

The long, promising evolution of screen-based tradingⁱ



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1. In the beginning

As exchanges were created, they adopted the technology of the time. Early on, the technology available was relatively primitive. The first stock exchange began in Amsterdam in 1603. And the earliest modern futures exchanges began in the 1860s. In those years, the human voice was the main mechanism for executing a trade. Pen and paper were the tools used to record trades. And chalk and chalk boards were the basic technology to display quotes.

Of course, as technology developed, it was embraced by the exchanges, though only up to the point that it did not interfere with a member's attempt to make a living in his occupation. For remember that exchanges were generally member-owned associations, and their major purpose was to ensure and support the ability of members to conduct their business of broking trades. So, technology was embraced in the pursuit of communicating prices and transactions to the rest of the world. When the ticker tape was developed in 1867, it was quickly adopted by exchanges first in the US, and then later in Europe. Likewise when technology made it possible to display clear, readable, and easily updatable prices to large numbers of members on the trading floors, electronic wallboards quickly pushed the chalkboards aside.

But exchange members jealously guarded the honey pot of trading, that process where traders yell their bids, offers, and acceptances of deals. Exchange members stood at the center of every trade and received a commission for their role in representing outsiders who wished to have their orders executed. They were not keen to give this role up to machines. They would gladly cede to machines the role of bringing orders to the trading floor, of confirming executions, and of disseminating market data to the public. So technology was

fine as long as it was confined to a supporting role at the existing, floor-based, member-owned exchanges.

The story of electronic trading told here is separated into three sections. First we look at the evolution of electronic trading by focusing on the pioneers and the problems they were trying to solve by creating fully automated exchanges. We contrast the new fully automated exchanges with the existing exchanges which resisted changes that might prove unpopular with their member-owners and made very limited use of the new technology. Second, we look at the changes wrought by electronic trading, including the increase in transparency, the precipitous decline in the cost of trading, the proliferation of new order types, the drivers behind and issues involved with customers having direct access to exchange matching engines, and the merger and acquisition frenzy driven by electronic trading. Third and finally, we present a brief assessment on where we currently stand in this transition to screens and the value of the major changes that have flowed from this transition.

2. The screen-based pioneers

Most of the early efforts to create fully electronic exchanges took place in derivatives during the 1980s. With a single notable exception, which we will explore shortly, stock exchanges did not show up in full electronic clothing until the very end of that decade. So we will look at the derivatives exchanges first, and then examine the stock exchanges. However, the first fully electronic financial marketplace was created for trading neither equities nor derivatives. As best we can tell, the first fully electronic market was the New York Stock Exchange's Automated Bond System (ABS), which after several years of development went live in 1977. The NYSE noted at the time of the launch that "...trading in corporate bonds has traditionally been a tedious, time consuming and mostly manual operation that involved nine different steps and hour-long searches through cabinet files for possible matches on bonds, prices, quantities."ⁱⁱ ABS simplified bond trading by listing bonds with bids and offers, allowing remote access to the system and "suggesting" matches. The suggested matches did not become binding, however, until a printed version was circulated on the floor of the bond room and approved by the relevant brokers.

ⁱ Thanks to Stuart School of Business graduate students Madhursh Rai and Rajeev Ranjan for research assistance in preparing this chapter.

ⁱⁱ William Batten, Chairman NYSE, "The ABC's of ABS," Draft, November 22, 1977, p. 2. Thanks to Larry Harris for pointing out that ABS apparently was first

and supplying the above reference and one other, available at: http://c0403731.cdn.cloudfiles.rackspacecloud.com/collection/papers/1970/1977_1122_ABSNYSE.pdf and http://c0403731.cdn.cloudfiles.rackspacecloud.com/collection/papers/1970/1976_0201_CentralProgress.pdf

Table 6.1: First 20 derivatives exchanges to become fully electronic

	Fully electronic	Partially electronic	Exchange
1	Oct 1984	Never	Intex
2	Jan 1985	Never	NZ Futures and Options Exchange
3	Jun 1985	Never	OM
4	Apr 1988	Never	Tokyo Grain Exchange
5	Jun 1988	Never	SOFFEX
6	Jan 1990	Never	DTB
7	1990	Oct 1987	Australian Stock Exchange
8	Aug 1990	Never	SAFEX
9	Apr 1991	N/A	Tokyo Commodity Exchange
10	May 1993	Never	Zhengzhou Commodity Exchange
11	1997	1990	BOVESPA
12	Dec 1997	N/A	Wiener Börse AG
13	Jun 1998	Apr 1998	MATIF
14	Sep 1998	Never	Eurex
15	Nov 1998	N/A	Budapest Stock Exchange
16	Jan 1999	1982	Tokyo Stock Exchange
17	Feb 1999	1998	Oslo Børs
18	1999	Never	Shanghai Futures Exchange
19	Jul 1999	Oct 1998	Osaka Securities Exchange
20	Jul 1999	Never	Taiwan Futures Exchange

Source: Mondo Visione, exchange websites, emails from exchanges, assorted news clips.

Derivatives pioneers

It should be no surprise then that the earliest electronic exchanges were generally not conversions of older floor-based exchanges, but were rather de novo events, creations of brand-new exchanges. On the derivatives side of the business, most of the new electronic exchanges were successful. In fact, of the first ten screen-based derivative exchanges, created during the pioneering period from 1984 to 1993, all but two got traction. In fact, these eight, either in their original form or after one or more mergers, have become highly successful. The first attempt was actually a North American exchange camouflaged as a Bermuda exchange. The second was

launched in New Zealand by a group of wool traders; the third in Sweden by a guy who loved options; the fourth and ninth in Tokyo; the fifth and sixth in Europe; the seventh and eighth in Australia and South Africa; and the tenth in China. Every one of these, except for the two Japanese exchanges, was created from scratch.

The first, failed and forgotten pioneer – INTEXⁱⁱⁱ

The first electronic derivatives exchange, called INTEX, is one that no one remembers. It was launched over a quarter century ago and it failed, and only historians remember failures. But it is an interesting case study because it is essentially a story of how a small group of people who believed that screens were better than floors worked hard to create the first electronic derivatives exchange, in a jurisdiction where they could gain quick regulatory approval, but were beaten back by entrenched floor-based interests on the mainland. In the early 1980s, a retired Merrill Lynch futures broker named Eugene Grummer had grown tired of what he felt were abuses on the trading floors in Chicago and New York,^{iv} and he felt that the time was right for an electronic solution to the problem. A venture like this needed capital and Grummer teamed up with a Texas oilman named Wallace Sparkman. He also needed someone with significant market experience to run the company, and he selected Junius Peake, a former partner in a major securities firm.

The group actually wanted to start the exchange in the United States. However after informal meetings with the CFTC staff, they realized that there would be huge delays in approval because of anticipated serious pushback by the big floor-based exchanges. So they began to put down roots in Bermuda. While this may seem like a strange choice, Grummer and Peake had already decided on the London Commodity Clearing House (LCCH) to clear the new exchange's trades and LCCH already had a presence in Bermuda. Also, the British territory was sufficiently close to the US to make it easy for the US-based officers of the exchange to travel there.

Building an electronic exchange in the early 1980s was not easy. This venture was complicated by the fact that the customers of the new exchange were almost 800 miles away in New York City and could be connected only by transatlantic cable. INTEX tried to create the perfect system for the time and attempted to incorporate all the suggestions that were given by potential participants. Launch dates were announced a number of times, but had to be canceled continually because the technology was not quite ready. At the

ⁱⁱⁱ Unless otherwise indicated, details in this section are taken from Patrick Catania, "Electronic Trading: A Brief History," in Patrick L. Young (editor), *An Intangible Commodity: Defining the Future of Derivatives*, Kent, England, derivatives.com Publishing, 2004, p. 51-55, and from discussions with Patrick Catania, who was an employee of INTEX during the period referenced.

^{iv} It's difficult to imagine today when we can see all or much of the limit order book, but in the floor-based world, the most a customer off the floor would

know was the price of the last transaction and possibly a recent bid and ask. By the time a market order reached the floor, it often would be executed at a worse price than indicated by the prices that had just been reported from the floor, and customers often felt they were being cheated. And because of the lack of an accurate trail, it was easier for brokers to front run customer orders. To make matters worse, when things got very busy, a fast market was declared and brokers were not held to all of the normal requirements of performance.

time of the exchange's opening in October 1984, less than half of the memberships and terminals had been sold. In addition, INTEX made the strategic mistake of choosing gold futures as its first new product. It was a mistake because the conventional wisdom is that new products do best in a bull market when there is a strong inclination to buy. Gold had been in a long bear market for almost five years and continued in that same trend for another six months.

But the biggest factor in the failure of INTEX was the pressure exerted by the big floor-based exchanges in United States on their member firms. Members of floor-based exchanges were understandably afraid of the rise of electronic trading and the fact that this could very likely put them out of business. So the Chicago exchanges did everything they could to discourage brokerage firms from doing business at the new electronic INTEX. This included suggestions that firms could lose prime booth space on the Chicago exchange floors, should they be sending any trades to INTEX. On opening day, 25 October 1984, the exchange saw only 142 gold contracts trade and it never got any better.^v This first attempt to create an electronic derivatives exchange was a failure, and the floor-based exchanges could breathe a little easier, at least for a while.

Screens solve the location problem down under

New Zealand is a short story. It is a story of seven wool traders spread over four different wool trading centers in New Zealand, who wanted to create a local futures market in New Zealand wool, but found themselves quibbling about which city would host the new exchange. Each trader, of course, wanted the new exchange to be in his city. They then did two smart things. First they decided to make the exchange screen-based so that no one would have any particular advantage and they all would be equally happy or unhappy. Second, they recruited ten financial institutions to join them in the project. The two groups pooled their funds, intelligence, and energy to create the world's second screen-based derivatives exchange. On January 20, 1985, the New Zealand Futures Exchange opened its doors with government bond, commercial paper and US dollar futures, followed a few months later by wool futures. The exchange got off to a slow start – 200 contracts represented a big trading day in the early years. But they kept at it, later added options and merged with the much larger Sydney Futures Exchange in 1991, which itself merged with the Australian Stock Exchange in 2006. The lesson from the New Zealand wool traders was that an electronic exchange solved the "where-to-locate" problem; and with adequate backing (from the bankers) and product diversification (including both commodity and financial products), the effort became the first successful electronic derivatives exchange.

Options and northern lights

Electronically traded options were the original foundation for the Swedish OM exchange that opened its doors in 1985 as the world's third screen-based derivatives exchange. Unlike the first two, OM was successful out of the gate. The force behind OM was a Swedish entrepreneur named Olaf Stenhammer, who first learned options as a broker in New Jersey shortly after the founding of the Chicago Board Options Exchange in 1973. When he returned to Sweden, he got involved in other ventures, but he couldn't get options out of his head and he began designing a system for the electronic trading of options by small retail customers. A very effective marketer, he signed up Sweden's largest bank, Enskilda, and its biggest industrial conglomerate, the Wallenberg Group, as his major backers. The exchange made a splash and was profitable from the very first year, a rare event.^{vi} Within two years the exchange was trading 30,000 contracts per day. As might be expected, the success created competitors and OM was in fact faced with a serious competitor during its second year of business. Luckily for OM, the competitor was a floor-based options exchange, and OM was so far ahead, and its transparency and cost advantages were so great, that the new competitor could never gain traction and quickly disappeared.

Not only was OM one of the very early pioneers in screen-based trading, in 1987 it became the world's first publicly listed exchange; and after a long string of mergers, in 2007 it became half of the giant, trans-Atlantic exchange Nasdaq OMX.

The pivotal event in the battle between screens and floors

The defining event in the transition from floors to screens took place in Europe and involved a battle between a floor-based Goliath and a tiny screen-based upstart. The London International Financial Futures Exchange (LIFFE) was the largest derivatives exchange in Europe ever since its creation in 1982, which was consistent with London's position as the world's most prominent financial center. In 1988, LIFFE listed futures on Europe's leading sovereign debt instrument, the German government bond, or Bund. Traditionally, exchanges listed derivatives chiefly on their own country's assets (stock indexes, government debt and agricultural commodities). But Germany had not yet started a derivatives exchange to list the German products. This was due to German law that viewed futures as gambling and futures contracts as non-enforceable. So LIFFE decided to list Bund futures, a smart move as trading in the product grew rapidly and by the early 1990s the Bund had become LIFFE's most actively traded product.

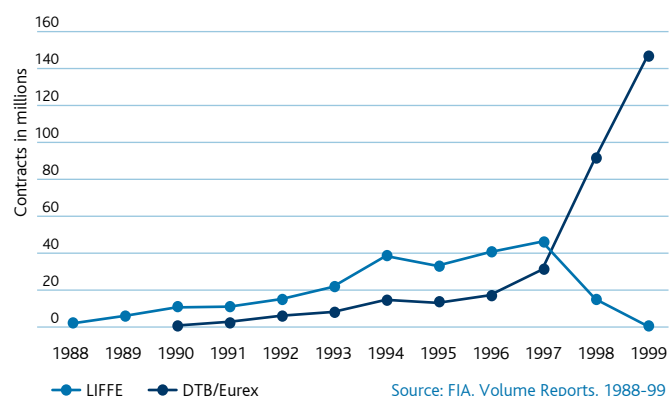
^v "Electronic Exchange for Futures, Intex, Opens in Slow Trading," Wall Street Journal, 26 October 1984, p. 1.

^{vi} With options listed on only six Swedish stocks, the exchange made a pre-tax profit of \$24.4 million on revenue of \$121.8 million, Wall Street Journal, November 18, 1988.

About the same time that LIFFE was launching Bund futures, a group of German banks began discussing the creation of a German derivatives exchange along with the change required in German law. They hired Jorg Franke, the head of the Berlin Stock Exchange, to set one up. Just like the wool traders in New Zealand, the banks sponsoring the exchange were spread around the country, in this case in Berlin, Hamburg, Stuttgart, Munich and Hanover, and each wanted the exchange to be in its city. As in New Zealand, they solved the problem by locating the exchange in cyberspace. And to speed up time to market, instead of building a new electronic matching engine from scratch, they bought one from their neighboring Swiss Options and Financial Futures Exchange (SOFFEX). In its first year (1990), the Deutsche Terminbörse (DTB) listed three products – futures on the German stock index (DAX), the German equivalent of Eurodollars (FIBOR), and LIFFE's crown jewel, the German Bund.

In the futures markets, once an exchange has attracted a reasonable number of buyers, built solid trading volumes and established good liquidity in a product, it has been virtually impossible for another exchange to successfully list the same product. This principle of liquidity-driven monopoly ensured that each exchange generally held a portfolio of monopoly products. So when DTB listed the product in which LIFFE had already built one of the most active markets in the world, seasoned observers expected the DTB to fail, just like virtually all other exchanges that had gone after a liquid market at another exchange. After all, here was the newest and smallest exchange in Europe trying to compete with Europe's biggest and oldest financial derivatives exchange.

Figure 6.1 German government bond volume at LIFFE and DTB



But there was an interesting difference in this contest. The little German challenger was a screen-based exchange, while the exchange being attacked was floor-based. This meant that DTB was more transparent and cheaper than LIFFE, but it was also quickly building an international following by pursuing the establishment of remote memberships and terminals in Paris, London and the US. In its first year, thanks in part to its banker owners that directed their trades to the new exchange, DTB traded 5 million German Bund contracts, and it continued growing almost every year thereafter. But LIFFE continued to grow just as rapidly and maintained a 2/3rds market share. Then things started to look up for DTB. In 1996, the CFTC gave it permission to place terminals in the US market. In 1997 and 1998, DTB cut fees and made its terminals free for foreign participants. With growing participation from traders in Chicago, London and Paris, DTB volume began to soar at the expense of LIFFE. By the end of 1998, volume at LIFFE had fallen virtually to zero and DTB had traded over 140 million contracts for the year –almost five times the level of two years earlier. It took eight years to do it, but a brand new electronic exchange had captured 100% of the market share of Europe's biggest contract at Europe's biggest floor-based exchange. Never again would the floor-based exchanges of the world be able to sleep peacefully. And to further underline the importance of the victory of the electronic exchange, in that same year, 1998, the German DTB merged with the Swiss SOFFEX to form Eurex, creating the largest derivatives exchange in the world. For over a century, the floor-based Chicago Board of Trade had been the world's largest derivatives exchange. It was now clear that the future belonged to screens.

The dangerous phase between floor and screen

What DTB's capture of all of LIFFE's Bund volume points out is that the transitional phase is especially dangerous for floor-based exchanges. This lesson was brought home again in 2006, when a large US exchange almost had its cornerstone product stolen by a new all-electronic exchange. While the New York Mercantile Exchange (NYMEX) did have an electronic platform, it was not robust and the exchange was not pushing it. In fact, in 2005 and 2006, the exchange was still pursuing a floor-based expansion strategy in Europe, Asia and the Middle East at the behest of its member-owners. It actually set up floor-based subsidiaries in Dublin and London and was planning to do the same in Singapore and Dubai. Meanwhile, the Intercontinental Exchange (ICE) had established liquid OTC and exchange-traded markets on a solid electronic platform. In February 2006, ICE listed a clone of NYMEX's benchmark West Texas Intermediate (WTI) crude oil contract. Within a few months, ICE went from zero to a 30% market share. It then launched clones of NYMEX's gasoline and heating oil contracts. What was playing out was a repeat of the DTB-LIFFE story. There

were two important differences. First, it's not clear that ICE really wanted NYMEX's crude oil contract to disappear. NYMEX's WTI contract was a traditional physically delivered contract, where anyone left with a position after the close of trading at the expiration of the contract either delivered or received actual crude oil. The ICE product, by contrast, was cash settled (often referred to as financially settled) based on the NYMEX price. If the NYMEX contract vanished, the ICE contract would lose its settlement mechanism. More importantly, NYMEX saw the folly of its floor-based orientation and quickly made a deal to use CME's battle-tested GLOBEX electronic platform. So the CME saved NYMEX from possible extinction at an undisclosed cost. Two years later, the CME bought NYMEX.

Baby steps – Floor-based exchanges try after hours electronic trading

While new exchanges were being created in an electronic format, existing floor-based exchanges took a much more cautious route. Several futures exchanges established electronic systems, but exclusively for after-hours trading, so as not to intrude on or compete with the regular trading hours of their members. Securities exchanges often would allow electronic trading only in lightly traded issues, again so as not to seriously impinge on the business of their members. This approach allowed the exchanges to take small steps toward competing electronically, while preserving for the exchange members exclusive rights to trade during regular daytime trading hours or in the most liquid markets.

Leaders of futures exchanges knew they must recognize the technological revolution that was engulfing the world, but they also knew that their members would have their heads if they began to shift their floors to screens. So they adopted electronic trading in a very limited way to solve a very different problem. The problem, especially in the US, had to do with the rise of Japan as a trading power. The Japanese, and to a lesser extent other Asian countries, had jumped into derivatives with both feet. Many Japanese brokerage firms decided to become members of US derivatives exchanges, so many in fact that the CME hired away a Northwestern University professor of Japanese to act as a full-time liaison with these Japanese firms. At the same time that Japanese trading was growing rapidly on US derivatives exchanges, it was also growing rapidly at home in Japan. What US exchanges worried about was whether the Japanese would soon list on their own exchanges the same products they were now supporting on the US and European exchanges. And the US exchanges realized that they were not exactly being customer friendly by requiring the Japanese wishing to trade on the Chicago exchanges to stay up all night to do so. There

was absolutely no overlap between Chicago or New York trading hours and Japanese trading hours. And there was only a very slight overlap between the opening on European exchanges and the closing times on Tokyo exchanges.

While some products were protected by exclusive licensing agreements, like the S&P 500 and all other branded stock indexes, most futures products were generic and could be started by any exchange at any time. For example, the contracts based on interest rate products, currencies, and physical commodities had absolutely no intellectual property protection. In the United States, exchanges feared that the Japanese and others in the Asian time zone would establish their own versions of all of the big blockbuster contracts that the Japanese were trading in Chicago and in New York. Of course, there were also low-tech approaches to protecting Western markets. For example, the Chicago Board of Trade was sufficiently committed to floor trading that it decided in 1987 to extend its hours into the Japanese trading day by having an evening session staffed with members making markets on the trading floor. This approach did not last long. The New York Cotton Exchange also had a floor-based evening session beginning in 1992 that actually went on for 15 years, but again the volumes were never very large.

The other approach, most successfully pursued by the Chicago Mercantile Exchange, but also by the Chicago Board of Trade, NYMEX, and the London International Financial Futures Exchange (LIFFE) was to set up screen-based systems for trading products after the trading floors closed in the afternoon. LIFFE was first, launching its Automated Pit Trading (APT) system in 1989. The system catered to pit traders and was sufficiently non-robust that LIFFE did not call on it when faced with the 1997-98 DTB attack described earlier. The most strategically important of these systems was the CME's GLOBEX. It wasn't an easy thing for any of these exchanges to sell electronic trading to their member-owners. Leo Melamed, long-time CME leader, was Chairman of the Strategic Planning Committee that came up with GLOBEX. He needed to convince CME members that after-hours electronic trading was in their interest.^{vii} So he and then chairman Jack Sandner tried to reduce fear by promising members that GLOBEX would never be open during regular daytime trading hours unless the members ever voted to do so. They also created a financial incentive by committing to give 70% of GLOBEX profits to the members. Finally, to convince members that the project had a high probability of success, they chose to partner with then technology pioneer Reuters Holdings PLC. The plan was unveiled to members in the fall of 1987. A few weeks later, the members approved the plan with a landslide vote, though the system would not actually light up until five years later, in June of 1992.

^{vii} This section draws upon Leo Melamed's recollections in Leo Melamed, *Escape to the Futures*, John Wiley and Sons, 1996, p. 336-339.

The approaches to creating a screen-based system took two major paths. One was to focus on making floor-trading members happy by creating a screen that resembled as much as possible the traditional trading floor. The other approach was to create trading screens that would appeal most to outside traders who had no particular familiarity with, and certainly no deep love of, the traditional trading floor. The "let's appeal to the floor trader" path to electronic trading was pursued by both the Chicago Board of Trade and the London International Financial Futures Exchange. The Chicago Board of Trade unveiled its floor-trader-friendly Aurora system at the annual Futures Industry Association Conference in Boca Raton Florida in March 1989. Aurora had a beautiful, colorful screen, and was much more interesting than the CME GLOBEX screen. It was a collaboration between Apple Computer Inc., which supplied the colorful Macintosh icons; Texas Instruments, which supplied the artificial intelligence; and Tandem Computer, which supplied the raw processing power. Pit traders loved Aurora. The rest of the world was not so crazy about it, and the product never came to market. The CBOT spent several years pretending to join the CME and Reuters in their GLOBEX system, but ultimately, in 1994, it broke ranks and returned to developing its own pit-trader-friendly, proprietary system renamed Project A. While Project A did have some advantages over its predecessor Aurora, it never really caught on, and the CBOT abandoned the system for a more robust and battle-tested system created by Eurex of Frankfurt. That relationship lasted only a few years before the CBOT switched from Eurex's system to LIFFE's system, and then finally to CME's GLOBEX after the 2007 merger of the two giant Chicago exchanges.

One thing that the CBOT's continuous swapping of trading platform partners points out is just how modular exchanges have become in the electronic age. In the floor-based days, exchanges were generally self-contained, having pretty much all functions in house – trading floor operations, product development, marketing, legal, regulatory and often clearing and settlement (in the case of futures exchanges). Today, exchanges can and do outsource many, and in some cases all, of these functions. This is especially true with trading platforms and related technology. The Swedish exchange OM, one of the early pioneers in electronic trading, was also early in leasing its trading platform to other exchanges. Today, in the form of NASDAQ OMX, it has leased technology to support trading and clearing in more than 50 countries. The London based LIFFE, now part of NYSE Euronext, created a widely respected trading platform called LIFFE CONNECT in 1998, which it has leased out to exchanges in the US, Canada, and Japan and which is used for all the European derivatives exchanges that have become part of the Euronext half of NYSE Euronext.

Automating the world's stock exchanges

As we have seen, the early pioneers of electronic derivatives trading created brand new exchanges starting in the mid 1980s. It took almost another decade before existing floor-based exchanges began fully converting to screens. Aside from the fact that conversions from floors to screens met stiff resistance from member-owners whose livelihoods were threatened, derivatives trading, especially in financial products, was still in its infancy and many countries did not yet have derivatives exchanges. New Zealand, Sweden, Switzerland, Germany, South Africa and China all had no derivatives exchanges. So during the mid 1980s and early 1990s, all these countries created new derivatives exchanges, and they were all electronic right out of the box.

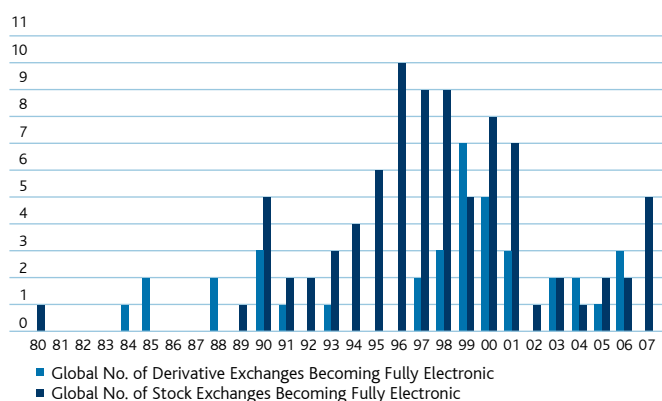
Stock exchanges, on the other hand, were relatively mature institutions, and most countries of any size already had one or more stock exchanges and were not generally building new ones. And given the natural resistance of member-owners, the existing stock exchanges, just like the existing derivatives exchanges, were not likely to quickly convert to screens. Consequently, early electronic activity on the securities side was carried out on an experimental basis, typically only for stocks that were relatively inactive. So in figure 6.2, we see that except for the isolated event of the Cincinnati Stock Exchange becoming electronic in 1980, it was not until 1989 that stock exchanges began to start converting to electronic trading in earnest.

Many partial steps were taken toward creating electronic trading platforms even in the 1970s and 1980s. In 1977, the Toronto Stock Exchange became the first exchange to create an electronic matching system.^{viii} NASDAQ, of course, had even earlier in 1971 created an electronic quotation system, whereby dealers could enter and view bids and offers for all NASDAQ stocks. But the matching, the deals, the actual trades, were still done over the phone, to preserve the dealers' role and ensure that they were able to earn the bid-ask spread for their market making contribution. Six years after NASDAQ lit up its quotation screens, Toronto lit up CATS (for Computer Assisted Trading System), an electronic limit order book in which brokers could match market orders against the limit orders in the book. But this new system was used only for inactive stocks. This was not threatening to the floor traders who found it much more profitable to focus their attention on the more actively traded issues.

Its innovation in electronic matching put the Toronto exchange on the map. As other exchanges explored the possibilities of computerized stock trading and began looking for models and mentors, Toronto became a compulsory stop on their world tours. In 1982, the Tokyo Stock Exchange introduced an automated system

^{viii} Roger D. Huang and Hans Stoll, *The Design of Trading Systems: Lessons from Abroad*, *Financial Analysts Journal*, Vol 48, No 5 (Sep-Oct 1992) pp 49-54.

Figure 6.2 Comparison of global number of derivatives and stock exchanges becoming fully electronic: 1980-2007



Source: Mondo Visione, exchange websites, assorted press articles

modeled on CATS. They altered the name to Computer Assisted Order Routing and Execution System, so CATS became CORES in Japan. One curious thing about the Japanese adaptation of CATS was that even though all the limit orders were placed in an electronic file, trades were actually matched manually by order clerks, called *saitori* members. It was less efficient, but was a way to preserve jobs, to make Schumpeter's "creative destruction" a little less destructive. Also, while CATS revealed the limit order book to all market participants, Tokyo restricted it to exchange members only. Many exchanges have licensed Toronto's CATS – the Brussels Bourse, the Paris Bourse and the Madrid Bourse as well as three other stock exchanges in Spain, to name a few.^{ix}

Even though the Toronto Stock Exchange was the first to create an electronic matching engine, it took another 20 years before trading became fully electronic in Toronto. As can be seen in the figure 6.2 (and table 6.2), the first fully electronic exchange of any kind was created in 1980 and involved the conversion of the 95-year old Cincinnati Stock Exchange into a fully automated marketplace. But it took almost a decade for the trend to really start. In 1989 there was an electronic exchange created in Chile, and then in each subsequent year, there was at least one and sometimes as many as nine or ten fully electronic stock exchanges lighting up screens. About 80% of these were conversions, like Cincinnati, and the other 20% were brand new ventures, like the Bolsa Electronica de Chile.^x The most intensive activity took place between 1995 and 2001. Of the 85^{xi} fully electronic stock exchanges that came on line between 1980 and 2007, most occurred in Europe (33%), the Asia Pacific region (29%) and the Middle East (11%).

Table 6.2: First 20 stock exchanges to become fully electronic

	Exchange	Established	Fully electronic	Location
1	National Stock Exchange*	1885	1980	Chicago, United States
2	Bolsa Electrónica de Chile	Nov 1989	Nov 1989	Santiago, Chile
3	Paris Bourse	Jun 1802	1989	Paris, France
4	OMX Nordic Exchange in Helsinki	1912	Apr 1990	Helsinki, Finland
5	Saudi Stock Exchange (TADAWUL)	1930	Apr 1990	Riyadh, Saudi Arabia
6	OMX Nordic Exchange in Stockholm	1863	1990	Stockholm, Sweden
7	Australian Stock Exchange (ASX)	1861	Oct 1990	Australia
8	Shanghai Stock Exchange	Nov 1990	Dec 1990	Shanghai, China
9	Warsaw Stock Exchange	1817	1991	Warsaw, Poland
10	Stock Exchange of Thailand	May 1974	1991	Bangkok, Thailand
11	New Zealand Exchange (NZX)	1915	Aug 1992	Wellington, New Zealand
12	Shenzhen Stock Exchange	Dec 1990	1992	Shenzhen, China
13	Prague Stock Exchange	1850s	Apr 1993	Prague, Czech Republic
14	Vilnius Stock Exchange	Sep 1992	Sep 1993	Vilnius, Lithuania
15	HKEx	1891	Nov 1993	Central, Hong Kong
16	National Stock Exchange of India	1992	Jun 1994	Mumbai, India
17	Tehran Stock Exchange	1936	Sep 1994	Tehran, Iran
18	Istanbul Stock Exchange	Oct 1984	Nov 1994	Istanbul, Turkey
19	Borsa Italiana	1808	1994	Milan, Italy
20	Indonesia Stock Exchange	1912	May 1995	Jakarta, Indonesia

* Originally Cincinnati Stock Exchange

Source: Mondo Visione, exchange websites, communications with exchanges, assorted news clips.

^{ix} Lewis D. Solomon and Louise Corso, *The Impact of Technology on the Trading of Securities: The Emerging Global Market and the Implications for Regulation*, *The John Marshall Law School Review*, Vol. 24:299, 1991.

^x Michael Gorham and Nidhi Singh, *Electronic Exchanges: The Global Transformation from Pits to Bits*, Elsevier, 2009, p. 66.

^{xi} The full 85 are listed in Gorham and Singh, though only the top 20 are displayed in the table here.

But the question remains: why was the Cincinnati Stock Exchange the first to become fully electronic in 1980 and why did it take almost a decade for another stock exchange to follow its lead?^{xii} Cincinnati converted to screens via a serendipitous combination of desperation and ingenuity. By the 1970s, most of the US regional stock exchanges had disappeared, and those remaining were looking for some way to survive in the shadow of the New York Stock Exchange. At the same time there were broker/dealers who felt squeezed between falling commissions (the SEC eliminated fixed commissions in 1975) and the high costs they faced dealing with the NYSE specialists. The Weeden brothers, Don and Frank, who had their own broker/dealer, approached Cincinnati with an electronic matching system they had developed. If they and others could become specialists on a regional exchange like Cincinnati, they could avoid the NYSE specialists altogether.

With revenues and membership values falling, the Cincinnati board felt they had nothing to lose. They began experimenting with the system in 1976 and designing a new exchange. By 1980 the exchange was ready to darken its floors and light up its screens. There were two things that Cincinnati did that helped them to succeed. First they created a system of multiple dealers for each stock, more like NASDAQ than NYSE. Second, they established a rule that allowed the dealers to trade against their own customers if they did so at a price that was better than the best bid or offer. Initially they did well. Tom Peterffy, who started Timber Hill and Interactive Brokers, was making markets in 35 stocks for as many as 3-4,000 shares at a time and was offering better prices than the NYSE.

Why did no other exchange follow suit? No member-owned exchange really wanted to convert to screens. And in the United States, there was tremendous resistance in New York to Cincinnati's strategy, especially when Cincinnati's share began to push up to 5%. In fact, the pressure was so great that no other American exchange appeared among the first 20 stock exchanges to become fully screen based. The Asia Pacific region and Europe accounted for 75% of the first 20 and both South America and the Middle East had more electronic stock exchanges than the US by 1995.

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About Michael Gorham

Michael Gorham is Industry Professor and Director of the IIT Stuart Center for Financial Markets at the Illinois Institute of Technology. He is also Adjunct Distinguished International Professor of Finance at EGADE, the graduate business school of Monterrey Tec, at the Santa Fe Campus in Mexico City. In addition, he currently serves on the board of directors for the CBOE Futures Exchange in Chicago and, until July 2008, served on the board of the National Commodity and Derivatives Exchange in Mumbai, India. He serves on the business conduct committee of the Chicago Mercantile Exchange, the editorial boards of the GARP Risk Review and of Futures Industry magazine. He is regional director of the Global Association of Risk Professionals for Chicago.

Hi is co-author of two books; India's Financial Markets: An Insiders Guide (July 2008) and Electronic Exchanges: The Global Transformation from Pits to Bits (May 2009), both published by Elsevier.

From 2002 to 2004, Mr. Gorham served as the first director of the Commodity Futures Trading Commission's new Division of Market Oversight, a division of 100 economists, lawyers, futures trading specialists and others dedicated to the oversight of the nation's 12 futures exchanges. Earlier, Mr. Gorham was an economist at the Federal Reserve Bank of San Francisco and VP of international market development at the Chicago Mercantile Exchange.

He has been involved in consulting projects to create a stock index futures market in India, establish a commodities market in the United Arab Emirates, evaluate the feasibility of Parmesan cheese futures in Italy, and to modernize financial markets in Egypt. He also served as Managing Editor of the Journal of Global Financial Markets.

He has written for newspapers, journals and magazines in Argentina, China, Japan, Mexico and the U.S. and has given talks on derivatives in 14 countries. After university, he was a Peace Corps volunteer working on an agricultural modernization project in Malawi, Africa. He holds a BA in English literature from the University of Notre Dame, an MS in food and resource economics from the University of Florida and a Ph.D. in agricultural economics from the University of Wisconsin.

^{xii} This discussion relies on discussions with David Colker, who served in many capacities at the Cincinnati Stock Exchange for two decades, retiring as CEO and president in 2006, and with Gary Lahey, former vice chairman of the CBOE and board member of the Cincinnati Stock Exchange.