

Evidence on the Impact of Information Technology at the NYSE

Extended Abstract

David Easley, Terrence Hendershott, and Tarun Ramadorai *

Securities markets have long made changes to their trading mechanisms, but with the increasing pace of technological change, and the increasing competition between markets, the pace of modifications to the structure of markets is increasing. These markets generate most of their revenue from listing fees, trading fees, and payment for data services. Modifications to the trading environment are costly, so one would expect that they generate additional revenue from these sources, or at least allow the market to maintain some revenue flow that would otherwise vanish. However, exchanges often claim that innovations will benefit other stakeholders. For example, in discussing the combination between the NYSE and Archipelago, John Thain, CEO of the NYSE, said; "This combination will be good for investors and for America. It will create a strong, dynamic and innovative enterprise capable of meeting the demands of investors and issuers throughout the world in the decades ahead." And Jerry Putnam, CEO of Archipelago, argued; "This combination benefits investors by providing a stronger and broader platform for trading and strengthens our abilities to expand into new products and services. It will also benefit the U.S. capital markets, as NYSE Group, Inc. becomes a leading player in global markets."

Our interest in this paper is in whether innovations to the trading environment do in fact benefit listed firms and their stockholders. To address this question we searched the NYSE archives for all modifications to the trading environment which could conceivably benefit these stakeholders. A chronology of the NYSE can be found at http://www.nyse.com/about/history/timeline_chronology_index.html. The NYSE's innovations typically affect all stocks traded on the exchange which makes untangling the affect of the innovation from other changes that may have occurred in the economy at or near the same time difficult. However, there are four modifications which were phased in rather than being applied to the whole market at once. These are the 1980-1981 post upgrade, the introduction of auto quotes, the introduction of online clearing and the 1995 post upgrade. We focus on the first post upgrade for two reasons. First, our preliminary study of the effects of these modifications suggests that it is likely to have had the most significant effects. Second, the post upgrade is particularly interesting because it included two types of changes to the trading environment, one improved communication on the floor and the other reduced latency experienced by those off the floor. These innovations took place at different times allowing us to sort out the differential effects of the two changes

In the 1980-81 post upgrade, the exchange replaced trading posts that had been in place since the 1920's with a cogwheel shaped trading post that could accommodate new technology. We describe the upgrade process in detail in Section 2. There were four phases to the installation followed by a retrofit program at the end of the process. These phases relate to the technology that was upgraded and to the room of the exchange which received the upgrade. The entire upgrade consisted of two main technological components. First, there were several technological innovations which improved the quoting and reporting process on the floor of the exchange, but did not significantly affect communication between those on the floor and those off the floor. These modifications began in July, 1980 when Phase I was applied to trading posts in the Blue Room, the Garage and four of the posts in the Main Room. The remaining posts in the Main Room received these modifications in Phases II through IV of the process. Second, there were technological innovations which reduced DOT turnaround time and ITS processing time. The primary effect of these innovations was to reduce the latency experienced by those off the floor. This set of modifications took place in Phases II and III which began in November, 1980. During Phases II and III, posts that were upgraded received both the innovations that improved communication on and the floor and the innovations that reduced latency. However, posts that were upgraded during Phase I did not receive the latency reducing improvements until the retrofit program which began in January of 1981.

* Cornell University, University of California, Berkeley, and Oxford University.

This sequencing of modifications provides a natural experiment which we use to examine the differential effects of improving information flow on the floor and reducing latency for those off the floor. It is conceivable that specialists, floor brokers and investors anticipated the effects of these innovations, and so some of the effects may have taken place after the innovation process was announced, but before it was actually implemented. It is also likely that it took market participants some time to understand how to best use the technology and that it took time for this knowledge to spread throughout the investor population. Thus some of the effects of the innovations may not have appeared until well after the innovations occurred. To control for both of these possibilities we compare the first stocks to experience Phase I, those in the Blue Room, with the stocks in the Main Room which were part of Phase II. The first group of stocks, which we call Room 1 stocks, received the Phase I upgrade between July 14, 1980 and August 12, 1980. The second group of stocks, which we call Room 2 stocks, received the Phase II upgrade between November 10, 1980 and January 5, 1981. In the three month period between these two events, Room 1 stocks have undergone the upgrade which improved communication on the floor, but which did not reduce latency. Then beginning in November, 1980, Room 2 stocks received the upgrade that improved communication on the floor and reduced latency. In the retrofit program, Room 1 stocks received the improvements which reduced latency.

We expect these innovations to the trading environment to have impacts on transactions costs, and thus on turnover and returns. According to the market microstructure literature there are at least two routes by which changes in the trading environment could have such effects. First, the literature shows that spreads and liquidity affect investors' demand for assets, and anything that changes the costs inherent in these factors should have an impact on turnover and returns. Second, innovations which affect the ability of agents on the floor of the exchange, the specialist and floor brokers, to exploit their natural informational advantage over those off the floor should affect the demand for assets. If these insiders have some flexibility to decide when an order is executed they may be able to take advantage of the free option provided to them by orders. An innovation that reduces latency reduces the value of this option, and thus reduces the premium demanded by investors. So reducing latency should also increase turnover and returns.

To investigate the impact of the 1980-81 post upgrade on turnover and returns we construct a portfolio of stocks which is long Room 1 stocks and short Room 3 stocks. We then examine the returns to this portfolio over various twenty day windows before, during, and after the upgrade process. Our most significant finding is that this portfolio exhibits a substantial negative return in the twenty day window beginning with the introduction of Phase II. That is, when the latency experienced by investors in Room 3 stocks was reduced, and the latency experienced by investors in Room 1 stocks was unchanged, Room 3 stocks appreciated relative to Room 1 stocks. The return on the long-short portfolio is approximately 19 basis points a day for a total return of about 3.8% over the window. This excess return is robust to correction for the Fama-French and momentum factors. It is also robust to the selection of a matched sample of stocks from Rooms 1 and 3 where the matching is done on market cap and prior turnover. Further, we find that this return effect is more pronounced for small market cap stocks than for large and medium stocks.

We also find that the reduced latency for Room 3 stocks increased the rate of trading in Room 3 stocks relative to that in Room 1 stocks. Cumulative turnover for Room 3, relative to Room 1, increased by about 2.5 basis points of market cap per day over the 20 day window at the beginning of Phase II. This result is robust to correction for market turnover and to selection of a matched sample of stocks. This effect is also more pronounced for small market cap stocks than for large and medium stocks.

The effect of the improved information flow on the floor experienced by Room 1 stocks in Phase I, and not experienced by Room 3 stocks until much later is ambiguous. If anything, this innovation disadvantaged Room 1 stocks relative to Room 3 stocks. But the effects on return are small and significant at best at the 10% level. Similarly the effects on turnover are generally in the same direction as those of the Phase II upgrade, but they too are small and at best significant at the 10% level. As expected we find that the retrofit program partially reversed these effects on turnover and returns.

Data and Descriptive Statistics

Our data on stocks, trading, and prices are from CRSP. Table 1 presents summary statistics about the total data sample used in our analysis. We group stocks based on the room in which the post on which they are traded is located. Stocks are identified as being in Room 1 or Room 3, and the remaining stocks are denoted as ‘Others’. The table shows that there are 159 stocks in total that can be identified as having trading posts located in Room 1, and 286 in Room 3. The average size of the stocks in Room 3 is \$ 670 million, which is higher than that in Room 1, at \$ 486 million. The mean market capitalization of the 981 other stocks lies in between these two numbers. This difference in market capitalization (also manifest in the difference in mean price of the two groups of stocks) appears to be the major difference between the Room 1 and Room 3 stocks. The mean and standard deviation of turnover and the mean and standard deviation of returns appear to be roughly similar across the two groups of stocks. Both turnover and return betas are close to one on average in both rooms.

Table 1. Summary Statistics: Overall Sample. The column headings denote the summary statistics that are calculated over the time period prior to the upgrade (1/1/79-4/14/80), except for the statistics pertaining to market capitalization and price, which are calculated as on 4/14/80. Daily turnover is calculated as share volume divided by daily shares outstanding reported in CRSP. The turnover and return betas (from a market model, described in the text) are calculated only for those stocks with more than 250 return observations, over (1/1/79-4/14/80), and then averaged across the group of stocks denoted in the row headings. The row headings denote the group of stocks for which the statistics are calculated (stocks in Room 1, Room 3 and ‘Other’ stocks, which are not in Room 1 or Room 3).

Stocks	Number	Mean Mkt. Cap (\$MM)	Mean Price (\$)	Mean Turnover (%)	Mean Beta Turnover	Mean Return (%)	Std. Return (%)	Mean Beta Return
All								
Room 1	159	486	20.45	0.191	1.058	0.090	2.297	1.020
Room 3	286	670	23.05	0.184	1.007	0.096	2.236	0.989
Others	981	563	21.50	0.184	0.986	0.092	2.287	0.995

Impact of the Technology Upgrade

When evaluating the impacts of the changes taking place on account of the post upgrades, we can use the fact that the upgrades occurred in a staggered fashion. The sequence indicated in the upgrade schedule can be condensed into the following three major dates: 7/14/1980, on which date Phase I of the upgrades commences in Room 1; 11/10/1980, when Phases I & II are rolled out in Room 3; and 1/19/1981, when the program of retrofitting commences, which encapsulates the introduction of Phase II in Room 1. The schedule reveals that the dates of the rollout of Phase I and Phase II of the upgrades do not coincide in Rooms 1 and 3. The returns and turnover of the stocks in the two rooms could be considered a control for one another, as they are not contemporaneously subject to the same upgrade-rollout generated movements.

We implement this control by creating portfolios of Room 1 and Room 3 stocks. Our first exercise is to assess the impacts of the upgrade on turnover. We do so by estimating the following equations:

$$(Turn_{Room1,t} - Turn_{Room3,t}) = \sum_{i=1}^9 a_i D_i + u_t \text{ and } (Turn_{Room1,t} - Turn_{Room3,t}) = \sum_{i=1}^9 a_i D_i + \beta Turn_{Mkt,t} + u_t \quad (1)$$

The left-hand side variable is created by subtracting off the equally-weighted mean turnover across all stocks in Room 3 ($Turn_{Room3,t}$) from the equally-weighted mean turnover across all stocks in Room 1 ($Turn_{Room1,t}$) each day. We then inspect the time-variation in this measure by regressing it on nine dummy variables, which pick out the pre-and post-periods surrounding the rollouts of Phases I and II of the upgrade and the retrofit program. We go on to check that our results are not driven by the propensity of stock-specific turnover to comove with market turnover. Equation (2) incorporates a measure of market-wide

turnover on the right-hand side, $Turn_{Mkt,t}$, computed by equally-weighting turnover across all stocks in the NYSE universe each day. This regressor is used to soak up variation in the left-hand side variable that may be driven by the greater propensity of Room 1 or Room 3 stocks to move with market-wide turnover.

We also investigate the return response to the upgrades, estimating:

$$(R_{Room1,t} - R_{Room3,t}) = \sum_{i=1}^9 a_i D_i + u_t, \text{ and} \quad (2)$$

$$(R_{Room1,t} - R_{Room3,t}) = \sum_{i=1}^9 a_i D_i + \beta_{Rm} (R_{mt} - R_{ft}) + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{UMD} UMD_t + u_t \quad (3)$$

Equation (2) is similar to the first equation in (1), but replaces the left-hand side variable with the daily difference between the mean return across all stocks in Room 1 and the mean return across all stocks in Room 3. In our specifications we use both equal-weighted and market capitalization-weighted mean returns when computing the returns of the long Room 1 short Room 3 portfolio. Equation (3) risk-adjusts the return on this long-short portfolio by regressing it on the Fama-French-Carhart four-factor model. The intercepts a_1, \dots, a_9 from equation (3) can thus also be viewed as the average abnormal returns to a trading strategy that goes long Room 1 and short Room 3 stocks over the periods selected by the dummy variables D_1, \dots, D_9 .

Table 2 presents the turnover and return regressions for an equally weighted portfolio of all stocks. The first two columns of coefficients in Table 2 show the results from estimating both equations in (1). There are three main points to note here. First, there is a slight tendency for the equal-weighted mean turnover to be higher for Room 1 stocks than for Room 3 stocks in the pre-upgrade period. Second, the intercept a_6 is significantly negative in both specifications. This indicates that turnover in Room 3 is higher than in Room 1 immediately following the rollout of Phase II in Room 3. The coefficient magnitude indicates that turnover in Room 3 is significantly higher by approximately 2.5 basis points of market capitalization per day in the 20 day period immediately following the rollout. This represents an increase of 13.5 percent over the average daily turnover in the pre-upgrade period.

The increase in turnover occurs for a period of 20 days following the rollout of Phases I & II in Room 3, and following the implementation of the retrofit program. However, this increase does not appear to be sustained past the 20 day mark (a_7 is not statistically significant). This is consistent with a model in which the relaxation of a trading constraint on a group of stocks permits portfolio rebalancing at lower cost, leading to an initial surge in trading volume as market participants achieve their desired allocations. While the costs of rebalancing may be permanently lower, the timing of turnover increases will also depend on the return horizon of market participants. Furthermore, the design of our study only allows us to observe relative changes in turnover between Room 1 and Room 3 stocks – and the retrofit program commences one trading month after the Phase I & II rollout in Room 3.

The last two columns of Table 2 present the results from estimating equations (2) and (3). The results are consistent with our turnover analysis. Both a_6 and a_9 are statistically significant, with a_6 negative and a_9 estimated positive. These return increases are relatively large. For the 20 days following the rollout of Phases I and II in Room 3, a_6 shows that the average stock in Room 3 outperforms that in Room 1 by 19 basis points per day after risk adjustment using the Fama-French-Carhart four-factor model. This translates into a cumulative abnormal return of 3.8 percent over the 20 day period. The relatively large size of the return response relative to the size of the turnover increase could be attributed to the fact that the price, being a forward-looking variable, responds to what is likely a permanent reduction in future trading costs.

Table 2. Equal-Weighted Long-Short Portfolio: Turnover and Returns.

Time Period	Coefficient	Turnover		Returns	
Pre-Upgrade (1/1/79 to 6/12/80)	a₁	0.010 <i>5.420</i>	0.008 <i>1.710</i>	-0.004 <i>-0.330</i>	-0.007 <i>-0.600</i>
Phase I (-19,0) (6/13/80 to 7/11/80)	a₂	0.006 <i>1.070</i>	0.004 <i>0.600</i>	-0.003 <i>-0.040</i>	-0.010 <i>-0.160</i>
Phase I (+1,+20) (7/14/80 to 8/8/80)	a₃	0.000 <i>0.010</i>	-0.002 <i>-0.240</i>	-0.081 <i>-1.160</i>	-0.087 <i>-1.270</i>
(8/11/80 to 10/9/80)	a₄	0.003 <i>0.760</i>	0.001 <i>0.170</i>	-0.011 <i>-0.420</i>	-0.013 <i>-0.460</i>
Phase II (-19,0) (10/10/80 to 11/7/80)	a₅	0.005 <i>1.220</i>	0.003 <i>0.490</i>	-0.012 <i>-0.300</i>	-0.009 <i>-0.240</i>
Phase II (+1,+20) (11/10/80 to 12/7/80)	a₆	-0.023 <i>-3.340</i>	-0.025 <i>-2.760</i>	-0.192 <i>-3.810</i>	-0.190 <i>-3.450</i>
(12/8/80 to 12/17/80)	a₇	-0.002 <i>-0.160</i>	-0.004 <i>-0.270</i>	-0.020 <i>-0.280</i>	0.009 <i>0.110</i>
Retrofit (-19,0) (12/18/80 to 1/16/81)	a₈	-0.002 <i>-0.250</i>	-0.004 <i>-0.380</i>	0.039 <i>1.000</i>	0.024 <i>0.630</i>
Retrofit (+1,+20) (1/19/81 to 2/13/81)	a₉	-0.005 <i>-1.130</i>	-0.006 <i>-1.010</i>	0.083 <i>1.770</i>	0.073 <i>1.490</i>
	Mkt Turn		0.803 <i>0.310</i>		
	R_m-R_f				2.898 <i>1.160</i>
	SMB				5.695 <i>1.280</i>
	HML				5.019 <i>1.000</i>
	UMD				1.099 <i>0.370</i>
R²		0.071	0.071	0.029	0.047
Observations		537	537	537	537

We redo the results in Table 2 for small stocks (omitted for brevity) and find that the turnover and return results are driven by differences in the smaller stocks. All of the above discussed results are robust to matching stocks in Room 1 and Room 3 by market capitalization and turnover to ensure that our results are not caused by differences in the characteristics of stocks in the two rooms.

Summary

As the amount of automation has steadily transformed securities trading in all financial markets, it is natural to ask what the impact has been. This paper analyzes a significant technological upgrade at the NYSE and demonstrates how the technology not only improved liquidity and trading, but also increased the prices of companies listed on the NYSE. The controlled structure of this technological innovation provides clear identification of the value of information technology in this setting. Because financial markets have historically led the way with technological innovations that are later applied in other markets, this research is relevant to technological innovation in many markets, particularly for the potential impacts and value of electronic markets and business-to-business electronic commerce.