Combining new technology with established financial market mechanisms.

THE INTERNET AND THE FUTURE OF FINANCIAL MARKETS

Rapid advances in computing and telecommunication tech-nologies, particularly the Internet, have profoundly changed the dynamics of financial markets. More people are trading online through the Web instead of using full-service brokerages. According to Jupiter Communications, the $415 billion online brokerage assets in 1998 will grow by more than sevenfold to $3 trillion in 2003 [4]. Investors

❀ MING FAN, JAN STALLAERT, AND ANDREW B. WHINSTON

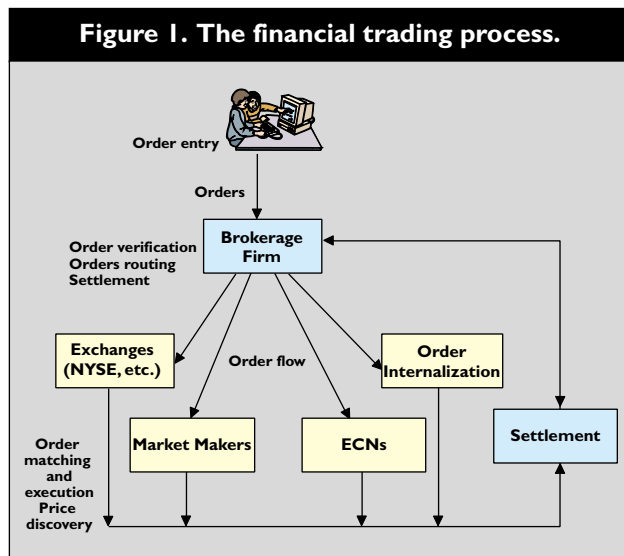can now trade stocks, access real-time market information, and conduct investment research in ways they could not dream of just a decade ago. However, if we look at the overall process of trading in financial markets (see Figure 1), which includes order entry by investors, order verification and routing by brokerage firms, and, finally, execution and settlement through various markets, online trading has only replaced telephones with the Web and provided a universal interface for individual investors to participate in the financial markets. It has not necessarily improved the overall efficiency level of the market.

Beginning several years ago, the U.S. financial markets have been experiencing a profound change that goes far beyond online trading. It is not an exaggerated claim to describe the ongoing development as a fundamental revolution [2]. Recently, we have witnessed the Nasdaq's acquisition of the American Stock Exchange, the phenomenal growth of the Electronic Communications Networks (ECNs), and the introduction of after-hours trading. Looking at all the changes, ECNs have been among the most significant. ECNs are electronic trading systems that can automatically match buy and sell orders without the intermedi-

JEAN MIELE/THE STOCK MARKET

Figure 1. The financial trading process.

System (FBTS) that can match and clear bundle orders. In financial markets, a bundle can contain a combination of stocks or other financial instruments such as commodity or interest futures, options, bonds, and foreign currencies. In our opinion, market process reform in current financial markets involves interrelated processes that span the boundaries of individual firms. Realigning the relationship between investors, brokers, and market centers will promote competition in exchange markets and encourage technology-driven innovations in trading services such as the FBTS.

Competition in the Exchange Marketplace

Recent developments in exchange markets provide more alternatives to trade stocks. Generally, investors' orders can be traded at the following venues:

- **Exchanges.** For a stock that is listed on the NYSE, the brokerage firm can send the order to the floor of the NYSE or other regional exchanges. The brokerage firm can also direct the order to firms called "third market makers" who buy and sell stocks listed on an exchange at publicly quoted prices. Most of the trading of the NYSE listed stocks happens at the NYSE, which has consistently captured over 80% of the order [7].
- **Market makers.** There are two types of market makers. The first type of market makers is the Nasdaq market makers, which are more important. They are essentially dealers who are ready to buy or sell stocks traded at the Nasdaq market. The other type is the "third market makers" as mentioned earlier.
- **ECNs.** Although ECNs are quite a new phenomenon in the equity markets, they already account for about 30% of total share volume traded on the Nasdaq market [6]. So far, the impact of ECNs on the NYSE has not been very significant. ECNs now account for approximately 3% of total share trading volume of exchange-listed stocks. However, ECNs, due to their cheaper and faster trading technology, pose a growing threat to the organized exchanges.
- **Internalization.** Finally, the brokerage firm can route orders to a market maker that is an affiliate of the brokerage firm for execution.

Market centers discussed here use different trading systems to compete with each other. Market efficiency is largely affected by the way trading is organized. Essentially, stock markets can be classified as two types: auction markets and dealer markets. In an auc-

ation of human agents. They have brought serious competitive challenges to the exchange markets that have been traditionally dominated by the New York Stock Exchange (NYSE) and Nasdaq market makers. Today, there are more venues in which a stock can be traded.

But online brokerage firms have not yet embraced the latest development in the market. As illustrated in Figure 1, different market centers such as the NYSE, market makers, and ECNs compete for order flows. They use different trading mechanisms to match buy and sell orders resulting in diverse market outcomes in terms of execution price and speed. In this competitive marketplace, brokerage firms play a vital role because they generally make order-routing decisions. Rarely do individual investors decide in which market the order should be executed. But at the same time, brokerage firms receive payments for order flow, or kickbacks, from market makers or exchanges, to which they route orders. The vertical relationships between the brokers and the market centers adversely affect investors' interest and undermine the competition at the exchange markets. These relationships also reduce the incentive for market centers to innovate to offer more efficient trading services. The order routing process has to be reengineered.

This article focuses on two processes of the exchange markets that will further enhance competition and efficiency in the marketplace: order routing and order execution. First, we describe a direct trading model, which allows individual investors to trade directly at different markets. The new technology ushers in disintermediation of the brokerage firms' order routing task as investors will be able to make their own decisions on which market to trade. Further, we describe a novel Financial Bundle Trading

tion market, buyers and sellers can trade directly with each other: sellers sell to the highest bidder and buyers buy from the lowest offer. In a dealership market, orders are traded against market makers, or dealers, who are ready to buy and sell out of their inventory and provide liquidity to the market. An auction maker derives its revenue from the access fees it charges while dealers receive their compensation primarily in the form of trading profits. In the real world, trading mechanisms at exchanges are often a hybrid of dealer and auction markets. For example, the NYSE is primarily an auction market with a special type of human auctioneers, specialists, who manage the auction process and handle the limit order book in which all unmatched buy (bid) and sell (ask) orders are stored. Nasdaq is mainly a dealership market with an average of approximately 12.3 market makers per Nasdaq stock [6]. But the emergence of ECNs has added an auction element in the Nasdaq market.

The fundamental difference between ECNs and

Market Imperfections

Competition at exchange markets could be diluted by imperfections that exist in the current marketplace. Order flow is critical to every market center's business. More order flow means more revenue and trading profits. Besides competing for order flow by using new technologies and improving operation efficiency, a market center may develop vertically integrated relationships with brokerage firms in order for the brokers to route orders to the market. The relationship usually takes two forms: payment for order flow and internalization. Under payment for order flow, a market maker may pay an agreed amount (for example, one cent per share) or other types of monetary inducement, to brokers for the order flow. As for internalization, the motivation of routing orders to an affiliate owned by the same company is quite obvious.

To the brokerage firms, the practice of payment for order flow and internalization allows them to share the profits that can be earned by a market maker in

THE VALUE OF INTERNET TECHNOLOGY
cannot be fully realized unless we streamline all the
interrelated processes in the marketplace.

NYSE and Nasdaq market makers is that the ECNs are electronic auction systems that can execute trades without human intervention. There currently are nine ECNs operating in the U.S. equities markets: Instinet, Island, Bloomberg Tradebook, Archipelago, REDIBook, Brut, Attain, NexTrade, and Market XT. Despite their recent entry into the financial markets, ECNs have already made a significant impact. With quick order execution and anonymity in trading, ECNs are competing fiercely for order flow with other market centers.

There is now more competition in the exchange markets than ever before, and execution costs have dropped significantly as a result. According to a recent study, bid-ask spread, which is a key measure of trading cost, has declined an impressive 30% since the emergence of ECNs [1]. The competition has benefited investors and provides individual markets stronger incentives to innovate, which will improve the efficiency of the equity markets. For example, the NYSE and Nasdaq are determined to change their organizational structure to for-profit exchanges in order to better compete with the electronic trading networks. New, innovative trading systems are being developed to provide better trading services.

trading as a dealer. On the other hand, by accepting orders and commissions, a broker is acting as the investors' agent and has a duty to seek best execution for customers' orders. A brokerage firm is supposed to route a customer's order to the marketplace that can best execute the order. It has been found that brokerage firms do allow payment for order flow and internalization influence their decisions on order routing, at the expense of the interests of individual investors [5]. This not only increases individual investors' trading costs, but also will potentially damage investors' confidence in the marketplace.

To market centers, the practice has a negative impact on competition and innovation. By sharing profits with brokerage firms, a market center can sit on the order flow and simply match the best prices in the marketplace without bidding aggressively. Subsequently, it will reduce the incentive of other markets to innovate and compete, which will undermine the competitive nature of the entire marketplace.

Trading Directly on Markets
To date, the only possible remedy to payment of order flow and internalization involves full disclosure. The Securities and Exchange Commission (SEC) believes

full disclosure will ultimately produce informed investors and will eventually put increased competitive pressure on brokerage firms [5]. However, monitoring the order routing process is too costly for most investors. In addition, it does not completely solve the problem of conflict of interests of brokers. Here, we develop a direct trading model that provides a structural solution to the problem.

A closer examination of the entire trading and execution process shows that the values a brokerage firm adds to online investors are largely pre-execution credit verification and post-execution settlement services. Since there are a lot of negatives associated with brokerage firms in performing the order routing function, new institutional structures should be designed to unbundle the service from brokers. Technologies are available today to allow investors to directly access markets while providing identities and assurance for the orders submitted by individuals. It is in the best interest of individual investors as well as the whole marketplace that each investor makes his or her own decision regarding in which market the order should be traded. As investors send orders to markets that offer the best price and fastest execution, they are in fact rewarding markets that have superior execution services.

In a future scenario the traditional broker's task of order verification can be replaced by new technology using digital certificates (Figure 2). Under this new setup, brokerage firms could continue to conduct the tasks of checking the credit of investors and the validity of orders, but in a more efficient way. Every time an investor wants to trade, he or she will open the trading application, which can be a Java applet. The application will have the digital certificate for the investor and the latest account status information including current positions and cash balance. The digital certificate is issued by a certificate authority (CA), which can be the brokerage firm or simply the investor's bank. The digital certificate carries information about the investor such as the name of the broker and the type of trading (stocks, options, futures, and so forth) for which the investor is authorized.

The desktop trading software will provide rich information from various markets to investors, including real-time quotes from different market makers, and best bids and offers at exchanges and ECNs. Investors can send orders directly to the markets of their choice, irrespective of whether they are the NYSE trading floor, traditional Nasdaq market makers, or ECNs. They also have the option to leave the routing decision to the trade application, which can be programmed to route the order to the market that offers the best price or the fastest execution

Figure 2. A direct trading model.
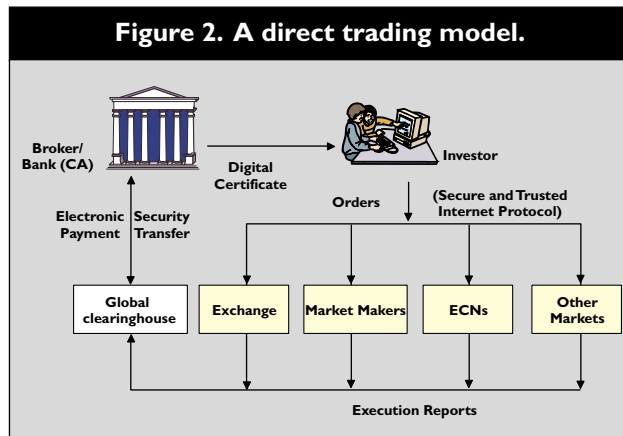
speed. After execution, trade reports will be forwarded from the market to the global clearinghouse where all trades will be settled with each trader's brokerage firm or bank.

Bundle Trading System

A trading system is crucial to an exchange market and plays a critical role in determining the overall efficiency of the market. Advances in technology are providing boundless opportunities to innovation in trading systems. The competition to provide advanced electronic trading systems is becoming more intensified. For example, ECNs are automated auction systems that can provide anonymity and fast execution. The OptiMark Trading System is a more complicated trading system that has been in operation at the Pacific Stock Exchange since January 1999 and at the Nasdaq market since October 1999. Instead of allowing an investor to submit an order with a single price-quantity combination, OptiMark allows a trader to specify multiple price-quantity combinations with varying levels of satisfaction, with total anonymity guaranteed. The system attempts to provide a solution to institutional investors who often have to trade a large number of shares. In June 1999 a group of leading brokerage firms, Merrill Lynch, Goldman Sachs, and Bernard L. Madoff, launched Primex, an electronic auction system that allows price improvement of market orders. In essence, the system tries to automate the trading process on the floor of the NYSE. When a market order arrives, the system will expose the order to its electronic crowd, one that could be potentially larger than the floor of the NYSE. It allows traders to compete for a sell (buy) order by improving on the best bid (offer) existing in the market at that moment. This feature is not offered by any of the ECNs. Nasdaq plans to launch the Primex system in 2001.

The equity markets, including the electronic systems mentioned here, have traditionally followed an

Table 1. A bundle trading example.					
Stock	Shares (i)	Previous Close Price (ii)	Next Day's Trading Range (iii)	Next Day's Worst Price (iv)	Trade Executed? Yes/No
IBM	+100	98	$98\frac{1}{2} - 98\frac{3}{4}$	$98\frac{3}{4}$	N
Microsoft	+200	$152\frac{1}{2}$	$150\frac{1}{2} - 151\frac{1}{2}$	$151\frac{1}{2}$	Y
Cisco	+125	73	$73\frac{1}{4} - 74$	74	N
GM	-200	$81\frac{1}{4}$	$80\frac{1}{4} - 81$	$80\frac{1}{4}$	N
Ford	-150	119	$120 - 120\frac{1}{2}$	120	Y
Chrysler	-50	93	$95 - 96\frac{1}{2}$	95	Y
(a)=Σ(i)*(ii)		10675			
(b)=Σ(i)*(iv)				10625	

asset-by-asset trading and clearing mechanism. For example, if you want to buy a portfolio of stocks you have to buy each individual stock separately. There are no markets available that allow you to purchase a bundle of stocks at a time. We learn from modern portfolio theory that investors prefer to hold a diversified portfolio of financial assets rather than an individual asset. For institutional investors who manage an index fund, they have to maintain a portfolio to match the investment performance of the U.S. equity markets as represented by the Standard & Poor's 500 Stock Index. As the composition of the index changes, the fund manager has to rebalance the portfolio by trading a basket of stocks. Using current financial market arrangements, fund managers have to trade stocks individually, a process that not only incurs large transaction costs but also increases the uncertainties of the overall cost of the portfolio. Bundle trading allows market participants to trade assets in bundles or baskets in arbitrary proportions. Therefore, an individual investor or a fund manager can pay more attention to the overall cost of the bundle, which essentially matters to the fund's performance, rather than the cost of individual stocks.

We use a trading example to illustrate the benefits of bundle trading. Assume that a fund manager decides to rebalance her portfolio and wants to execute the following trades: buy 100 shares of IBM, 200 shares of Microsoft, 125 shares of Cisco; sell 200 shares of GM, 150 shares of Ford, and 50 shares of Chrysler (see the table appearing here). If the manager thinks the previous day's close prices are fair values for all six stocks, and places limit orders based on the prices as displayed in column (ii), the buy order for IBM and Cisco and sell order for GM will not be executed according to the next day's trading ranges for these stocks (column (iii)). Instead of having a balanced portfolio, the investor is overexposed to the auto sector and underexposed to the technology sector. The investor could use bundle trading to avoid such trading risks, and could have specified a limit order price of $10,675 (line (a)) for the whole basket of orders as shown in the table. The order as a bundle would have been executed with certainty, since the highest cost of the bundle, based on the worst prices of the assets during the day (that is, the highest price for buys and lowest price for sells) would have been $10,625 (line (b)), which is still lower than the investor's valuation of $10,675.

Bundle trading can also be applied for other types of markets. Recently, there have been studies on using an electronic market to trade commodities such as natural gas. The Federal Energy Regulatory Commission is pushing the natural gas industry to adopt the Internet as a universal commerce platform to help cope with the increased volumes of trade that ongoing deregulation is bound to produce. We believe bundle trading is an ideal solution for gas trading. Buyers can buy gas and pipeline capacity in bundles, ensuring there will always be pipelines available if gas is purchased.

There are two major advantages of trading bundle assets. First, investors can trade a bundle of assets simultaneously in a unified market instead of dealing with separate orders, ensuring they will have balanced portfolios at all times. Second, in real life, an investor may need a bundle of resources that cannot be matched at all by any single seller. The bundle trading mechanism provides the function of market intermediary, automatically recombining resources from different sellers to satisfy the buyer's request for a specific bundle. By offering traders an additional trading option, the bundle trading mechanism increases the liquidity of the markets.

The automated bundle matching program matches orders by solving a mathematical optimization problem. The logic of our bundle matching mechanism can be summarized as follows:

- **Order eligibility.** A bundle is matched with one or more other bundles under the following conditions: For each financial instrument in the bundle, a buy order must be matched with a sell order; and the buy price is greater than or equal to the sell price.
- **Transaction price.** The transaction price will be automatically calculated by solving the mathematical problem. Traders will get prices no worse than the price they submit.
- **Trade quantity.** If a match is found based on order eligibility, the trade will take place for a quantity that is the maximum number of shares allowed to be traded based on the availability of the matched bundles.

• **Trade priority.** For matched bundles, the trading system will give priority to those orders that will maximize the trade surplus. In other words, a higher buy price has higher priority, and a lower sell price has higher priority. For the same price priority level, trade priority is on a first-come first-served basis.

The bundle matching mechanism is able to find one-to-one, one-to-many, or many-to-many matches between offers. This type of match requires sophisticated computation and is too complicated to be handled manually. Computerized automated matching is the ideal solution for this type of problem.

The Financial Bundle Trading System was developed as an experimental financial market at the University of Texas at Austin's Center for Research in Electronic Commerce [3]. The system uses a distributed object architecture. The market houses a Web server and an Internet remote application server. On the trader side, the trading application is implemented using a Java applet. Each time a trader wants to access the market, he or she will go to the market's Web site and dynamically download the trading applet. The applet is used as an interface for an investor to submit orders and view account and market information. There are many advantages in using this approach. First, it guarantees the trade application can be deployed without additional effort on different computing platforms. Traders can always access the updated software and their account information, which is stored centrally on the server side. Second, the applet is a full-fledged application that can communicate dynamically and interactively with the application server. For example, market price information and open order status will be dynamically updated on the applet. In contrast, traditional online trading applications based on HTML and CGI scripts do not support this kind of dynamic communication. This architecture also supports the direct trading model discussed earlier. The applet is able to display information from multiple markets using different windows, and the investor can make an informed decision on where to route the order.

Conclusion

Here, we have addressed two issues central to the competition and overall efficiency of the exchange markets: order routing and order execution. The order execution system plays a critical role in determining the operational efficiency and competitive advantage of a market. The tremendous growth of ECNs has introduced serious competition in exchange markets and the race to develop advanced, innovative automated trading systems has become accelerated. This is essential to the vitality of the whole marketplace as more markets will try to provide innovative trading services that were unavailable previously. The FBTS is an example that will allow investors to trade a bundle or a portfolio of stocks. However, new trading system development cannot be isolated from the overall environment of the equities market. Existing industrial practice in order routing such as payment for order flow and internalization becomes a serious threat to the power of competition in our marketplace. Therefore, we have developed a direct trading model that attempts to realign the incentive structure in the marketplace and protect competition in the exchange markets.

It is clear that the value of Internet technology cannot be fully realized unless we streamline all the inter-related processes in the marketplace. The present financial markets are undergoing a major revolution and will alter beyond recognition in a few years. There are a lot of challenging issues, ranging from market fragmentation and information transparency to new payment and settlement procedures that need to be addressed, which may require further change to existing institutional structures of brokerage firms and exchange markets. **C**

REFERENCES
1. Barclay, M., Christie, W.G., Harris, J.H., Kandel, E., and Schultz, P.H. The effects of market reform on the training costs and depths of Nasdaq stocks. *Journal of Finance 54*, 1 (1999), 1–34.
2. Fan, M., Srinivasan, S., Stallaert J., and Whinston, A.B. *Electronic Commerce and the Revolution in Financial Markets.* Harcourt Brace, to be published in 2001.
3. Fan, M., Stallaert J., and Whinston, A.B. Creating electronic markets. *Dr. Dobb's Journal*, (Nov. 1998), 52–57.
4. Jupiter Communications. Financial Services Online, (Sept. 1999); www.jup.com.
5. Levitt, A. *Best Execution: Promise of Integrity, Guardian of Competition.* SEC Chairman speech at Securities Industry Association (Boca Raton, FL, Nov. 1999); www.sec.gov/news/speeches/spch315.htm.
6. National Association of Securities Dealers (NASD). *Market Data.* (May 2000); www.marketdata.nasdaq.com/mr6d.html
7. New York Stock Exchange. *Fact Book.* 2000; www.nyse.com/about/about.html.

MING FAN (mfan@nd.edu) is an assistant professor in the Mendoza College of Business at the University of Notre Dame in Indiana.
JAN STALLAERT (stallaer@usc.edu) is an assistant professor in the Marshall School of Business at the University of Southern California, Los Angeles.
ANDREW B. WHINSTON (abw@uts.cc.utexas.edu) is the Hugh Cullen Chair Professor in information systems, computer science, and economics; and the director of the Center for Research in Electronic Commerce at the University of Texas at Austin.