The Transition to Electronic Trading in the Secondary Treasury Market

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Abstract:

This article reviews the history of the recent shift to electronic trading in equity, foreign exchange and fixed-income markets. We analyze a new data set: the eSpeed (Cantor Fitzgerald) electronic Treasury network. We contrast the market microstructure of eSpeed with the traditional voice assisted networks that report through GovPX. The electronic market (eSpeed) has greater volume, smaller spreads and a lower estimated impact of a trade than the voice market (GovPX).

Keywords: microstructure; Treasury bond; spread; market impact; ECN.

JEL Codes: G14; G12; D4; C32;

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1. INTRODUCTION

In the last 15 years, advances in information technology have revolutionized electronic trading—posting quotes, transacting and confirming orders electronically. Electronic methods have grown to dominate trading in major asset markets, like equities, foreign exchange and fixed-income.

The Securities and Exchange Commission (SEC) (2000) defines electronic communications networks (ECNs) as "electronic trading systems that automatically match buy and sell orders at specified prices." Such systems have several advantages over other trading systems, like the open-outcry pit system or telephone trading. First, ECNs permit users all over the world to trade, without regard to physical location. Second, ECNs permit the number of traders, the size of trades or the asset to vary costlessly. Third, ECNs automate the processing and clearing of trading, reducing the risk of clearing errors and facilitating risk management (BIS (2001)). The advantages of ECNs are most evident in the markets for more liquid and homogenous assets. Barclay, Hendershott and Kotz (2004) discuss the conditions under which human brokers outperform ECNs in conveying complex information ("market color") during trading for less liquid assets or nonstandard agreements.

By dramatically reducing the cost of trading for relatively liquid and homogeneous assets, electronic trading has facilitated portfolio management for institutional investors and banks. Rising volume has mirrored the fall in the cost of trading, enabling customers to rebalance portfolios more quickly, making them less risky.

ECNs have one more advantage: They create a continuous trail of data that can include limit orders, quoted and/or traded prices, volumes and other information that illuminates the microstructure of financial markets. The purpose of this article is to closely scrutinize a previously unexamined data set, the U.S. Treasury bond market data from the eSpeed trading platform, whose majority owner is Cantor Fitzgerald. We examine volume measures, determinants of bond price spreads and the impact of order flow on prices. A detailed understanding of market microstructure can contribute to better regulation and improvements to market architecture.

2. STAGES OF THE TREASURY BOND MARKET

The sale of Treasuries undergoes three distinct phases: primary, on-the-run and off-the-run. Each of these three stages has a distinct market structure.

2.1 The Primary Market

In the first or *primary* stage, the U.S. Treasury auctions off debt to the public. Garbade and Ingber (2005) describe this process in detail. The Treasury provides a predictable flow of auction information to "promote competitiveness by enhancing market transparencies" and to improve the size of offerings. Since August 8, 2002, the Treasury has made auction announcements (for all new securities) at 11:00 AM Eastern Standard Time (EST). There is also a stable schedule[1] for auctions. For example, 3- and 6-month bills are auctioned every Monday. 2-year notes are generally issued on the fourth Wednesday of the month; 5-year notes are auctioned on the first or second Wednesday of the month. 30-year bonds were reintroduced on February 9, 2006, after a five year hiatus, and will be auctioned in February and August.

A few days prior to the auction, the specific dollar amount (*par value*) of the securities to be auctioned is announced and the *when-issued* security market begins. The when-issued market continues until settlement of auction purchases. Nyborg and Sundaresan (1996) document that when-issued trading provides important information about auction prices prior to the auction and also permits market participants to reduce the risk they take in bidding.[2]

Bids for Treasury auctions can either be competitive bids by primary dealers or noncompetitive bids by firms and individuals. Firms and individuals can also competitively bid through brokers and primary dealers. Competitive bids specify a price to be bid and a quantity sought. In the recent past, there have been two types of auctions: multiple-price and single-price.

Prior to October 1998, multiple-price auctions were used to sell 3- and 10-year notes and the 30-year bond. In multiple-price auctions, the competitive bids were ranked to determine the highest yield that will sell all the Treasuries. The average yield for all accepted competitive bids is called the *stop-out yield*. First, all noncompetitive bids are satisfied at the stop-out yield and then the remainder of the auctioned securities are allocated to competitive bidders with the lowest bid yield (highest bid price). Competitive bids above the stop-out yield are not filled while those at the stop-out yield may be only partially filled.

Garbade and Ingber (2005) report that the Treasury began to experiment with single price

[1] The Treasury auction schedule can be found at: http://www.treasury.gov/offices/domestic-finance/debt-management/auctions/Treasury

[2] On August 20, 1998, the Treasury shortened the when-issued period for 13- and 26-week bill auctions. Similarly, the Treasury shortened the when-issued period by two days for 2-year notes beginning with the August 2, 2002 auction. Fleming (2002) and Garbade and Ingber (2005) discuss the results of such changes in when-issued periods.

auctions in 1992 for the 2- and 5-year notes. In this auction design, all securities are allocated to bidders at the price implied by the highest accepted yield. In October 1998, the Treasury adopted this procedure for all maturities, safeguarded by quantity restrictions on the amount a single bidder can purchase.

Upon completion of the auction, the most recently issued bill, note or bond becomes *on-the-run* and the previous on-the-run issue goes *off-the-run*. Both on-the-run and off-the-run trading occurs in the *secondary* Treasury market. Secondary market participants are often divided into two parts: the sell side and the buy side. The primary securities dealers constitute the sell side while the diverse group of final users of Treasury bonds constitutes the buy side. The buy side includes—commercial and investment banks, insurance companies, financial firms, investors and pension funds—those who use Treasuries for speculation, as well as hedging real and financial risk.

2.2 The Overall Secondary Market

It is difficult to get primary source data for all secondary market transactions, therefore we will use market-share[3] estimates made by the Federal Reserve and industry participants. Figure 1 shows that, in 2005, two large *interdealer brokerage* (IDB) firms dominate the overall secondary market: ICAP PLC, with a 60% market share, and Cantor Fitzgerald with 28%. Both of these firms trade a large array of fixed income financial instruments, including swaps, mortgage backed and agency securities, using both electronic and voice brokered systems. We describe these two firms and their purely electronic Treasury platforms in greater detail in the next section. Tullett Prebon[4] with 9% and Hilliard Farber & Co. with 3% complete the secondary Treasury market.

[Insert Figure 1 Here]

On- and off-the-run markets differ by volume and trading methods. We turn first to the more liquid on-the-run market.

[3] Mizrach and Neely (2005) explore a related concept known as *information share*. This is a statistical measure of where (in which market) price discovery takes place. From 1995 to 1999, we found the spot and futures market played nearly equal roles, with futures dominating after 1999.

[4] Collins Stewart Tullett PLC is an agglomeration of a number of prior firms: (1) Collins Stewart Ltd. was a London based financial services firm founded in 1991; (2) Tullett & Riley was founded in 1971, originally focusing on foreign exchange; (3) Tokyo Forex took a stake in Tullett in 1986 creating Tullett & Tokyo; (4) In 2000, Tullett & Tokyo merged with Liberty Brokerage to create Tullett & Tokyo Liberty; (5) Prebon was formed in 1990 following the merger of three leading London-based money broking businesses, Babcock & Brown, Kirkland-Whittaker and Fulton Prebon; (6) Prebon's close business alliance with the Tokyo-based Yamane Tanshi provided its current title of Prebon Yamane. Collins Stewart acquired Tullett in March 2003, and Prebon in October 2004. The firm's IDB business uses the name Tullett Prebon.

On-the-Run

There is much more secondary volume in on-the-run securities than off-the-run securities, with the former representing 70% of all trading volume (Fabozzi and Fleming (2005)). Because of this liquidity difference, off-the-run securities trade at a higher yield (lower price) than on-the-run securities of similar maturity. The amount by which the off-the-run yield exceeds the on-the-run yield is known as the *liquidity premium*. Trading of benchmark (on-the-run issues) is *commoditized*, and nearly all of it has migrated to the electronic networks.[5]

Figure 2 shows market share estimates for the ECN portion of the on-the-run market.[6] We estimate that on-the-run trading for the third quarter of 2005 was $21.19 trillion.[7] In their financial filings, eSpeed reports transactions volumes of $8.014 trillion during the quarter. We then estimate BrokerTec ECN revenue of $12.29 trillion.[8] These figures imply on-the-run ECN market shares reported in Figure 2, 61% for BrokerTec and 39% for eSpeed, which are consistent with industry estimates (Securities Industry News (2006)).

[Insert Figure 2 Here]

We now turn to the more numerous but less actively traded off-the-run issues.

Off-the-Run

Barclay, Hendershott and Kotz (2004) report that transaction volume falls by more than 90%, on average, once a bond goes off-the-run. There are a large number of issues—99 notes and 43 bonds as of February 2006—but with each being relatively illiquid, most off-the-run trading occurs in traditional voice networks.

eSpeed does not compete with BrokerTec in off-the-run trading, but the voice assisted part of Cantor Fitzgerald does compete with ICAP. Since neither firm breaks out their off-the-run voice assisted trading from their overall figures, we cannot estimate a market share for off-the-run trading.

[5] Commoditized securities are those that are undifferentiated, liquid and trade only on price. See the glossary for further definitions.

[6] Electronic trading in fixed income refers to both electronically brokered, voice assisted transactions and pure ECN trades. We focus only on the latter here.

[7] Total Treasury market trading volume averaged $473 billion per day or $30.27 trillion for the whole quarter. Assuming 70% was on-the-run, we arrive at the $21.19 trillion estimate.

[8] ICAP-BrokerTec reports a 58% overall secondary market share in their filings, and we assume the same market share in the on-the-run portion.

3. THE GROWTH OF ELECTRONIC TRADING

Compared to equity or foreign exchange markets, bond markets were slower to adopt electronic trading. The bond market is large and decentralized, like the Nasdaq equity market or foreign exchange market, but has more varied assets—many types of bonds, maturities, coupons, strips, etc. Two boxed inserts describe the growth of electronic trading in equity and foreign exchange markets, respectively. The greater complexity of trading in sundry instruments, each of which has less liquidity than large capitalization stocks or the major currencies, retarded the transition to electronic trading.

Electronic communications can play different roles in the trading process. For more than a decade, bond trading screens have displayed quotes from dealers that helped to initiate voice transactions. This section focuses on the completely electronic trading via ECNs. These ECNs permit dealers to post transactable prices and quantities and execute trades electronically.

Cantor Fitzgerald introduced the first ECN in bond markets, eSpeed, in 1999. A consortium of Wall Street firms, including Morgan Stanley and Goldman Sachs, launched a competitor, BrokerTec, the same year. BrokerTec began commercial operations in 2000. ICAP PLC, a global, London-based IDB, acquired BrokerTec in April 2003. On-the-run trading is now almost completely electronic, with the market split roughly 60-40 between the two ECNs, as Figure 2 illustrates. While these ECNs (eSpeed and BrokerTec) have captured most bond market trading activity, voice brokerage systems are used for trading in less liquid assets (or more complex deals).

3.1 History of Cantor Fitzgerald

Bernie Cantor and John Fitzgerald founded the firm of Cantor Fitzgerald in 1945 to provide investment advice to wealthy individuals. Cantor Fitzgerald rose to prominence as a Wall Street bond market *broker*. Cantor's fortunes rose in 1972 when it bought a controlling interest in Telerate and began to post bond prices for its bond dealer clients through the Telerate computer network. Customers purchased the data streams and naturally directed business toward its source, Cantor. The strategy was so successful in generating trading volume that Cantor gained a "nearly monopolistic" bond market share (Zuckerman, Davis, and McGee, 2001).[9] Rising federal government budget deficits in the 1980s aided Cantor's fortunes by greatly expanding the bond market. By

[9] Hall and Rust (2003) study why Cantor Fitzgerald became a successful market maker in the U.S. Treasury bond market but such a strategy has not emerged in another market—the market for steel.

the early 1990s, Cantor Fitzgerald had 20 to 25 percent of the IDB market (Department of the Treasury et al (1992)).

In 1991, demands by the SEC and bond market dealers for greater transparency led to the formation of GovPX, a joint venture among five IDBs.[10] Cantor was the only IDB that did not participate in GovPX. GovPX was established to provide real-time interdealer trade prices and volume for U.S. Treasury bonds. The information is public and currently made available on the Internet and through data vendors.

As electronic trading became commonplace in the equity and foreign exchange markets, Cantor followed suit by starting the first electronic brokerage system for bonds, eSpeed, in March 1999. Cantor subsequently spun off eSpeed in a December 1999 public offering, but retained a 55 percent controlling interest. eSpeed Inc. is listed on the Nasdaq and trades under the symbol ESPD.

The terrorist attacks of September 11, 2001 struck Cantor particularly hard, destroying its offices in the World Trade Center and killing 658 employees. Despite this tragedy, eSpeed became one of the two dominant trading platforms in the IDB market for U.S. Treasuries.

3.2 ICAP and BrokerTec

Cantor was not alone in seeing the potential of an electronic IDB bond-trading system. In 1999, several other Wall Street firms, including Morgan Stanley Dean Witter & Co., and Goldman Sachs Inc., founded BrokerTec Global LLC.

ICAP is the product of a merger between Garban PLC and Intercapital PLC in September 1999. Originally called Garban-Intercapital, the name was changed to ICAP in July 2001. ICAP is currently the world's largest IDB with a revenues of £794.00 million, and operating profits of £122.70 million. The company trades publicly on the London Stock Exchange under the symbol IAP.

In February 2000, Garban-Intercapital launched the Electronic Trading Community (ETC), a hybrid voice, electronic brokering system for the Treasury market. They eventually struck alliances with Tullett & Tokyo Liberty in November 2000, and SunGard in September 2001.

ICAP realized that it needed to grow its' ECN business and bought BrokerTec's Treasury

[10] The original IDBs reporting to GovPX were Garvin Guy Butler, Liberty Brokerage, Hilliard Farber, RMJ, and Tullet & Tokyo Securities. As the structure of the market changed, so did the brokers reporting to GovPX. Fleming (2003), which examines the period 1997-2000, listed GovPX coverage as including Garban-Intercapital, Hilliard Farber, and Tullett & Tokyo Liberty. After ICAP's purchase of GovPX in January 2005, ICAP PLC was the only broker reporting through GovPX.

platform in April 2003 for $185.9 million. The U.S. Department of Justice approved the purchase after restructuring commission agreements between the pre-merger entities (DOJ (2003)). ICAP has used the BrokerTec platform to form partnerships like the one with MarketAxess in March 2004 (Wall Street and Technology (2004)). ICAP also acquired the data provider GovPX, Inc, in January 2005.

3.3 Recent Competition

eSpeed briefly had a dominant 70% share in on-the-run trading, but BrokerTec gained market share with lower transactions costs (Kruger (2005)). Cantor Fitzgerald responded the old-fashioned way: with a lawsuit alleging patent infringement on eSpeed's trading systems. The case, filed in January 2003, was dismissed in February 2005 by a Delaware court.

eSpeed's price improvement facility, a tool that allowed traders to offer prices between the quotes, reportedly also hurt them in the marketplace (Computer Business Review (2005)). The price improvement system proved complex and unpopular with customers. Quantity, rather than price negotiation, had been standard in the industry in the days of voice brokerage, and eSpeed eliminated the price-improvement tool in January 2005. These changes seem to have stabilized a duopoly in ECN on-the-run trading with the market split 60-40 between BrokerTec and eSpeed.

4. DATA SOURCES AND ANALYSIS

To study trading activity, spreads and price impact, we rely on two publicly available historical transactions databases. The first is GovPX, which consolidated voice-brokered inter-dealer quotes and trades from Garban-Intercapital, Hilliard Farber, and Tullett & Tokyo Liberty during our sample period of 1999. Fleming (2003) describes the characteristics of liquidity in this market in the period from 1997 to 2000. Our second source is Cantor's eSpeed which recently began to offer a transactions database.

Both the GovPX and eSpeed data sets have their limitations. GovPX does not provide a reliable indicator of transactions after March 2001. The market share of voice brokerage trading has also substantially diminished since 1999. The Cantor data set is from 2004, contains only on-the-run securities, and includes transactions but no quotes.

4.1 Trading Activity

Volume continues to grow in the government bond market. Figure 3 shows that the average volume of Treasury security transactions by primary dealers has grown steadily since its 1999 nadir of under $200 billion per day. Since that low point, daily volume has almost tripled to nearly $575 billion per day.

[Insert Figure 3 Here]

GovPX trading volume declined markedly after 1999 as ECNs like eSpeed and BrokerTec began to attract business. Because the GovPX trade volume data become very thin after 1999, Table 1 contrasts average daily trades and volume in 1999 in GovPX with eSpeed data from 2004.

[Insert Table 1 Here]

With the exception of the 2-year note, the eSpeed trading activity in 2004 is at least seven times as large as the GovPX activity in 1999, whether measured as trades or volume of bonds sold. Trades in the 5-year note are up 635%, more than 1,000% in the 30-year and more than 2,000% in the 10-year.

The rising supply of Treasuries from 1999 to 2004 can explain only about 20% of the growth between the 1999 GovPX activity and the 2004 eSpeed data. The marketable federal debt grew from $3.64 trillion in fiscal 1999 to $4.31 trillion in fiscal 2004.[11] Lower cost of trading through ECNs has facilitated much higher turnover, which appears to explain much of the rest of the difference.

4.2 Spreads

A standard measure of liquidity is the bid/ask *spread*. Dealers in the Treasury market post quotes to both buy and sell Treasuries along with a quantity known as *depth*. A combination of inventory and adverse selection costs explains the existence of spreads in the interdealer market. The inventory component is the cost of keeping a ready supply of securities for sale. The adverse selection component is due to the risk that the dealer's counterparty has private information about future price changes which could lead to losses for the dealer. We compute several measures of this

[11] Ironically, market participants and the Federal Reserve were concerned about running out of Treasuries just a few years ago when federal budget surpluses were growing. Alan Greenspan (2001) testified in January 2001: "At zero debt, the continuing unified budget surpluses currently projected imply a major accumulation of private assets by the federal government."

markup in this section for both the GovPX database in 1999 and eSpeed in 2004.

The most basic measure of the bid/ask spread is the *quoted spread*. The quoted spread is the gap between lowest ask price p_t^a and the highest bid, p_t^b.[12] It is computed it in percentage terms to compare spreads across securities and over time,

$$s_t^q = 100 \times \frac{(p_t^a - p_t^b)}{p_t^a}. \tag{1}$$

Unfortunately, the eSpeed database does not include posted bid and ask prices, and we must compute an alternative measure based on transactions.

A commonly used procedure, first proposed by Thompson and Waller (1988), is to compute the absolute value of the changes in the transactions prices,

$$s^{TR} = \sum_{t=1}^{T} |p_t - p_{t-1}|^+ / T^+. \tag{2}$$

where T^+ is the number of transactions in which the price changes. The correlation between quoted spreads and the transactions measure is 0.99 in the GovPX data.

Table 2 summarizes the differences in bid-ask spreads as on-the-run trading moved to ECNs.

[Insert Table 2 Here]

The GovPX voice market spreads average 0.8344 basis points for the 2-year note, versus 0.2053 for the eSpeed ECN quotes, a reduction of 75%. The reduction is similar for other maturities, a 0.8834 basis point decline in the 5-year, or 76%, 1.7167 basis points in the 10-year, or 82%, and finally, 4.2622 basis points in the 30-year, or 78%. These substantial declines are statistically and economically significant.

5. MARKET IMPACT

A purchase or a sale of an asset might influence prices either through inventory effects or by revealing private information about fundamentals to other market participants. One would like to know how much trades impact prices. Price impact increases the cost of large trades and such costs are often larger than brokerage commissions and spreads. This section examines the interaction between trades and quotes using the vector autoregressive (VAR) system methods that Hasbrouck (1991) introduced.

[12] Many transactions take place within the quoted spread though. GovPX provides a *workup facility* to increase the transaction size but not change the price. Until January 2005, the eSpeed network provided an explicit mechanism for trading between the bid and ask, a process known as *price improvement*.

Hasbrouck proposed to study intra-day price formation with a standard bivariate VAR model. Time t here is measured in 1-minute intervals. Let r_t be the percentage change in the transaction price. x_t^0 is the sum of signed trade indicators (+1 for buyer initiated, −1 for seller initiated) over minute t. Fortunately, both data sets directly indicate trade initiation as a "hit" −1 or a "take" +1.[13]

The bivariate vector autoregression assumes that causality flows from trade initiation to returns by permitting r_t to depend on the contemporaneous value for x_t^0, but not allowing x_t^0 to depend on contemporaneous r_t. The quote revision model is specified as follows

$$r_t = a_{r,0} + \sum_{i=1}^{5} a_{r,i} r_{t-i} + \sum_{i=0}^{15} b_{r,i} x_{t-i}^0 + \varepsilon_{r,t}, \tag{3}$$

$$x_t^0 = a_{x,0} + \sum_{i=1}^{5} a_{x,i} r_{t-i} + \sum_{i=1}^{15} b_{x,i} x_{t-i}^0 + \varepsilon_{x,t}. \tag{4}$$

For comparison to other more recent market impact studies, such as Cohen and Shinn (2003), we include 15 lags of the signed trades.

Our estimates show that transactions are positively autocorrelated and highly predictable. As one might expect, however, only the contemporaneous trade term explains returns very well.

The market impact of the trade can be measured by the dynamic effect on subsequent trade prices. The impact grows over time, generally stabilizing after about 15 minutes. We report 15 minute impact estimates in Table 3 for the 2-, 5-, 10- and 30-year bonds. GovPX estimates for January 1999 are reported in the first column, and eSpeed estimates for January 2004 in the second column. The coefficients are in basis points (100^{ths} of a percent).

[Insert Table 3 Here]

The smallest GovPX market impact is for the 2-year note. Nonetheless, a one unit (1 million dollar) buy order, still moves trade prices by 0.4235 basis points, nearly double the eSpeed impact for the same issue. The relative market impact is inversely related to the relative volumes of the two markets. For the other issues, the GovPX market impact is 5 to 8 times as large, with the latter figure for the illiquid 30-year Treasury. On average, the eSpeed market impact is 73.6% lower than GovPX.

We believe that market impact is the most comprehensive measure of market quality, reflecting spreads, depths and trading volume. The eSpeed ECN seems to illustrate that electronic trading

[13] In microstructure databases, this inference is usually determined by distance from the quote midpoint.

in the secondary Treasury market has benefitted market participants by reducing spreads and transactions costs.

6. CONCLUSION

This article has reviewed the growth of ECNs in equity, foreign exchange and fixed-income markets. The growth of such ECNs has enabled firms and individuals to trade and rebalance their portfolios at much lower cost, thereby enabling them to reduce the risk to which they are exposed.

In particular, this article has examined the growth of electronic competition in the market for U.S. Treasury bonds. The eSpeed and BrokerTec ECNs have captured virtually the entire market for the on-the-run Treasuries. This paper has studied transactions from eSpeed for 2004, a data set that has not yet been explored in the literature, and documented improvements over the earlier voice assisted technology. The electronic market (eSpeed) has greater volume, smaller spreads and a lower estimated impact of a trade. Lower spreads can benefit smaller traders by lowering their costs of portfolio rebalancing. A smaller market impact assures that institutional investors are getting similar benefits.

GLOSSARY

A *broker* is firm that matches buyers and sellers in financial transactions. *Brokerage firms* in bond markets do not trade for their own account. An *interdealer broker (IDB)* is an intermediary providing trading services to hedge funds, institutions, and other dealers. IDB's handle the majority of Treasury securities transactions in the secondary market.

A *commoditized* security has been altered to increase its liquidity, making it an undifferentiated product traded solely on price.

Depth is the quantity the dealer is willing to sell at the bid or offer.

Electronic communications networks (*ECN*s) are electronic trading systems that automatically match buy and sell orders at specified prices.

A *limit order* is a request to buy or sell a security at a specific price. Market orders are buy/sell orders that are to be executed immediately, at current market prices.

On-the-run refers to the most recently auctioned Treasury security of a particular maturity. After the next auction, the other bonds go *off-the-run*.

The *quoted spread* is the gap between lowest ask price and the highest bid.

Trading in on-the-run and off-the-run securities makes up the *secondary* Treasury market.

Boxed insert: **ELECTRONIC TRADING IN EQUITY MARKETS**

The equity markets were the first to embrace electronic trading. Over-the-counter stocks have traded electronically at least since the creation of the National Association of Security Dealers (NASD) automated quote (NASDAQ) system in 1971. Nasdaq was a dealer market without a central trading floor. It was a distant second competitor to the floor based New York Stock Exchange (NYSE).

The Philadelphia Stock Exchange was one of the first floor exchanges in the United States to introduce electronic trading with the PACE (Philadelphia Automated Communication and Execution) System in 1975. PACE permitted two-party trading from anywhere in the world but allowed for only limited information flow. Purely electronic limit order books began with Instinet in 1979. Instinet provided inter-dealer equity trading in both NYSE and Nasdaq securities.[14] Despite the early adoption of this technology, U.S. equity markets tended to lag behind foreign markets in establishing electronic markets. ECNs were created in Toronto in 1977, Tokyo in 1982, Paris in 1986, Australia in 1990, Germany in 1991, Israel in 1991, Mexico in 1993, and Switzerland in 1995 (Economides and Schwartz (1995)).

The Chicago Board of Trade (CBOT) moved the equity futures and options markets significantly toward electronic trading with the successful introduction of GLOBEX, in 1994. The CBOT followed this effort with GLOBEX2, in 1998, which permitted round-the-clock trading.

Christie and Schultz (1994) triggered a watershed in electronic trading by finding Nasdaq market makers to be colluding over spreads. Following this discovery, in 1997, the SEC allowed electronic communication networks (ECNs) or alternative trading systems (ATS) to compete with Nasdaq dealers on an equal footing. This legal deregulation sparked a surge in electronic trading in U.S. equity markets. However, in moving to electronic trading through independent ECNs, the U.S. equity markets have differed from those in the rest of the world, where existing exchanges have largely developed electronic trading.

By 2004, ECNs had grabbed a dominant market share of equity trading. In 2005, both Nasdaq, now incorporated as a for-profit market trading center, and the NYSE, which also plans to go public, initiated mergers with their major electronic competitors. Nasdaq completed its merger with Instinet in 2005 and the NYSE plans to merge with Archipelago as of early 2006, subject to

[14] A limit order is a request to buy or sell a security at a specific price. Market orders are buy/sell orders that are to be executed immediately, at current market prices.

the approval of the SEC. Even with major changes and new electronic competition, the market structure appears to be returning to a duopoly.

[Insert Figure for Boxed Insert on Electronic Trading in Equity Markets Here]

Although Nasdaq dealers held only a 35% market share in October 2005, this figure understates the market power of the for-profit Nasdaq. The combined market share of Nasdaq's own anonymous trading facility SIZE, and the Brut and Instinet ECNs that Nasdaq has acquired, gives this ECN more than 3/4 of the market (Mizrach (2005)).

Going forward, it appears that a hybrid market model with floor based, open outcry trading will co-exist with electronic trading both through limit order books and the Nasdaq dealer structure. Both Nasdaq and NYSE will be able to trade securities listed on either market center.

Boxed insert: **ELECTRONIC TRADING IN FOREIGN EXCHANGE MARKETS**

The foreign exchange market is made up of customers, dealers, and IDBs. Customers are firms or individuals who buy or sell foreign exchange to hedge risk associated with business activities or balance sheet exposure, or take speculative positions to profit from expected changes in exchange rates. Firms may be engaged in finance, like hedge funds, or in nonfinancial activity like importing and/or exporting. Dealers, who typically work for banks, stand ready to "make a market"—that is, to quote prices at which they are ready to buy or sell foreign exchange. Dealers wish to minimize their position in any currency to reduce their exposure to adverse exchange rate movements; dealers profit from the spread between the prices at which they buy and sell, not currency movements. Therefore, most trading in the foreign exchange market is between dealers who are seeking to reduce their currency exposure. Interdealer brokers exist to facilitate this trading by matching buyers and sellers of foreign exchange. They do not take positions of their own.

Until the early 1990s, all foreign exchange trading was conducted via telephone. Reuters introduced the Reuters Market Data Service (RMDS) in February 1981, which permitted the exchange of information over computer screens, but did not allow actual trading. Reuters Dealing 2000-1 replaced RMDS in 1989. The new system facilitated direct trading that used to take place over the telephone (Rime (2003)).

Reuters continued to lead electronic trading in foreign exchange when it launched Dealing 2000-2 (D2000-2) in 1992. This network brokered trades between anonymous parties. Competitors soon followed, however. Minex launched an automated trading system in April 1993 and a consortium of large banks—ABN-AMRO, Bank of America, Barclays, Chemical, Citibank, Citicorp, Commerzbank, Credit Suisse, Lehman Brothers, Midland, J.P. Morgan, NatWest, Swiss Bankcorp, and Union Bank of Switzerland—followed suit by creating Electronic Broking Service (EBS) in April 1993, which later bought out Minex in 1996 (Chaboud and Weinberg (2002)).

For the first few years of their existence, the electronic trading systems (ETS) share of foreign exchange trading grew slowly. But the figure shows that electronic trading was clearly the dominant method of operation in the interdealer market by the late 1990s. Chaboud and Weinberg (2002) estimate the share of inter-dealer trading volume executed through electronic platforms at over 90% by 2001. Voice trading remained important for customers and for less liquid currencies. This is consistent with the general observation that electronic trading has its greatest advantages in the most liquid markets for homogenous assets.

[Insert Figure for Boxed Insert on Electronic Trading in Foreign Exchange Markets Here]

Reuters and EBS remain the principal ETSs in the interdealer foreign exchange market as of early 2006. The latest incarnation of the Reuters network is called D3000. EBS has the foremost market share in trading in the two largest currency pairs, the euro-dollar and yen-dollar, while Reuters has a leading share in British pound rates and the major market shares in a broader selection of exchange rates, including emerging market rates.

In recent years, the already large foreign exchange market has continued to grow. The Bank for International Settlements reports that foreign exchange trading volume grew by 36 percent, from 2001 to 2004 (BIS (2005)). Some of this growth has come on exchanges like the Chicago Mercantile Exchange, which currently only handle a very small proportion of the foreign exchange market. In the midst of this expansion, the dealer market has consolidated; more trading is done by fewer and larger banks.

But a growing amount of foreign exchange trading bypasses the large dealer banks. That is, there are now a number of smaller electronic networks that facilitate transactions between customers and dealers (e.g., FX All, FX Connect and Currenex) and between customers without dealers (e.g., OANDA, HotSpot FX, IG Markets, FXDealerDirect, DealStation, ChoiceFX, Deal4Free Forex, GFT's DealbookFX, GCI, IFX Markets, Grain Capital). These ECNs enable non-bank actors—such as hedge funds—to trade at prices that are very close to those enjoyed by the largest banks.

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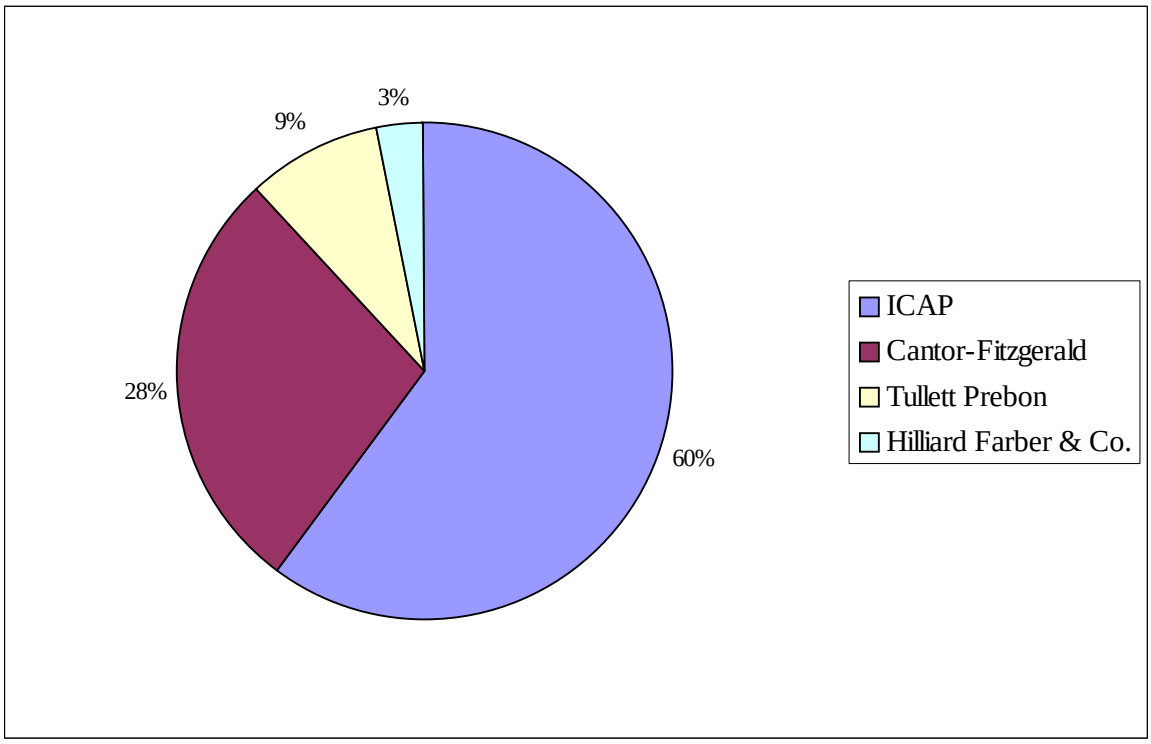
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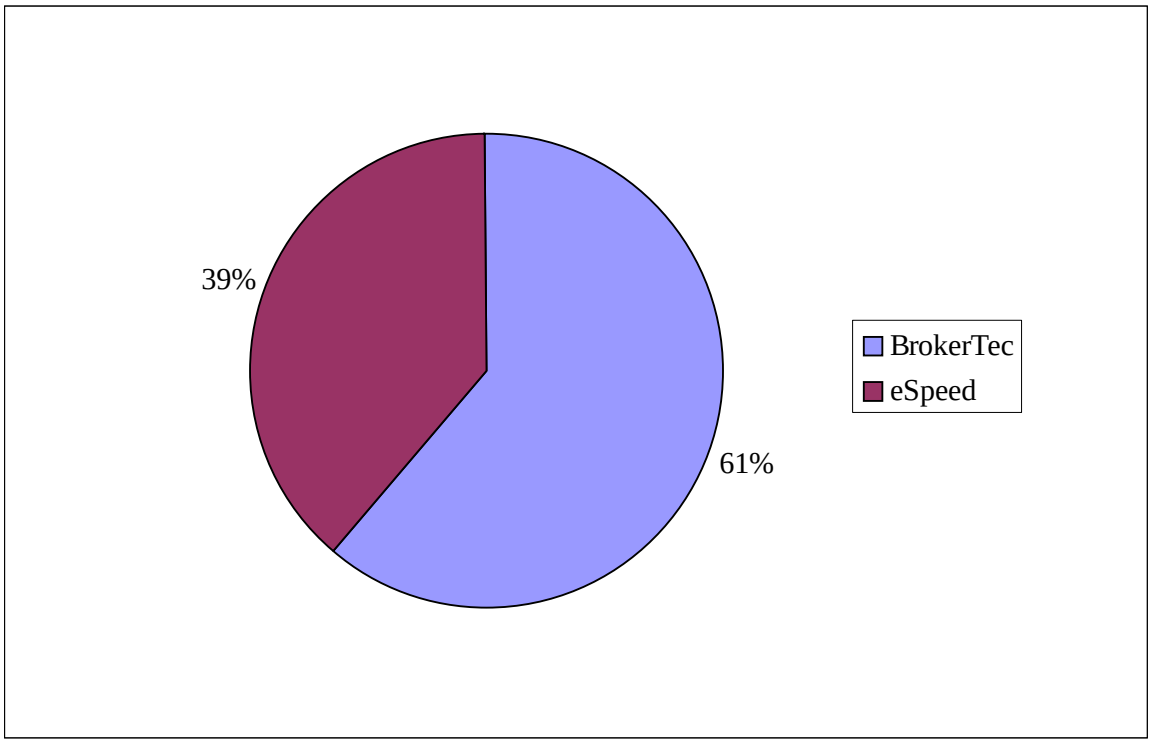
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Figure 1
Secondary Government Bond Market
2005 Market Share



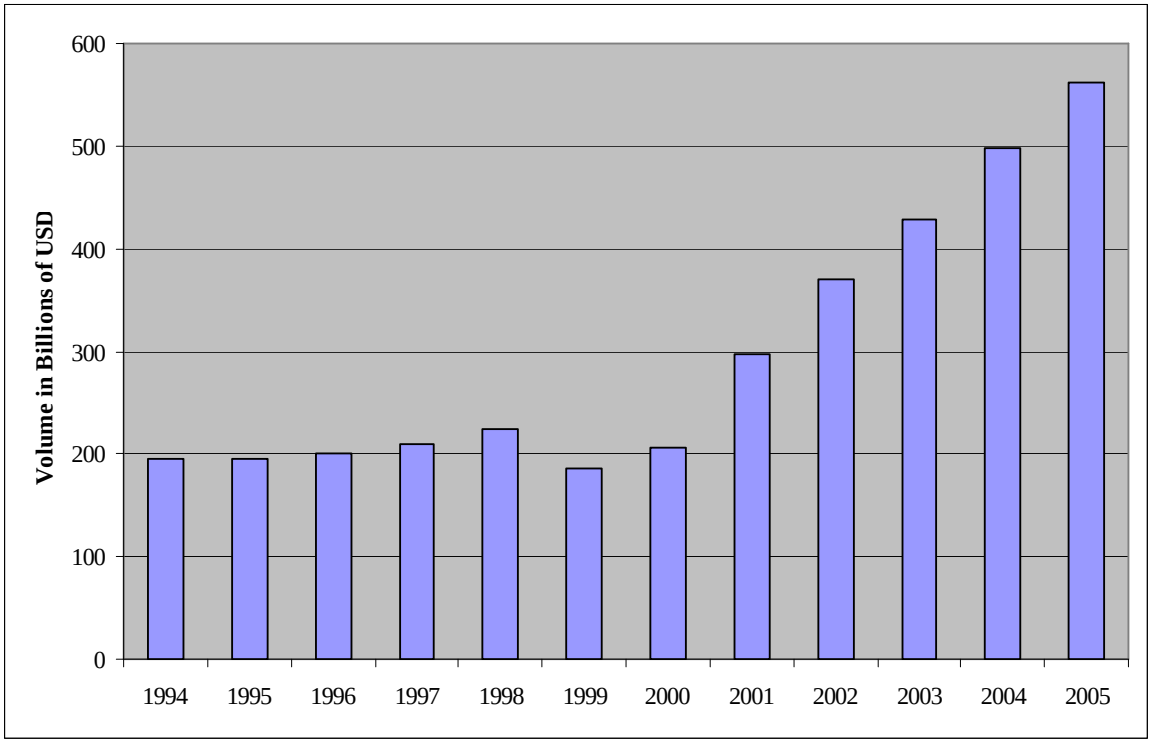
Source: Federal Reserve Bank of New York primary dealer data; ICAP 2005 Annual Report; eSpeed Quarterly Report; Market estimates from www.espeed.com; http://www.cstplc.com (Tullett Prebon).

Figure 2
ECN Trading of On-The-Run Treasury Securities
Market Share 2005:Q3



Source: Federal Reserve Bank of New York primary dealer data; eSpeed and ICAP financials; and author's estimates.

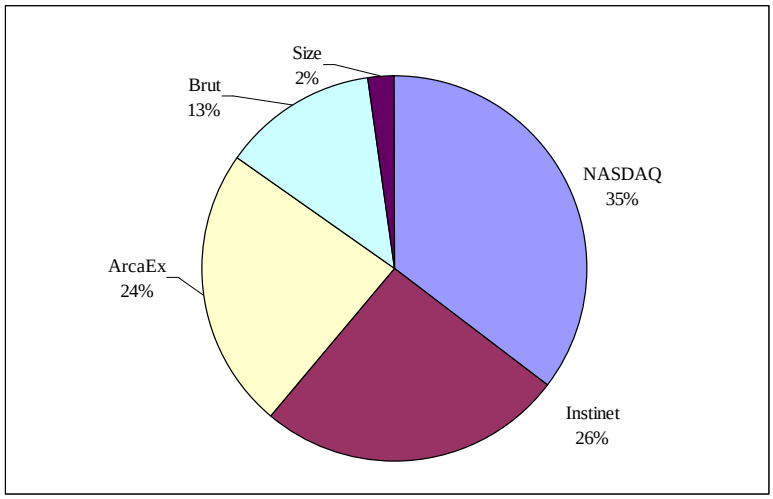
Figure 3
Average Daily Treasury Volume



Source: Federal Reserve Bank of New York primary dealer data. The figure displays average daily volume of U.S. Treasury securities primary dealer transactions, by year.

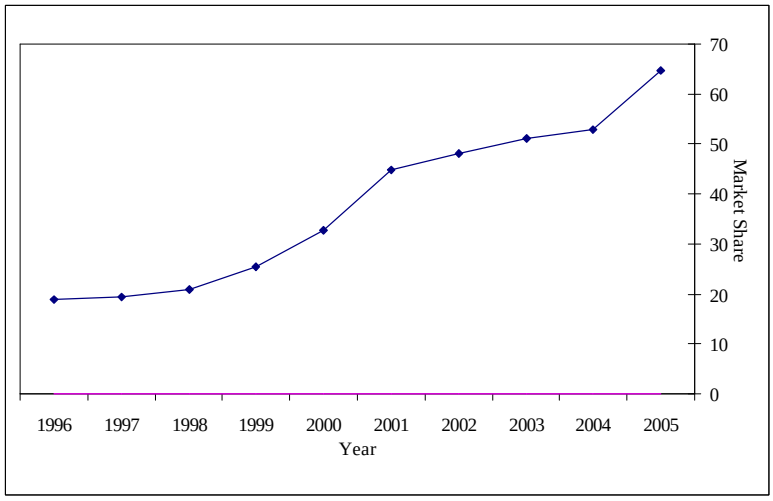
Figure for Boxed Insert on Electronic Trading in Equity Markets
ECN Share in OTC Equities

(a) **Trading Volume of NASDAQ-Listed Shares**



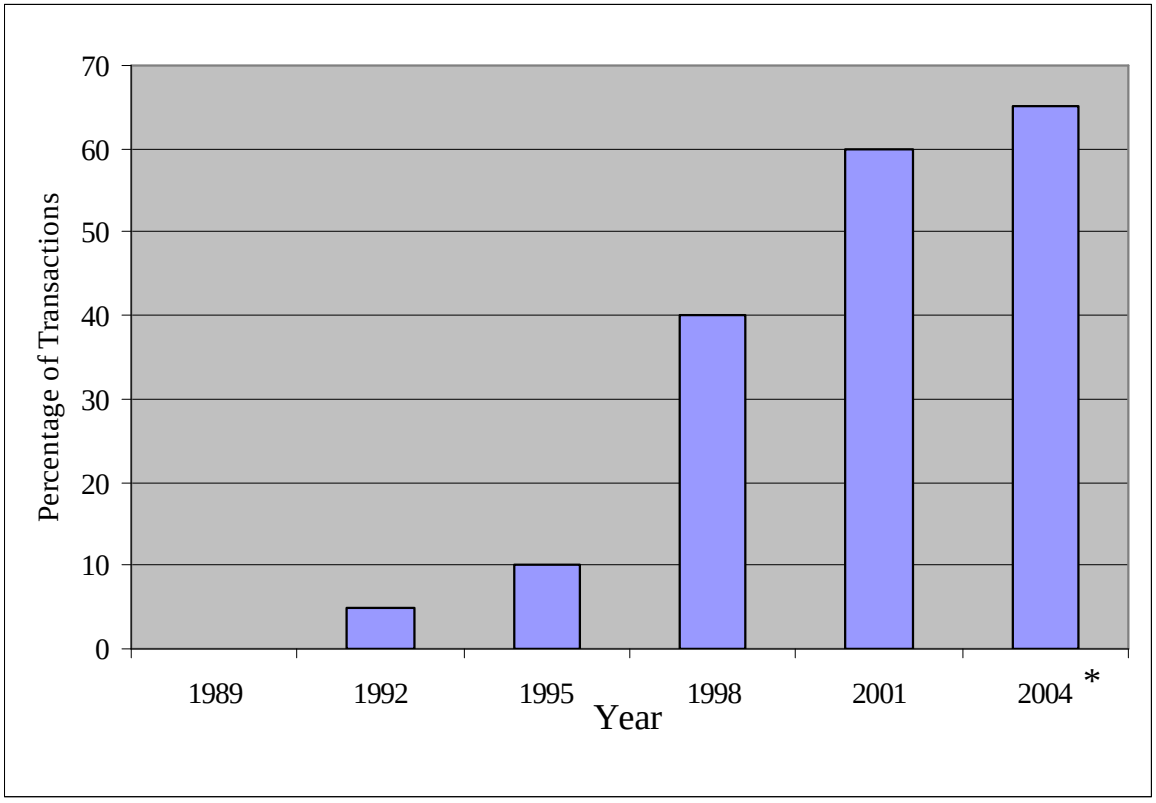
Source: Securities Industry News; Bloomberg; Instinet; Archipelago and Nasdaq. In panel (a), Brut is the Brass Utility ECN, Arca Ex is the Archipelago ECN, INET is Instinet, and SIZE is the Nasdaq anonymous trading facility. All other Nasdaq market makers are grouped into the Nasdaq 35% share. Nasdaq acquired BRUT in September 2004 and Instinet in December 2005.

(b) **ECN's Share of Trading Volume in Nasdaq Listed Shares**



Source: Smith (2002), Merrill Lynch; Bloomberg; Instinet; Archipelago and Nasdaq. Panel (b) shows the growth of ECN trading, since they entered the Nasdaq quote display in 1996.

Figure for Boxed insert on Electronic Trading in Foreign Exchange Markets
Market Share of ECNs in Foreign Exchange Market Transactions



Source: Precise estimates of electronic foreign exchange broking systems' market share are difficult to come by because of the foreign exchange market's decentralized nature. Estimates for 1989-2001 are from Chaboud and Weingberg (2001). The BIS (2004) estimates the 2004 number and states that the share increased slightly in that year by an unspecified amount.

Table 1
Trading Activity in the Voice and ECN Markets

	Trades			Volume		
	GovPX	**eSpeed**	$\%ch$	**GovPX**	**eSpeed**	$\%ch$
2Y	97,105	225,505	132%	1,282,294	1,983,135	55%
5Y	90,150	663,152	636%	521,519	3,760,419	621%
10Y	33,514	777,301	2,219%	246,047	3,647,615	1,382%
30Y	15,533	213,275	1,273%	44,785	578,052	1,191%

The GovPX estimates are from 1999 and the eSpeed estimates are from 2004.

Table 2
Spreads in the Voice and ECN Markets

	GovPX	**eSpeed**	**Δ**spread	%*ch*
2Y	0.8344	0.2053	0.6291	75%
5Y	1.1572	0.2738	0.8834	76%
10Y	2.0986	0.3819	1.7167	82%
30Y	5.4484	1.1862	4.2622	78%

The GovPX estimates are from 1999 and the eSpeed estimates are from 2004. The spread units are in basis points (100^{ths} of a percent.)

Table 3
Market Impact Estimates for the Voice and ECN Markets

	GovPX	**Cantor**
2Y	0.4235	0.2321
5Y	0.9368	0.1709
10Y	0.9066	0.1850
30Y	2.2936	0.2749

These are the 15-minute cumulative market impact effects for the January 1999 GovPX database and for the January 2004 eSpeed transactions based on the VAR analysis (3) and (4). The units are in basis points (100^{ths} of a percent.).