Information Technology and the New York Stock Exchange's Strategic Resources from 1982-1999

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Abstract

This paper applies an extended version of the resource-based view (RBV) of competitive strategy to an 18-year history of investments in information technology by the New York Stock Exchange. The extended RBV predicts that firms will use information technology to enhance their existing resources and to create a system of resources for competitive advantage. It also suggests that once a firm has chosen to compete with technology, it opens up future opportunities to enhance the organization's effectiveness through continued technology investments. . The paper describes the Exchange's IT investments and illustrates them with qualitative and quantitative data from several different sources. The extended model helps to explain the strategy and IT investment pattern at the Exchange. The results provide insights for firms that invest in information technology to create a system of traditional and IT resources to obtain a sustainable competitive advantage.

Introduction

An extended version of the resource-based model of competitive strategy provides insights into the New York Stock Exchange's (NYSE) information technology (IT) investments over an 18-year period. The NYSE is a membership organization owned and governed by its 1,366 seat holders. The NYSE has a dominant position among global equities markets with market capitalization of over $10 trillion, making it more than three time larger than any other Exchange in terms of trading volumes. A successful market infrastructure is a key NYSE resource, and IT plays a crucial role in market operations. Based on extensions to the resource based theory of strategy, we examine how the NYSE's IT investments have enabled higher volumes of transactions processing, which in turn has led to the need for increasing investments in IT.

The NYSE's strategic resource position is considerable, and difficult to replicate. Reflecting the value of market access and positions on its floor, NYSE seat prices have risen from $190,000 in 1982, to over $2.5 million in 2002. A number of researchers have conjectured that organizations with strong leadership positions in an industry will use IT less aggressively and innovatively than smaller rivals and new entrants (Stoneman, 1987)[1]. The analyses indicate that greater market power provides less incentive to undertake costly innovation than a firm in a more competitive market. We believe the opposite is the case at the NYSE.

Using NYSE data on IT investments and market characteristics, we illustrate the Exchange's use of information technology to create a set of resources to try and sustain

[1] Reflecting the slow development of its internet strategy, Merrill Lynch's vice chairman, John Launny Steffans remarked in a keynote address at the June 1998 PC Expo in New York, that "the do-it-yourself model, centered around Internet trading, I think should be regarded as a serious threat to American

its competitive position. This research makes several contributions to our understanding of the relationship between IT investment and strategy. First, the paper explores IT as a strategic resource, using both quantitative data analyses, and a series of interviews with senior management of the NYSE. We use time-series analyses and cross-correlation functions, to investigate causality between the NYSE's IT investment and its operational performance and market quality measures. The results support an extended version of the resource-based view of strategy. We find that the NYSE provides a unique setting in which to study how technological leadership and innovative system enhancements enable an organization to sustain its competitive position over time.

Past Research on IT and Strategy

There is an extensive literature in the information systems field on IT and strategy, dating back to the mid-1980s. Porter and Millar (1985) offer a framework for analyzing the strategic significance of information technology, while Johnson and Vitale (1986) focus on strategic advantage from interorganizational systems. Clemons and Weber (1990a) examined the 1986 Big Bang reforms of the London Stock Exchange, and concluded that IT and the Exchange's new screen-based market were a "strategic necessity." Clemons and Weber (1990b) and Clemons (1991) presents a framework for evaluating strategic IT investments, and Clemons and Row (1991) provide an analysis of the role of information technology in the rapid growth of Rosenbluth travel, a world-wide Philadelphia travel agency. Venkatraman and Zaheer (1990) conducted a quasi-experimental field study of strategy and IT in the insurance industry and found that insurance agencies that adopted new technology generated more new business, though

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financial lives." "Online Trading A Serious Threat, Says Exec", InternetWeek, June 17, 1998. To be fair, Merrill was offering clients online access to research and funds transfers later in 1998.

these agencies began with a better history of new business than matched firms that had not yet implemented a new system

Copeland and McKenney trace the history of computerized reservations systems (CRS) and the strategy of CRS vendors during from the development of these systems in the mid 1960s. Duliba, Kauffman and Lucas (2001) extend this study using a framework of cospecialized assets to show that the benefits of CRS vendors' strategy of deploying their systems to travel agencies. Their work drew on an analysis of ATMs also using a framework of cospecialized assets by Dos Santos and Pfeffers (1995). Research has shown that individual IT investments have provided strategic advantages, but few studies have examined an organization's stream of IT investments over many years to determine its impact on its competitive position.

Prior studies of individual IT investments have shown they provide strategic advantage to some organization under certain conditions for a period of time. Few studies have looked at the impacts of IT investments over a period of nearly 20 years.
Our research presents an example of an established organization extending its information technology resources over time as a part of its strategy to compete with rivals whose operations are enabled by advances in information technology. The New York Stock Exchange offers a unique example of such a setting as it has faced increasing competition from the computer-based Nasdaq, the regional exchanges such as the Chicago Stock Exchange, and from Alternative Trading Systems (ATSs), and ECNs (Electronic Communication Networks), which are based on network technology and online computer systems to match buyers and sellers. Yet, the NYSE has maintained a dominant share of trading volume in NYSE-listed issues -- above 80 percent since 1988.

The market value of NYSE listed companies was $10.0 trillion in July 2002, more than five times greater than Nasdaq $1.9 trillion. The NYSE's share of the market value of NYSE, Nasdaq, and Amex listed companies was 82.3% in January 1998, and 83.0% in July 2002 (see Figures 9-10)

THE RESOURCE BASED VIEW OF STRATEGY

The resource-based view (RBV) of strategy provides a framework for analyzing the response of the NYSE to increasing levels of competition. Two succinct presentations of the RBV are papers by Barney (1991) and Peteraf (1993). The theory defines firm resources as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm."(Barney, 1991, p.101), and proposes that a firm has a competitive advantage when it creates a successful strategy based on firm resources that cannot be duplicated by a current or potential competitor.

An important consideration is that a competitive advantage from resources does not necessarily last forever. Important resources become strategic necessities. The theory states only that a resource-based advantage will not be competed away through the duplication of resources by other firms. There still may be "revolutions" in an industry so that resources that once sustained an advantage for a firm are no longer valuable. "…What were resources in a previous industry setting maybe weaknesses, or simply irrelevant in a new industry setting (Barney, 1991, p. 103)."

The ability of a firm to gain a first mover advantage by implementing a strategy before its competitors depends on its ability to control resources that are not controlled by other firms. In the world of open IT standards and large technology vendors, obtaining such control is very difficult. No one has control over understanding the technology,

access to networks, or a business model. Recent attempts have been made by some entrepreneurs to patent narrow aspects of e-commerce, such as auction designs or single-click buying procedures. It is uncertain how strictly such patents will be enforced. . Resource theorists discuss resource "mobility," which can be thought of as the ease with which one can obtain a resource. If resources are highly mobile, they are easily acquired and a firm cannot obtain a strategic advantage from them.

Barney (1991) contends that heterogeneity of firm resources, and resource immobility can combine to make resources rare, valuable, inimitable and nonsubstitutable. He also suggests that one cannot expect to purchase or acquire strategic resources on the open market; they must come from within the firm. Barney, Mata, Fuerst and Barney (1995) looked at information technology as a source of strategic resources and argue that only IT management skills meet the four criteria for a sustained advantage.

Lucas (2002) presents an extended resource-based model in which an organization's information technology can become a resource that is rare, valuable, inimitable and nonsubstitutable. This model is dynamic and contains a feedback loop to illustrate the fact that strategy and resources are not static. Strategy researchers have noted that the firm must constantly develop and enhance resources that have the potential to provide a sustainable advantage (Teece, Pisano and Shuen, 1997).

Lucas's (2002) extensions to the basic RBV include network externalities and critical mass, and assets to enhance resources. In addition, we can think of resources as a system in which new assets, knowledge and capabilities emerge from the interaction among a firm's stock of existing resources. An example will help illustrate the

extensions to the basic RBV of strategy. Airline computerized reservations systems began as transactions processing systems for making reservations. CRS vendors like American and United extended the systems to travel agencies, and added features to appeal to the agencies, turning the systems into travel-related supermarkets (Duliba, Kauffman and Lucas, 2001), as well as travel agencies' back-office workstations. The airlines continued to invest heavily in these systems creating a technology-based resource that would be very difficult and expensive to duplicate.

In the next section of the paper we describe the New York Stock Exchange and its tangible and intangible resources, and then analyze its strategy using the extended resource-based theory of strategy. We find that the Exchange invested heavily in information technology to enhance its resources and respond to increasing competition. As a result, it developed resources not easily replicated and maintained its strategic position. We do not claim that all IT investments contributed positively to the NYSE's position and advantage. Rather the time series data reveal growing IT investment at a time of increasing competition leading to improvements in the quality of the NYSE's market. The aggregate data shows growing IT investments at the NYSE at a time of increasing competition.

THE NEW YORK STOCK EXCHANGE

Background

The organization that eventually became the New York Stock Exchange was founded in 1792 by a group of investment brokers who met under a tree in lower Manhattan and signed the Buttonwood Agreement. As part of the agreement, the original

24 brokers agreed to transact only with each other and to charge their clients a minimum fixed commission of at least 0.25 percent.

Today, the NYSE is a not-for-profit corporation and self-regulatory organization that, since the 1934 Securities Exchange Act, has been overseen by the Securities and Exchange Commission (SEC). The Exchange had $815 million and $884 million in revenue in 2000 and 2001[2], which would place it just outside of the Fortune 1000, which ranks U.S. firms by sales revenue.

The Exchange is controlled by its 353 member firms, which are the broker-dealer and specialist firms that own the NYSE's 1,366 "seats." The role of the Exchange is to provide a fair and cost-effective market, which in turn encourages liquidity and attracts issuers (companies) to list their stock on the NYSE and become a "Big Board", or "NYSE listed" company. As of March 28, 2002, there were 2,784 listed companies with 343 billion shares and $16.3 trillion in total market capitalization. Direct participation in the NYSE market requires a seat to be owned or leased. In December 2000, a seat was sold for $1.7 million, and in February 2002 one was sold for $2.5 million. A seat provides trading privileges and access to the trading floor, an iconic 37,000 square foot space on Wall Street. On the floor there are about 3,000 traders, 481 of whom are specialists using their own capital to trade. The rest are floor brokers, handling orders for clients, clerks or exchange officials.

Through a provision known as unlisted trading privileges (UTP), the SEC allows other market centers to trade NYSE-listed stocks. The other venues are the five regional stock exchanges, which include the Boston Stock Exchange, the Chicago Stock

Exchange, the Cincinnati Stock Exchange, the Philadelphia Stock Exchange, and the Pacific Exchange. The second non-NYSE venue is the "third market" in which a broker routes an order to a market-making firm, which is registered with the National Association of Securities Dealers (NASD) to trade NYSE-listed stocks as a dealer. The dealer firm is obligated by SEC rules to provide "best execution", and may sell to a customer at the offer quote or less, and may buy at the bid price or greater.

During the past 50 years, the NYSE has faced competition for trading and company listings from a variety of sources. First, it competes with the regional exchanges for trade executions of NYSE-listed stocks. A broker may see a better price on a regional exchange and route an order there for execution. The other market for companies to list their stock is the Nasdaq Stock Market, and the NYSE faces competition for listings from the Nasdaq. The Nasdaq system began operations in 1971, and for many years investors viewed it as a market for small capitalization firms from the over-the-counter marketplace. Typically, when a firm grew too big for the Nasdaq, it moved to the American Stock Exchange and subsequently the NYSE. In the mid 1980s, however, the Nasdaq began to retain firms as they grew, with as one example being Microsoft, which was eligible for NYSE listing shortly after its mid-1980s IPO. In the mid-1990s, the Exchange also faced competition from Electronic Communications Networks (ECNs), such as Instinet, and electronic markets that the SEC is allowing to become stock exchanges in their own right. While ECNs handled 45 percent of all

[2] The four largest revenue sources for the NYSE in 2001 were Listing fees (33%) paid by companies whose stock is listed on the NYSE, Data fees (18%) paid by traders and investors that receive real-time NYSE market data, Regulatory fees (17%), and Trading fees (16%) paid by NYSE broker-dealers.

Nasdaq trades, and 36 percent of Nasdaq shares volume in July 2002, just 1.5 percent of trading of NYSE-listing shares went through ECNs in fourth quarter of 2001.[3]

Electronic Communications Networks (ECNs), such as Instinet, and electronic markets that the SEC is allowing to become stock exchanges in their own right.

NYSE Resources

During its long history, the NYSE has developed a number of important tangible and intangible resources including:

Type	Resource	Measures
Tangible	A roster of listed firms	Number and share of all U.S. listings
	Market capacity	Maximum volume, peak load in messages per second (MPS), order turnaround
	Trading infrastructure.	Downtime, accuracy, error rates, order turnaround, execution quality
Intangible	Market quality	Bid-ask spread, trading volume, quotation size
	Technological innovation	Online comparison systems, off-hour trading facilities, wireless order management, 3D trading floor, e-Commerce initiatives (NYSE direct+)

Listings -- The NYSE has the world's leading roster of listed firms, including most of the largest and most successful U.S. corporations. These listed firms constitute a resource that is rare, valuable and inimitable. However, it is possible to trade shares of NYSE listed firms in other market centers. While firms choose to have a primary listing on the NYSE, there are substitute venues for trading. Hence, the resource does have a substitute.

[3] Nasdaq.com, and "Equity Trading Market Share Quarterly", Salomon Smith Barney, February 8, 2002.

Capacity -- The NYSE has the capacity to process large volumes of trading messages, hence to transact a substantial number of trades. Reported NYSE trades per day averaged 50,400 in 1982, rising to 1,356,400 in 2001, a 27-fold increase. In addition, the NYSE has the ability to handle peak loads in messages per second (MPS) and provide a speedy order turnaround (from order entry to order reporting). Although enhanced system capacity and fast order handling are valuable, it is unlikely that they will confer a sustained competitive advantage.

Trading infrastructure -- The Exchange has built, using technology, a smoothly functioning trading infrastructure consisting of specialists, brokers, computer systems, communications networks and market data reporting systems. However, Nasdaq and electronic exchanges have imitated enough of this infrastructure to be successful.

Market Quality and Fairness -- The New York Stock Exchange is generally regarded as providing a high-quality market with liquidity. Amihud and Mendelson (1989) note that "The value of liquidity is substantial. It could therefore be worthwhile to invest significant resources in improving the exchange's trading systems, since the security traded in the market will then enjoy greater liquidity and their value will correspondingly increase." However, it is possible for other exchanges to offer quality marketplaces, although they need to convince users of their benefits to attract trading volume away from the NYSE. The rules and market procedures of the NYSE are well-known, and trusted. Trading scandals have occurred, but are rare with stiff penalties handed out by the NYSE's enforcement unit. Surveillance and trading rule enforcement are considered to be particularly effective and strengths of the NYSE.

Technological innovations – The introduction of the stock ticker in 1867 marked the beginning of an increasingly important role for IT in the NYSE markets. Over the past 20 years, the NYSE has focused on the technological innovation that includes automatic order routing and processing, online order comparisons, wireless order management, off-hours trading facilities, and lately, internet delivery initiatives. The NYSE's ability to develop innovative, usable, and readily-adopted systems is rare, valuable, and appears to be extremely difficult to imitate, although not impossible.

Resource-Based Advantage

Does the NYSE have any competitive advantage based on these resources? While each of the resources above taken alone does not appear to confer a sustained competitive advantage, the combination of both tangible and intangible resources may do so. Market capacity, trading infrastructure, its roster of listed firms, market quality, and technological innovation are a system of resources from which a sustainable competitive advantage may emerge.

The New York Stock Exchange offers a convenient, efficient and liquid market to trade the stocks of the firms in which a large number of individuals and institutions want to invest. The NYSE has long had a critical mass of buyers and sellers, and its trading infrastructure makes it easy to execute transactions on the Exchange. The established liquidity and the inertia in industry practices helps sustain the Exchange, but history shows that markets will shift to new locations when the established market becomes unattractive (Clemons and Weber, 1996). This combination of resources at the NYSE is rare, valuable, and relatively inimitable and nonsubstitutable. However, as competitors and new entrants seek ways to capture trading volume – as predicted by the RBV -- the

NYSE is forced to continue its investments to enhance and strengthen its strategic resources.

Component of IT Strategy

An organization's strategy evolves over time as new opportunities and threats from competitors arise. We interviewed the Chief Information Officer of the exchange and several of his staff members about strategy and IT investments, and reviewed documents that discussed Exchange strategy dating back 20 years. During the time period covered by the data in this paper, a number of managers were involved in determining strategy and planning for information technology. Details of their thinking and motivation for investing in technology are unknown today, so we collected historical data to try and answer questions about the role and contribution of information technology and strategy at the Exchange.

The Securities Act of 1933 and the Securities and Exchange Act of 1934 made the fair and reliable operation of the nation's capital markets a matter of government and regulatory concern. Given the regulatory environment, it is extremely important that the NYSE be able to meet the requirements of investors and issuers by providing a fast, efficient, and liquid market. We expect investments in information technology to be focused on enhancing the existing resources of the Exchange. Just as the airlines invested over the years to build their CRS's capabilities, the NYSE can be expected to show continued investment in adding to its IT functionality. The components of the Exchange's IT strategy for the last 18 years include investment to:

1. Enhance and extend strategic resources by providing sufficient capacity for processing trade transactions.
2. Enable efficient trade execution.

3. Provide a high quality market for securities
4. Reduce labor expenses and demands for costly physical space.
5. Compete effectively with new types of electronic markets.

Past studies have confronted the critical question of causality. That is, whether or not investments in IT lead to better performance, or higher performance leads to great IT investment (Duliba, Kauffman and Lucas, 2001). The extended resource-based view suggests that firms must continue to invest in IT once they have begun to use technology strategically. According to this model, a successful strategy leads to further investments in IT, which should lead to strengthening one's strategic position. As a result, we expect to find that IT investment and performance exhibit simultaneity or mutual causality.

VARIABLES IN THE STUDY

Table 1 describes the variables in the study. The description of the technology developed at the NYSE came from NYSE publications and interviews at the Exchange. We obtained further data from the NYSE's annual Fact Books, which provides various statistical data on market performance. Share volume is the number of shares traded on the Exchange. The number of trade transactions refers to the total number of annual stock trade transactions at the NYSE, consisting of a count of every sale that occurred on the floor. In some of the analyses, we use the number of trades, rather than number of shares, as one of the dependent variables because the number of shares per trade (known as "trade size") is not critical to trading capacity. The technology resources to process one trade are the same as another trade regardless of how many shares an investor buys or sells; a 100 share trade requires the same processing capacity as a 10,000 share trade.

Due to rapid volume growth, we use log-transformed trade counts in the analyses. The resulting time series has less heteroscedasticity and is nearly linear.

The NYSE and the Securities Industry Automation Corporation (SIAC) provided data on IT investment at the NYSE. SIAC develops and operates the various systems used at the NYSE including trading and regulatory surveillance systems. Since this paper focuses on the extent to which IT enables trades on the floor, we collected only the IT investment data associated with developing and operating floor support systems such as SuperDOT, Common Message Switch, Post Support System, Display Book, and the communication infrastructure. IT investment for developing market surveillance systems was excluded because such systems are not related to order handling productivity.

IT Investment – It should be noted that we adjusted IT investment for inflation since unadjusted IT investment data overstates the true IT investment. To deflate the nominal into real terms, we used the Bureau of Labor Statistics consumer price index (CPI) that measures percentage changes in prices over time. To deflate IT investment, 1983 was chosen as the base year since its price index was closest to 100, and each year's CPI ($CPI_{n=1982,\ldots,1999}$) was then divided by the CPI of 1983 (CPI_{1983}) to obtain the price deflation factor (DF). Finally, we compute inflation-adjusted IT investment by multiplying the unadjusted IT investment by the deflation factor. The data may be found in Appendix A.

Staff - IT headcount refers to the number of IT staff members working for the NYSE and SIAC staff assigned to the NYSE in a calendar year. These IT professionals are typically involved in developing, operating and maintaining the trading systems at the Exchange while providing ongoing technical support. The number of floor employees

indicates the actual number of NYSE employees who handle and process orders *on the trading floor*. It is important to note that we excluded the NYSE employees who work off the floor since they are not generally involved in the market's actual order handling, and we excluded all of the floor personnel who work for member firms, including brokers, specialists and clerks.

Market Quality - The Exchange uses three indicators to measure the quality of markets including, price continuity, quotation spread, and market depth. The Exchange defines and reports these indicators, and we have collected data on them for the period of our study.

Price continuity denotes the size of the price variation from one trade to the next in the same stock (NYSE FactBook, 1999). Figures in our data correspond to the percentage of all transactions that occurred with no change or a minimum of $1/8^{th}$ point ($0.125) change, which is the breakpoint used by the Exchange in compiling statistics.[4] Price continuity is one indicator of the quality of the market; it is associated with trading capacity. If the Exchange is not capable of handling order messages and trades in a timely fashion due to capacity limitations (i.e. network delays or bottlenecks in orders reaching the post.), large order imbalances and trading halts result that can reduce price continuity.

The quotation spread is the difference between what a buyer is willing to bid for a stock, and the seller's asking price. This spread is one of the key measures of market quality. It can also be viewed as a transaction cost that market makers charge to keep the market liquid. Numbers in the dataset indicate the percentage of bid and ask spreads that

[4] On June 24, 1997 the minimum price increment on the NYSE changed to $1/16 ($0.0625) from $1/8. On January 29, 2001, decimal pricing began and the minimum price increment became 1 cent.

was ¼ point ($0.25) or less, which is the breakpoint used by the Exchange for collecting data. For example, the number 85 means that the quotation spread was ¼ point or less in 85 percent of exchange-published quotes. The higher the percentage, the more liquid is the market.

According to the NYSE FactBook (1983), market depth implies "the amount of buying and selling pressure a stock will withstand before its price changes significantly". In the traditional finance literature, the depth of the equity market is usually determined by the number of shares of a security that can be bought and sold without causing a substantial change in price. Figures in our dataset from the Exchange indicate the percentage cases in which the average stock price showed no change or a 1/8th change on 3,000[5] shares of volume (a larger percentage is associated with more depth in the market). For example, in 1998 the average stock showed no price change or a 1/8th point change in 3,000 shares of volume 85.3 percent of the time. Market share is the share of all trades and all traded shares of NYSE-listed stocks that take place on the NYSE (as opposed to the Third Market, or the American Stock Exchange.

RESULTS

Conducting a study of an organization over an 18-year period with mostly secondary data creates several limitations, and the data available for this study is both qualitative and quantitative. We would like to have detailed investment timing and amounts for each major system so we could investigate each system's impact on daily transactions. Unfortunately, such data are not available. Instead, to analyze the Exchange's strategy and IT investments, we are forced to present descriptions of the

[5] After 1988 the data is based on 3,000 shares of volume – all other years on 1,000 shares of volume.

major trading systems at the Exchange, and data on the overall performance of the Exchange.

The results strongly suggest that the NYSE has invested in IT to provide an adequate reserve of transactions processing capacity and an operationally efficient market. We were able to perform an econometric analysis to provide a picture of IT investment and volume growth, and enhancements to market quality. However, we cannot quantitatively demonstrate that IT "caused" market quality improvements, nor can we quantify the innovativeness of the NYSE in adding new systems to their marketplace.

Information Technology to Support the Market

The paper argues that the NYSE has invested in IT to create new resources for advantage and enhance existing resources. In particular, the IT at the Exchange provides for efficient trade execution and adequate trading capacity. IT has also helped insure a high quality securities market, and has reduced labor expenses and the demand for physical space. All of the Exchange's resources, when viewed as a system, have enabled it to compete successfully with other exchanges, especially Electronic Communications Networks like Island and Instinet, which announced a $508 million merger in mid-2002

NYSE IT Investments. The U.S. securities industry's back-office crisis in 1969, accelerated the NYSE's computerization plans. Increased trading volumes and a paper-based settlement system forced the NYSE and other U.S. stock markets to close for trading on Wednesdays for six months through mid-1970. On these days, brokers and traders helped back-office clerks to process trades and sort out unsettled transactions. The opening of the National Securities Clearing Corp. (NSCC) and the Depository Trust Co. (DTC) in 1972 and 1973 led to better back-office efficiencies and greater clearing and

settlement capacity. The continuing growth of trading volumes and additional listings in the 1970s led the NYSE to consider its alternatives for expanding its trading capacity. Rather than undertake costly expansion of its physical floor, The NYSE chose to invest in IT to increase the capacity of the market. The systems introduced between 1977 and 1987 enabled the Exchange to remain open for trading and to process record volumes during the October, 1987 market crash.

During this first period of investment for which we have data (1983-1987), the Exchange developed a number of systems to speed transactions processing and provide adequate capacity to handle the growth in volumes and new listings. See Figure 1 and Table 2. Its IT strategy was to provide enough processing capacity and systems to assure that the market could function properly with volumes three time those of an average day.

The early projects to develop e-market capabilities at the NYSE's included the (1) Common Message Switch (CMS, 1977), the (2) Designated Order Turnaround system (DOT, 1976), which became SuperDot (November 1984), and (3) Display Book and (4) Broker Booth Support System (both in 1993). These four systems are described below:

Category	System	Descriptions	Specific Functionality
Order Processing	Common Message Switch (CMS, 1977)	a message forwarding device that links member firms to Exchange systems	• receive/forward messages

	DOT and SuperDOT (1984)	an order processing system that receives incoming orders from member firms and routes them directly to specialist post or broker booth	• process incoming orders, assigns an order reference number • route orders to trading posts • match buys and sells for the opening and report imbalances to specialists • provide a "circuit-breaker"
Broker Support	Broker Booth Support System (BBSS, 1993)	an order management system that enhances brokers processing capability on the Trading floor	• integrate many different applications, services, and functions into a single unit • handle booth- routed orders • monitor, report and research orders
	e-Broker (1997)	a wireless hand-held device that connects floor brokers to their booth and off-floor locations	• improves communication between floor brokers and booths
Specialist Support	DisplayBook(1993)	an electronic workstation that displays all limit orders and incoming market orders	• sort the limit orders and display them in price/time priority • improves the speed and efficiency of reporting executed orders

Source: NYSE FactBook, 1997

NYSE Major IT Investments
Table 2

From about 1988 until 1994, investments in IT showed little increase, matching an economy that was growing slowly. See Figure 1. The Exchange's IT strategy at the time was to maintain the status quo with its major initiative being broker booth support. After 1994, the NYSE invested more heavily in IT as trading volume accelerated, and it faced competition from the Nasdaq, which was becoming known for the IPOs of

attractive new technology listings, and the ECNs. The Exchange also saw transactions rising dramatically in the buoyant capital markets and the expanding economy of the 1990s. In this period continuing to the present, the NYSE's IT strategy has been to use technologically aggressively to meet competition from a number of sources as well as demands for trading capacity.

The NYSE's important market systems challenges are opening in the morning when a burst of orders arrive and the opening price is set, and maintaining adequate message capacity at other times to prevent delays and latencies. Capacity planning is based on a model that translates trading volumes per day into a number of messages per second required to send orders, cancellations, and trade reports. The NYSE has continuously improved its peak-message capacity from 29 messages per second in 1984, to 110 in 1989, and 285 in 1997.

The cycle time for completing a trade has decreased dramatically in the last 18 years. SuperDot routes orders directly to the floor specialist, bypassing the floor broker and eliminating the need to communicate an order to a person who must walk to the specialist's booth. The Broker Booth Support System electronically routes complex orders to floor traders. Displaybook reduces the time a specialist requires to complete a trade. In addition, the Exchange's overall IT infrastructure makes possible online trading via the Internet by providing real-time quotes, instant trade confirmations, and a short trade cycle.

The newest NYSE system is called Openbook; it provides a real-time view of the aggregate limit-order volume at every bid and offer price for every NYSE-listed security (www.nyse.com). This proprietary data product is used by market professionals as they

try to assess liquidity in a particular stock. Some 950 firms and 26 vendors who sell data currently subscribe to the system. Openbook is a good example of a technology that extends the NYSE's network externalities. Openbook provides important information to market participants, and by doing so encourages them to trade on the NYSE rather than in an alternative market.

NYSE Market Performance. There are several measures of market performance at the Exchange.

1) Market Capacity: Figure 2 shows the number of NYSE listed stocks at the Exchange from 1982 to 1999 while Figure 3 presents data on total transactions volume. Note how level the number of transactions is during the first two periods of the Exchange's IT strategy, 1982-88, and 1989-94. In 1994, the number of transactions increases dramatically in response to the booming economy, the technology investing craze and the growth of dot.com firms.

Figure 4 contains the number of transactions plotted against the number of floor employees. There are increases in the number of listed stocks, and large increases in the number of annual transactions processed at the Exchange during the period. At the same time, the number of NYSE floor employees has steadily declined. Is information technology responsible for these results? Investments in message processing and systems like SuperDot, Broker Booth Support System and Displaybook facilitate the substitution of electronic workflows for physical movement of floor brokers, and voice and written communications. The systems described above make it possible to execute transactions faster, and thus increase the capacity of the Exchange to handle trading. The ability to process all trades submitted within seconds is one part of providing a liquid market.

These systems have led to a reduction in the number of NYSE floor employees by automating previously manual tasks.

Interviews with NYSE senior management provide further information on the role of IT in trading capacity. The Exchange's policy is to have:

1. Capacity for twice the highest 5 minute peak in messages per second.
2. Capacity for 2.5 times the average high peak over a 10 day period.
3. Capacity to process 5 times the average daily volume.

As of the time of data collection in 2000, the Exchange's peak volume was 455 messages per second over a one second period. This number is nearly half of the Exchange's maximum capacity of 1,000 messages per second. The highest daily volume was 1.5 billion shares and the Exchange's models indicate it could process 4 billion shares a day. The NYSE is doubling message capacity to 2,000 messages per second. These capacity expansion policies require regular investment to upgrade network hardware.

The recently retired CIO of the Exchange stated that his most significant technology challenge was opening in the morning.[6] While opening for business does not sound like a major challenge, it is of vital importance given the significance of the NYSE in world financial markets. Imagine the resulting financial panic if the New York Stock Exchange failed to open for trading one morning! One measure of market performance, then, is the long history of openings and the Exchange's history of successfully maintaining a market.

Senior IT management at the Exchange said that the number of uncompared trades has dropped considerably over the years because of online comparison systems. In 1987 the number of uncompared trades (buys and sells that did not match at the end of

the trading day) was 3.4%. By 1997 the rate of uncompared trades was 0.06%, on double the trading volume (The Exchange, November 1997). At one time there was a room full of clerks who worked into the night to resolve out-trades in which a buy order did not match a sell. The room no longer is in operation.

2) Market Quality: There are three indicators of market quality in Table 1, price continuity, quotation spread and market depth. Table 2 presents the results of regressing these variables against IT investment in the previous year, controlling for average trade size.[7] IT investment is lagged to reflect the fact that we do not know when during the year the investment occurred; in addition an IT investment takes some time to have an impact (Brynjolfsson and Yang, 1996). OLS estimates indicated significant autocorrelation, so we present the results of the Prais-Winsten (1954) procedure for time-series data. The Prais-Winsten method is a popular procedure for correcting for autocorrelation in time series data. In Table 2 IT investment is significantly positively associated with price continuity and quotation spread, but not market depth. The evidence suggests that the Exchange's extensive investments in technology have helped smooth trading and speed execution, resulting in fewer price fluctuations and more narrow spreads. These factors in turn improve the quality of the market by providing more liquidity and greater capacity. The market depth indicator reflects the price changes after 3,000 shares trade, and we see little reason to believe IT systems influence this economic decision.

[6] Comments by William Bautz in an NYU class on 4/26/2000.
[7] The table shows statistical significance, but the data are a census and not a sample.

Figure 5 shows the number of IT employees rising gradually over time while the number of floor employees declined considerably. This decline in the face of increasing trade volume shows a shift of employment from floor personnel to technology workers.

The curve in Figure 6 of number of transactions divided by adjusted IT investment shows that the Exchange has become more efficient with respect to IT inputs over time; each dollar of IT investment is associated with an increasing volume of transactions, especially since 1990. (To some extent this increase in investment/volume is due to the "bull market" of the 1990s. However, the adjusted investment curve is generally linear suggesting that the Exchange has consistently invested in IT.)

The evidence illustrates the NYSE's strategy of investing in information technology to increase capacity, the efficiency of trading and market quality, and to reduce labor and space requirements of growing volumes. The systems described earlier were designed for this purpose, and the data on market operations shows that the Exchange has been successful in providing capacity and market quality to meet investor demands. Systems like SuperDot allow the rapid execution of orders so the NYSE can reduce transactions turnaround time and increase throughput. BBSS, SuperDot, DisplayBook and CMS all contribute to the Exchange's ability to processing an increasing transactions (trade) volume and to do so with adequate response times as shown by the performance of the Exchange for the 18 year period of this study.

IT Investment and Trade Transactions

When a firm invests in technology to create strategic resources, it can expect to face demands for continuing IT investments to enhance and extend these resources (Lucas, 2002). We suggested earlier that investment in IT enhances the ability of the

Exchange to process transactions, and increasing volumes of transactions call for further investment in IT. If this argument is correct, we should see evidence of simultaneity in trade volumes and IT investments at the Exchange. Technology budgets are frequently based on the events of the prior year, e.g. last year's IT budget, corporate sales, or a similar measure. A likely basis for setting the IT budget at the Exchange is the prior year's transactions volume as it suggests the demand for new technology to meet current and projected processing requirements. IT investment in one year provides the ability to process transactions in the next year by increasing hardware capacity and developing new software applications. Due to the lead time of acquiring hardware and the development time for software, there is a lag between investment in IT and the results of that investment. Consistent with past research (Duliba, Lucas and Kauffman, 2001), we have chosen a one-year lag. The logic behind this analysis is that IT investments in one year enable the processing of a higher volume of transactions in the following year, and that higher transactions processing loads lead to more investments in IT in the following year's budget.

To explore the relationship between IT investment and transactions we tested the models in Table 3. We regressed trade transactions against adjusted IT investment and IT headcount in a contemporary model (time t) and a model in which investment is lagged one year (time t-1). We followed the same procedure using trade transactions to predict IT investment. The objective is to determine whether IT investment predicts transactions or transactions predict IT investment or both. The OLS estimates indicated the presence of significant autocorrelation, so we ran both Prais-Winsten and Yule-

Walker estimates. Figure 7 presents a cross-correlation analysis of the data; see Appendix B for an explanation of this analysis.

There is very little difference between the contemporary and lagged models in Table 4.[8] IT investment and headcount are positively related to the log of transactions in the contemporary model, while headcount has a negative relationship in the lagged model. Log of transactions at time t and at time t-1 strongly predicts IT investment. The cross-correlation analysis in Figure 7 provides weak evidence that IT investment precedes transactions and that transactions precede IT headcount. However, the differences in predicting transactions volume from IT investment and vice versa are not strong, supporting the presence of simultaneity. IT investment predicts present and future transactions volume and transactions volume predicts present and future IT investments.

HAS THE NYSE STRATEGY BEEN SUCCESSFUL?

Market Share

Figures 8 and 9 show two calculations of NYSE market share, the Exchange's share of the consolidated ticker and its share of all trades at the NYSE, American, and Nasdaq markets. Despite its investments in IT and its competitive strategy, the NYSE has lost some market share in the U.S. For NYSE-listed stocks, the decline has been less than 5 percent since 1982. The Exchange's investment in IT may have limited its market share decline during a period of intense change in the financial markets brought on in part by the Internet, and new rival trading systems. In 1998, the Nasdaq Stock Market acquired the American Stock Exchange. In Europe and elsewhere, exchanges are consolidating. The future of the London Stock Exchange as an independent organization is in doubt partially because it failed to invest in IT (*Wall Street Journal*, 11/2/2000). The NYSE's

substantial investments in IT have maintained its competitive position by enhancing and strengthening its strategic resources.

The data strongly suggest that the NYSE has achieved higher capacity, reduced cycle times, higher quality and greater efficiency from its investments in information technology. While the NYSE's market share has fallen, we argue that IT has helped keep the decline to a minimum during a time of great change in financial markets. Technological innovations also seem to have contributed to protecting market share. For example, a new Exchange e-commerce initiative, NYSE Direct+, was implemented in April of 2001. This service is a no-fee, automatic and immediate execution of limit orders up to 1,099 shares at the published quote. This initiative is the first time the NYSE has offered automatic trade execution within the auction market model. The new investment in IT is intended to compete with ECNs, and to improve on their operations since orders are executed against the full liquidity of the NYSE.

The Exchange's investments in IT over the last 18 years prepared it to deliver on many of the promises of electronic commerce including direct access, real-time quotes, market information and the new automatic execution system just announced. Reduced trade cycle times facilitate e-commerce, while all of the Exchange's technology helps it meet the challenges of electronic markets. The *Wall Street Journal* compares the NYSE and the troubled London Stock Exchange:

> "…The New York Exchange is one of the few international markets to survive … combining new technology with an old-time trading floor. The others, including London in 1987, have shut their trading floors in favor of computers. Since then, London has been unable to stay ahead of rivals in technology (*Wall Street Journal,* 11/2/2000, p. C1)."

---

[8] Please see Note 3.

So far, NYSE investments in information technology have allowed it to remain a leading exchange by 1) facilitating electronic trading, and 2) continually enhancing strategic resources to compete with regionals, the Nasdaq and electronic exchanges.

DISCUSSION

The NYSE is an example of how an established organization applied investments in information technology to reinforce strategic assets and remain competitive over a long period of time. While each resource alone may not be rare, valuable, inimitable or nonsubstitutable, their combination with appropriate technology can produce a system of resources that helps an organization remain competitive. IT investments provided a modern trading infrastructure, which reduced the time for clearing and facilitated increasing trading volumes. The upgraded IT infrastructure improved the quality of the market, and helped reduce bid-ask spreads. All of these outcomes continue to attract investors and listed companies to the NYSE.

This study supports an extension of the resource based strategy model for IT resources. Information technology can be used to create highly specialized assets that become strategic resources. The NYSE followed a unique path to create IT-based resources that augment its existing resources of brand name, roster of listed firms, capacity, and quality of market operations. We believe that the combination of traditional and IT based resources combine to form a system of emergent resources that may be rare, valuable, inimitable and nonsubstitutable.

However, a strategy that includes information technology is difficult to sustain due to technological discontinuities. The Internet is one such frame-breaking change that has affected strategy at the NYSE. Advanced IT and the Internet have made possible

virtual, electronic exchanges that do not require a physical floor for trading, and e-brokers who route trades directly to ECNs. Competing with these new threats has required further investment in IT by the Exchange, and the need to change long-standing practices. For example, the new direct execution system bypasses the specialist.

If a firm chooses to compete through the creation of technologically-based resources, it faces continued demands for innovation and investment. The 18-year history of IT investment and strategy at the NYSE illustrates a continuing cycle of IT investment to enhance the Exchange's resource base and meet the competition. We believe that an extended resource-based model can help organizations understand the role of IT in creating such a system of resources.

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Appendix A
NYSE Investment Data

Year	$ITInvestment_{unadjusted}$ (in thousands)	$ITInvestment_{adjusted}$ (in thousands)	Deflation Factor (DF)	Consumer Price Index (CPI)
1982	22264	23072	1.04	96.5
1983	26614	26721	1.00	99.6
1984	35844	34499	.96	103.9
1985	37237	34607	.93	107.6
1986	42454	38735	.91	109.6
1987	46606	41026	.88	113.6
1988	56022	47356	.85	118.3
1989	68675	55383	.81	124.0
1990	67856	51917	.77	130.7
1991	62002	45523	.73	136.2
1992	72275	51515	.71	140.3
1993	78580	54381	.69	144.5
1994	96874	65367	.67	148.2
1995	96811	63524	.66	152.4
1996	97283	62003	.64	156.9
1997	111404	69411	.62	160.5
1998	122977	75446	.61	163.0
1999	143322	86028	.60	166.6

Appendix B
Statistical Procedures

See *Applied Econometric Time Series*, Walter Enders, John Wiley and Sons, Inc., New York, Chichester, Brisbane, Toronto, Singapore, 1995.

We will use a number of time-series summaries. Consider a series noted as $x_1, x_2, ..., x_n$.

The following come from Enders, p 86. Let the mean of the series be $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$. The sample variance is $\hat{\sigma}^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$.

The autocovariance of lag s ($s > 0$) is computed as $C_s = \frac{1}{n}\sum_{i=s+1}^{n}(x_i - \bar{x})(x_{i-s} - \bar{x})$. This is made symmetric about $s = 0$ by using $C_s = C_{-s}$.

The lag s autocorrelation is then

$$r_s = \frac{C_s}{\hat{\sigma}^2} = \frac{\sum_{i=s+1}^{n}(x_i - \bar{x})(x_{i-s} - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

By construction we have $r_s = r_{-s}$.

For cross-correlations, see *Time Series Analysis*: *Forecasting and Control*, 3rd edition, by George E. P. Box, Gwilym M. Jenkins, and Gregory C. Reinsel, Prentice-Hall, 1994. For positive lag *k (p. 411)*, define

$$c_{xy}(k) = \frac{1}{n}\sum_{t=1}^{n-k}(x_t - \bar{x})(y_{t+k} - \bar{y})$$

The lag is positive, x-to-y. Notice that the divisor is n, even though there are $n - k$ summands. Also note that $\bar{x}$ and $\bar{y}$ are computed from the entire time length even though the last k of the x's and the first k of the y's are not used.

This notation can be extended (with k as a positive integer so that $-k$ is negative) to

$$c_{xy}(-k) = \frac{1}{n}\sum_{t=k+1}^{n}(x_t - \bar{x})(y_{t-k} - \bar{y})$$

It should be noted also that $c_{xy}(-k) \neq c_{xy}(k)$; in fact these two quantities do not even have to be close.

Along with this, we let

$$s_x = \sqrt{c_{xx}(0)} = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(x_t - \bar{x})^2}$$

$$s_x = \sqrt{c_{yy}(0)} = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(y_t - \bar{y})^2}$$

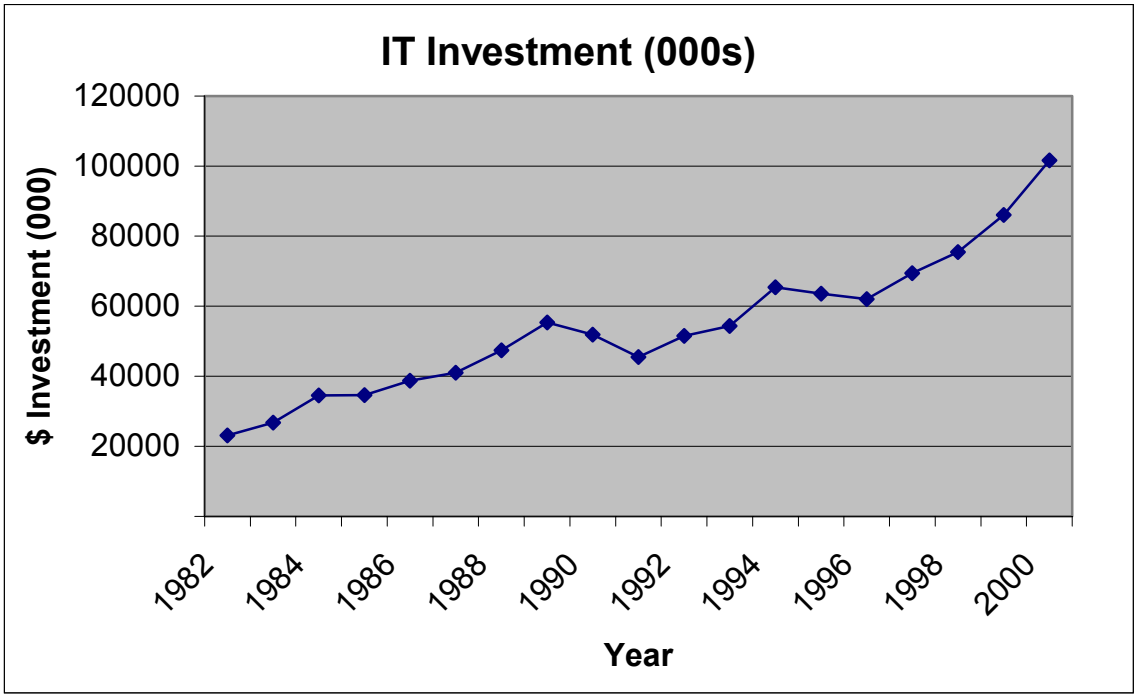
Finally, we use

$$r_k = \frac{c_{xy}(k)}{s_x\, s_y}$$

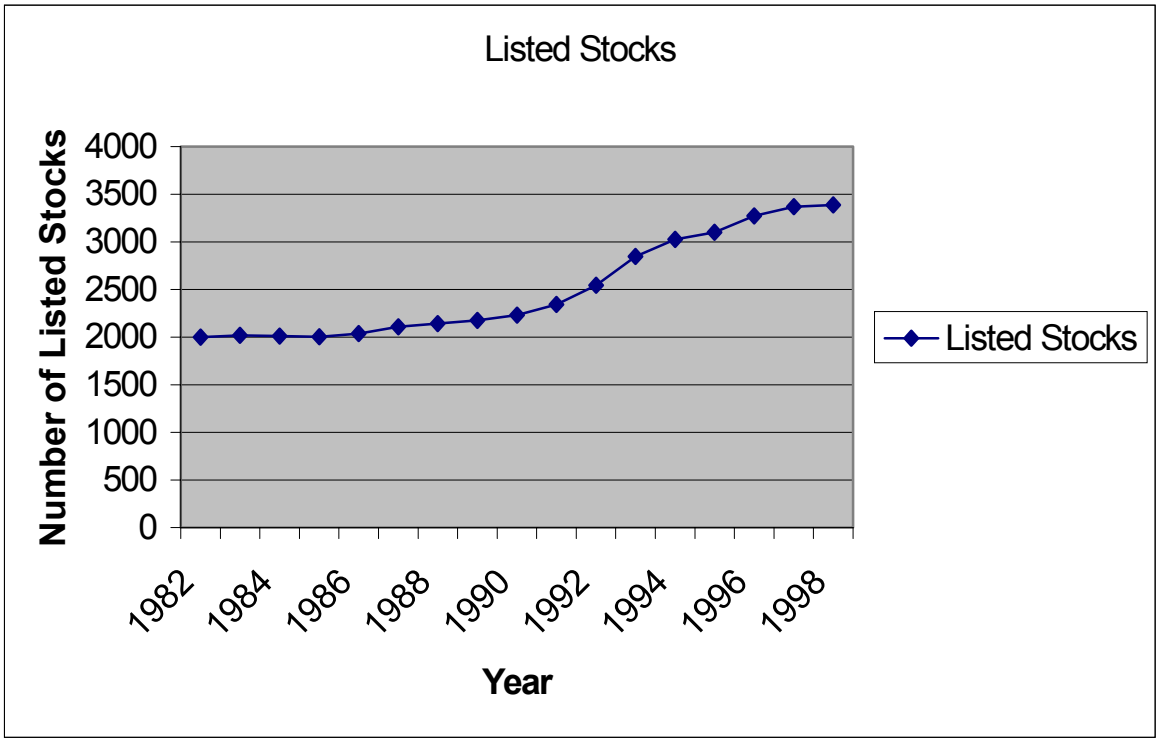
It should be noted that r_{-k} will have no special relationship to r_k .

Variable	Definition	Source
Systems	Trading systems	NYSE Factbook, interviews
Volume	Share volume	NYSE Factbook
Log (Transactions)	Total trade transactions per year	NYSE Factbook
IT investment	Yearly NYSE investment in IT at the Exchange and through SIAC, adjusted for inflation	NYSE & SIAC
IT head count	Number of IT staff at the NYSE and SIAC each year	NYSE & SIAC
Number of floor employees	Number of people employed by the NYSE on the floor of the Exchange (note specialists and traders are not NYSE employees)	NYSE
Price continuity	The size of the price variation, if any, from one trade to the next in the same stock=% of all transactions that occurred with no change or minimum of $1/8^{th}$ point change	NYSE FactBook
Quotation spread	% of the quotation spread of 1/4 point or less	NYSE FactBook
Market Depth	% of the average stock in 3000 shares that showed no price change or $1/8^{th}$ point change	NYSE FactBook
Market share	Percentage of trades on the NYSE	NYSE FactBook NASDAQ Web site

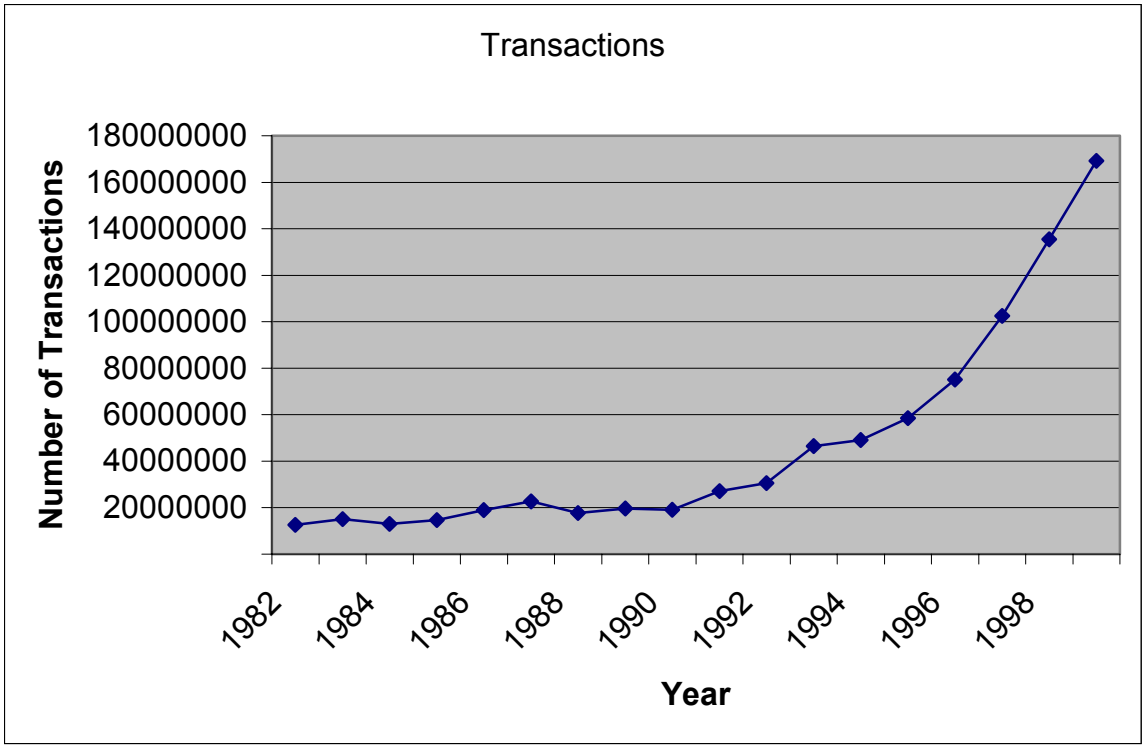
Variables in the Study
Table 1



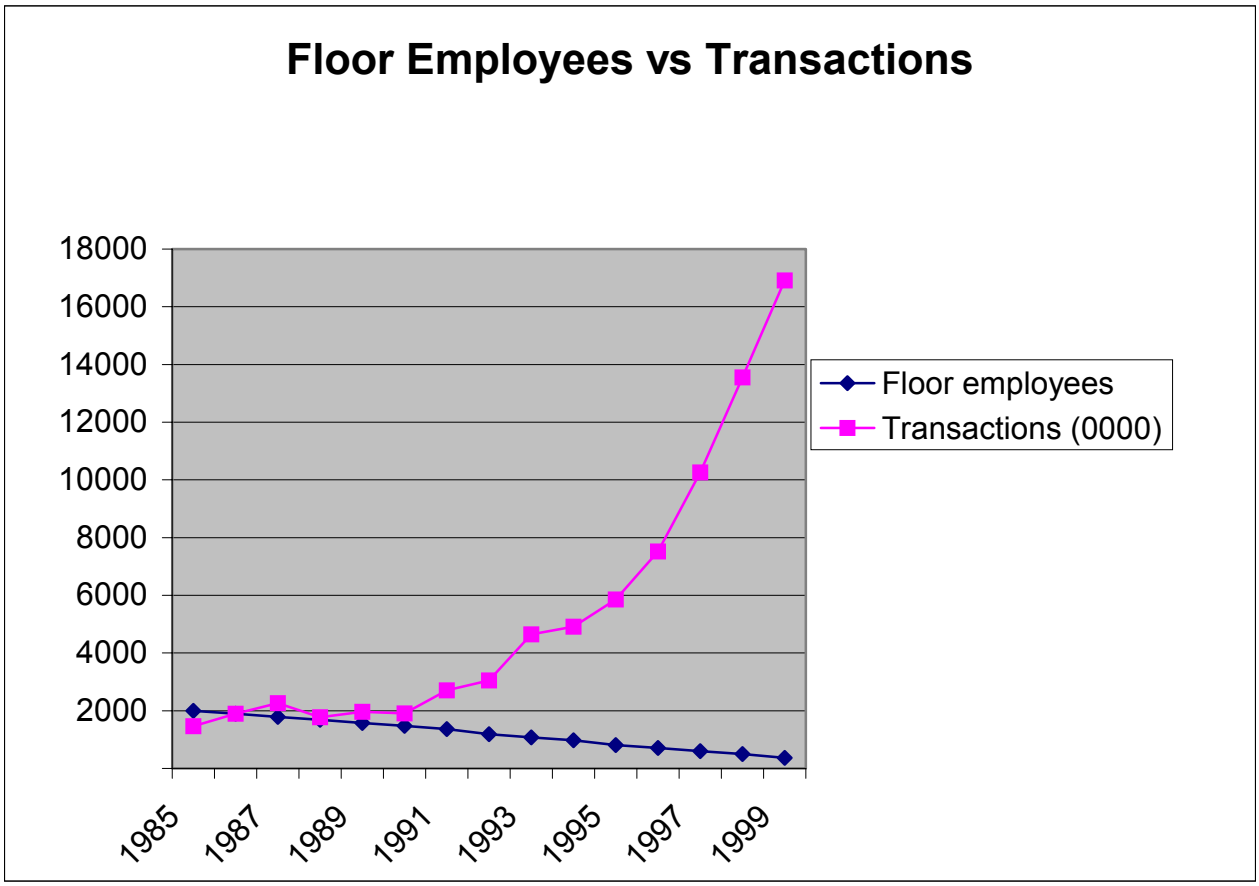
Adjusted IT Investment
Figure 1



Number of NYSE Listed Stocks
Figure 2



Annual Transactions Volume
Figure 3

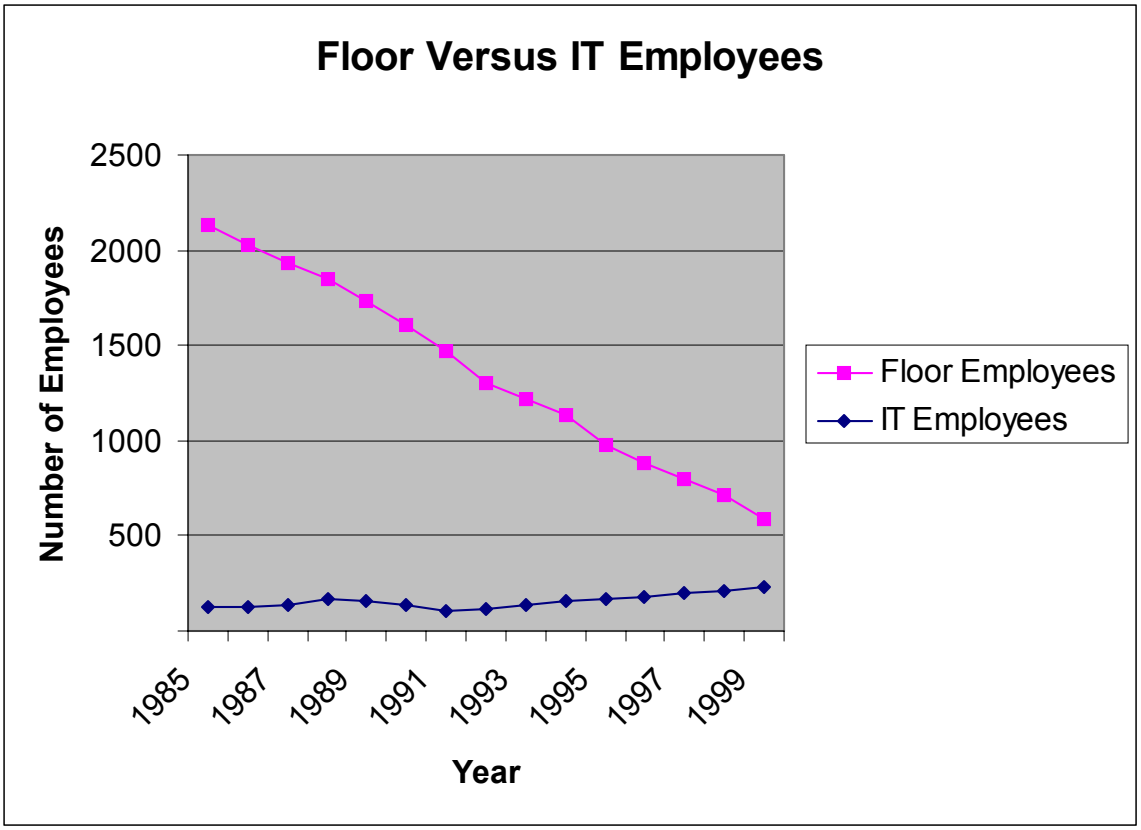


Floor Employees and Transactions
Figure 4

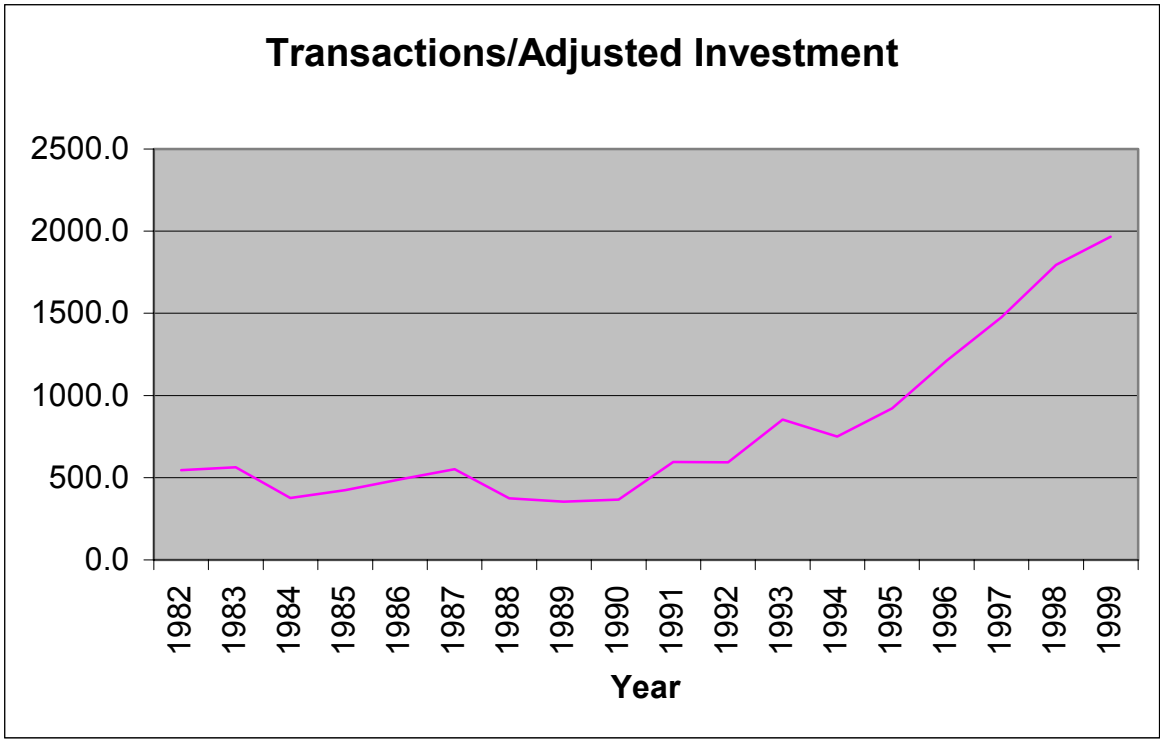
	Dependent variable		
Prais-Winsten analysis on annual data	**Price Continuity (minimum variance)**	**Quotation Spread (% low spread)**	**Market Depth (No or 1/8th change after sale)**
Estimated noise autocorrelation	.26	.57	.27
Estimated intercept	84.86	50.74	84.85
Estimated coefficient on $Investment_{(t-1)}$ (*t* statistic)	1.85E-04 (4.47)***	6.00E-04 (5.39)***	1.4-E05 (.27)
Estimated coefficient on AverageSize (*t* statistic)	4.79E-04 (.26)	6.51E-04 (.14)	1.43E-03 (.63)
R^2 based on $n = 17$	.55	.64	-.19

* $p <= .10$, ** $p <= .05$, *** $p <= .01$

IT Investment and the Quality of Markets
Table 2



IT and Floor Employees
Figure 5



Trade Tansactions/Adjusted IT Investment
Figure 6

Dependent variable is *Log(Transactions)*						
Contemporary Regression				**Lagged Regression**		
	Prais-Winsten analysis	Yule-Walker analysis			Prais-Winsten analysis	Yule-Walker analysis
Estimated noise autocorrelation	.78			*Estimated noise autocorrelation*	.80	
Estimated intercept	6.91	6.61		*Estimated intercept*	7.03	6.76
Estimated coefficient on Investment (*t* statistic)	1.17 E-05 (1.79)*	1.60 E-05 (2.84)**		*Estimated coefficient on* $Investment_{(t-1)}$ (*t* statistic)	1.49 E-05 (2.08)*	1.94 E-05 (2.97)**
Estimated coefficient on Headcount (*t* statistics)	2.20 E-04 (.08)	6.13 E-04 (.24)		*Estimated coefficient on* $Headcount_{(t-1)}$ (*t* statistics)	-1.19 E-03 (-.45)	-1.04 E-03 (-.38)
R^2 based on $n = 18$	.33	.90		R^2 based on $n = 17$	.26	.89
Dependent variable is *Investment*						
Contemporary Regression				**Lagged Regression**		
	Prais-Winsten analysis	Yule-Walker analysis			Prais-Winsten analysis	Yule-Walker analysis
Estimated noise autocorrelation	.42			*Estimated noise autocorrelation*	.45	
Estimated intercept	-273,712	-272,948		*Estimated intercept*	-345,220	-304,350
Estimated coefficient on Log(*transact*) (*t* statistic)	43,229 (7.01) ***	43,128 (6.98) ***		*Estimated coefficient on* $Log(transact_{(t-1)})$ (*t* statistic)	53,360 (9.92)***	47,787 (8.90) ***
R^2 based on $n = 18$	.73	.88		R^2 based on $n = 17$	.85	.93

* $p <= .10$, ** $p <= .05$, *** $p <= .01$

IT Investment and Securities Transactions Processing
Table 3

Cross Correlation Function: LTrans, AdjInvest
Figure 7

```
CCF - correlates LGTRANS(t) and ADJINV(t+k)
```

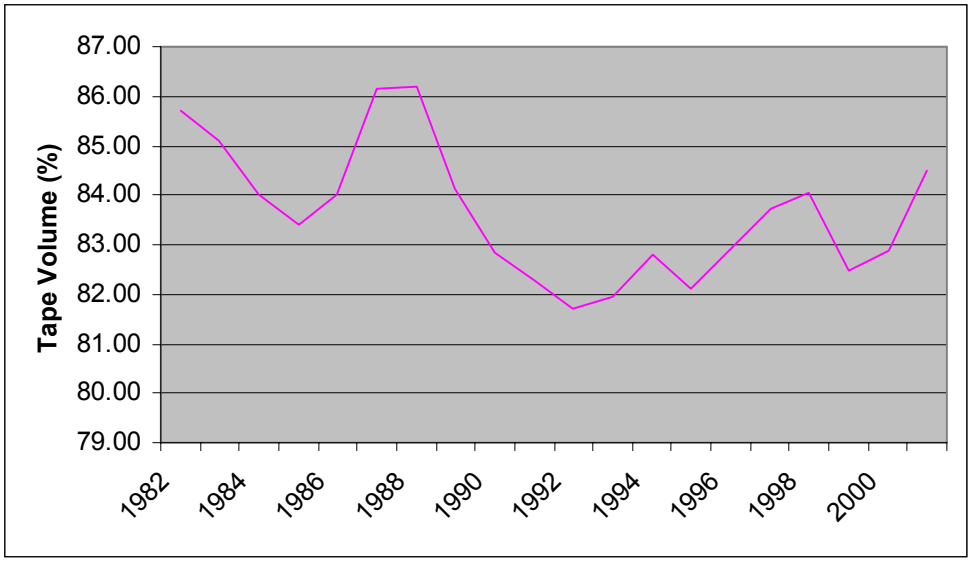
```
          -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8  1.0
            +----+----+----+----+----+----+----+----+----+----+
 -6   0.163                          XXXXX
 -5   0.290                          XXXXXXXX
 -4   0.393                          XXXXXXXXXXX
 -3   0.486                          XXXXXXXXXXXXX
 -2   0.609                          XXXXXXXXXXXXXXXX
 -1   0.733                          XXXXXXXXXXXXXXXXXXX
  0   0.925                          XXXXXXXXXXXXXXXXXXXXXXXX
  1   0.741                          XXXXXXXXXXXXXXXXXXX
  2   0.541                          XXXXXXXXXXXXXXX
  3   0.370                          XXXXXXXXXX
  4   0.195                          XXXXXX
  5   0.066                          XXX
  6  -0.040                         XX
```

There is near symmetry for the corresponding lags. That is, $r_{-1} \approx r_{+1}$, $r_{-2} \approx r_{+2}$, and so on, a suggesting that the relation is rather simultaneous. The negative cross-correlations are very slightly stronger, so that log-investment (very slightly) tends to precede log-transactions.

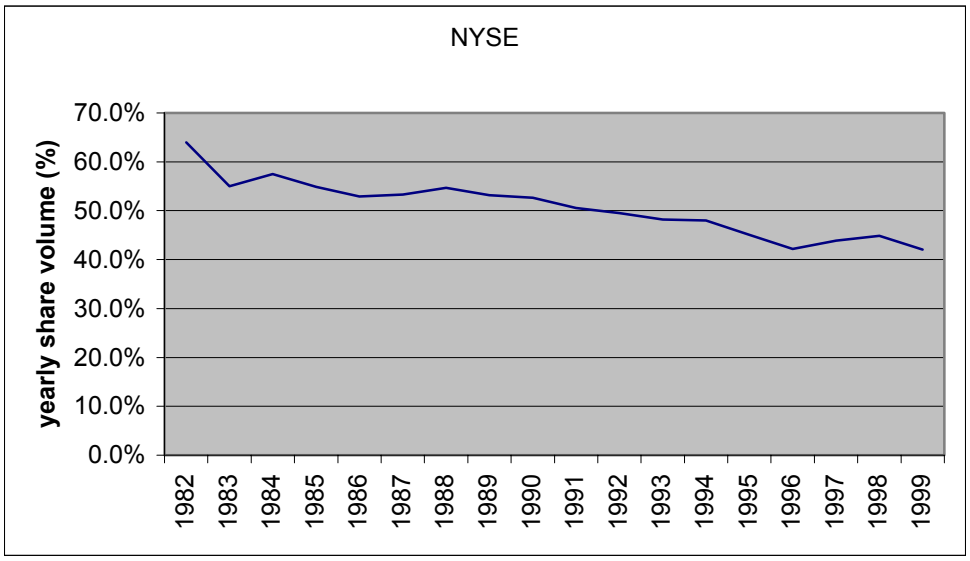
```
CCF - correlates LGTRANS(t) and IT HEADCOUNT(t+k)
```

```
          -1.0 -0.8 -0.6 -0.4 -0.2  0.0  0.2  0.4  0.6  0.8  1.0
            +----+----+----+----+----+----+----+----+----+----+
 -6  -0.123                       XXXX
 -5  -0.036                         XX
 -4   0.076                          XXX
 -3   0.223                          XXXXXXX
 -2   0.402                          XXXXXXXXXXX
 -1   0.595                          XXXXXXXXXXXXXXXX
  0   0.839                          XXXXXXXXXXXXXXXXXXXXXX
  1   0.698                          XXXXXXXXXXXXXXXXX
  2   0.558                          XXXXXXXXXXXXXX
  3   0.422                          XXXXXXXXXXXX
  4   0.275                          XXXXXXXX
  5   0.159                          XXXXX
  6   0.076                          XXX
```

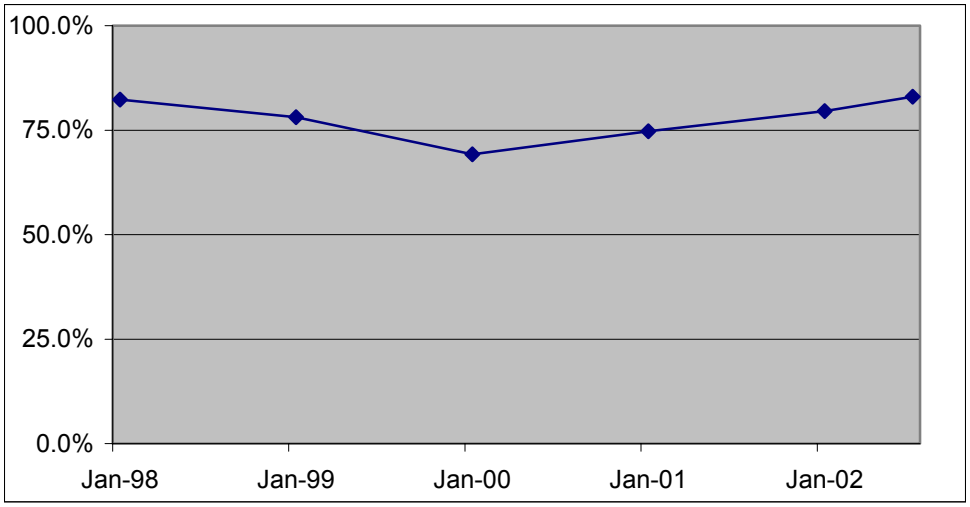
There is again near symmetry for the corresponding lags, but it's not as strong as in the preceding picture. Here the positive lags seem a little bigger, suggesting that log-transactions precede log-headcount.



NYSE Share of the Consolidated NYSE-listed Trading Volume
Figure 8



NYSE Share of NYSE+AMEX+NASDAQ Volume
Figure 9



Market Value (mil)	Jan-98	Jan-99	Jan-00	Jan-01	Jan-02	Jul-02
NYSE	$9,535,600,000	$11,060,000,000	$11,688,000,000	$12,312,900,000	$11,584,600,000	$9,975,300,000
Nasdaq	$1,886,936,000	$2,949,808,324	$5,048,404,519	$4,040,681,077	$2,872,865,856	$1,941,678,309
Amex	$159,458,637	$158,146,899	$140,894,083	$130,906,225	$101,516,992	$98,490,007
NYSE share	82.3%	78.1%	69.3%	74.7%	79.6%	83.0%

NYSE Share of NYSE+AMEX+NASDAQ Market Value
Figure 10