increased competition when exchanges listing differentiated products merge trading rights. This implies that exchanges sometimes limit inefficiently the variety of products they trade or the trading rights of their members.

These results are novel. There is little if any existing research that attempts to explain the determinants of the equilibrium size of exchanges and the rents that their members earn.

The empirical evidence supports the model's predictions. Exchanges strictly limit membership. In addition, futures exchanges often limit the trading rights of members to subsets of the products traded on them. Moreover, trading of particular financial instruments exhibits strong natural monopoly characteristics; exchange market shares of the trade of major financial instruments are extremely high, and typically equal 100 percent for futures and futures options contracts. Perhaps most important, members of financial exchanges earn substantial economic rents. The ratios of the value of claims against financial exchanges (as measured by the value of membership–"seat"–prices) to the value of the tangible assets of exchanges are very large (especially when compared to q's observed for manufacturing firms), sometimes exceeding 5 for extended periods. Indeed, these ratios actually understate the rents that members earn due to limitations on exchange membership because (1) seat prices capitalize the rents the marginal member earns, and (2) limits on the number of memberships generate larger rents for inframarginal members than marginal ones. Since alternative explanations of these ratios (such as congestion effects and investment options) are not plausible in this context, these figures provide strong evidence that exchange members earn rents on the right to trade on an exchange; this right is artificially scarce as a result of the exchange's limit on the number of members. All of these findings correspond closely to the predictions of the theoretical models.

This work reconciles two apparently incompatible views of financial exchanges. According to the property rights view (Coase, 1988, Mulherin et al, 1991, Pirrong, 1995a), exchanges reduce transactions costs by creating and enforcing rules and property rights, and by investing in a trading infrastructure. The more skeptical "exchange-as-monopoly" view asserts that exchanges cartelize the supply of financial transaction services to generate rents for trading firms (Oesterle, Winslow, and Anderson, 1992, McInish and Wood, 1996). This article and its companion piece (Pirrong, 1997) demonstrate that these theories are complementary, rather than conflicting. Exchange members earn rents in equilibrium by restricting their numbers, and perhaps by enforcing cartel agreements or passing self-interested but inefficient rules that elevate the prices of transaction services. Scale economies in the provision of semi-private exchange services or liquidity effects serve as the barrier to entry necessary to ensure that exchange members can capture rents. Put differently, the property rights and exchange-as-monopoly views are not in conflict; instead, exchange members earn rents precisely *because* scale economies in the provision of trading infrastructure and the enforcement of property rights and rules allow the exchange to limit strategically the number of members while still preventing entry by a competing exchange.

The empirical and theoretical analyses have normative implications. Most important, financial exchanges worldwide are subject to extensive legal and regulatory restrictions. Numerous economists have argued that these regulations are largely unnecessary because exchanges have incentives to adopt efficient rules and practices without external prodding because competition between exchanges or the mere threat of competition between exchanges forces them to do so.[1] The theory and evidence presented herein cast doubt on these arguments. The theory suggests that there are strong reasons to believe *a priori* that direct competition between exchanges will be limited, if it exists at all. The empirical results provide strong evidence of rents persistently accruing to exchange members and virtually no evidence of direct competition between exchanges in particular financial instruments. Given these results, any presumption that self-regulation necessarily dominates external regulation is no more defensible than a presumption that external regulation is superior. Pirrong (1997) demonstrates that when are not perfect competitors, they may adopt inefficient rules that benefit members at the expense of customers and third parties. Thus, recognizing the inefficiencies inherent in external regulation, the determination of whether external regulation or exchange self-regulation is superior in a specific instance requires a detailed, fact-intensive analysis of the particulars.

Recent developments in financial markets illustrate the practical relevance of this article. There have been announcements of major exchange mergers between US securities markets (NASDAQ and AMEX) and between European derivatives exchanges. Moreover, other consolidations or alliances of exchanges are under active consideration. The theory presented herein has predictions concerning when consolidation is likely to take place, the form merger is likely to take, and the effects of merger on competition in financial markets.

[1]See Easterbrook (1986), Fischel and Grossman (1984), Edwards and Edwards (1984), Abolafia (1985), and Mulherin *et al* (1991). Pirrong (1995b) and Pirrong (1997) present a contrary view.

The remainder of this article is organized as follows. Section 2 presents a theoretical analysis of exchange organization which derives conditions under which (1) an exchange has monopoly of the trade of a particular financial instrument, and (2) exchanges inefficiently limit membership size to generate economic rents for members. Section 3 demonstrates that product differentiation permits the survival of multiple exchanges. Indeed, an inefficiently large number of exchanges each may trade an inefficiently narrow variety of instruments, or may restrict the ability of members to trade all instruments offered by the exchange, in order to preserve member rents. Sections 4, 5, and 6 present empirical evidence on exchange market shares in the trading of specific financial instruments, the rents earned by exchange members, and exchange membership policies, respectively. Section 7 summarizes the work.

2 The Equilibrium Number and Size of Financial Exchanges

2.1 Introduction

This section presents a formal model of the formation of financial exchanges. The objective of the analysis is to determine the number of exchanges that exist in equilibrium, the size of these exchanges, and the profits their members earn. There is little research on the determinants of exchange size and member profitability, so the results presented in this section are novel.[2]

[2]Brown and Zhang (1997) present a model in which intermediaries can choose to join an exchange or trade off-exchange. Membership of an exchange is costly, but members can observe order flow whereas non-members cannot. The trade-off between these costs and benefits of membership determines how many intermediaries join exchanges in their model. Their model posits an exogenously given cost of membership and interprets the exchange seat price as this cost. This is incorrect because the seat price endogenously capitalizes rents to membership rather than providing a measure of the true cost of belonging to an exchange; such costs properly would include the fees required to pay for exchange infrastructure, trading processing and clearing fees, etc. Put differently, in reality seat prices and the number of exchange members are simultaneously determined, rather than sequentially as in Brown-Zhang. Saloner (1984) presents a non-cooperative model of exchange formation. This model predicts that many exchanges may survive and that entry of multiple exchanges may dissipate trader rents. In Saloner's model the sum of the number of members on all exchanges combined is constant regardless of the number of exchanges that operate. His model also relies on some counterfactual assumptions concerning loss sharing among exchange members.

In this model, investors desire to trade a particular asset or financial contract for risk shifting or speculative reasons. In order to focus on the crucial aspects of the analysis, there is no informed trading. The assumption of no informed trading is not extreme for some markets, such as futures markets. There is a population of noise traders who trade due to exogenous hedging or endowment shocks. The quantity demand by noise traders is inelastic with respect to execution price P. I make the conventional assumption that the net noise trading demand $z \sim N(0, S)$. The traded asset is risky. Its value $v \sim N(0, \sigma^2)$. Value is revealed after trading takes place. Moreover, z and v are independent.

There is a continuum of length M of risk averse traders who can absorb net noise trader order imbalances. I will refer to these traders as "intermediaries." Each intermediary has a constant risk aversion coefficient. For a trader located at point $i \in [0, M]$, this risk aversion coefficient is α_i. Moreover, for $j > i$, $\alpha_j \geq \alpha_i$, with strict inequality for some i and j. Thus, the supply of risk bearing services in this market is upward sloping.

Trading must take place on an organized exchange. The exchange provides a trading infrastructure (e.g., an exchange floor or computerized trading system) and enforces trading rules and adjudicates disputes between traders. These activities are subject to economies of scale. Formally, creation of an exchange requires payment of a fixed cost c.

Groups of risk averse intermediaries can cooperate to form an exchange. An exchange must form prior to the realization of noise trader order flow z. For example, some coalition of intermediaries $\mathbf{K} \subseteq [0, M]$ can form an exchange. If they do so, the exchange members split the fixed cost proportionally to their trading volume. This would be consistent with an exchange charging per trade fees to cover fixed costs. Call a_j the fixed cost assessment of intermediary j.[3]

Any set of coalitions/exchanges can form. An equilibrium consists of an allocation of intermediaries to a collection of coalitions. Specifically, exchange i is a set of intermediaries $\mathbf{S_i} \subseteq M$. An allocation is given by a collection $\{\mathbf{S_i}\}_{i=1}^{N}$, where N is the total number of exchanges, $\mathbf{S_i} \cap \mathbf{S_j}$ for all $i \neq j$, $i, j \leq N$, and $\cup_{i=1}^{N} \mathbf{S_i} \subseteq M$. Define $V_j(\mathbf{S_i}, \{\mathbf{S_h}\}_{h \neq i})$ as the expected risk-adjusted profit net of fixed cost assessment of intermediary j who belongs to

[3]The main results of the article go through under alternative assumptions about the division of fixed costs. In particular, no major results change if an exchange apportions fixed costs equally among its members.

exchange i, where $\{\mathbf{S_h}\}_{h\neq i}$ is the collection of the other coalitions that form in this allocation.

An equilibrium collection of exchanges $\{\mathbf{S_i}\}$ must satisfy the following conditions:

1. $V_j(\mathbf{S_i}, \{\mathbf{S_h}\}_{h\neq i}) \geq 0$ for all $j \in \cup_{i=1}^{N}\mathbf{S_i}$

2. If $k \in \cup_{i=1}^{N}\mathbf{S_i}$ then $j \in \cup_{i=1}^{N}\mathbf{S_i}$ for all $j < k$.

3. For all $k \in \mathbf{S_i}$,

$$V_k(\mathbf{S_i}, \{\mathbf{S_h}\}_{h\neq i}) \geq V_k(\mathbf{S_i} \cup \mathbf{S_l}, \{\mathbf{S_h}\}_{h\neq i,l})$$

   and for all $f \in \mathbf{S_l}$

$$V_f(\mathbf{S_l}, \{\mathbf{S_h}\}_{h\neq l}) \geq V_f(\mathbf{S_l} \cup \mathbf{S_i}, \{\mathbf{S_h}\}_{h\neq i,l})$$

   for any $i, l \leq N$.

4. For each $i \leq N$ there is no $\mathbf{S_i^-} \subset \mathbf{S_i}$ and no $\{\mathbf{S_m}\}$ with $\cup\mathbf{S_m} \subseteq M - \mathbf{S_i^-}$ such that:

$$V_k(\mathbf{S_i^-}, \{\mathbf{S_m}\}) \geq V_k(\mathbf{S_i}, \{\mathbf{S_h}\}_{h\neq i})$$

   for all $k \in \mathbf{S_i^-}$ and

$$V_g(\mathbf{S_y}, \{\mathbf{S_i^-}, \{\mathbf{S_m}\}_{m\neq y}\}) \geq 0$$

   for all $g \in \mathbf{S_y}$ and all $\mathbf{S_y} \in \{\mathbf{S_m}\}_{m\neq y}$.

5. There exists no $\mathbf{S_q} \subseteq M - \cup_{i=1}^{N}\mathbf{S_i}$ such that:

$$V_e(\mathbf{S_q}, \{\mathbf{S_i}\}_{i=1}^{N}) \geq 0$$

   for all $e \in \mathbf{S_q}$.

Each condition is straightforward and intuitive. Condition 1 requires all intermediaries who belong to exchanges to earn non-negative profits in equilibrium. Condition 2 reflects the transferability of exchange memberships. If $k > j$ belongs to an exchange and j does not, k and j can find a mutually beneficial price at which to transfer the membership, so it cannot be an equilibrium for k to belong to an exchange while j does not. Condition 3 states that in equilibrium, merger of two exchanges cannot raise the profits of all members of the merging exchanges. Condition 4 means that in equilibrium no subset of members can increase profits by splitting off and forming their own exchange, assuming that the remaining intermediaries form exchanges in which each member earns a non-negative profit.[4] Condition 5 is a no-profitable-entry requirement. It means that no set of intermediaries outside the equilibrium set of exchanges/coalitions can profitably form an exchange assuming the exchanges in the equilibrium set remain in existence.

Once exchanges form, trading takes place in a batch auction. Noise traders submit orders to the market. Intermedaries on each exchange observe the net order flow directed to their exchange. Intermediaries can condition their trades on price. Thus, equilibrium is of the rational expectations type.

Two factors influence trader profits. The first involves competition between intermediaries and its effects on their trading profits. The greater the competition between intermediaries, the lower their trading profits. The severity of competition may depend the number of exchanges that form and the total number of intermediaries active in the market. The second involves fixed costs. The greater the number of exchanges, the greater the total investment in fixed costs and the lower are intermediary profits, all else equal.

The following subsections investigate competition between exchanges and member profits under two diametrically opposed assumptions the costs of intermarket arbitrage. In 2.2 it is assumed that arbitrage between markets is costless; this is equivalent to allowing noise traders to choose where to transact after observing prices and their own demands. In this case, there is effectively perfect competition between intermediaries and exchanges. In 2.3, in contrast, noise traders must select their exchange prior to observing their demand and there is no arbitrage linkage between markets.

2.2 Equilibrium with Perfect Intermarket Arbitrage Linkages

This section analyzes equilibrium exchange market structure when there are arbitrageurs who can trade in all markets simultaneously in addition to the noise traders. The arbitrageurs are infinitely risk averse; this prevents the arbitrageurs from providing any risk bearing services, and isolates their role in linking markets from any risk bearing function. Each open exchange has an

[4]It may be the case that there is no set of exchanges which allow all of the remaining intermediaries to earn a non-negative profit. In this case, $\mathbf{S_i}$ is a monopoly.

auctioneer who calls out prices. If several exchanges exist, the auctioneers call out prices simultaneously. Noise traders, intermediaries, and the arbitraguer submit the quantity that they want to buy or sell at that price. Noise traders are assigned to exchanges by some process that is not modeled; it will soon become clear that the allocation of noise traders to exchanges is irrelevant when arbitrage is costless.

In equilibrium, it is clear that prices must be equal across all open exchanges, as otherwise arbitraguers would take arbitrarily large buy positions in the low-price markets and arbitrarily large sell positions in the high-price markets. Moreover, due to the extreme risk aversion of the arbitraguers, in equilibrium it must be the case that arbitraguers have a zero net position in all exchanges combined. This, in turn, implies that the combined net position of all intermediaries on all exchanges and all noise traders must equal zero as well.[5]

Although the assumption of costless arbitrage in a batch auction market is implausible if taken literally, it may represent a good description of trading in multiple markets linked by near real time communications and arbitrage. Arbitrageurs who monitor prices in multiple markets simultaneously can effectively shift order flow from a low price market (where there is a net sell imbalance) to a high price one (where there is a net buy imbalance) by purchasing on the former and selling on the latter. This activity sharply circumscribes the degree to which prices in the various markets can diverge. In the limit, when this arbitrage activity is costless and instantaneous, prices must be equal even across spatially separated markets.

There is considerable empirical evidence that demonstrates that arbitrage serves to limit severely intermarket price variations. For example, deviations between the S&P 500 futures price and the price of the underlying bundle of stocks are arbitraged quickly; deviations as small as .1 percent trigger index arbitrage transactions that ensure that price deviations are eliminated quickly. Nor is this a new phenomenon. When silver traded actively on both the COMEX in New York and the Chicago Board of Trade during the 1970s and 1980s, arbitrageurs monitored prices in both markets and quickly traded when these prices diverged even slightly. Arbitrage between LME and COMEX copper, and between LCE and CSCE cocoa and coffee, simi-

[5]Identical results hold if noise traders can choose which exchange to trade on after the auctioneers in each market call out prices. In this case, prices must be equal across markets (otherwise noise traders would all choose the low-price market) and the combined net position of intermediaries and noise traders must equal zero.

larly serves to ensure that these prices vary only within tight ranges when both markets are open. Arbitrage served to eliminate intermarket price differentials even in the early days of futures trading. For example, telegraphic communication between the British and American futures markets facilitated arbitrage and prevented wheat or cotton prices in the two markets from diverging significantly and persistently during the hours when exchanges in both countries were open. Therefore, the assumption of a common market clearing price across all spatially dispersed trading exchanges may represent a good working approximation of the actual trading process when rapid communications facilitate arbitrage between them.

Given this assumption, it is straightforward to characterize the equilibrium pricing function given the number of exchanges that exist and the characteristics of the intermediaries who belong to exchanges. Without loss of generality, assume that $I \geq 1$ exchanges have formed, and that intermediaries $j \in [0, L]$, $L \leq M$ belong to exchanges. Given the assumptions of constant risk aversion coefficients and normally distributed noise trader order flow and asset value, intermediary j chooses a position y_j to maximize his risk-adjusted profits:

$$\Pi_j = -y_j P - .5\alpha_j \sigma^2 y_j^2 \tag{1}$$

where P is the market price observed by the trader. This implies:

$$y_j = -\frac{t_j P}{\sigma^2} \tag{2}$$

where $t_j = 1/\alpha_j$ is the risk tolerance of trader j.

Since there is perfect competition between intermediaries and complete linkage of markets, a single market clearing condition holds. Specifically, if noise trader net order flow equals z, market clearing implies:

$$0 = z + \int_0^L y_j dj = z - P \int_0^L \frac{t_j dj}{\sigma^2} = z - P\frac{T(L)}{\sigma^2}. \tag{3}$$

This condition reflects the requirement that in equilibrium, arbitraguers have a zero net position. In this expression, $T(L) = \int_0^L t_j dj$ is the total risk tolerance of active intermediaries. Therefore,

$$P = \frac{z\sigma^2}{T(L)} \tag{4}$$

$$Py_j = -\frac{t_j z^2 \sigma^2}{T^2(L)} \tag{5}$$

and

$$y_j^2 = \frac{t_j^2 z^2}{T^2(L)} \tag{6}$$

Substituting these expressions into (1) implies that market maker j's risk-adjusted trading profit as a function of z is:

$$\Pi_j(L) = \frac{.5 t_j z^2 \sigma^2}{T^2(L)} \tag{7}$$

This implies that the expected risk-adjusted trading profit of intermediary j prior to the realization of z, (that is, at the time that exchanges are formed), is:

$$E\Pi_j(L) = \frac{.5 t_j S \sigma^2}{T^2(L)} \tag{8}$$

Moreover, (2) and (4) imply that intermediary j's fixed cost share equals:

$$a_j = \frac{t_j c di}{T(L)}$$

These results allow determination of the equilibrium number of exchanges and the equilibrium supply of intermediation. First note that only one exchange survives in equilibrium. To see why, consider a candidate equilibrium in which the set of traders $\mathbf{S_1} = [0, L_1]$ cooperate to form an exchange ("exchange 1"), and the set of traders $\mathbf{S_2} = (L_1, L_2]$, $L_2 \leq M$ cooperate to form another, competing exchange ("exchange 2"). The expected profit net of fixed cost assessment for $j \in \mathbf{S_1}$ is given by

$$V_j(L_2) = \frac{.5 t_j S \sigma^2}{T^2(L_2)} - \frac{t_j c}{T(L_1)} \tag{9}$$

while the profit for $k \in (L_1, L_2]$ is

$$V_k(L_2) = \frac{.5 t_k S \sigma^2}{T^2(L_2)} - \frac{t_k c}{T(L_2 - L_1)}. \tag{10}$$

This cannot be an equilibrium because if the exchanges merge, the profits for $j \in [0, L_1]$ are

$$V_j(L_2) = \frac{.5 t_j S \sigma^2}{T^2(L_2)} - \frac{t_j c}{T(L_2)} > \frac{.5 t_j S \sigma^2}{T^2(L_2)} - \frac{t_j c}{T(L_1)} \tag{11}$$

while the profits for $k \in (L_1, L_2]$ are:

$$V_k(L_2) = \frac{.5 t_k S \sigma^2}{T^2(L_2)} - \frac{t_k c}{T(L_2)} > \frac{.5 t_k S \sigma^2}{T^2(L_2)} - \frac{t_k c}{T(L_2 - L_1)}. \tag{12}$$

The candidate multiple exchange equilibrium therefore cannot be an equilibrium because it violates condition 3. This proof can be generalized to any number of exchanges and any exchange membership composition. Thus, only one exchange exists in equilibrium.[6]

This analysis permits the determination of the equilibrium set of members of the monopoly exchange, and thus the equilibrium supply of intermediation. It is readily apparent that there is a crucial L^* such that if intermediaries $j \in [0, L^*]$ form an exchange, no other competing exchange can form. To see why, note that since the profits of each member of an exchange are proportional to the aggregate profit of all its members, a necessary and sufficient condition for a competing exchange to survive is that its total profit be non-negative. Formally,

$$\frac{.5 T' S \sigma^2}{(T' + T^*)^2} - c \tag{13}$$

must be non-negative for a competing exchange to survive, where $T' = \int_{L^*}^{L'} t_i di$ and $T^* = \int_0^{L^*} t_j dj$. Note that as L^* increases, T' must approach 0 and hence this profit becomes negative. Thus, there is some L^* such that no competing exchange can survive.

Given a value for c it is straightforward to solve for the T^* such that (13) is negative. Since choosing L' is equivalent to choosing T' (holding T^* fixed), the value of L' that maximizes (13) sets the derivative of this term with respect to T' equal to zero. It is readily verified that $T' = T^*$ maximizes

[6] Note that consolidation of exchanges (holding the total number of active intermediaries constant) has no influence on market liquidity if arbitrage is costless. In this context, the responsiveness of price to order flow shocks (i.e., depth) is the only relevant measure of liquidity. With perfect arbitrage between markets, market depth depends only on the total risk tolerance of all the intermediaries that belong to exchanges, and does not depend upon their distribution among exchanges. Given L_2 total market makers, liquidity is the same regardless of whether these market makers belong to a single exchange or a dozen. Thus, improved liquidity does not provide any impetus for merger. Instead, a single exchange exists in equilibrium because this minimizes fixed costs. That is, this model implies that exchanges may be natural monopolies for the most traditional of reasons; economies of scale arising from fixed costs.

the bracketed term in (13). Therefore, if

$$[\frac{.5T^* S\sigma^2}{(2T^*)^2} - c] < 0 \tag{14}$$

no competing exchange can form. Thus, an exchange with membership $j \in [0, L^*]$ with $\int_0^{L^*} t_i di = S\sigma^2/8c$ can deter entry by any competing exchange.

A single exchange with membership $j \in [0, S\sigma^2/8c] = [0, L^*]$ forms in equilibrium. To see why, define $V_j(L)$ as the risk-adjusted trading profits net of assessment of firm $j \leq L^*$ as a function of total exchange membership size. Assume that some coalition $\mathbf{S_{\bar{L}}} = [0, \bar{L}]$, $\bar{L} < L^*$ attempts to form an exchange. In this case, some set of intermediaries with $i \in (\bar{L}, X]$, $X > L_1^*$ could form an exchange to compete; therefore $\mathbf{S_{\bar{L}}}$ cannot be the only equilibrium exchange as entry is profitable in violation of condition 5. Since $X > L^*$, all of the intermediaries $j \in \mathbf{S_{\bar{L}}}$ would earn a profit smaller than $V_j(L^*)$. Thus, the equilibrium exchange has no fewer than L^* members.

Moreover, it is also the case that all $j \in [0, L^*]$ would be harmed by the admission of additional members to the monopoly exchange. The derivative of the profit of a member $j \in [0, L^*]$ with respect to exchange size is proportional to:

$$-\frac{t_j}{(T^*)^2}[\frac{S\sigma^2}{T^*} - c] < 0 \tag{15}$$

Assume that intermediaries $[0, \hat{L}]$ form the monopoly exchange, with $\hat{L} > L^*$. By (15) $V_j(L^*) < V_j(\hat{L})$ for all $j \leq L^*$. Therefore, all $j \in [0, L^*]$ could make themselves better off by defecting from the putative equilibrium exchange with $\hat{L}$ members and forming their own exchange; this violates condition 4. Therefore, the coalition consisting of intermediaries $[0, L^*]$ generates the highest profit for this group of intermediaries, cannot be blocked by any other coalition, and blocks entry of any other exchange. It therefore satisfies all 5 equilibrium conditions. It is the only exchange that exists in equilibrium. Therefore, in this case the only equilibrium is an exchange with membership $[0, S\sigma^2/8c]$.

The restriction on membership size in the monopoly exchange generates rents for the members. That is, although (1) liquidity would increase if the monopoly exchange admitted more than L^* members, and (2) some intermediaries $i > L^*$ could earn non-negative profits net of fixed cost assessment if they were admitted, the monopoly exchange has no incentive to grow this large.[7] Since by (15) profits for all $j \in [0, L^*]$ are decreasing in the number of members L, this implies that the profits of the intermediaries $j \in [0, L^*]$ are higher if membership is restricted to this set of intermediaries than if it is increased to include all whose trading profits would exceed their fixed cost assessment. Thus, the monopoly exchange restricts membership size to enhance member profits, and does not provide the maximum amount of liquidity consistent with all members covering their fixed cost assessment.

A numerical example illustrates these results. Let $S = 4$, $\sigma^2 = 5$, and $c = 5$. Moreover, $M = 1$, and $t_k = 4 - 4k$, $k \in [0, 1]$. That is, risk tolerance is a decreasing linear function of location along the intermediary continuum. (This means that risk aversion is an increasing function of this location that asymtotes to infinity as i approaches 1). In this case, $T^* = .5$ and $L^* = .134$. That is, the exchange includes only 13.4 percent of available intermediaries who offer only 25 percent of total risk bearing capacity. In this case the average member of the monopoly exchange earns a profit (net of fixed cost assessment) of 22.39 and the marginal member earns 20.78. If the exchange did not set a membership limit, all intermediaries $i \in [0, M]$ would join. In this case, all members would earn zero profit under the proportional sharing rule.[8]

The marginal member of the exchange is willing to pay 20.78 to belong to the exchange. This measures the rent earned by the marginal member and equals the equilibrium price of an exchange membership–the seat price. If the exchange were to admit all comers willing to pay their share of fixed costs, the seat price would equal 0. Thus, the theory predicts that seat prices should be positive; if a membership also confers an ownership share for the exchange's physical assets, the seat price should exceed the value of this share. This implies that the q-ratio for a financial exchange should exceed 1.00; that is, the total value of memberships divided by the value of exchange assets should exceed 1.

In summary, the model of this section provides one explanation as to why

[7] To prove that more than L^* intermediaries would join the monopoly exchange if allowed, define $\mathbf{S}^- = [0, L^*)$ and $\hat{\mathbf{S}} = [L^*, L_2^*]$, where $V_{L_2^*}(\hat{\mathbf{S}}, \mathbf{S}^-) \geq 0$. $V_{L_2^*}(\mathbf{S}^- \cup \hat{\mathbf{S}}) > V_{L_2^*}(\hat{\mathbf{S}}, \mathbf{S}^-) \geq 0$, where the first (strong) inequality follows from (9)-(12), and the second (weak) inequality holds by the definition of L_2^* and L^*. Therefore, at least L_2^* intermediaries could earn a profit as members of a monopoly exchange so at least this many firms would join if the exchange accepted all who want to do so.

[8] It is not generally true that all members earn zero profit under free entry. It is generally true that members earn smaller profits with free entry than without.

one exchange is likely to survive in equilibrium. In this theory exchanges are natural monopolies to economize on fixed costs, not because consolidating all trading on a single exchange improves liquidity. With efficient arbitrage between markets, competing exchanges "share" liquidity, so their merger does not enhance it. Although consolidation does not increase liquidity, it occurs nonetheless if there are traditional economies of scale in the creation and operation of an exchange.

Moreover, these economies of scale create an entry barrier that allows low cost intermediaries (i.e., the more risk tolerant traders) to earn economic rents. By creating an exchange that is just large enough to make entry by a competing exchange unprofitable (because some members of any competitor would not cover their fixed cost assessment), the low cost intermediaries constrain the supply of intermediation and thereby increase their profits. Thus, the theory predicts: (1) trading in a particular financial instrument should be concentrated on a single exchange if intermarket arbitrage permits effective sharing of liquidity across exchanges, and (2) the members of the monopoly exchange should earn economic rents as measured by the value of an exchange seat.

2.3 Equilibrium Market Structure Without Arbitrage

In contrast to the analysis of section 2.2, now assume that there are three stages in the trading process. In the first stage, intermediaries form one or more exchanges. Fixed costs are incurred when an exchange is formed. In the second stage noise traders select which exchange to patronize in order to minimize their expected trading costs. Noise traders are atomistic and take other traders' choice of exchange as given. In the third stage, noise traders' demands are realized. In this third stage, each noise trader is locked into the exchange she selected in the second stage; there is no arbitrage between markets after noise trader demand is realized. This implies that prices may differ between markets once noise trader demand is realized.

The analysis proceeds using backward induction. First consider the equilibrium in the third stage. Assume that in the first stage $N \geq 1$ exchanges were formed. Call $\mathbf{S_j} \subseteq M$ the set of intermediaries that belong to exchange $j \leq N$. Define $T_j = \int_{i \in \mathbf{S_j}} t_i di$. That is, T_j is the total risk tolerance of the members of exchange j. Moreover, call S_j the variance of the noise trader net order flow for the traders who have selected exchange j. For each exchange, an analysis similar to that presented above implies that:

$$P_j = \frac{z_j \sigma^2}{T_j} \tag{16}$$

where z_j is the realization of the noise trader order flow for the customers who selected exchange j in the second stage. Note that

$$z_j P_j = \frac{z_j^2 \sigma^2}{T_j}. \tag{17}$$

Thus, the expected total trading cost for the customers of exchange j is

$$E z_j P_j = \frac{S_j \sigma^2}{T_j}. \tag{18}$$

Define N_j as fraction of noise traders who select to trade on exchange j in the second stage; note that $\sum_{j=1}^{N} N_j = 1$. If noise trader demands are independent, $\sum_{j=1}^{N} S_j = S$. Moreover, given the independence of noise trader demands, $S_j/N_j = S$. Therefore, the expected per noise trader trading cost is

$$\frac{S_j \sigma^2}{N_j T_j} = \frac{S \sigma^2}{T_j} \tag{19}$$

Note that the expected cost of trading on exchange j depends only on the risk tolerance of the members of that exchange. Therefore, the exchange with the largest membership risk tolerance has the lowest expected average trading cost. The equilibrium choice of atomistic noise traders in the second stage of the process is therefore straightforward to determine. Since these traders take N_j as given, each chooses to trade on the exchange with the largest T_j; all other exchanges receive no business. Therefore, trading concentrates on a single exchange if exchanges offer different total risk tolerances.[9] I assume that if two or more exchanges offer the same risk tolerance, and this common risk tolerance exceeds that offered by any other exchange, noise traders are divided equally among these exchanges.

The following proposition identifies conditions in which all trading is concentrated on a single exchange. This proposition also determines the largest size of the single exchange.

[9] This is equivalent to having noise traders choose the market with the greatest depth. Depth depends only on T_j. Therefore, the market with the greatest T_j has the greatest depth, and all traders select this exchange.

Proposition 1 *Define L^* and $\hat{T}$ as follows:*

$$\hat{T} \equiv \int_0^{L^*} t_j dj = .5 \int_0^M t_k dk \tag{20}$$

If intermediaries $j \in [0, L^*]$ form an exchange, they face no competing exchange under the size-proportionate cost division rule if:

$$\frac{.25 S\sigma^2}{\hat{T}} - c < 0 \tag{21}$$

If this condition holds, the equilibrium monopoly exchange has no more than L^* members.

Proof: Expression (21) is the total profit of the members of an exchange ("exchange 2") consisting of all intermediaries in the interval $(L^*, M]$ if intermediaries $j \in [0, L^*]$ form an exchange ("exchange 1"). This expression holds because the exchange with members in $(L^*, M]$ attracts one-half of the noise traders when competing with an exchange consisting of all intermediaries in $[0, L^*]$. Since the profits of each individual member of exchange 2 are proportional to total exchange profit, if (21) holds the members of exchange 2 incur losses. Therefore, exchange 2 cannot compete against exchange 1. Nor can any other exchange with members $i \in (L^*, M)$ survive because such an exchange would offer less risk bearing capacity than exchange 1, and hence would attract no noise traders. Therefore, if exchange 1 forms it faces no competition. A coalition with membership $[0, \hat{L}]$, $\hat{L} > L^*$ is not an equilibrium because by (15) intermediaries $i \in [0, L^*]$ could defect, form their own exchange, and earn profits that exceed the profits they would enjoy in an exchange with membership in $[0, \hat{L}]$.[10]

Therefore, there is a critical value of the fixed cost such that an exchange with membership $[0, L^*]$ is the monopoly exchange. With $t_j = 4 - 4j$, $S = 4$

[10] There are two possible outcomes if condition (20) does not hold. If $c = 0$, the equilibrium involves the formation of two or more exchanges, each with a membership that offers a risk tolerance equal to 50 percent of the total available risk tolerance. If $c > 0$, but (20) does not hold, there is no equilibrium. Proofs of both of these results are available from the author. It must be emphasized that these results are an artifact of the assumption that there is a continuum of intermediaries. If interemdiaries are discrete, there is a single equilibrium with a monopoly exchange regardless of cost conditions when arbitrage is precluded. This monopoly equilibrium exchange has N^* members, where $\sum_{i=1}^{N^*} t_i > .5 \sum_{j=1}^{N_T} t_j$, $\sum_{i=1}^{N^*-1} t_i < .5 \sum_{j=1}^{N_T} t_j$, and N_T is the total number of available intermediaries. Again, proof is available on request.

and $\sigma^2 = 5$, this critical value of fixed cost is $c = 5$. If $c = 5 + \epsilon$, where ϵ is an arbitrarily small positive number, the average member of the monopoly exchange earns a profit of 17.07 and the marginal member earns a profit of 14.14. If all intermediaries are allowed to join the exchange, all earn a zero profit given these parameters.

As in section 2.2, this exchange is smaller than optimal. If allowed to join the monopoly exchange, some intermediaries in $(L^*, M]$ could earn a non-negative profit net of fixed costs. Permitting them to join the exchange would improve market liquidity and make noise traders better off. The intermediaries in $[0, L^*]$ have no incentive to allow these additional intermediaries to join the exchange, however, because this would reduce their profits. Therefore, the equilibrium exchange is suboptimally small. Moreover, due to the limit on the number of members, those that belong to the exchange earn rents. The seat price measures the rent earned by the marginal member (i.e., the intermediary at L^*). The limitation on exchange size generates additional rents for inframarginal members. Indeed, inframarginal members benefit more from the limitation on exchange size because the inframarginal intermediaries trade in larger quantities, and thus benefit more from the higher per unit trading profits that result from the limit on membership size.

The next proposition demonstrates that the equilibrium exchange could actually have fewer than L^* members.

Proposition 2 *Assume that intermediaries $i \in [0, L^{**}]$ form an exchange. Consider an L_2 such that:*

$$T(L_2 - L^{**}) \equiv \int_{L^{**}}^{L_2} t_k dt > \int_0^{L^{**}} t_i di \tag{22}$$

If

$$[\frac{.5S\sigma^2}{T_2(L_2 - L^{**})} - c] < 0 \tag{23}$$

for all L_2 satisfying (22), and then there is a monopoly exchange in equilibrium with no more than L^{**} members.

Proof: If intermediaries $i \in [0, L^{**}]$ form an exchange ("exchange 1"), any competing exchange ("exchange 2") must have a membership $(L^{**}, L_2]$ that satisfies (22) to attract any noise traders. If such an exchange forms, but (23) holds, the members of exchange 2 lose money. Therefore, this exchange will not form in competition with exchange 1. Moreover, (15) implies that any exchange with membership $j \in [0, \hat{L}]$, $\hat{L} > L^{**}$ would not exist in equilibrium because intermediaries $i \in [0, L^{**}]$ could defect, form their own exchange, and all earn a higher profit.

In the costly arbitrage model it is possible to dispense with equilibrium condition 2 if there are (even very slight) congestion effects. To model congestion effects, assume that the fixed cost of an exchange depends on size:

$$c(X) = c^* + g(X) \tag{24}$$

where X is the size of the exchange (e.g., $b - a$ in an exchange with membership $j \in [a, b]$). Here $g'(X) > 0$, but I assume that $d[c(X)/X]/dX < 0$. That is, average fixed costs decline with size over the relevant range.

It is plausible that exchanges are subject to some congestion costs. For instance, in an open outcry futures market trading errors ("out-trades") are reasonably more likely the larger the trading pit. Similarly, it is plausibly costlier to communicate across larger trading pits than across smaller ones; indeed, this greater difficulty of communication can cause a higher error rate in a big pit.

Defining L^* so that $\int_0^{L^*} t_j dj = .5 \int_0^M t_i di = \hat{T}$, it is possible to show that in this case any $j \leq L^*$ strictly prefers to belong to an exchange with membership $[0, L^*]$ than to any other exchange that offers total risk tolerance $\hat{T}$. The reason for this is straightforward. An intermediary's trading revenue is the same when he belongs to any exchange that offers total risk tolerance of $\hat{T}$. This agent's *share* of fixed costs is also independent of the composition of the exchange as long as its total risk tolerance is $\hat{T}$. This implies that the profit of a particular intermediary in an exchange with total risk tolerance of $\hat{T}$ is maximized when $c(X)$ is minimized. With congestion costs, $c(X)$ is minimized (across all exchanges offering total risk tolerance of $\hat{T}$) when the exchange is as small as possible. This requires $X = L^*$. This is the exchange with membership $[0, L^*]$.

Note that if this exchange forms, it generates an income for its members that exceeds the income they could earn in any other exchange. Trading revenues are maximized when total risk tolerance equals only $\hat{T}$. This exchange faces no competition, and (15) implies that increasing size would reduce the profits of each member. Moreover, if some $j \in [0, L^*]$ were to join another exchange with total risk tolerance $\hat{T}$, he would pay a higher fixed cost assessment but generate no higher trading income. Therefore, every $j \in [0, L^*]$ achieves his maximal net profit by joining an exchange with membership limited to $[0, L^*]$. This exchange cannot be blocked by any other exchange if condition (21) holds. Therefore, it is the only exchange in equilibrium if (21) holds. Thus, size-proportional cost sharing and even the slightest congestion cost ensures that the equilibrium exchange has L^* members even if exchange memberships are not transferrable.

To summarize, there are cost and demand conditions that ensure that a monopoly exchange equilibrium results when arbitrage is precluded. In this case, the equilibrium exchange is sub-optimally small and its members earn rents.

2.4 Summary and Conclusions

The models presented in sections 2.2 and 2.3 derive conditions under which (1) trading in a financial instrument is concentrated on a single exchange, and (2) economies of scale result in an equilibrium in which an exchange restricts the size of its membership to ensure that its members earn supercompetitive profits. Scale economies permit an exchange to select a membership size which is large enough to deter entry. Once large enough to be safe from the threat of entry, the exchange does not permit additional members to join. This limitation on entry generates a stream of rents for low-cost suppliers of trading services.[11]

Received theories imply that economies of scale may lead to natural monopoly, but that a natural monopolist may not earn rents due to potential competition (Demsetz, 1968; Telser, 1978; Baumol, et al 1982). These theories typically assume that all potential producers have access to the same production technology. The co-existence of natural monopoly and economic rents in the model of this article is due to a difference in costs between the incumbent monopolist and potential competitors. Although any group of firms can form an exchange by incurring a fixed cost of c, individual intermediaries

[11] The theory's implication that exchanges extract rents through control of membership size superficially resembles the theory of Saloner (1984). The theories differ on several crucial dimensions, however. Saloner's is a non-cooperative theory which fails to predict that only one exchange will exist in equilibrium. Instead, his model has multiple equilibria in which the total number of traders that belong to exchanges is the same, but the number of exchanges that form is indeterminate. Moreover, the entry of multiple exchanges in Saloner's model can dissipate member rents. Saloner's assumption of individual entrepreneurs creating exchanges and selling memberships is counterfactual and obscures the cooperative nature of exchanges. Finally, his model relies upon assumptions about loss-sharing arrangements among members which are clearly counterfactual.

have different costs due to differences in risk aversion. The risk tolerant intermediaries form an exchange with enough members to foreclose entry by exchanges with more risk averse members. Thus, the heterogeneity of trading firms produces differences between this article's implications and those derived from more traditional models of natural monopoly. Such heterogeneity is plausible. Moreover, heterogeneity explains why mutual exchanges are organized as non-profits (Pirrong, 1997).

There are other theories that predict that all trading occurs in a single market. For example, Telser and Higinbotham (1977), Telser (1981), Pagano (1989), and Glosten (1994) all predict the survival of a single market due to liquidity effects; in these models, liquidity is maximized when all trading concentrates on a single exchange. These theories differ from the one presented in this paper in several crucial ways. Most important, the Telser-Higginbotham-Pagano-Glosten models are "intermediary free." As a consequence, they provide no insight on the equilibrium size of financial exchanges. In contrast, the model analyzed here treats exchange members as "market makers" in the most fundamental sense; they create, maintain, and pay for the trading infrastructure. This incorporation of "market makers" (in this sense) into the analysis allows explicit determination of the size of exchanges. This, in turn, generates testable implications concerning the profitability of exchange membership. Thus, this analysis is more relevant to the study of real-world financial exchanges with intermediary-members.

These considerations have implications for the incentives of exchanges to merge. Improvements in communications technology that reduce the costs of arbitrage and/or reduce costs that investors incur to trade on distant markets should lead to consolidation of exchanges. The experience of regional exchanges in the United States is broadly consistent with this analysis. The importance of these exchanges has declined dramatically as communications technology has improved, and many regional exchanges disappeared or merged due to improvements in intermarket linkages (Mulherin, Netter, and Hersch, 1998). Ongoing events in international markets may also reflect favorably on the theory. Exchanges across Europe are merging, and exchanges in the US, Europe, and Asia are exploring strategic alliances of various sorts. These developments coincide with the recent revolution in computer and communications technologies that has dramtically reduced the trade of financial claims across vast distances.

The theory makes two other important empirical predictions. First, under certain circumstances financial exchanges will be natural monopolies. That is, it is consistent with the theory to observe that a particular financial instrument is traded on a single exchange. Second, exchange members should earn economic rents. These implications are tested in the later sections.

3 The Scope of Financial Exchanges

Exchanges may trade multiple products. These products may be closely related (e.g., corn futures and corn futures options) or quite distinct (e.g., corn futures and T-bond futures). This raises the question: What determines the scope of products traded on a particular exchange?

This section examines the incentives of intermediaries to form a single exchange trading differentiated products if there are scope economies. In particular, it investigates whether multiple exchanges each trading a different product may survive even when consolidation would economize on fixed costs and improve liquidity. In this model, there are two traded products (e.g., futures contracts on corn and Treasury bonds). The noise trader demand for product j is z_j, $j = 1, 2$, where $z_j \sim N(0, S)$. Moreover, $corr(z_1, z_2) = \rho_z$. The values of the products are given by $v_j \sim N(0, \sigma^2)$, $j = 1, 2$ with $corr(v_1, v_2) = \rho_v$; the v's are revealed after trading is completed. As before, there is a continuum of length M of risk averse potential intermediaries. The risk aversion coefficient of a trader $i \in [0, M]$ is α_i. There are two intermediaries at each point in the continuum.

Exchanges may enjoy economies of scope when offering multiple products for trade. Formally, assume that if an exchange offers both products, its fixed costs equal $(1 + d)c$, where $0 \leq d \leq 1$. Economies of scope are greater, the smaller is d.

Finally, arbitrage is costless. As in section 2.2, this implies that prices for a particular product are equal across exchanges if multiple exchanges offer the same product. It is possible to show along the lines of the argument in section 2.2 that with costless arbitrage at most one exchange offers each product in equilibrium as otherwise merger could make all intermediaries better off by reducing fixed costs.

First consider intermediary risk-adjusted trading profits in a candidate equilibrium in which both products are traded on a single exchange that includes all intermediaries $i \in [0, L_1]$; assume that no competing exchange can enter profitably if this set of intermediaries forms an exchange. In this case, intermediary i chooses the quantity of each product to trade, y_{i1} and

y_{i2}, to maximize:

$$\Pi_{i1} \equiv -y_{i1}p_1 - y_{i2}p_2 - .5\alpha_i\sigma^2[y_{i1}^2 + y_{i2}^2 + 2\rho_v y_{i1}y_{i2}]$$

where p_1 and p_2 are the equilibrium prices of the products. Intermediaries condition their demands on these prices. The relevant first order conditions are:

$$-p_1 = \alpha\sigma^2[y_{i1} + \rho_v y_{i2}]$$
$$-p_2 = \alpha\sigma^2[y_{i2} + \rho_v y_{i1}].$$

Solving these first order conditions implies:

$$y_{i1} = \frac{-t_i p_1}{\sigma^2(1-\rho_v^2)} + \frac{t_i\rho_v p_2}{\sigma^2(1-\rho_v^2)}$$

$$y_{i2} = \frac{-t_i p_2}{\sigma^2(1-\rho_v^2)} + \frac{t_i\rho_v p_1}{\sigma^2(1-\rho_v^2)}.$$

In equilibrium, $-z_j = 2\int_0^{L_1} y_{ij}di$, $j = 1, 2$; the integral is multiplied by 2 because there are now two intermediaries at each point along the continuum. Therefore, in equilibrium:

$$p_1 = \sigma^2\frac{z_1 + \rho_v z_2}{T}$$

$$p_2 = \sigma^2\frac{z_2 + \rho_v z_1}{T}$$

where $T = 2\int_0^{L_1} t_i di$. Moreover,

$$y_{i1}p_1 = \sigma^2 t_i \frac{z_1^2 + \rho_v z_2 z_1}{T}$$

$$y_{i2}p_2 = \sigma^2 t_i \frac{z_2 + \rho_v z_1 z_2}{T}.$$

Substituting these values in the expression for Π_{i1} implies:

$$\Pi_{i1} = .5\sigma^2 t_i \frac{z_1^2 + z_2^2 + 2\rho_v z_1 z_2}{T^2}.$$

Taking expectations conditional on information available prior to the observation of the noise trader demands:

$$E\Pi_{i1} = \frac{t_i S\sigma^2}{T^2}[1 + \rho_z\rho_v].$$

A single multiproduct exchange cannot be an equilibrium if intermediaries have an incentive to split off and form single-product exchanges. Consider payoffs when a coalition consisting of one of the intermediaries for each $j \in [0, L_1]$ splits off to form an exchange which trades product 1 and a coalition consisting of the other intermediary for each $j \in [0, L_1]$ splits off to form an exchange that trades product 2. The aggregate risk tolerance of each exchange is $.5T$. An analysis similar to that completed for the two-product exchange case implies that

$$E\Pi_{i2} = \frac{.5t_i S\sigma^2 S}{(.5T)^2} = \frac{2t_i\sigma^2 S}{T^2}.$$

If there are economies of scope, $d < 1$ and the fixed costs of a single exchange are smaller than the combined fixed costs of two exchanges. The expected risk-adjusted profit net of fixed cost assessment of member i of a single exchange offering both products is then

$$V_{i1} = \frac{t_i S\sigma^2}{T^2}[1 + \rho_z\rho_v] - \frac{t_i(1+d)c}{T}$$

while the expected risk-adjusted profit net of fixed cost assessment that intermediary i would enjoy as a member of an exchange offering only one product is

$$V_{i2} = \frac{2t_i S\sigma^2}{T^2} - \frac{2t_i c}{T}. \tag{25}$$

A single exchange trading both products can be an equilibrium if and only if its members do not have an incentive to split off and form separate single product exchanges. For the multiproduct exchange to survive in equilibrium, the following must hold:

$$\frac{t_i S\sigma^2}{T^2}[1 + \rho_z\rho_v] - \frac{t_i(1+d)c}{T} > \frac{2t_i S\sigma^2}{T^2} - \frac{t_i c}{T}. \tag{26}$$

This requires:

$$(1-d)c > \frac{\sigma^2 S}{T}[1 - \rho_z\rho_v]. \tag{27}$$

Expression (27) implies that if the products traded on the exchange are very similar, with highly correlated order flows and prices (i.e., with $\rho_z \approx 1$ and $\rho_v \approx 1$), merger into a single exchange is likely to dominate the creation of separate exchanges each trading a single product. In this case merger reduces fixed costs without impairing trader profits. However, if the products have a very low order flow correlation or a very low price correlation, or both, separate exchanges may offer intermediaries higher profits net of fixed cost assessments. Survival of a single multiproduct exchange in equilibrium is also more likely, the greater the scope economies (i.e., the smaller is d).

This analysis demonstrates that exchanges need not be structured to maximize liquidity; multiple exchanges may survive when their merger would increase liquidity. When order flows and prices are highly correlated, consolidation has little impact on liquidity; this is when consolidation is most likely. In contrast, when the correlation between order flows is low, or the correlation between prices is low, or both, consolidation tends to increase liquidity substantially. This occurs for two reasons. First, with low price correlation, consolidation allows intermediaries to diversify risk. This shifts out the supply of intermediation services, thereby lowering prices in absolute value for a given realization of z_1 and z_2. Second, with low order flow correlation, market making resources can often shift from a product with a low realization of $|z|$ to product with a high realization. This tends to increase competition among intermediaries, thereby reducing customer trading costs. Both effects tend to erode intermediary trading profits. As a result, consolidation is least likely when it has the greatest potential to increase liquidity.

This model predicts the existence of multiple exchanges each offering a narrow range of similar products that are differentiated from products trading on the other exchanges unless economies of scope are large. This analysis presumes that exchange members have the right to trade all products offered by their exchange. If exchanges can create separate trading rights, however, a single exchange will offer both products if there are scope economies. To see why, consider an exchange in with membership $[0, L_1]$ that allows each member to trade either product 1 or product 2, but not both. That is, it creates separate "product 1 memberships" and "product 2 memberships." The exchange creates L_1 memberships of each type. One of the intermediaries at each $j \in [0, L_1]$ receives a product 1 membership and one receives a product 2 membership. By trading both products on the same exchange, the exchange captures scope economies. Therefore, the payoffs net of fixed cost assessement for each member are:

$$V_{i2} = \frac{2t_i S\sigma^2}{T^2} - \frac{(1+d)t_i c}{T}.$$

A comparison of this expression with (25) shows that if $d < 1$ this payoff exceeds that which the intermediary could obtain as a member of a single-product exchange. This occurs because consolidation with distinct membership categories reduces fixed costs but does not reduce trading profits. Therefore, creation of a single exchange with multiple membership classes with restricted trading rights dominates multiple single-product exchanges because trading profits are the same in each, but economies of scope imply that fixed costs are lower for the former. Put differently, if exchanges merge to capture scope economies, they will not merge the trading rights of their members.

It is essential to note that a single exchange with separate membership types with restricted trading rights does not provide more liquidity than separate single product exchanges with the same intermediary-members; it only economizes on fixed costs. With multiple membership types, market making resources cannot flow from high demand products to low demand products. The model therefore demonstrates that exchange product offerings and membership trading rights are not necessarily configured to maximize liquidity, but are instead structured to enhance trading profits and reduce overheads.

The analysis also speaks to the competitive implications of exchange mergers. The analysis in this section and section 2 predicts that exchanges have a monopoly in the trade of a particular contract or security. Therefore, merger does not reduce competition in a particular contract or security. Merger actually *increases* competition if trading rights are merged as well. The model demonstrates, however, that it is not in the interest of merging exchanges to merge trading rights, so this increase in competition is unlikely to occur. Since merger has no major competitive implications, but does reduce costs, the model implies that consolidation of separate exchanges is wealth increasing.

4 Evidence of Structural Exchange Monopoly

The theory presented in section 2 shows that under some circumstances, exchanges can choose membership size to deter entry of competing exchanges. If these conditions hold, an exchange has a monopoly over the trade of a particular financial contract. This section presents evidence from futures markets that is broadly consistent with this prediction.

I utilize the Herfindahl-Hirschman (HHI) index as the measure of concentration/monopoly in exchange traded financial contracts. The HHI is defined as the sum of squared market shares of exchanges trading contracts in a particular category. A HHI value of 10,000 indicates a monopoly. A value close to 0 indicates an industry populated by a large number of small firms.

Trading volume measures output. An exchange's market share is defined as 100 times the ratio of its volume to the total volume of contracts traded in that category. I adjust for differences in contract size, where possible. For example, since MidAmerica Commodity Exchange (MACE) currency contracts are one-half the size of Chicago Mercantile Exchange contracts, I multiply MACE currency volume by .5. As another example, the 20 ton Winnipeg Commodity Exchange canola contract is 14 percent the size of the Chicago Board of Trade soybean contract, so I multiply the WCE contract volume by .14.

Table 1 presents HHI values by year from 1986 to 1992 for a variety of financial and commodity derivative products traded on organized exchanges. HHI values are calculated for relatively broad categories of derivatives. When commodities are traded on different continents (e.g., sugar) multiple HHI numbers are reported: one for each continent where the commodity is traded and a combined figure for the world. Separate reporting by continent reflects the fact that trading in a particular contract in different time zones may be very imperfect substitutes.

The grouping of multiple contracts into broader categories for some contracts (e.g., equity index futures, U.S. government bonds) makes the analysis more tractable. It also tends to produce HHI values below 10,000 even when no exchange trading a particular contract faces a competitor offering an identical contract. Grouping contracts into broad categories eliminates the need to make judgments regarding the substitutibility of related but differentiated products. For example, the NYSE index contract traded on the New York Futures Exchange (NYFE) is an imperfect substitute for the S&P 500 contract traded on the CME, and each exchange has a monopoly in its particular contract. Nonetheless, each is included in the stock index futures category. This tends to generate HHI's less than 10,000 even when it is possible that the degree of differentiation between two related contracts is sufficient to make them economically distinct.

A review of Table 1 reveals HHI values of 10,000 for a number of these broadly defined categories, and HHI values of in excess of 9500 for several more. The lowest HHI values for trade within a particular continent are for US wheat, US stock index futures, US stock index options and futures options, and Japanese stock index futures. The low values for wheat may not be inconsistent with the prediction that exchanges will be monopolies in equilibrium because the three exchanges that trade wheat in the US, the Chicago Board of Trade, the Kansas City Board of Trade, and the Minneapolis Grain Exchange, trade distinct varieties of this grain which are imperfect substitutes in consumption and production and which have different production cycles. These factors may differentiate the different wheat futures contracts sufficiently to permit the factors discussed in the analysis of exchange scope in section 3.3 to well explain why trade in different wheat varieties occurs on several exchanges.[12]

HHI values are sometimes well below 10,000 when aggregating across continents (as with sugar, cocoa, coffee, copper, and energy products). However, there is little if any overlap in the trading hours for these products on different exchanges. For example, the Coffee, Sugar, and Cocoa Exchange (CSCE) of New York trades these commodities from 0915 to 1405 Eastern Time, whereas the London Commodity Exchange (the LCE, recently absorbed by LIFFE) trades them from 0945 to 1232 Greenwich Mean Time, which corresponds to 0445 to 0732 Eastern Time. Given this lack of head-to-head trading, it is plausible to treat contracts on a particular commodity or asset (e.g., cocoa) traded on different continents as different products. Under this interpretation, the HHI figures reported in Table 1 are broadly consistent with the hypothesis that exchanges are natural monopolies.

The evidence presented in Table 1 indicates that unless one defines markets extremely broadly as world-wide in scope (which is not entirely plausible), the predictions of the model presented in section 2 clearly hold for futures and futures options. The markets for many exchange traded derivatives products are monopolized, and those that are not completely monopolized are dominated by a single large exchange which at most faces competition from a small fringe.

The HHI figures provide evidence of *structural* exchange monopolies in specific products. It is well known, however, that structural monopoly does not imply that the monopolist earns supercompetitive profits (Demsetz, 1989; Telser, 1978; Baumol, et al 1982). The next section demonstrates, however, that exchange members earn substantial rents that are most plausibly at-

[12]Until recently, LIFFE and the Deutsche Terminbörse (DTB) split trading volume in German government bonds almost equally. In the summer of 1998, however, virtually all trading of this contract migrated to DTB. At present, DTB market share is 99.9 percent.

tributable to entry barriers as predicted in the model of section 2.

5 Evidence of Economic Rents Accruing to Exchange Membership

The theory in section 2 implies that both the marginal member and infra-marginal members of a financial exchange should earn rents due to the ability of an exchange to limit membership and deter entry by competing exchanges. The price of an exchange membership, the seat price, incorporates the value of exchange trading privileges to the marginal member. Seat prices therefore capitalize any rents attributable to entry limits that accrue to the marginal member. This section examines membership prices for evidence of such rents.

Lindenberg and Ross (1981) and Smirlock, Gilligan, and Marshall (1984) show that Tobin's q ratio can be utilized to detect the existence of economic rents. Tobin's q is defined as the ratio of the market price of financial claims outstanding against a firm to the replacement value of the firm's assets. Homogeneous firms in perfectly competitive industries with free entry should earn no rents; in long run equilibrium, the market value of these firms should equal the replacement value of their assets, implying a q ratio of 1.00. Thus, it is consistent with the hypothesis that firm X exercises market power or benefits from entry barriers to observe a q ratio for firm X in excess of 1.00.

Q ratios can exceed one even in the absence of market power or entry barriers. For example, firms may not be homogeneous. Some companies may possess specialized assets which allow them to produce at lower cost than their rivals. If the replacement value of these assets is not recognized (as may well occur if they are intangibles), the advantaged firms will have q ratios in excess of one. Finally, the new theory of investment under uncertainty (Dixit and Pindyck, 1994) implies that q's may exceed 1.00 if firms have valuable investment options.

These caveats imply that q's in excess of 1.00 do not necessarily indicate market power or the existence of entry barriers. Nonetheless, the persistence of q's greater than 1.00 in an industry provides evidence consistent with market power or entry barriers in that industry. Moreover, some of the alternative explanations for q greater than 1.00 can be examined to determine whether market power/entry barriers or the alternative explanation is more persuasive.

This section examines data on q ratios for 6 major financial exchanges: the Chicago Board of Trade, the Chicago Mercantile Exchange, the New York Cotton Exchange, the Coffee, Sugar, and Cocoa Exchange, the New York Stock Exchange, and the Chicago Board Options Exchange. The CBOT and CME are the two largest futures exchanges in the world and trade a broad variety of commodity and financial derivatives. The NYSE is the world's largest stock exchange, and the CBOE is the world's largest equity options exchange. The NYCE and CSCE are futures exchanges that are smaller and more narrowly focused than the CBOT and CME. Each has a dominant niche in a particular commodity segment, the NYCE in cotton and orange juice and the CSCE in the trade of "soft" commodities in North America.

To calculate q's for these exchanges, I collect the high and low seat transactions prices for each membership category for each year from 1986-1996.[13] The high and low prices for each membership category are multiplied by the number of outstanding memberships in this class to determine the high and low values of the equity claim represented by this ownership class. The high (low) values of all membership classes for a given exchange are added to estimate an annual upper (lower) bound on the value of equity claims on the exchange. To both the high and low equity values I add the difference between the exchange's book value of assets and book value of equity; this gives the book value of the exchange's outstanding liabilities. Most exchange liabilities are payables or other short term borrowings, so book values should measure their market values accurately. These values are derived from each exchange's balance sheet. The sum of seat equity value and liabilities is the numerator in the q ratio. For the denominator, I use the book value of each exchange's assets, as disclosed in its annual report, as an estimate of the replacement value of its assets. The structure of exchange assets is relatively simple. These assets consist primarily of marketable securities, which implies that book values are accurate measures of replacement cost for these assets since they are marked-to-market on exchange books. Nor do exchanges hold inventories, which also eliminates a potential problem that can result from using book values to calculate replacement costs. Moreover, Chung and Pruitt (1994) and Perfect and Kiles (1993) show that estimates of q based on asset book values are highly correlated with estimates based on more involved measures of replacement cost. Given the simplicity of exchange asset

[13] For example, the CBOT has 5 different classes of membership representing different trading rights and claims on the exchange's physical assets.

structures and the quality of book values as a proxy for replacement costs, the ratio of exchange equity values and liabilities to exchange asset book values should be a reliable estimate of the true q.[14]

Table 2 presents the q values for 1986-1995 for the 6 exchanges studied. For each exchange, the q ratio (even based on the annual low value of the seat price) is typically above 2.00 and always exceeds 1.00. For the two largest futures exchanges in the sample, the CBOT and the CME, the q ratios are above 3 for the entire ten year period, and reach nearly 10 (based on the annual high seat prices) for the CME in 1995. The average of the high and low q's exceed 4 for all but two years (1990 and 1991) for the CBOT and exceed 5 for all years but 1986 and 1987 for the CME. The New York Cotton Exchange q's are also typically above 2, and average 3.27 (2.37) based on the high (low) seat price. The high CSCE q's are typically above 2.0 and exceed 3 in 1988 and 1989. The low q's for this exchange are below 2.0 but always exceed 1.0. The CBOE q ratios range between 2.2 and 5. The NYSE q's are usually the lowest of the exchanges studied, but exceed 1.73 at some time during every year in the sample period.

A comparison of these figures with q's for non-exchanges firms reported in other studies strongly suggests that exchange q's are high. The average value from a long time series of q's from a sample of publicly traded US firms produced by the Federal Reserve Board equals .7. The highest value for this economy-wide q during this period equals only 1.6 as observed in 1996. Lindenberg-Ross (1981) report mean and median q's for 1960, 1965, 1970, and 1977 for a sample of 246 firms. For these years, the mean values are 1.54, 1.51, 1.53, and 1.53, respectively; the median values are 1.20, 1.25, 1.23 and 1.25. Perfect and Kiles (1994) report mean and median q (calculated using book values as a measure of replacement cost) for a random sample of 62 firms. Their mean q is 1.09, and the median is .96. The standard deviation of q in their sample is .44. The maximum q in their sample is 3.76. Thus, the q's observed for financial exchanges are very large compared to q's for US industrial and service firms.

A more detailed analysis of the Lindenberg-Ross (1981) results illustrates

[14] Two exchanges, the CME and NYCE, consolidate the balance sheets of the exchange and its clearinghouse. As a result, they carry the value of margin accounts as an asset and a liability on their books. Since these sums do not contribute to (1) the value of owning a membership, or (2) the assets to which members have a claim on dissolution of the exchange, the year end value of margin accounts are removed from the assets and liabilities of these exchanges when computing q.

the distinctive character of exchange q's. The average of the high and low q's for both the CME and CBOT are above 4.00 for virtually all of the 1986-1995 period. In contrast, only 6 firms in the Lindenberg-Ross sample have q's in excess of 4.00, while only an additional 6 have q's between 3.00 and 4.00. Firms with large q's are concentrated in the pharmaceutical industry, which contributes 8 of the 17 largest q's in their sample. The pharamaceutical industry is characterized by patent protection (which serves as an entry barrier), substantial intangible capital (R&D and advertising expenditures are expensed instead of capitalized, thereby biasing estimates of asset values in the q denominator downwards), and growth options. Other firms with large q's include Avon, Coca-Cola, Johnson & Johnson, and Kellogg, all of which are advertising-intensive and likely possess substantial brand name capital that is not reflected in replacement value calculations. The remaining firms with large q's, Xerox (5.52), IBM (4.21), and DuPont (2.47) had dominant market positions during the year in which q was reported, and thus plausibly exercised market power and likely had valuable investment options.

When comparing exchange q's with the q's for publically traded firms one must also remember that the former underestimate the total rents generated by restrictions on membership size and entry barriers. The seat price of an exchange measures the rents earned by the marginal member. The rents earned by inframarginal members exceed the seat price; lower cost suppliers of trading services benefit more from any rise in the price of trading services that results from a limitation on memberships than does the marginal member. In contrast, all shareholders of a publicly traded corporation are marginal and all of its shareholders are average because all own an identical claim on firm cash flows. All shareholders benefit equally from market power or an entry barrier. Thus, securities prices for a publicly traded corporation capitalize all of the rents attributable to the firm's market power or entry barriers. In contrast, the seat prices of financial exchanges measure only a fraction of the rents earned by exchange members as a result of entry restrictions or the exercise of market power. As a result, the differences between exchange q's and the q's of publicly traded firms do not fully reveal the exceptional nature of the former.

The foregoing comparisons demonstrate that exchange q's are very high relative to other firms in the economy. Moreover, factors other than market power or entry barriers which can cause high q values for other firms (such as substantial intangible brand name capital and investment options) are not plausible for financial exchanges. Nor can indivisibility rents (Demsetz,

1989) or congestion effects simultaneously explain high exchange q's and the extremely high exchange market shares documented in the previous section. Demsetz shows that firms in an industry can earn substantial rents even if they act as price takers if they incur substantial fixed costs but are subject to *decreasing* returns to scale over some range of output. Similarly, the literature on club goods demonstrates that a combination of fixed costs and congestion effects (which cause decreasing returns to scale) can generate economic rents for club members; fixed costs make it costly to form additional clubs, thereby limiting entry, and the congestion effects cause the marginal value of club services to exceed their average cost.

In the present context, it could be argued, for example, that physical constraints on the size of a trading pit create congestion effects which tend to create rents. In both the Demsetz and club theories, however, diseconomies of scale typically result in the formation of multiple firms/clubs producing the same product. In contrast, the evidence presented in the previous section shows that exchanges have a monopoly or near monopoly in the products they trade; exchanges which trade high-volume products simply create big pits.

In sum, exchange q ratios provide strong evidence that exchange members earn substantial rents. Exchange q ratios are persistently above 1.00, and are very high relative to the ratios for US non-exchange firms. These high q's are consistent with the hypothesis that exchange members earn rents as predicted by the model presented in section 2. The most plausible explanation for exchange q's so far above 1.00 is that exchange members earn rents due to the combination of entry barriers that result from scale economies and the ability of exchanges to control membership size.

6 Exchange Membership Policies

Member owned derivative and securities exchanges strictly limit the number of members. The only notable exception is the London Stock Exchange. English common law required this exchange to admit all qualified applications (Davis and Neal, 1998).

The expansion of futures exchange memberships to permit the trading of new products is consistent with the analysis of scope economies in section 3.3. When the Chicago Board of Trade expanded operations to permit the trading of futures options and financial futures, it created new membership categories: Associate members can trade only financials, GIM membership interests can trade only futures and options on government instruments, IDEM members can trade only index, debt, and energy contracts, and COM members can trade only commodity options. None of these special membership categories can trade the exchange's agricultural futures products; only Full Members have this privilege. Similarly, the Chicago Mercantile Exchange created special membership categories to trade foreign currency and short term interest rate futures (IMM members), stock index futures and futures options (IOM), and emerging market products (GEM). The New York Cotton Exchange created new membership categories to trade Orange Juice futures (Citrus Associates).

These membership categories distinguish between broadly different types of underlying instruments (e.g., financial futures and commodity futures) which are likely imperfect substitutes with relatively low demand shock correlations. For instance, trading volume for corn and soybeans varies with changes in weather, crop, and inventory conditions which have little bearing on the demand to trade futures on United States government debt, whereas macroeconomic shocks that influence government debt trading have little effect on the demand to trade corn or soybeans. Similarly, government debt futures and corn futures are likely very imperfect substitutes; a grain merchant cannot effectively hedge his commitments using T-bond futures. Thus, the specification of trading rights is consistent with the hypothesis that exchanges define these rights in order to mitigate intra-exchange competition.

The few observed mergers of financial exchanges also conform with the theory. Specifically, upon the merger of The Commodity Exchange of New York (COMEX) and the New York Mercantile Exchange (NYMEX), COMEX members did not receive NYMEX trading privileges, and vice versa. Similarly, when the LIFFE acquired the LCE, the members of the LCE (LIFFE) did not receive trading rights for LIFFE (LCE) contracts. The recently announced plans for the merger of the Pacific Stock Exchange (PSE) and the Chicago Board Options Exchange (CBOE) countenance no merger of trading rights; CBOE (PSE) members will not receive rights to trade option series currently traded exclusively on the PSE (CBOE). Press releases announcing the merger clearly indicate that the merger is intended to exploit scope economies by reducing the costs of developing and implementing automated trading systems. The outlines of a merger plan between the CBOT and the CME also countenances no merger of trading rights. It is clear, futhermore, that the CBOE-PSE merger and the proposed CBOT-CME deal are clearly driven by a desire to exploit the increasing scope economies created by electronic trading. A single computerized trading engine can be expanded to handle trading in a large number of different futures and options contracts, whereas doubling the number of contracts traded via open outcry requires nearly a doubling of floor space. Therefore, exchanges can economize on the costs of developing and operating of computerized trading systems by creating these systems jointly. The CBOE-PSE and CBOT-CME proposals involve joint development of trading technology but no merger of trading rights, just as the theory predicts. Moreover, when North American and European or Asian exchanges have entered into agreements to cross-list contracts, these agreements are structured to ensure that trading does not overlap; trading of American products on European exchanges is allowed only when the American exchanges are closed, and vice versa.

The recent consolidation of trading on three major Continental European exchanges, Germany's DTB, France's MATIF, and Switzerland's SOFFEX, and the possible addition of other European exchanges to this grouping, are also consistent with the theory. DTB's main products are German interest rate futures, and MATIF's are French interest rate futures. Absent introduction of a common European currency, these products are imperfect substitutes affected by different shocks (e.g., news about German monetary policy hasrk a different effect on demand to trade German government bond futures than on the demand to trade French government bond futures). With monetary union increasingly likely, German government securities and French government securities will become much closer substitutes. This "convergence" reduces the dis-incentive of exchanges to merge; when the products the exchanges trade become closer substitutes, consolidation reduces fixed costs without substantially increasing competition between members of the previously separate exchanges. It is especially interesting to contrast this development with the failure of an early attempt of DTB and MATIF to merge when the prospects for monetary union were considerably more uncertain.

In sum, the observed limitation of exchange membership, the expansion of futures exchanges through the creation of new membership categories with trading rights limited to the newly-launched products, the failure to merge membership trading rights when exchanges merge (or cooperate through cross-listing), mergers to exploit increases in scope economies driven by technological changes, and the consolidation of European exchanges as monetary union approaches are all consistent with the theoretical analysis of sections 2 and 3. These features are consistent with the view that exchanges strive to reduce competition among members by limiting both their number and the scope of their trading rights.

7 Summary and Conclusions

Traditional financial exchanges are membership organizations that supply semi-private goods (such as trading facilities and rule enforcement) to member firms. This article demonstrates that if (1) intermarket arbitrage is cheap and exchanges enjoy scale economies, or (2) investors can trade on any exchange they choose, a group of trading intermediaries can form an exchange to trade a particular financial contract or security that has enough members to deter trading of a close substitute on a competing exchange, but which has fewer members than optimal. Restricting the number of members generates rents for member firms.

The evidence is broadly consistent with these implications; trading in particular types of financial instruments (e.g., government interest rate futures contracts) is typically limited to a single exchange, and exchange membership values substantially exceed the values of exchange assets. Moreover, exchanges limit the scope of member trading rights in a way that is consistent with a desire to limit inter-member competition. In sum, the cooperative structure of financial exchanges explains salient features of the industrial organization of financial markets.

The analysis has normative as well as positive implications. Specifically, there is a large literature on the regulation of financial markets which claims that exchanges have strong incentives to implement first-best or nearly first best rules and policies. If self-regulation is first best (or nearly so), government regulation of transactions made on financial exchanges is superfluous if not harmful. These arguments are based explicitly or implicitly on the presumption that exchanges operate in highly competitive environments. The theory and evidence presented herein undercut any such presumption. Theory suggests that exchanges are likely to be subject to little direct competition, and the evidence is consistent with this implication. Pirrong (1997) demonstrates that if exchanges are not perfect competitors, their members may extract rents by adopting inefficient rules or designing inefficient contracts. Under these circumstances, external regulation can be preferable to self-regulation, but may not be so in practice due to the well known inefficiencies that frequently plague government oversight and control. The evidence presented herein clearly demonstrates that those who claim that inter-exchange competition causes self-regulation to dominate external regulation must find a different rationale for their conclusion. Given the well-known problems that can afflict external regulation of markets, the economist and policy maker face a conundrum because no *prima facie* case can be made for either self-regulation or government oversight. Thus, the relative efficiency of government regulation requires a fact-intensive comparison of the costs of these two alternative modes of governing transactions on exchanges.

TABLE 1
Panel 1
Financial Futures Contract Herfindahls

CONTRACT	CONT.	1986	1987	1988	1989	1990	1991	1992
US TREASURIES	NA	10000	10000	9797	9889	9966	9980	9992
GERMAN BUND	E	-	-	10000	10000	9877	6995	6530
FRENCH NOTIONAL	E	10000	10000	10000	10000	10000	10000	10000
EUROMARK	E	-	-	-	10000	10000	10000	10000
EUROMARK	A	-	-	-	-	10000	10000	10000
EUROMARK	W	-	-	-	10000	8500	9440	8248
EURODOLLARS	NA	10000	10000	10000	10000	10000	10000	10000
EURODOLLARS	E	10000	10000	10000	10000	10000	10000	10000
EURODOLLARS	A	10000	10000	10000	10000	10000	10000	10000
EURODOLLARS	W	7725	7535	7497	7714	7837	8061	8269
DM/USD	NA	9889	9863	9913	9935	9911	9915	9808
JY/USD	NA	9883	9892	9932	9925	9928	9933	9889
SF/USD	NA	9803	9821	9848	9902	9886	9875	9880
BP/USD	NA	9937	9958	9894	9906	9925	9921	9858
CD/USD	NA	9917	9917	9935	9949	9935	9965	9959
US INDEX FUTURES	NA	7033	7360	7590	7813	7978	8140	8699
US INDEX OPTIONS	NA	7518	7452	7391	7586	7732	7723	7582
GERMAN INDEX FUTURES	E	-	-	-	-	10000	10000	10000
FRENCH INDEX FUTURES	E	-	-	10000	10000	10000	10000	10000
UK INDEX FUTURES	E	10000	10000	10000	10000	10000	10000	10000
JAPANESE INDEX FUTURES	A	10000	10000	3927	4900	6323	8162	5613

TABLE 1 Panel 2 Commodity Futures Contract Herfindahls								
CONTRACT	CONT.	1986	1987	1988	1989	1990	1991	1992
WHEAT	NA	5034	4545	5123	4831	4592	4662	4279
OILSEEDS	NA	9622	9682	9866	9859	9873	9833	9826
OILSEEDS	A	10000	10000	10000	10000	10000	10000	10000
OILSEEDS	W	8603	8738	8540	8348	8295	8404	8189
CRUDE OIL	NA	10000	10000	10000	10000	10000	10000	10000
CRUDE OIL	E	10000	10000	10000	10000	10000	10000	10000
CRUDE OIL	W	10000	10000	9700	8608	7492	6785	6499
HEATING OIL	NA	10000	10000	10000	10000	10000	10000	10000
HEATING OIL	E	10000	10000	10000	10000	10000	10000	10000
HEATING OIL	W	6538	6749	6353	6208	5883	5799	5789
GASOLINE	NA	10000	10000	10000	10000	10000	10000	10000
GOLD	NA	9841	9735	9776	9965	9972	9981	9988
GOLD	A	10000	10000	10000	10000	9953	9981	9997
GOLD	W	7940	6968	6959	6640	5130	5183	5153
SILVER	NA	9447	9569	9587	9762	9809	9888	9928
SILVER	A	10000	10000	10000	10000	10000	10000	10000
SILVER	W	6867	6289	5419	7602	7843	6705	8616
PLATINUM	NA	10000	10000	10000	10000	10000	10000	10000
PLATINUM	A	10000	10000	10000	10000	10000	10000	10000
PLATINUM	W	5101	5633	6299	5946	6791	8190	8029
COPPER	NA	10000	10000	10000	10000	10000	10000	10000
COPPER	E	10000	10000	10000	10000	10000	10000	10000
COPPER	W	-	-	9998	9686	8438	8631	8673
LEAD	E	10000	10000	10000	10000	10000	10000	10000
ALUMINUM	E	10000	10000	10000	10000	10000	10000	10000
ZINC	E	10000	10000	10000	10000	10000	10000	10000
NICKEL	E	10000	10000	10000	10000	10000	10000	10000
COFFEE	NA	10000	10000	10000	10000	10000	10000	10000
COCOA	NA	10000	10000	10000	10000	10000	10000	10000
COCOA	E	10000	10000	10000	10000	10000	10000	10000
COCOA	A	10000	10000	10000	10000	10000	10000	10000
COCOA	W	5007	5001	4983	4986	4979	5051	4998
SUGAR	NA	10000	10000	10000	10000	10000	10000	10000
SUGAR	E	9992	5965	5000	5003	7899	5248	5133
SUGAR	A	10000	10000	10000	10000	10000	10000	10000
SUGAR	W	6087	5669	6224	5532	5059	5359	6077
COTTON	NA	10000	10000	10000	10000	10000	10000	10000

This table presents Herfidahl index values for financial contracts traded on organized exchanges around the world. Separate Herfindahl values are *reported for each continent where a particular type of contract trades. The column labeled "CONT." gives the continent for which the Herfindahl is relevant. NA indicates trading in North America. E indicates trading in Europe. A indicates trading in Asia. W indicates trading worldwide. Some Herfindahls aggregate trading across a variety of contracts. Specifically, the "US Treasuries" entry aggregates across all futures contracts for US Treasury notes and bonds. The "US Index Futures" entry aggregates across the S& P 500, NYSE, and Value Line futures contracts. The "US Index Options" includes S& P 500 and OEX (S& P 100) index options, and the S& P 500 futures option. The "Japanese Index Futures" category includes Nikkei futures and TOPIX futures. The "Oilseeds" category for North America includes soybeans, soybean oil, soybean meal, and canola.*

TABLE 2
Financial Exchange *q* Ratios

	CBOT		*CME*		*NYCE*		*CSCE*		*CBOE*		*NYSE*	
Year	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
1986	5.18	3.23	4.08	3.31	2.49	1.87	2.57	1.82	3.56	2.27	2.76	2.21
1987	7.69	4.29	5.28	3.02	4.41	2.49	2.19	1.57	4.16	3.13	4.05	2.37
1988	7.08	4.98	8.40	4.43	3.46	2.39	3.05	1.63	3.42	2.78	3.22	2.40
1989	5.45	4.08	6.95	4.76	2.87	1.63	3.09	1.22	3.22	2.78	2.49	1.74
1990	4.28	3.46	7.23	4.98	2.29	1.49	2.20	1.77	2.75	2.56	1.83	1.73
1991	4.44	3.48	6.47	4.72	2.43	1.79	2.90	1.24	3.26	2.45	1.73	1.25
1992	4.63	3.57	5.88	4.48	3.09	2.50	1.46	1.16	3.77	3.31	1.92	1.47
1993	5.03	3.88	7.54	5.86	2.03	1.62	1.95	1.24	4.33	3.31	2.00	1.48
1994	6.26	4.10	7.26	6.32	7.02	4.50	2.13	1.46	5.23	3.82	1.93	1.81
1995	5.80	4.10	9.89	6.25	4.22	2.78	2.46	1.77	5.03	3.22	2.15	1.73

References

[1] Abolafia, M. "Self-regulation as Market Maintenance: An Organizational Perspective" in R. Noll (ed.) *Regulatory Policy and the Social Sciences.* Los Angeles: UCLA Press, 1985.

[2] Baumol, W., J. Panzar, and R. Willig. *Contestable Markets and the Theory of Industry Structure.* New York: Harcourt Brace Jovanovich, 1982.

[3] Brown, D., and Z. Zhang. "Market Orders and Market Efficiency." *Journal of Finance* 52 (1997): 277-307.

[4] Chung, K. and S. Pruitt. "A Simple Approximation of Tobin's q." *Financial Management* 23 (1994): 70-74.

[5] Coase, R. *The Firm, the Market, and the Law.* Chicago: University of Chicago Press, 1988.

[6] Davis, L., and L. Neal. "Micro Rules and Macro Outcomes: The Impact of Micro Structure on the Efficiency of Security Exchanges, London, New York, and Paris, 1800-1914." *American Economic Review.* 88 (1998): 40-45.

[7] Demsetz, H. "Why Regulate Utilities." *Journal of Law and Economics* 11 (1968): 55-66.

[8] Demsetz, H. *Efficiency, Competition, and Policy.* London: Blackwell Publishers, 1989.

[9] Easterbrook, F. "Monopoly, Manipulation, and the Regulation of Futures Markets." *Journal of Business* 59 (1986): S103-S128.

[10] Edwards, L. and F. Edwards. "A Legal and Economic Analysis of Manipulation." *Journal of Futures Markets* 4 (1989): 333-366.

[11] Fischel, D. and S. Grossman. "Consumer Protection in Futures and Securities Markets." *Journal of Futures Markets* 4 (1984): 273-295.

[12] Glosten, L. "Is the Electronic Limit Order Book Inevitable?" *Journal of Finance* 49: 1127-1161.

[13] Lindenberg, E., and S. Ross. "Tobin's q Ratio and Industrial Organization." *Journal of Business* 54 (1981): 1-33.

[14] McInish, T., and R. Wood. "Competition, Fragmentation, and Market Quality" in A. Lo (ed.) *The Industrial Organization of the Securities Industry.* Chicago: University of Chicago Press, 1996.

[15] Mulherin, H., J. Netter, and J. Overdahl. "Prices are Property: The Organization of Financial Exchanges from a Transaction Cost Perspective." *Journal of Law and Economics* 34 (1991): 591-644.

[16] Mulherin, H., J. Netter and P. Hersch. "Merging Markets." Unpublished manuscript. College Station, PA: Pennsylvania State University, 1998.

[17] Oesterle, D., D. Winslow, and S. Anderson. "The New York Stock Exchange and its Outmoded Specialist System: Can the Exchange Innovate to Survive?" *Journal of Corporate Law* 17 (1992): 223-310.

[18] Pagano, M. "Trading Volume and Asset Liquidity." *Quarterly Journal of Economics* 104 (1989): 255-274.

[19] Perfect, S. and K. Wiles. "Alternative Constructions of Tobin's q." *Journal of Empirical Finance*

[20] Pirrong, C. "The Efficient Scope of Private Transaction Cost-reducing Institutions: The Case of Commodity Exchanges." *Journal of Legal Studies* 24 (1995a):

[21] Pirrong, C. "The Self-regulation of Commodity Exchanges: The Case of Market Manipulation." *Journal of Law and Economics* 38 (1995): 141-206.

[22] Pirrong, C. "A Positive Theory of Financial Exchange Organization and Governance." Unpublished manuscript. St. Louis: Olin School of Business, Washington University, 1997.

[23] Saloner, G. "Self-Regulating Commodity Futures Exchanges" in R. Anderson (ed.) *The Industrial Organization of Futures Markets.* Boston: Lexington, 1985.

[24] Smirlock, M., T. Gilligan, and W. Marshall. “Tobin's Q and the Structure-Performance Relationship.” *American Economic Review* 74 (1984): 1051-1060.

[25] Telser, L. *Economic Theory and the Core.* Chicago: University of Chicago Press, 1978.

[26] Telser, L. and H. Higinbotham. “Organized Futures Markets: Costs and Benefits.” *Journal of Political Economy* 85 (1977): 969-997.

[27] Telser, L. “Why There Are Organized Futures Markets.” *Journal of Law and Economics* 24 (1981): 1-22