Chapter 7

How Technology Is Transforming Securities Markets

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In the early 19th century, delivery of a message (or a market quote) from New Orleans to New York took from 4 to 7 days. The telegraph was first demonstrated in 1844. By January 27, 1846, telegraphic communication linked New York and Philadelphia, via Newark. Until direct lines were installed a few months later, messengers ran between the telegraph office and Wall Street. It was 2 years more before the New York and New Orleans foreign exchange markets could directly communicate, but then message time was nearly instantaneous.[1] Financial markets were quick to realize the possibilities. The New York Herald of March 3, 1846, mentioned that "certain parties in New York and Philadelphia were employing the telegraph for speculating in stocks." The use of the telegraph greatly reduced price differences between the participating markets.

A successful trans-Atlantic cable was completed on July 27, 1866. Four days later the New York Evening Post published price quotations from the London exchange. The first cable transfers occurred about 1870 and arbitrage between the London and New York exchanges began immediately. This led to further reductions in price differences between markets.

The third invention that revolutionized the exchanges was the stock ticker, introduced in 1867. Before that, reports of transactions were recorded by ''pad shovers'—boys who ran between the trading floor and the brokers' offices with messages. Several ticker companies had men on the trading floor to type results directly into the ticker machine. These reports went to the ticker companies' headquarters and were retyped to activate indicator wheels at local tickers, which then printed the results on paper tape.

In 1878, the telephone, successfully tested 2 years earlier by inventor Alexander Graham Bell, reached Wall Street. Until then, a messenger carrying a customer's order could take 15 minutes to get to the floor; with the telephone, it took 60 seconds. By 1880, most brokers had telephones linked directly to trading floors, and in the next few years, telephones were installed by the thousands. Finally, in 1882, the Edison Electric Illuminating Co. gave Wall Street electric lights.[2]

By 1880 there were over a thousand tickers in the offices of New York banks and brokers. In 1885, the New York Stock Exchange (NYSE) began to assemble the information for ticker company reporters to ensure consistency. The New York Quotation Co. was created by NYSE members in 1890 to consolidate existing ticker companies and integrate the information distribution. This did not eliminate "bucket shops," where the ticker tape output was rigged to swindle investors.

TWENTIETH CENTURY MARKET TECHNOLOGY

Trading Support Systems

Fully electronic transmission and storage of trading information began in the 1960s. Quotation devices were first attached to ticker circuits to provide bid and ask quotations and prices. An improved stock ticker was introduced in 1964 that could print 900 characters per minute and report transactions without delay up to 10 million shares per day. The pneumatic tube carried information to the ticker and quotation system, until it was replaced with computer-readable cards in 1966. Reporters on the floor recorded the transaction on a card and put it into an optical seamer. The scanner read the information into a computer where it entered the ticker system. At about this time the Central Certificate Service was created as an exchange subsidiary, to computerize the transfer of security ownership and reduce the movement of paper. In 1973, this became the Depository Trust Company. The computer display of dealers' bids and offers, described in chapter 3 and called NASDAQ (National Association of Securities Dealers Automated Quotations), began to operate in 1971.

Despite these technologies, the securities industry had a severe back-office paper-work crisis during

[1]Kenneth D. Garbade and William L. Silber, "Technology, Communication, and the Performance of Financial Markets," *The Journal of Finance*, vol. XXXIII, No. 3, June 1978, pp. 819-832.

[2]Deborah S. Gardner, ''Marketplace: A Brief History of the New York Stock Exchange," for The New York Stock Exchange, Office of the Secretary, 1982.

the 1960s. Brokerage houses could not keep up with paper-work for the high transaction volume. Finally, in April of 1968, the crisis forced trading hours to be curtailed so that the back-offices could catch up. This led to development of automated systems for back-office processing. In 1972 the Securities Industry Automation Corp. (SIAC) was established by the NYSE and the American Stock Exchange (AMEX) to coordinate the development of their data processing.

Three systems were introduced by SIAC during the 1970s: the Market Data System (MDS), the Designated Order Turnaround System (DOT) and the Common Message Switch (CMS). The MDS, originally introduced in 1964, was improved in the 70s to process last-sale information. DOT, introduced in 1973, automated the delivery of small orders (fewer than 199 shares) from member-firm offices to exchange floors. The CMS let member firms communicate with the other SIAC systems.

Since the 1970s these trading support systems have been improved in speed, accuracy, and efficiency. Regional exchanges have developed comparable systems. In many cases the regional exchanges led the way-e. g., in continuous net settlement (the Pacific Stock Exchange) and bookkeeping systems (the Midwest Stock Exchange). As early as 1969, the Pacific Stock Exchange (PSE) automated some trade execution. This meant that unless halted by the specialist, a trade was completed by a computer without human intervention. This first-of-its-kind system was called COMEX.

In 1979 the PSE introduced an improved version of COMEX, called the Securities Communication Order Routing and Execution (SCOREX). When an order reaches the SCOREX system, the current Intermarket Trading System (ITS) price is determined, and the order and price are displayed at the appropriate PSE specialist post. The specialist has 15 seconds to better the price for market orders, before the order is automatically executed by the computer, at the ITS price, for the specialist's account. For a limit order, the specialist also has 15 seconds to accept, reject or hold the order in his electronic book. If the order is rejected, it is routed back to the member-firm. Otherwise, when the order's designated price coincides with an ITS bid or offer, the specialist executes the order.

Most stock exchanges now have small order execution systems similar in function to SCOREX. There are also systems for small orders in options contracts, and in NASDAQ for small orders of over-the-counter stocks. These electronic small order execution systems were introduced with relative ease despite the reduction in the services of the "two-dollar broker,' but electronic systems for executing larger orders threaten the livelihood of more powerful professionals on the exchange floor, and thus are controversial.

Technology may reshape the entire exchange structure. The Cincinnati Stock Exchange and the London International Stock Exchange (ISE) do not use physical trading floors but operate through computer rooms. The ISE and NASDAQ combine screen-based quotation systems with telephone negotiation. Exchanges in Toronto, Madrid, Brussels, Copenhagen, Zurich, and Frankfurt are also essentially '' floorless. " For the time being, most U.S. exchanges have chosen to maintain their automatic trading support systems at a level that preserves the roles of specialists, floor brokers, and other intermediaries. Enhancements now usually mean faster computers or new devices that work around the traditional trading infrastructure and established participants.

Market Surveillance Systems

Today's financial environment has increased securities markets' vulnerability to illegal activity, even as today's technology has increased the ability to monitor markets. The magnitude and frequency of mergers and acquisitions and other major corporate transactions, and the allure of staggering profits increase the market's susceptibility to insider trading. The addition of new derivative products and new players around the globe further complicates surveillance.

Manual processes for detecting illegal activity are no longer adequate. People are not fast enough to inspect and evaluate the enormous volumes of information. Computers can improve detection of some kinds of illegal activity. They are less effective against the illegalities that occur in the least auto-

3 'The Two-dollar broker" or ' 'Broker's broker' executes overflow trades for other floor brokers too busy to execute them personally. These free agents were once paid $2 for every round lot executed, thus the name.

mated trading arenas-the Chicago trading pits-and insider trading in securities markets. For example, to detect insider trading, exchanges must obtain information from broker/dealers (as well as from the Securities and Exchange Commission (SEC)).[4] Some of them are not yet able to transmit trade data automatically, and paper-based data are difficult to work with.[5]

Surveillance in Self Regulatory Organizations (SROs) (i.e., exchanges, NASD) follows three general steps. First, the SROs monitor market data using computerized systems, to detect unusual price and/or volume fluctuations. Second, when an unusual trading pattern is detected, the SRO's staff conducts analyses to determine the probable cause of the fluctuation. If a satisfactory answer is not found, the staff conducts further investigations, using automated systems and analytical tools.[6] SROs maintain large computer databases of historical information about trades, personal background of traders, news, and past case materials, to identify, compare, and probe suspicious trends.

Market surveillance may be further improved by several emerging technologies, including expert systems (computer programs that incorporate the decision rules and judgment criteria of many human experts). The thrust has been to build systems and databases with great analytical power, to enable market analysts to sift through large amounts of data. If an expert system can give the analyst an advanced starting point in an investigation, the rest of the job can be done faster and more effectively.

Personal computers and "intelligent" workstations are replacing dumb terminals in market surveillance. Although interactive computing requires greater technical expertise, such as a database query language, it also enables analysts to retrieve information faster and integrate applications more effectively. Data feeds and programs from many sources can be combined locally, and better analytical tools can be applied to real-time market information. The emerging trends in software and hardware are entwined. The ability to manipulate data locally is also important for the development of expert systems for recognizing trends and abnormalities in market surveillance.[7] Until recently, market surveillance systems lagged behind the technology for trading support. Now computers offer critical tools such as expert systems, artificial intelligence, voice response, and complex relational databases for further improving market surveillance.

Clearing and Settlement Systems

Clearing and settlement (ch. 6) is the process whereby ownership of a security or options contract is transferred from the seller to the buyer and payment is made. The participants in this process are the principals to the trade (investors or broker/dealers and banks), the market places, clearing organizations, and settlement organizations. In the case of futures, the clearing and settlement process also involves the posting of margin by both the buyer (long) and the seller (short) to the accounts of the clearinghouse.

Banks transfer funds from the buyer to the seller. The 12 Federal Reserve Banks, their 24 branches, the Federal Reserve Board in Washington, D. C., the U.S. Treasury offices in Washington, D. C., and the Chicago and Washington, D. C., offices of the Commodity Credit Corporation are all connected by the Fedwire, a high-speed, computerized communications network over which banks transfer reserve balances from one to another for immediately available credit. The depositories and registrars are involved in the transfer of ownership. Depositories register all securities in the name of the depository as nominee and then transfer ownership via book-entry. Transfer agents physically transfer ownership by creating new registered certificates.

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[4]The SEC has also applied automation to its task of financial filings and registration. The Electronic Data Gathering Analysis and Retrieval system (EDGAR) is designed to receive and display financial filings. When the project is completed it is expected that over 11,000 publicly traded companies and 2,700 investment firms will submit their required filings and disclosures electronically.

[5]As of August 1989, 373 broker-dealers were submitting automated data to the New York Stock Exchange, according to exchange officials, August 1989.

[6]For example, they may monitor the covariance between securities to capture their price interrelationship and hypothesize the Correct price probability distribution for the securities. The parameters are set by computers using a moving average algorithm or standard deviation to determine the "acceptable" ranges of price movement and volume activity. When these limits are violated the staff is alerted by the computer to investigate unusual activity.

[7]In general, an expert system is a computer program that attempts to replicate, to some degree, human logic and decision processes. The long range benefits of using such systems are many, including better utilization of professional time, cost savings and improved quality and consistency of decision making.

Participants are linked by paper, tape, electronic systems, and direct computer-to-computer links. For example, the Options Clearing Corp. (OCC) in Chicago receives taped data from nine exchanges,[8] and has some direct computer-to-computer linkage with them. OCC also has electronic feeds to market data vendors. Communication with banks is via paper and facsimile, and with regulators it is through paper transactions. Clearing members are linked by dial-up capabilities, leased lines, microfiche, tape, and paper media. Clearing corporations communiate with OCC with magnetic tape transfer as well as some direct computer-to-computer linkage. The Depository Trust Co., the Midwest Securities Trust Co. and the Philadelphia Depository Trust Co. are all linked to the OCC via direct computer-to-computer connection.

Since 1982, trade volume has surged. Critical problems can occur in trade matching when heavy volume, manual entry, and tight time constraints combine to strain the system. Continuous net settlement (CNS)[9] and electronic book-entry systems have allowed the processing of these high transaction volumes, as have faster, higher capacity mainframe computers. The critical element in handling rising trade volume on a sustained basis, however, is the first step in processing the trade, i.e., the trade entry or trade capture component. Manual trade entry processes are prone to error and result in a disproportionately high rate of unmatched trades as trade volume rises.

The development, operational and maintenance costs of automation have risen over the past two decades. Rapid technological obsolescence in management information systems and technical infrastructures implies high reengineering costs. Regulatory rules often influence or even dictate specific technologies that must be used. In many cases such rules have had a positive impact. For example, NYSE Rule 386 requires all members to use the Depository Trust Co's. automated Institutional Delivery system or its equivalent. The Municipal Securities Rule-making Board's rules G12 and G15 require municipal bond clearinghouse members to use a municipal bond comparison system. The rules go so far as to define the output specifications for the system.

On the other hand, there are also regulatory, legislative, and political factors that inhibit automation. These include domestic disputes over regulatory jurisdiction, resistance to change, tradition, and customs; and overseas, legislation prohibiting dissemination of some data.

In hopes of achieving a competitive edge, firms are evaluating new relational database management systems and communication systems of copper, fiber-optics, and microwave. Communications networks such as LANs (local area networks), hypernets, and shared terminal networks will also be increasingly used in clearance and settlement. Higher density storage media will be needed to accommodate anticipated increases in on-line storage requireents. As an alternative to the direct access storage devices in use today, optical disk storage technology may have greater use. Optical disk is also an effective data distribution medium; for example, Lotus sells a service providing historical price information on securities on CD for use with the Lotus 1-2-3 spreadsheet. Today's systems are being designed with several levels of backup, fault-tolerant redundant hardware, and data storage backup.

INFORMATION SERVICES VENDORS

As early as 1850 Paul Julius Reuter first used carrier pigeons to fly stock market quotations between Brussels and Aachen, Germany. One year later, an underwater telegraph cable opened between Dover and Calais. Reuter then began delivering news and market quotes from London to Continental Europe. Reuters is, 150 years later, still one of the dominant market information services vendors.

The market for financial information can be broadly divided into three categories-news, data on exchange-traded instruments, and data on over-the-counter instruments. The market structure is different for each of these.

[8]The PHLX, PSE, NASD, PBOT, ACC, NYFE, CBOE, AMEX and NYSE. The PBOT is the Philadelphia Board of Trade, the ACC is the *AMEX* Commodities Corp. and the NYFE is the New York Futures Exchange.

[9]CNS was developed by the Pacific Stock Exchange in the late 1960s and is much more effective than settling on a trade-for-trade basis, which is probably not viable with today's volumes.

Financial News

Financial news may be gathered by information vendors themselves, or they may carry reports from leading news organizations. Dow Jones & Co. Inc., is the leading provider of financial news in the United States. Dow Jones has tried to extend its dominant position in equities news to the fixed-income bond market through the Dow Jones Capital Markets Report, but in-depth news is not as essential for the bond trader as it is for the stock trader.

Reuters has an edge over Dow Jones in news that affects foreign exchange and fried-income prices because of its vast international communications network. Reuters is also a strong competitor in delivering news about U.S. commodity markets, but Knight-Ridder is a major presence in this market through its Commodity News Service, and has also made headway in supplying news concerning financial futures and underlying cash markets. Other providers of online financial news include the Associated Press, McGraw-Hill Inc., Financial News Network, and Market News Service.

Stock Quotations

Five companies dominate the market for securities and futures quotations in the United States—Reuters Holdings PLC, Quotron Systems Inc., Automatic Data Processing Inc. (ADP), Telerate Inc. (now owned by Dow Jones), and Knight-Ridder Inc. These five companies had a total of approximately 426,000 terminals worldwide as of February 1989.[10] For most stocks, all commodity and financial futures, and all options, the market data—bids, offers, last-sale prices, and volume information—are generated by exchanges and the over-the-counter market and delivered to vendors. In foreign exchange and fixed-income markets, where there is no central exchange, price information is contributed by banks and securities firms to vendors.

Quotron Systems Inc. has long dominated the market for U.S. stock quotations, but this market is now in ferment.[11] ADP is a strong competitor. Outside the United States, the leading position is held by Reuters, which recently entered the U.S. market for stock prices. In the past, Reuters supplied quotes and news for foreign exchange, money market instruments, and commodities in this country, but not equities.

The internationalization of the securities markets has prompted foreign vendors such as Reuters and Telekurs of Switzerland to enter the U.S. market, while American companies such as Quotron and ADP have been expanding their operations overseas. The growing links between the equities, futures, freed-income and foreign exchange markets have also led to diversification among vendors who traditionally specialized in one market. Telerate Inc., which holds a near monopoly in the market for U.S. government securities prices, has entered the equities market through acquisition of CMQ Communications Inc., the leading stock quote provider in Canada. It remains to be seen whether Reuters and Telerate can replace Quotron and ADP, or will merely add equities quotes to their existing terminal base. There are about 200,000 terminals receiving real-time prices from U.S. stock exchanges, and some industry observers are skeptical that the pie will become bigger with the entrance of new players.

Nevertheless, the relative ease of acquiring and distributing prices for exchange-traded instruments has attracted several new competitors in recent years, including PC Quote Inc., and ILX Systems, a new venture backed by International Thomson Organization. Despite the competitive conditions in the securities quotation business, there is always room for new ‘‘niche’ companies offering innovative products, such as proprietary analytics.

Value-Added Products

The relative ease with which any vendor can obtain data from American stock markets and many of their foreign counterparts has made the market for

[10]Eric Philo and Kenneth Ng, **“Reuters Holdings PLC,” Goldman, Sachs & Co., New York, NY, February 1989, p. 5. There may be some double-counting here due to screens displaying more than one vendor’s data.**

[11]Following Quotron’s **acquisition by Citicorp in 1986 for $680 million, two major firms—Merrill Lynch & Co., Inc. and Shearson Lehman Brothers, Inc., now known as Shearson Lehman Hutton Inc.-announced they would not renew their contracts with Quotron because they consider Citicorp a competitor. ADP has recently begun installing a personal computer-based stock quotation system for registered representatives at Shearson and Merrill. If these installations are completed, and ADP achieves a one-for-one replacement of the terminals at both Merrill and Shearson, Quotron’s network of approximately 100,000 terminals could be reduced by up to 30 percent and ADP could surpass Quotron as the leading stock quotation provider in the U.S. (Waters Information Systems, Transcript of Quotron-Reuters-Telerate Conference, New York, NY, November 1988, p. 19.) To date, ADP’s conversion of terminals at Merrill and Shearson is running behind schedule, and Quotron has added more terminals than it has lost. (Roxanne Taylor, Quotron, Los Angeles, CA, personal communication August 1989).**

exchange trade data into a‘ ‘commodities” market, in the sense of highly standardized products competing on price or value-added features. In order to maintain their profit margins, vendors are trying to add value through new technology or exclusive products, and to generate as much revenue per terminal as possible. This has encouraged third-party suppliers to offer historical information, research, analytics and tailored news services through the terminals of vendors such as Quotron, Reuters and Bridge Brokerage Systems. Vendors that control the distribution network typically keep 30 to 40 percent of the revenue generated by third-party Products.[12]

Foreign Exchange Data

The commoditization of exchange trade data has no parallel in markets where there are significant barriers to entry for vendors. Reuters created the market for real-time foreign exchange data in 1973 when it frost put computer terminals on the desks of traders and convinced them to enter their rates into the system. Reuters charges subscribers a flat monthly fee but does not pay banks for contributing their quotes to the service. Reuters also launched the Monitor Dealing Service in 1981, allowing traders to negotiate transactions over their terminals instead of telephones. This system has been successful in part because of its built-in audit trail. In 1989, between 30 and 40 percent of the $640 billion traded each day in the interbank foreign exchange market took place on the Monitor Dealing Service.[13]

While Reuters is the best established in the foreign exchange market, Telerate is a competitive alternate service. Traders probably like having a backup quotation system, and also like the idea of competition for Reuters. It was nevertheless difficult for Telerate to gain a place in foreign exchange (“forex”) until Reuters agreed to permit its subscribers to install ‘‘binco boxes’ ‘—bank in-house computers—that let them simultaneously update their rates on Reuters and Telerate. Until then, Telerate’s forex market coverage was often slightly behind because dealers posted their rates on Reuters frost. Other reasons for Telerate’s success in penetrating this market are the availability of AP-Dow Jones foreign exchange news on Telerate, and traders’ need for U.S. interest rate data.

Telerate did not until recently offer dealers a transactional system such as Reuters’ Monitor Dealing Service. It has now launched a foreign exchange conversational (on-line) dealing system through a joint venture with AT&T. Known as The Trading Service, this service allows dealers to talk to several dealers at once, unlike the Monitor Dealing Service. Now Reuters in turn is taking another step forward with an enhanced version of the Monitor Dealing Service and a centralized order database facility. While the original Dealing Service facilitates one-on-one negotiation between two traders, Dealing 2000 will emulate an auction market where bids and offers from multiple parties are exposed. This is designed to replace ‘blind’ brokers, who act as middlemen in foreign exchange trading. The system will display the aggregate size of all bids and offers at each price, but will not disclose the identities of the dealers participating.

U.S. Government Bond Data

Telerate is currently the only vendor broadly distributing prices in the government securities market. Under an exclusive agreement scheduled to expire in 2005, Telerate disseminates bids, offers and last-sale prices from Cantor Fitzgerald Securities Corp., the only major inter-dealer broker serving both primary dealers and retail customers. Other brokers provide price information only among the primary dealers, those who are authorized to deal directly with the Federal Reserve Bank of New York.[14] In a 1987 study, the General Accounting

[12]Among companies successfully exploiting demand for third-party services is MMS International, which delivers analysis and commentary on Telerate, Bridge and Reuters. MMS was recently acquired by McGraw-Hill Inc. Another third-party provider is First Call, part of International Thomson’s InFiNet group, along with ILX Systems. Jointly owned by Thomson and a group of securities firms, First Call is a leading provider of on-line research produced by Wall Street analysts. Both Quotron and Reuters have tried to compete against First Call’s research distribution service, but Reuters recently discontinued its own service and signed an agreement to offer First Call to its subscribers.

[13]Speech by Robert Ethrington, international marketing manager for transaction products, Reuters Holdings, PLC, New York, NY, July 1988.

[14]Prices *from* one or more primary dealers are not as representative of current market conditions as are those from inter-dealer brokers, who receive quotes from all the dealers. One vender, Bloomberg (30 percent owned by Merrill Lynch), packages quotes entered by Merrill’s primary dealer operation with proprietary analytics that can help traders spot arbitrage opportunities. Bloomberg also delivers versions of this that include inter-dealer broker prices, but only to dealers authorized to see these quotes. If wider distribution of inter-dealer broker prices does come about, Telerate could be hurt financially. Under its agreement with Cantor Fitzgerald, it cannot carry quotes from any other inter-dealer broker. Telerate also distributes information provided by Market Data Corp.. It is possible Market Data Corp. could be used as the distributor of bids, offers, and last-sale prices from other dealers.

Office encouraged brokers to distribute quotations to non-primary dealers within 2 years.[15] In April 1989, major government bond dealers reportedly pressured a large government bond broker into abandoning a controversial effort to broaden access to bond-trading information by offering its electronic trading information screens to a wider group of customers.[16]

Reuters, Quotron, and Knight-Ridder have periodically held talks with individual brokers about disseminating their quotes, and three inter-dealer brokers have discussed distributing consolidated last-sale prices, but none of these efforts have reached fruition. When they do, 'commoditization' will probably also occur in the market for U.S. government securities prices. Vendors would have to compete by providing proprietary analytics or news, or by specializing in a particular area of the Treasury market.

Reuters and Quotron are likely to try to expand into the fixed-income information business. Since its acquisition by Citicorp, Quotron has been developing information and transactional services in both foreign exchange and fixed-income markets. However, Quotron faces the same obstacles here as do Reuters and Telerate in equities: lack of critical mass and a shortage of space for terminals on the already crowded desks of traders.

Competition and Technological Change

Since the financial information business is still growing, it continues to attract aggressive competitors. This may eventually bring down prices for information services, but some observers report that customers who complain about the high costs of the established vendors often ignore lower cost firms who lack track records. Several securities brokers have tried to use raw data directly from exchanges and process this information in-house using customized software. They were largely unsuccessful, having underestimated the time and expense of becoming self-suppliers.

Technological change is creating upheaval and uncertainty among financial information vendors. As recently as 5 years ago, an equities trader typically had one terminal on his desk—probably a Quotron-which carried Dow Jones News Service and gave the trader access to prices for U.S. securities only. In the freed-income department of the same firm, each trader would have a Telerate terminal. In the foreign exchange area, each desk would have a Reuters terminal, and perhaps one from Telerate. Because markets did not greatly affect one another, there was no need for most traders in one market to be watching other markets.[17]

The technology used by the vendors was essentially the same, a dumb terminal connected to a host computer by dedicated telephone circuits. But as a number of niche services sprung up, traders ended up with more and more dedicated terminals on their desks. The use of single dumb terminals declined sharply when the PC permitted local storage and manipulation of price information. Now, because of digital technology, the way vendors transmit the data is becoming less important than what data they transmit.

Several other technological advances in the early and mid- 1980s also irrevocably changed the delivery of financial information. The video switch, long used in the broadcast industry, reduced the clutter of terminals on traders' desks by allowing several screens to be controlled by a single keyboard. They became an important part of trading rooms, and were also responsible for the rapid rise of two companies that installed thousands of new trading room systems integrators worldwide. There were also rapid changes in the reamer in which stock quotations were transmitted from vendors to customers. In addition to delivering prices over dedicated telephone lines, vendors began exploring other alternatives, such as broadcasting data by FM sideband and satellite. Midwestern commodity market data vendors began in 1981 to use small, low cost, receive-only satellite dishes which were particularly effective for one-way broadcast communications such as financial quotations. They now distribute financial data for vendors such as ADP, Dow Jones, Knight-Ridder, PC Quote, Reuters, and Telerate. Although dedicated interactive networks remain the primary delivery mechanism of financial information vendors, financial data accounts for 63 percent of the

[15]U.S. General Accounting Office, U.S. *Government* Securities: *Expanding Access to Interdealer Brokers' Services* (Washington, DC:1987).

[16]Tom Herman, "Big Dealers Keep Monopoly on Bond Data," *Wall Street Journal,* Apr.11, *1989.*

[17]However, fixed-income traders always needed t. follow the foreign exchange markets since currency prices and interest rates are closely linked.

114,000 data broadcasting satellite receiving sites currently in operation.[18]

Digital Data Feeds

To satisfy the demand for analytical tools, vendors have begun to offer their data in digital as well as analog form. Digital data gives users more flexibility in viewing and using data, such as the ability to create customized composite pages. This has created a dilemma for financial information vendors and their customers because neither exchanges or vendors are sure how best to price digital information. The fees paid by customers have in the past been based on the number of terminals or display devices authorized to receive information. This created some inconsistencies; for instance, a workstation with four separate screens will be charged four exchange fees while a workstation with one screen and four windows will be charged one exchange fee. Many users will not tell vendors the number of screens on which their data are displayed. Several industry efforts are under way to address the issues raised by digital data: the Financial Information Services Division of the Information Industry Association has formed a subcommittee on digital data feeds and workstations, and the Financial Industry Standards Organization, a user group, is also doing analysis.

It is now often cheaper for securities firms to buy hardware off the shelf than it is for them to lease equipment from vendors. In addition, the securities firms want to be able to choose whether they get a dumb terminal, a PC, or a UNIX-based workstation, and they would like industry-standard hardware that can be integrated with the firms's other systems. In recognition of this, Reuters recently stopped manufacturing terminals and Quotron plans to sell off-the-shelf equipment. ADP is also moving to industry-standard hardware.

Diversification Into Transactional Services

With data treated as a commodity and a diminished role as systems providers, financial information vendors may move toward offering transactional services, using automated execution systems. Citicorp and McGraw-Hill failed with the GEMCO electronic commodity trading system a few years ago. In the futures market, the World Energy Exchange and the International Futures Exchange of Bermuda (INTEX) both failed to convert open outcry traders to screen-based trading. Security Pacific Corp. has not had much success in automating the front office. But these failed ventures in automated trading have not deterred Reuters, which owns Instinct Corp., a registered broker/dealer offering an electronic securities trading system. Instinct began in the 1970s, but was acquired by Reuters in 1987. The company is now executing an average of 13 million share-trades a day (including both over-the-counter and exchange-listed stock), a volume still dwarfed by the 150 million or more shares traded by NYSE on an average day, but Reuters hopes that exchanges will begin using Instinct during the hours when their trading floors are closed.

It remains to be seen whether the foreign exchange market will accept the automated trading Reuters is offering through Dealing 2000, but the technology used in that system was adapted for GLOBEX, an electronic 24-hour futures trading system jointly developed by Reuters and the Chicago Mercantile Exchange and the Chicago Board of Trade, and projected to be ready for use in 1990-91. MATIF, the French financial futures exchange, has already agreed to use GLOBEX for after-hours trading and other foreign futures exchanges may also participate.

The Chicago Board Options Exchange (CBOE) and the Cincinnati Stock Exchange have agreed to form a joint venture with Reuters and Instinct to create a worldwide system for entering, routing, and executing trades of options listed on the CBOE and equities traded by the Cincinnati Stock Exchange, the only fully automated securities exchange in the Intermarket Trading System.

Quotron has not moved as rapidly as Reuters, but reportedly has electronic execution facilities in development for both foreign exchange and fixed-income markets. It has been aggressively marketing Currency Trader, which allows corporate customers of Citicorp to execute automatically foreign exchange trades of $500,000 or less.

Telerate is licensing software from INTEX and they are working together to offer exchanges and exchange members automated order-routing and execution facilities. In the freed-income market, INTEX has licensed the rights to its order-matching

[18] Waters Information Services, *Data Broadcasting Marketplace (New* York, NY: 1989).

software to Security Pacific Corp., and ADP is collaborating with a municipal bond broker on an automated trading system.

If this kind of competition from vendors is not successful, Reuters may acquire a near-monopoly in automated execution systems as it did in the foreign exchange market. This would mean that the after-hours transactions, and possibly all transactions, of the Nation's futures and options (and perhaps later stock markets) would be processed by a single vendor, and that a foreign one. About 46 percent of Reuters' stock is held by Americans, and 25 percent of its employees are American, but by Reuters' charter it will remain a British company.

Reuters' emergence as the leader in providing exchanges with trading infrastructure is surprising because other vendors have closer relationships to exchanges. ADP and Quotron, through the latter's Securities Industry Software (SIS) subsidiary, have extensive networks that route orders from brokerage firm offices to exchanges. These networks were installed in the stock market following the paper crunch of 1968, but are only recently being adopted by futures exchanges. The Chicago Board of Trade (CBOT) has selected Bridge Brokerage Systems, a unit of Bridge Information Systems, to build its order processing network, while the Chicago Mercantile Exchange (CME) went to SIS for its order-routing network. Since the futures exchanges contend that automated execution during regular trading hours does not provide the same liquidity as pit trading, they do not see automatic execution as becoming integrated with order-routing.

ADP has been dominant in securities order-routing through its Data Network Services subsidiary and the BTSI unit that it acquired from Control Data Corp. There are also Tandem-based order-routing systems offered by SIS and Bridge Brokerage Systems. Many operating order-routing systems were overwhelmed during the 1987 stock market crash, although most have since been upgraded and enlarged. Several industry observers believe however that brokerage firms' back-office infrastructure is outmoded, in part because securities firms have concentrated during the 1980s on installing video switches and personal computers in their trading rooms. Because of lower volumes since the crash, those firms appear less concerned about capacity shortages and are reluctant to make large investments in order-routing and back-office systems.

REGULATION OF INFORMATION SERVICES

So far, the financial information vendors have not been subject to much Federal regulation. Under Federal law, the SEC has jurisdiction over companies that distribute and publish securities transaction data and quotations and over companies that collect, process or prepare this information for distribution or publication. To date, the SEC has registered only those organizations that process information on an exclusive basis for a securities exchange or association the Securities Industry Automation Corp., the National Association of Securities Dealers Automated Quotation System, and the Options Price Reporting Authority. But it has been keeping close watch over vendors since the stock market crash of 1987.[19]

Options markets are particularly sensitive now. Many quote vendors were overwhelmed by the proliferation of options series and strike prices. They were not prepared to handle the increased number of different strike prices when volume shot up on October 19 and 20, 1987. They could be further overwhelmed in the future with multiple-trading of options, introduction of automated trading systems, and 24-hour trading.

Most options are now traded exclusively on one exchange, but this is to change over the next 2 years (see ch. 5). The trading of options on several exchanges (''multiple-trading") will require an expansion of capacity by financial information vendors. The SEC has been working closely with options data vendors on their plans to handle this problem. The introduction of automated trading systems for after-hours trading by futures and options exchanges is expected to provide quote vendors with a glut of information to package and sell. Smaller vendors are also concerned about the potential for discrimination in favor of their large competitor, Reuters, who is helping exchanges to build the trading systems.[20]

[19] "SEC Expresses Concern About Vendor Capacity," *Trading Systems Technology,* Sept. 26, 1988, p. 6.

[20] After Reuters built a real-time price reporting service for the London Metal Exchange (LME), the exchange proposed a pricing structure that favored large vendors such as Reuters. Each vendor would have had to pay a sign-up fee of 50,000 pounds sterling regardless of how many users were taking that vendors' quotes. After protests by vendors with small subscriber bases, the LME withdrew the plan and is formulating a new one.

The transactions systems of securities information processors are not now subjected to SEC regulation as exchanges. The SEC has in the past issued no-action letters exempting proprietary trading systems from registering as exchanges. No-action letters have been issued for 11 proprietary trading systems to date, with the understanding that the operators of automated trading systems would keep the SEC informed of their progress. The agency is still using the no-action approach, but is working on a new rule after several sponsors ignored Commission requests for information; it wants to prevent possible abuses by foreign counterparties and ensure that access to the systems is fair and open.[21]

The agency recently proposed a rule requiring sponsors of proprietary trading systems to file a financial and operational plan with the Commission.[22] Proposed Rule 15c2-10 also gives the SEC authority to examine all books and records of both the sponsor and the trading system.

In January 1990 SEC again considered the question of what constitutes an exchange.[23] Delta Government Options Corp. had applied for registration as a clearing agency, to issue, clear, and settle options on Treasury securities, executed through an over-the-counter options trading system operated by RMJ Securities, Inc. This was granted temporarily in 1989, with a concurrent "no-action" letter saying that the system need not register as an exchange. CBOT and CME challenged in court the view that the trading system was not an exchange. The court returned the case to the SEC for reconsideration and the SEC reaffirmed its decision after hearing arguments from those opposed to requiring the system to register as an exchange, and those in favor.

Those opposed to registration argued that to constitute an exchange, there must be members with a proprietary interest and representation in the administration of the exchange, a trading floor to which orders are routed, listing of securities, an auction process, a limit order book, and execution of trades. They further argued that exchange registration of proprietary trading systems would serve no regulatory purpose and would deter development of innovative trading systems.

Those advocating a registration requirement (the CBOT, CME, and CBOE) argued that an exchange was any mechanism that affords to prospective buyers and sellers advantages in 'finding a market, obtainin g a price, and saving time"; establishes criteria for admission and discipline of members; sets margin requirements and trading and position limits; and has the discretion to terminate trading. Characteristics such as a system of specialists with market-maker obligations, a trading floor, and member ownership and representation, they argued, are historical rather than fundamental attributes of an exchange.

The SEC, in reaching its decision not to require exchange representation, said that the fundamental characteristic of an exchange is its centralization of trading and the fact that it provides quotations "on a regular or continuous basis so that those purchasers and sellers have a reasonable expectation that they can regularly execute their orders at those price quotations. The means employed to do this, the SEC acknowledged, might range from a physical floor or trading system to other means of intermediation such as a formal market-making system or a consolidated limit order book or single price auction. The bulletin board established by the RMJ System, the SEC said, does not meet this central characterization.

No clear definition of a "bulletin board" was offered, although it was incidently described as ''a mechanism whereby indications of interest may be displayed by participants" (a function **subject to regulation as part of the government securities brokerage function), and again as "for the episodic display, by broker-dealers and institutions, of buying and selling interest. " Such bulletin boards were not clearly distinguished** from either a NASDAQ-like system or a GLOBEX-like system, if such

[21] On July 19, 1985, the SEC issued a no-action letter to Security Pacific National Bank concerning their options on government securities on-line trading system. Concerned about competition, and customer protection and financial integrity in the unregulated system, The Chicago Mercantile Exchange brought their concerns to the attention of the Federal Reserve Board and Cong. John D. Dingell. Convinced that banking could be adversely effected by such an unregulated exchange, Mr. Dingell urged further consideration by the SEC. Security Pacific sold the system to RMJ.

[22] Proposed Rule 15c2-10 would apply to Reuters' Instinct subsidiary, but would not affect GLOBEX, since the CFTC, not the SEC, has jurisdiction over futures trading. The CFTC has already reviewed and approved GLOBEX.

[23] SEC Release No. 34-27611. Self-Regulatory Organizations: Delta Government Options Corp.; Order Granting Temporar Registration as a Clearing Agency, Jan. 12, 1990.

distinction was intended. The SEC said that an ''overinclusive' approach to its prerogative of determining what constitutes an exchange "would place those evolving systems within the 'strait jacket' of exchange regulation" or force it "into a regulatory scheme for which it is ill-suited. . ..'

As financial information vendors increase their presence in transactional services, they will have to deal with regulation for the first time. Even if they do not enter the transactional business, information providers may face growing government involvement in their markets because of technological changes occurring in the industry. If vendors, exchanges, and customers fail to come to terms on a pricing structure for digital data transmissions, customer use of data received from vendors, and proprietary rights to financial information, these issues may ultimately be resolved by a government agency or by the courts.[24]

U.S. BROKERAGE HOUSES

Brokerage houses use computers to assist in four major functions of the firm: data compilation and analysis, trading support, back-office functions, and surveillance activities.

Data Compilation and Analysis

Brokerage houses receive and monitor market information via electronic news wire services that provide the broker with market price information. In the retail branch offices of U.S. stock brokerage fins, 90 percent of information services are provided by Quotron and ADP;[25] but increasingly emerging as strong contenders are Reuters, Telerate, CMQ, Bridge Information Systems, Knight-Ridder Financial Information, Beta Systems, and Standard & Poor. Other vendors include Shark (Wang) and PC Quote. The annual expenditure for information services is forecast to increase to about $3 billion by 1991.[26]

A great deal of computing power is spent in analyzing and formatting raw data for decision support. Since all brokerage houses have access to basically the same information, the analytical software and graphics packages they apply to this data is thought to determine their competitive edge.[27] Individual brokers analyze and use the information differently, so the firm's computer facility must support many types of analytical software.

Trading Support

Brokerage houses were once called wire houses' because of their use of leased wire systems and their function as a collection point for orders to be wired to the floor of an exchange. Individual and institutional customers still telephone their broker, but today orders are then collected by computers and sent via dedicated lines to trading departments and exchange floors. Every major wire house has some type of electronic order entry and routing system. Program trading (buying and selling diversified portfolios or baskets of stock) uses computers to track market movements and enter simultaneous buy/sell orders according to an algorithm (see chs. 3 and 4).

There are thousands of commercial software packages available to brokers and traders that focus on tasks such as portfolio management and risk assessment.[28] Many of these packages are ' 'projective "[29] they use statistics to predict the price of a stock or derivative product in a certain time frame. There are also commercially available pocket-pagers, or 'electronic watchdogs," often offered by information services vendors, that offer a variety of services including alerting brokers to stock price movements, news events, or SEC filings.

Back-Office Functions

Since the back-office crisis of the 1960s, when brokerage houses were overwhelmed by paperwork, the back-offices have relied on computers. To aid in

[24]Potential regulation of financial information vendors will become a larger issue as digital data becomes the significant portion of information cost. The present trend is towards unbundled costs; one price for view only, another for cut and paste capabilities and another for data manipulation rights.

[25]Terry Landi, IBM Securities Application Systems, New York, NY, personal communication, February 1989.

[26]Henry Fersko-Weiss, "The Battle for the Broker's Desk,'' *High Technology Business,* September 1988, p. 30.

[27]''As Telerate and Reuters move toward elementized digital feeds, the way they displa the data will no longer be as important as what they display," says Robert Mark in Marine Midland Bank's capital markets sector, "because software is able to grab specific data elements and create customized pages.'

[28]Risk assessment encompasses the analysis of both market risk and credit risk. Credit risk is the risk that a counterparty will go bankrupt whereas market risk is the risk that market prices wilt move adversely (away from you).

[29]Grant J. Renier, ''The Electronic Investment System,'' *The Futurist*, vol. 16, April 1982.

clearing and settlement of accounts, brokerage houses batch-process massive amounts of data. Trade confirmation reports from the exchange floors and information from the clearinghouses must be reconciled to complete the transaction. Some brokerage houses process these in-house, some use service vendors. Much of this batch-processing goes on in the evening hours, or all night, and this will be a problem for 24-hour trading. In many cases, the computers used to support trading during trading hours are used as batch processors in the evening. This could be remedied with the purchase of additional machines, but most clearing programs are designed to run in a batch mode rather than on-line. The conversion into on-line processing will be costly, time-consuming, and technologically difficult, considering the massive databases which will have to be maintained and updated concurrently. Although 24-hour/global trading may be the strong impetus, on-line processing has other benefits. Risk could be greatly reduced by more timely and accurate characterization of investment positions.

Surveillance Activities

Brokerage houses monitor trading patterns and investor positions for indications of fraud, violations of firm policies or other improper activities by brokers servicing customer accounts and employees with "information sensitive" jobs (e.g., research analysts) who may be the source of information leaks. Compliance efforts also emphasize educating employees as a deterrent to illegal activity,[30] but surveillance and auditing activities are now among the more technologically advanced aspects of financial institutions' technology. Analysts often have the capability for on-line query or real-time market surveillance activity. But human analysts are still the crucial factor; computers merely indicate where further attention should be directed.

Customer Services

Many brokerage houses lease or sell personal computer investment systems to small investors. For example, a personal computer dial-up service lets people in their homes receive market information, conduct analysis, and enter buy and sell orders. One such service has no annual sign-up fee but can cost the user 27.5 to 44 cents per minute. A large discount broker serves over 26,000 customers through its computerized trading system.[31] With these systems individual investors feel "in control" and may feel able to compete with institutional investors. On the other hand, many argue that when telephone lines are jammed on a busy trading day, an investor is no more likely to get through to a broker on his computer than he is on his telephone.[32] Most systems are equipped with 'fail-safe' techniques to protect the investor, such as requiring second confirmations, or stopping them from selling stock they don't own or buying more than their margin limit. Virtually all mechanisms a firm uses for entering customer orders have a human review element to protect the firm from error, liability and loss.[33] Thus, regardless of the transmission details, there is still a "gatekeeper" that can become a bottleneck during heavy trading. The function of the gatekeeper could be an application for expert systems.

TECHNOLOGY FOR THE INDIVIDUAL INVESTOR

Of the *40* million individual investors in the United States, an estimated 2 million use PCs, and the securities industry claims that perhaps 100,000 are using them to manage portfolios.[34] In the near future, individual investors should have the technology available on home workstations to incorporate on-line trading, real-time quotes, graphics, portfolio management, on-line news, reports on investment activity, and historical data. Some of these services are now available, but not readily accessible; "windowing" software to split the screen and merge these services may be expensive and difficult to operate.

Largely within the last 5 or 6 years, individual investors have begun to use at-home trading systems based on a personal computer. Many of them have

[30] Ray Vass, "Detection of Illegal Trading; Systems and Realities in a Large Firm," presented at the Securities Industry Association Forum on the Prevention of Insider Trading in New York, NY, June 23, 1987.

[31] Earl Gottschalk, "Computerized Investment Systems Thrive as People Seek Control Over Portfolios," *Wall Street Journal*, Sept. 27, 1988.

[32] However, ISDN and *Broadband* ISDN via intelligent networks could provide network services to help surmount traditional telecommunications problems.

[33] T. Williams, Information Industry Association, discussion with OTA staff.

[34] Lee Siegfried, "Investing in the Year 2000," *Financial World*, Feb. 21, 1989, p. 56.

been quoted as saying that these systems give them a feeling of being "in control" (although none of the systems provides automated execution) and better equipped to compete with the institutional funds' professional investment managers. This perception is encouraged by the brokers who provide the systems, and who have been alarmed by the perceived "flight of the small investor. "[35] The industry estimates that 400,000 individual investors will be using home trading systems by 1992.[36] Such estimates sometimes display more enthusiasm than analysis, but it appears that the number of users could have tripled in the last 3 years.

The most widely used home trading system, provided by the largest discount broker, claims approximately 50,000 users. Several similar systems claim about 10,000 to 12,000 customers each.[37] These trading systems offer similar services. They allow the investor, at his computer, to:

- access research databases,
- receive real-time quotes,
- . place orders and receive confirmations,
- . track the progress of a portfolio, and
- . set up dummy portfolios and track their progress.

Trades ordered through one of these systems go to a broker who routes the order to an exchange.[38] The customer usually gets immediate conflation of a trade, or if there is to be a delay of a minute or longer a confirmation is left in a "mailbox' in the system. The advantages to the investor are access to information before the trade, greater ease in tracking the portfolio after the trade, the ability to place orders 24 hours a day (but they can only be executed when the exchange is open), and a slight reduction in transaction time, chiefly because there is no wait on the telephone for a broker. (Trades are said to take 15 to 20 seconds, in most cases.) The feeling of "greater control,' although it may exist, is not highly justified.

THE FUTURE: STRATEGIC TECHNOLOGIES AND THEMES

Expert Systems

An expert system is a computer program that attempts to replace a human decision process by using several primary components.[39] The first component is the experiential knowledge of an expert expressed as a set of rules and facts (if/then statements), more commonly referred to as the knowledge base. Second is the inference engine, or the computer program that sorts through the knowledge base and decides which rules apply. With the inference engine go the user interfaces, an explanation subsystem and a knowledge acquisition subsystem. Respectively, these "front end" components communicate with the user of the expert system, reconstruct the reasoning of the system for inspection, and allow the expert or knowledge engineer to add new or modified rules and facts. The potential long-range benefits of using expert systems include savings of professional time, cost savings, and improved quality and consistency of decisionmaking.

There were early high hopes for applying expert system (ES) technology to many brokerage house activities, even possibly replacing the trader, but users today generally have more conservative expectations.[40] ES applications for financial firms are made more difficult both because it is difficult to formulate real rules for investment decisions and because there is little agreement on who the experts are. Systems designed to make investment suggestions *are* controversial, but have sometimes been successful. Systems designed to make investment *decisions are* met with great resistance from traders, who trust their instincts to set them apart from other traders. Only a handful of companies are experimenting with expert systems to ''replace" traders.

Two areas in which ES technology is rapidly developing are data compilation and analysis and

[35]The ''small investors'' do 18.2 percent of the trading, down from 19.7 percent in 1987, according to a study by the Securities Industries Association. This has been deereasing for years.

[36]OTA discussion with various company representatives.

[37]The systems identified b, OTA are those of Charles Schwab, Inc., Fide@ Investments, and Quick & Reilly. There may be others with comparable level of use.

[38]The Fideliy Express Service says that trades are checked within the system without human intermediaries and go directly to the exchange floor.

[39]Paul Harmon and David King, *Expert Systems (New* York, NY: John Wiley & Sons, Inc., 1985).

[40]Jonathon Friedland, "The Expert Systems Revolution, " *Institutional Investor,* July 1988, p. 107.

market surveillance. A common example of the first is a ''news wire sifter. ' One security firm's new workstation will include an expert system that sorts through the news wire information to determine whether a user should be alerted to news of an event or impending event. The New York Stock Exchange has a similar expert system to sort and analyze news for market surveillance purposes.

Another application of ES is risk assessment, i.e., a rule-based system to analyze the risk of a firms position in rapidly changing markets. For example, one firm has a risk management system for corporate and municipal bond trading, running on a Compaq 386, that sorts through massive amounts of trading data and asks for additional information when necessary, to produce a statement of risk for managements review.

Brokerage house surveillance is beginning to use rule-based systems to identify trends and anomalies in trade information. One already in use, that runs on a PC, has a set of 25 rules; it analyzes trade data and may suggest that a study should be made of a particular firm, broker or customer.

Hardware

The strategic initiatives described above are pushing firms towards faster and better hardware. Computer industry experts expect that brokerage houses may buy supercomputers before exchanges do. Mini-supercomputers are popular but are already being challenged as having insufficient power to meet the expanding needs of brokerage houses. Until April 1989, when Control Data's ETA Systems division was closed, Wall Street firms could rent time on the ETA 10P, the first air-cooled supercomputer that was running portfolio analysis software and complex freed-income analytics.[41] An analysis of 150 stocks, each with 15 options, for 500 accounts that would normally take 6 hours on a 386 (20 mhz) computer would take only a few minutes on a supercomputer. However, not many firms utilized this service.

FURTHER TRENDS

Some industrywide trends are:

- *Firm-wide system integration—Firms are mov-* ing towards workstation integration with windowing, so that a user can reach many systems and information services through distributed processing. Relational databases are replacing hierarchical or flat file architectures.[42]
- ***More*** *end-user computing—This will* ease the burden of the central data processing department and makes system development for user needs more cost-efficient.
- *More automation of the back-office-The off-* floor support functions have the greatest percentage of labor which could be made more efficient by automation.
- *Flexibility to allow for multiple vendors—With UNIX* and 0S/2[43] becoming more nearly standard as operating systems, this task is becoming easier.
- New tools *for easier, faster program writing—* One example is Computer Aided Software Engineering, CASE. Although firms continue to buy information services and integration software, they are increasingly choosing to build rather than buy their trading room systems."
- *Emerging telecommunications capabilities—* ISDN and fiber optic networks are the keys in this area.[45]
- *Cross-training of technical and "business" side* staff—-This is increasing and has been found especially useful in systems development .[46]

[41] ''Frontline,'' *Wall Street Computer Review,* November 1988, p. 7.

[42] Saul Hansell, "The Moving Target, " *Institutional Investor,* January 1989, p. 79.

[43] A relational database is a data schema in which the data is stored in tables and the associations between the tables are represented within the data itself, as opposed to the schema defining the relationships as in hierarchical or flat file architectures. David M. Kroenke and Kathleen A. Dolan, *Database Processing, 3d cd.,* (Chicago, IL: Science Research Associates, Inc., 1988).

[44] The market penetration of OS/2 has been somewhat slow, and its probability for success is a continuing debate.

[45] Ivy Schmerken, "ToBuild or Buy?' *Wall Street ComputerReview,* January 1989, p. 33. Peter Penczer, "Wall Street Rolls Out CASE Technology," *Wall Street Computer Review,* February 1989, p. 55.

[46] Discussions with J.W. Palmer, AT&T Bell Laboratories, Holmdel, NJ. Ne, York Telephone recently announced that it will develop an independent fiber optic network for securities firms in the New York City area. As of October 1989,27firms had agreed to purchase voice and data services off of the network. In the future this network could serve as a platform for other developments such as trading, clearing and settlement processes. New York Telephones public network will serve as a backup to the private network.

- Increased obstacles—Technological advances in brokerage houses may be proceeding faster than at exchanges, but they will increasingly be hampered by an aging computer infrastructure that has grown difficult to manage.[47]

The strategic automation initiatives of today's brokerage house are being driven by four major forces: 1) customer demand for service and efficiency; 2) regulatory pressure to maintain a fair and orderly market; 3) domestic competition and the resurgence of program trading, which demands faster computers with more capacity; and 4) fear of Japanese competition.

There are two major differences in the approach to automation of the Japanese "Big Four' securities firms (Nomura, Daiwa, Nikko, and Yamaichi) and American firms.[48] The Japanese appear to take a more unified, standardized, long-term approach, probably because of comparatively loose Japanese antitrust laws and the influence of the Ministry of Finance. Japanese firms also appear to plan for 5 to 10 years, unlike the shorter term but more varied plans of American securities firms.[49]

For example, the Japanese have standardized home trading system software on the Nintendo Family Computer. The Big Four have also issued magnetic identification cards to customers that enable them to transfer funds from and to stock trading accounts at automated teller machines. They have agreed on protocol, architecture, and command standards for lap-top computers.[50]

Although the Japanese seem to be making faster technological progress with respect to customer service and hardware, they have lagged behind in software for analytics and investment strategies. However, this may not be true with the next generation of software.

THE MARKETS AND TECHNOLOGICAL PROGRESS

Technological progress in securities related organizations is subject to two opposing factors: the urge to use technology for competitive advantage and resistance from established, powerful market participants whose role is threatened. Brokerage houses, regional exchanges, and other organizations in which automation is a strategic necessity may be technologically progressive, because they have the benefit of strong trade-room and executive level Support.[51]

Research and development on leading-edge technologies in the financial industry are often behind the technical advances and enthusiasm of universities and other industry research laboratories. In July 1988, Coopers & Lybrand estimated that only 50 percent of the major financial services firms in the United States either used or were developing leading-edge technology, such as expert systems.[52]

For example, in 1988, Ford spent approximately $200 million on expert systems research and development, while the entire financial services industry spent only $50 million. Competitive secrecy is perhaps part of the reason that universities and electronics research and development facilities are not utilized for joint financial information projects. It may also be that the right financial incentives for, or vehicles to establish, cooperative efforts are lacking or not known to the financial industry. Many States have started technology transfer centers, which facilitate industry and university consortia. The long-run benefits of being on the leading edge of technology may make it worth efforts to utilizing them.

Standards for Automation

Standards are needed for securities industry automation in three categories: data, technology, and operational standards. Data standards apply to the definition, form, and transmission of data. Technol-

[47]Discussions with Joseph Rosen, RosenKupperman Associates, Riverdale, NY.

[48]Pavan &@@, "Automation at the 'Big Four' Securities Firms, ' *Wall Street Computer Review,* January 1989, p. 22. These Japanese firms are much larger than the biggest five U.S. firms combined.

[49]"The U.S. short-term focus is hurting our technological Prowess)" according to Robert Mark, Manufacturers Hanover.

[50]See Sahgal, Op. cit., footnote 48.

[51]The U.S. futures and options exchanges' recent technological progress with GLOBEX (MERC) and AURORA (CBOT) was reportedly resisted by floor brokers until competitive pressures forced the systems' acceptance for off-hours trading.

[52]According t. Fred Clowney, Drexel Burnham Lambert, Inc., New York, NY, personal communication, March 1989.

ogy standards apply to the hardware, software, and communications aspects of automation. Operational standards apply to the way inter-professional transactions are handled. Currently the sea of "standards" includes AT&T/Sun, IEEE (Institute of Electrical and Electronic Engineers), CCITT (Comite Consultatif Internationale de Telegraphique), POSIX (Portable Operating System Interface Specification), X/OPEN, and OSF.[53]

In general, standardization in the securities-related industry is driven by two pressures: normal attrition in the computer/electronics industry, which leaves the survivors as market leaders the "preferable' companies from which to buy, and the industry-wide need to integrate diverse systems. Attrition is a double-edged sword, as it intensifies competition in the computer industry, making standards resolution even more difficult. During the 1970s and 1980s, as volume increased, Wall Street firms used high profits to acquire systems of all makes and models with little concern that they might be incompatible, or would have a short economic life.

Although competition in the vendor community is still fierce, these two pressures toward standardization are prompting vendors of software, market information, hardware, and other systems to form strategic alliances to solve automation needs. Tighter Wall Street budgets are also forcing firms to look to integration rather than replacement. Those companies specializing in systems integration platforms are currently very important to the industry. However, this requires software vendors to expand their hardware compatibility and the hardware vendors to expose their proprietary architecture. Although more established standards may begin to appear, systems builders will still incorporate sufficient flexibility and variation in the systems to enable organizations to create their own competitive advantage.

It may be that market forces could produce data standards in a reasonable length of time. However, the road to technology standards is much longer, and, given the competitive computer industry, is less likely to be brought about by market forces. Proprietary (provider-controlled) technology standards setting could be bad not only for the U.S. computer/electronics industry, but also for the securities-related industry. Progress and innovation in technology are more likely to be fueled by a competitive environment.

On the other hand, "open' technology standards, which allow multiple suppliers to furnish systems elements and enhance their ability to work cooperatively, may promote this competition and improve system efficiency and productivity. Standardization will certainly be necessary for the United States to move further toward an integrated national market system. Such open standards could be developed by broad-based industry groups, standards organizaions, and/or government.

By comparison, data standards could be established more easily and would also increase productivity and U.S. competitiveness. Beyond the issue of U.S. data standards, is the issue of global standards. The array of considerations necessary when attempting to set such global standards range from language agreements to holiday s.% The development of securities-related industry data standards could, however, give the United States an early advantage in non-U.S. markets, such as Japan and 1992 Europe. As an example, the development, deployment, and acceptance of broadband, or even narrowband, Integrated Services Digital Network (ISDN) would increase productivity and efficiency by integrating voice with high-speed computer-to-computer communications and video for complex analysis graphics capabilities.

Currently, telecommunications domestically (Tl, ANSI, and IEEE) and internationally (CCITT and ISO) are progressing towards broadband ISDN standards.[55] However, to achieve real standards, a serious industry-wide effort must be made which targets coordination of U.S. with global standards. A standing committee with a charter and discipline might bean effective way to approach data standards-setting.[56] The committee members would have to be influential and committed to a long-term effort.

[53] Victor Kulkosky, "Strategic Alliances Buoy New Technology Boom," *Wall Street Computer Review, May 1989,* p. 19.

[54] Consider the scenario of the Oct. 19,1987 market break occurring 1 week earlier, on Columbus Day, when the exchanges were open but the banks were closed.

[55] The State Department, Communications and Information Policy/Technical Standards Development Bureau (CIP/TSD) has been active in coordinating the U.S. position on broadband ISDN and related work.

[56] Useful areas of inquiry could include standardizing order message and execution report formats and a symbol scheme for find-income and money market instruments (very complex).

Government oversight, perhaps including the State Department and National Institute of Standards and Technology, may be the most effective method of ensuring implementation of such an entity and charter. Another alternative would be an industry driven approach such as the Securities Industry Association (SIA) or the Futures Industry Association (FIA).

24-Hour Global Trading Systems

There are financial centers in Aukland, London, Paris, Frankfurt, Zurich, Hong Kong, Tokyo, Singapore, and Sydney, all of which now operate futures and options exchanges as well as stock exchanges. Because foreign exchanges began to offer their own versions of U.S. contracts, investment firms were able to offer products to customers without regard to trading hours in the United States. U.S. futures exchanges began to suffer volume losses. This trend originally drove the exchanges to consider accommodating 24-hour trading.[57] The first attempts to meet this need took the form of mutual offset agreements, such as the one between The Chicago Mercantile Exchange (CME) and the Singapore International Monetary Exchange (SIMEX) for Eurodollar and foreign currency contracts. Of the many offset agreements attempted by exchanges, SIMEX was for a time one of the most successful, although only marginally so.

In September of 1987, CME announced that it had developed, together with Reuters, the Post (Pre) Market Trade System, later renamed GLOBEX for "global exchange. " With the assurance that GLOBEX was strictly an off-hours system, and in exchange for receiving a portion of the revenues generated by GLOBEX, CME members accepted the idea.

In 1989 The Chicago Board of Trade (CBOT) unveiled plans for another off-hours global system, "AURORA." The GLOBEX system is an automatic order matching system, while AURORA attempted to emulate the traders in the pit with icons that offered the ability for traders to select the counterpart to their trade. However, there were complaints from the financial community about the necessity of installing two terminals, and in late May 1990, the CME and the CBOT announced they would merge GLOBEX and AURORA. In fact, the GLOBEX system was the victor. Despite the fact that Reuters is a British company, this is a strategic move for the preservation of the U.S. position in commodities and futures trading.[58]

There are many risks and barriers involved with implementing 24-hour global trading systems. Some foreign countries still restrict access to their markets. Involving the country's own securities exchange is in that case often seen as a good entry strategy .59 Clearinghouses in moving into 24-hour operation may incur large costs in changing operations and practices. However, clearing in a shorter time frame should reduce traders financial risk.[60] ''Fedwire' '[61] does not operate 24 hours a day; other methods of money transfer will need to be devised, some of which may not be as secure. Communications outages, in general, are an important factor. Line outage contingency plans, which must coordinate several countries, different languages, staggered time zones and varying numbers of telephone companies, are difficult to formulate.[62] Lastly, there is a management barrier: 24-hour operations require competent and experienced management at all levels around the clock.

Electronic 24-hour global trading, regardless of product, has several barriers yet to be conquered. The first pertains to basic global data standards, as addressed above. There is also the issue of international regulation. In order to control market and credit risk globally, there will have to be an international government/industry effort.[63] This is also true of coordinating post-trade practices, which could prove to be difficult, considering that some foreign exchanges presently remain with a 2-week or

[57]Karen Pierog, "How Technology Is Tackling 24-Hour Global Markets," *Futures*, June 1989, p. 68.

[58]William Crawford, Jr., ''MERC, CBOT Plan After-Hours Trade System," *Washington Post*, May 27, 1989, p. D1l.

[59]For example, the MERC-Osaka joint effort on the Nikkei index facilitated workings with the Japanese Ministry Of Finance.

[60]GLOBEX has a parallel "Guard" system, which monitors positions real-time and prevents participants from entering into certain unsafe transactions.

[61] For further information on Fedwire, see ch. 6.

[62]F.. example, to maintain a dedicated circuit from New York to Tokyo can involve from five to seven telecommunications companies.

[63]In the case of GLOBEX, the Commodity Futures Trading Commission (CFTC) asserting jurisdiction was a major enticement to Sydney and the MATIF to join. However, the CFTC alone may have limited jurisdiction over foreign participants in the instance of a crisis.

longer settlement cycle. It is not, in other words, technological capabilities that can hold back the movement toward 24-hour global trading, but policy problems such as data standards, regulation, and post-trade activities. Additionally, international competition is also a major force. These are all areas in which the private sector can do only so much and government participation may increasingly be crucial. These international issues are discussed in an OTA Background Paper, *Trading Around the Clock: Global Securities Markets and Information Technology.*