Exit, survival, and competitive equilibrium in dealer markets

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Abstract

In this study we analyze dealer exit, survival, and competitive equilibrium in the NASDAQ Stock Market using a natural experiment that entails major changes in regulatory and competitive environments. We decompose the forces that affect dealer survival into market factors and dealer attributes. Market factors encompass those variables that affect the demand for and profitability of dealer services as a whole. Variation in survival probability across dealers arises mainly from their competitive advantages in business strategies, information, quote aggressiveness, access to order flow, and economies of scales. On the whole, our results suggest that the Darwinian survival of the fittest applies to dealer markets as well.

JEL Classification: G14; G18

Keywords: Market structure, Dealer competition, Order flow, Competitive advantages, Quote aggressiveness, Bid-ask spread, Market share, Survival probability, Exit decision

1. Introduction

A dealer firm's entry and exit decisions may be viewed as adjustments to new equilibrium that are dependent on a variety of factors. The probability of a dealer firm's survival or exit in a given interval of time is likely to be a function of both market environments and dealer attributes. There are two types of dealers' exit decisions. A dealer firm may exit the market entirely, quitting its market-making operation in all stocks. More often than not, a dealer firm may exit the market partially, quitting its market-making operation only in select stocks. In this study we analyze the dealer firm's exit and survival in the NASDAQ Stock Market using a natural experiment that entails major changes in regulatory and competitive environments.

The NASDAQ Stock Market went through a major transformation during the last decade. The number of stocks on NASDAQ declined significantly due in large part to the delisting of many high-technology stocks after the dot.com bubble. For instance, the number of stocks listed on NASDAQ in our study sample went down from 5,931 in 1999 to 3,509 in 2006. In addition, there was a significant decrease in the bid-ask spread of NASDAQ stocks due to a number of regulatory changes and market-wide changes in competitive environments (e.g., decimalization, SEC Rule 605, SuperMontage, and proliferation of ECNs).[1] We perform empirical analysis of dealer exit, survival, and competitive equilibrium by looking at how NASDAQ dealers responded to these exogenous shocks.[2] To our best knowledge, the present study is the first to analyze the consequences of these events in the NASDAQ Stock Market.

Previous studies have examined factors affecting the firm's entry, exit, survival

[1] Bessembinder (2003b) shows that decimal pricing significantly reduced the bid-ask spread of both NYSE- and NASDAQ-listed stocks. Zhao and Chung (2007) find a significant reduction in spreads after the implementation of Rule 605. Chung and Chuwonganant (2009) find the implementation of SuperMontage significantly reduced the bid-ask spreads of NASDAQ stocks.
[2] In this paper we use the terms 'dealers' and 'market makers' synonymously as those who compete for customer order flow by displaying buy and sell quotations for a guaranteed number of shares.

probability, and survival length in an industry. Under the rubric of organizational ecology, prior research employs survival analysis to understand the forces shaping exit, niches, and the number of competing organizations in both industrial and nonindustrial populations (Carroll and Hannan, 1995). Researchers have also analyzed collections of different product markets to search for regularities in firm survival over the life cycle of industry evolution (Suarez and Utterback, 1995; Klepper and Miller, 1995; Agarwal and Gort, 1996; Klepper, 1996; Klepper, 2002). Agarwal and Gort (2002) show that firm survival is dependent on both the product and the firm life cycles. Lenox, Rockart, and Lewin (2007) show that variation in the potential for interdependency in activities among industries explains varying levels of shakeout as well as differing patterns of entry and exit among industries. Our study contributes to the literature by expanding the domain of survival analysis to a market that is subject to considerable and sudden exogenous shocks that reduce both profitability and the size of the market. Our analysis centers on whether a dealer firm's survival probability and survival length could be explained by a set of measures that capture the dealer firm's competitive advantages.

A number of studies have examined the NASDAQ market structure and dealer behavior. Wahal (1997) shows that the number of dealers in a security is related to trading volume, return volatility, and the bid-ask spread, and that a large-scale dealer entry (exit) results in a decrease (an increase) in quoted spreads. Weston (2000) shows that changes in the number of dealers are negatively related to changes in quoted spreads, return volatility, and firm size, and positively related to changes in trading volume and the number of trades. Weston also shows that the 1997 NASDAQ market reform results in a significant decrease in market share concentration. Schultz (2003) and Chung and Cho (2005) show that dealers are more likely to make markets in stocks in which they have an information advantage. Chung and Kim (2005) show that although the total market share of the top five dealers in each stock on NASDAQ is stable over time, there is significant monthly variation in the composition of the top five dealers. They show that market share turbulence among top dealers is another form of competition that narrows bid-ask spreads, especially for stocks with less competitive dealer market structure. Madureira and Underwood (2008) show that dealers with affiliated analysts post more aggressive quotes than dealers without such analysts. Our study complements and extends this literature by analyzing the long-term effects of changes in market and regulatory environments on dealer markets and dealer behavior.

We show that as the number of stocks and the bid-ask spread on NASDAQ declined, many dealers exited the market entirely, resulting in a significant reduction in the total number of dealers on NASDAQ. For instance, the total number of dealers went down by 57% from 516 in 1999 to 221 in 2006. Those dealers with competitive advantages survived and each of these survived dealers handled an increasingly larger number of stocks to make up the reduced market-making revenues (i.e., smaller spreads) from each stock. The mean number of stocks that were handled by NASDAQ dealers increased by more than 120% from 112 in 1999 to 248 in 2006. As a result, the mean number of dealers in *each* stock actually increased from 10 in 1999 to 14 in 2006, despite the considerable decrease in the *total* number of dealers.

We show that dealers were more likely to survive when their market-making businesses were evenly distributed across stocks and when they made markets in a larger number of stocks. We interpret these results as evidence that dealers with diversified market-making operations across stocks suffered less from the shrinking market than dealers whose market-making businesses were concentrated on select stocks, and that dealers with market-making operations in a larger number of stocks survived more because of their economies of scale. We find that dealers who were at the inside market longer and dealers who quoted larger depths exhibit a higher survival probability. We interpret these results as evidence that dealers that posted competitive quotes attracted more order flow and thus had larger market shares, increasing the probability of survival.

We show that survival probability is higher for dealers with affiliated analysts who follow the same stock. This result supports the conjecture that the order flow and informational advantages provided by affiliated analysts increase the survival probability of dealers. We show that geographical proximity between dealers and firms provides dealers with the order flow and informational advantages and thus increases their survival probability. On the whole, our results suggest that the Darwinian survival of the fittest applies to dealer markets as well.

The rest of the paper is organized as follows. Section 2 explains data sources and variable measurement methods, and present descriptive statistics. In Section 3 and Section 4, we provide various empirical results that collectively support our conjecture that dealers with competitive advantages survived longer through their greater market dominance. Section 5 concludes the paper with a brief summary.

2. Data sources, variable measurement, and descriptive statistics

This section explains our data sources, variable measurement methods, and descriptive statistics.

2.1. Data sources

We obtain dealer quote, inside quote, and trade data from the NASTRAQ Trade and Quote database. We use the data from January 1999 to December 2006 because the NASTRAQ data are available only for this eight year period. To minimize data error, we exclude the following quotes and trades: quotes if either the bid price or ask price is non-positive; quotes if either the bid size or ask size is non-positive; quotes if the bid-ask spread is greater than $5 or non-positive; off-trading hours quotes and trades; trades if price or volume are non-positive; bid quotes, ask quotes and trades if the magnitude of the change between two consecutive values is greater than 0.5.

We retrieve stock trading volume data from the Center for Research in Security Prices (CRSP) database and company location data from the Standard & Poor's Compustat database. We obtain analyst affiliation data from the Institutional Brokers' Estimate System (I/B/E/S) detailed history file. We identify each analyst's brokerage affiliation using the broker and analyst identification numbers included in the detailed history file. We obtain monthly dealer trading volumes, dealer affiliations, and dealer locations from the data provided by NASDAQ.[3] The dealer affiliation file contains market maker symbols, broker identification numbers, and the names of the brokerage firms. The NASTRAQ database contains market maker symbols for each stock. We obtain the affiliation of each dealer by first matching the market maker symbol from the NASTRAQ file with the market maker symbol in the dealer affiliation file to get broker identification number, which is then used to match with the broker identification number in the I/B/E/S file. We identify affiliated analysts by checking whether the analysts and dealers are associated with the same company.

2.2. Time-series variation in the number of dealers

Panel A shows descriptive statistics on the number of dealers per stock. For each stock, we first obtain the number of dealers that make a market in each month. We then aggregate the number of dealers in each stock across months to obtain the number of dealers in each year.

[3] The dealer location data are available at www.nasdaqtrader.com.

Panel A also shows the number of newly entered dealers, the number of dealers who exited the market, and the total number of (survived) dealers on NASDAQ across all stocks in each year. The results show that the total number of dealers on NASDAQ decreased by 57% from 516 in 1999 to 221 in 2006. In contrast, the average number of dealers per stock increased from 10 in 1999 to 14 in 2006 and the median number of dealers per stock increased from 8 in 1999 to 11 in 2006. Figures 1 and 2 show the monthly time-series variation in the average number of dealers per stock and the total number of dealers on NASDAQ from January 1999 through December 2006.

2.3. Time-series variation in the number of stocks

Panel B shows descriptive statistics on the number of stocks per dealer. For each dealer, we first obtain the number of stocks in each month. We then aggregate the number of stocks across months to obtain the number of stocks handled by each dealer in each year. Panel B also shows the number of newly listed stocks, the number of stocks that are delisted, and the total number of remaining stocks on NASDAQ that are handled by all dealers in our study sample in each year. The results show that while the total number of stocks declined by 41% from 5,931 in 1999 to 3,509 in 2006,[4] NASDAQ dealers on average made markets in an increasingly larger number of stocks during the same period. For example, the mean (median) number of stocks that were handled by each NASDAQ dealer *increased* by 121% (213%) from 112 (15) in 1999 to 248 (47) in 2006. Figures 3 and 4 show the monthly time-series variation in the average number of stocks per dealer and the total number of dealers on NASDAQ from January 1999 through December 2006.

[4] The decrease in the number of stocks on NASDAQ may be due, in large part, to the delisting of many high-technology stocks after the burst of the dot.com bubble.

2.4. Time-series variation in trading volume

Panel C reports the total dollar trading volume across our sample stocks and dealers, the average dollar trading volume per stock, and the average dollar trading volume per dealer for each year from 1999 to 2006. In contrast to the time-series variations in the number of dealers and in the number of stocks discussed above, the time-series variations in all three measures of trading volume do not exhibit a general upward or downward trend during the sample period. Instead, all three measures of trading volume reach a peak in 2000, gradually decline until 2004, and increase again thereafter. These results suggest that there is no apparent relation between trading volume and either the number of dealers or the number of stocks reported in Panel A and Panel B.

2.5. Stock Herfindahl-index

To shed additional light on dealer market structure over time, we calculate the Herfindahl-index (H-index) of each stock, together with its two components. The H-index of stock i in month t is defined as: $\text{H-index}_{i,t} = \sum_j[V_{i,j,t}/\sum_j V_{i,j,t}]^2$, where $V_{i,j,t}$ is stock i's volume accounted for by dealer j during month t and $\sum_j$ denotes the summation over j. Note that $\text{H-index}_{i,t}$ can be decomposed into two components. The first component ($\text{H-COMPO1}_{i,t}$) is the sum of squared deviations of dealer market share in stock i from the mean, $\sum_j[(V_{i,j,t}/\sum_j V_{i,j,t}) – (\sum_j V_{i,j,t}/N_i)]^2$, and the second component ($\text{H-COMPO2}_{i,t}$) is $1/N_i$, where N_i is the number of dealers in stock i. We calculate the $\text{H-index}_{i,t}$, $\text{H-COMPO1}_{i,t}$ and $\text{H-COMPO2}_{i,t}$ for each month from January 1999 to December 2006 and obtain their mean values for each year. Similarly, we calculate the H-index and its two components for the NASDAQ market as a whole using the aggregate market share of each dealer across all stocks.[5]

[5] A higher H-index implies a greater concentration in market share and the H-index increases as the proportion of

The first three columns in Panel A of Table 2 show the H-index and its two components for the NASDAQ Stock Market as a whole. Note that the H-index and its two components increased during the study period. This result is in line with the result in Panel A of Table 1 that the total number of dealers declined during the same period. Hence, for the NASDAQ market as a whole, there was a steady increase in market share concentration among fewer dealers as many dealers exited the market.

The next three columns show the mean value of the H-index and its components for *individual stocks*. The results show that both the H-index and its second component declined during the study period, indicating a decrease in market share concentration. This result is in line with our earlier finding that the mean number of dealers for each stock increased during the sample period. The results show however that the first component of the H-index increased during the same period, indicating an increase in the disparity (i.e., greater concentration) in market share among dealers. Hence the decrease in the H-index was driven by the increase in the number of dealers at the individual stock level, which more than offset the counterbalancing effect of the increased market share concentration among dealers.

2.6. Dealer Herfindahl-index

To shed some light on dealer behavior, we also calculate the H-index of each *dealer*. The H-index of dealer j in month t is defined as: $\text{H-index}_{j,t} = \sum_i [V_{i,j,t}/\sum_i V_{i,j,t}]^2$, where $V_{i,j,t}$ is stock i's volume accounted for by dealer j in month t and $\sum_i$.is the summation over i. Note that $\text{H-index}_{j,t}$ can be decomposed into two components. The first component ($\text{H-COMPO1}_{j,t}$) is the sum of squared deviations of dealer j's trading volume in each stock from the mean, $\sum_i[(V_{i,j,t}/\sum_i V_{i,j,t}) - (\sum_i V_{i,j,t}/N_j)]^2$, and the second component ($\text{H-COMPO2}_{j,t}$) is $1/N_j$, where N_j is

volume by the leading dealers increases or the number of dealers decreases.

the number of stocks handled by dealer j. The first component indicates whether dealer j's market-making business is concentrated on select stocks or distributed evenly across stocks. The second component measures the breadth of dealer j's market-making operation, i.e., whether dealer j makes markets in a large number of stocks or just a few stocks. The dealer Herfindhal-index declines as the dealer's market-making operation is distributed evenly across stocks or as the dealer makes market in many stocks.

Panel B of Table 2 shows the yearly mean values of H-index$_{j,t}$, H-COMPO1$_{j,t}$, and H-COMPO2$_{j,t}$ from 1999 to 2006. The results show that the H-index and its two components declined during the study period, indicating a decreasing concentration in the dealer's market-making operation over time. The results for the H-index and its second component are in line with the result in Panel B of Table 1 that NASDAQ dealers handled an increasingly larger number of stocks during the same period. The decrease in the first component of the H-index indicates that NASDAQ dealers' market-making business became more evenly distributed across stocks.

2.7. Time-series variation in spreads

We calculate the quoted, effective, and realized spreads of stock i at time t using the following formulas: Quoted spread$_{i,t}$ = (Ask$_{i,t}$ – Bid$_{i,t}$)/M$_{i,t}$; Effective spread$_{i,t}$ = 2D$_{i,t}$(P$_{i,t}$ – M$_{i,t}$)/M$_{i,t}$; and Realized spread$_{i,t}$ = 2D$_{i,t}$(P$_{i,t}$ - P$_{i,t+5}$)/M$_{i,t}$; where Ask$_{i,t}$ is the best ask price of stock i at time t, Bid$_{i,t}$ is the best bid price of stock i at time t, M$_{i,t}$ is the quote midpoint ((Ask$_{i,t}$ + Bid$_{i,t}$)/2) of stock i at time t, P$_{i,t}$ is the transaction price of stock i at time t, P$_{i,t+5}$ is the first transaction price at least five minutes after the trade for which the realized spread is measured, and D$_{i,t}$ is a binary variable which equals +1 for customer buy orders and -1 for customer sell orders. We estimate D$_{i,t}$ using the algorithm in Lee and Ready (1991) as modified by Bessembinder

(2003c). The realized spread measures the average price reversal after a trade (or market-making revenue net of losses to better informed traders).

For each stock, we then calculate the time-weighted average quoted spread and trade-weighted average effective and realized spreads for each month from January 1999 to December 2006. We then calculate the yearly mean values of these variables. Table 3 reports the mean and median values of the yearly average quoted, effective, and realized spread for our study sample of stocks from 1999 to 2006. Figure 5 shows the monthly time-series variation in the mean effective spread from January 1999 through December 2006.[6] Consistent with the results in prior studies, the quoted, effective, and realized spreads declined significantly during our study period. For example, the mean quoted spread declined from 0.039 in 1999 to 0.0128 in 2006, and the mean effective spread declined from 0.0329 to 0.0084 during the same period. The decrease in spreads during our study period may largely be due to regulatory changes and/or market-wide changes in competitive environments (e.g., decimalization, SEC Rule 605, SuperMontage, and proliferation of ECNs).[7]

2.8. Interpretation

Collectively, we interpret the above results as evidence that as there were fewer stocks in the market, together with reduced spreads, many dealers (presumably less competitive ones) exited the market, resulting in a significant reduction in the total number of dealers on NASDAQ. Only those dealers who were able to recoup the reduced market-making revenue from each stock by expanding their market-making business to other stocks (despite the decrease in the total number of stocks) through their competitive advantages survived during the period. Survived dealers handled an increasingly larger number of stocks to make up the reduced

[6] The results for the quoted and realized spreads are similar.

[7] See footnote 1 for relevant references.

market-making revenues (smaller spreads) from each of these stocks: the number of stocks that were handled by each survived dealer increased dramatically from 112 in 1999 to 248 in 2006, despite the fact that the total number of stocks on NASDAQ decreased from 5,931 in 1999 to 3,509 in 2006. As each surviving dealer made a market in an increasingly larger number of stocks, the number of dealers in each stock increased also.

3. Can quote aggressiveness and other dealer attributes explain exit/survival decisions?

In Section 2 we show that the number of dealers decreased significantly during our study period. Our data show that the total number of dealers declined from 516 to 221 between 1999 and 2006, representing a 57% decline. In this section we perform empirical test of our conjecture that dealers with competitive advantages survived better in the shrinking market.

3.1. Dealer quote aggressiveness and dealer survival

Prior research shows that market makers who quote more aggressively have larger market shares. Blume and Goldstein (1997) show that non-NYSE market makers attract more order flow for NYSE stocks when they post the best available quotes. Bessembinder (2003a) finds substantial quote-based competition for order flow in NYSE-listed stocks. Goldstein, Shkilko, Van Ness, and Van Ness (2008) find that trading venues attract more orders when they quote aggressively on both sides. Klock and McCormick (2002), Chung, Chuwonganant, and McCormick (2006), and Chung and Chuwonganant (2007) show that aggressive quotes help increase dealer market share on NASDAQ. All things being equal, dealers with large market shares are more likely to survive than dealers with small market shares. Hence, we conjecture that dealers who quote more aggressively survive longer.

We measure dealer j’s quote aggressiveness in stock i during month t by (1) the percentage of dealer j's time at the inside market, $PINS_{i,j,t}$; (2) the percentage of dealer j's time at the inside market *alone*, $PINSA_{i,j,t}$; (3) the ratio of dealer j's spread in stock i to the average spread of all dealers in stock i, $RELSP_{i,j,t}$; and (4) the relative magnitude of dealer j's quoted depth to the average quoted depth of all dealers at the inside for stock i, $RELQS_{i,j,t}$. For each stock, we use all dealers that existed at the beginning of our study period (i.e., January 1999) and identify two groups of dealers in each month.[8] Group $SURVIVE_{i,t}$ includes all dealers that made a market in stock i in month t and continued their market making in the stock in the following month. Group $EXIT_{i,t}$ includes all dealers that made a market in stock i in month t but exited the market in stock i after month t. We then calculate mean quote aggressive measures for each group during two years, one year, six months, and one month preceding the exit. We repeat the process for each month from January 1999 to December 2006 and for each stock in our study sample and aggregate the above four quote aggressive measures over months and stocks.

Table 4 shows the mean quote aggressiveness measures of the survived and exited dealer groups and the difference in each quote aggressiveness measure between the two groups. The results show that exited dealers quoted less competitive prices and sizes than survived dealers. For example, the mean value of PINS (PINSA) for dealers in the EXIT group during the 24 months preceding the exit is 0.1614 (0.0608), which is significantly smaller than the corresponding figure [0.2630, (0.0803)] for dealers in the SURVIVE group. The mean value of RELQS for dealers in the EXIT group during the 24 months preceding the exit is 0.6494, which is significantly smaller than the corresponding figure (0.8261) for dealers in the SURVIVE group. Not surprisingly, the mean relative dealer spread (RELSP) for the EXIT group during the 24 months preceding the exit is 2.2902, which is significantly wider than the corresponding

[8] We do not include dealers who entered after January 1999 in the analysis because our main focus here is to examine who survived and who exited the market among those dealers that were active in January 1999.

figure (1.3097) for the SURVIVE group. We find qualitatively similar results when we compare quote aggressiveness measures between the two groups over different time intervals (i.e., 12 months, six months, and one month preceding the exit). Overall, our results show that survived dealers posted more competitive price and size quotes than exited dealers.

3.2. Determinants of dealer survival

In the previous section we show that dealer survival is related to quote aggressiveness. Dealer survival is likely to depend not only on quote aggressiveness but also on other competitive advantages. For example, Schultz (2003) and Chung and Cho (2005) show that NASDAQ dealers make markets in those stocks in which they have competitive advantages in access to order flow and access to information. In particular, these studies show that dealers are more likely to make markets in local stocks, stocks that are covered by affiliated analysts, and stocks that their firms have participated in initial public offerings because they have both order flow and informational advantages in these stocks. In a similar vein, we conjecture that dealers are more likely to survive when they have similar competitive advantages.

To determine factors that affect dealer survival probability, we first classify dealers into two groups, Group $SURVIVE_{i,t}$ and Group $EXIT_{i,t}$, as we did in the previous section. We then estimate the following probit regression model:

$$S_{i,j,t} = \gamma_0 + \gamma_1 \text{H-COMPO1}_{j,t} + \gamma_2 \text{H-COMPO2}_{j,t} + \gamma_3 \log(PINS_{i,j,t}) \text{ [or } \gamma_3 \log(PINSA_{i,j,t}) \text{ or } \gamma_3 \log(RELSP_{i,j,t})] + \gamma_4 \log(RELQS_{i,j,t}) + \gamma_5 WS + \gamma_6 WH + \gamma_7 IB + \gamma_8 AFAN + \gamma_9 SSTATE + \varepsilon_{i,j,t}; \quad (1)$$

where $S_{i,j,t}$ is a binary variable which equals one for dealers that belong to Group $SURVIVE_{i,t}$ and zero for dealers that belong to Group $EXIT_{i,t}$.

We include the two components of the *dealer* Herfindahl index in the regression model to test whether survival probability varies with the concentration and breadth of dealer business operation. The first component captures whether dealer j's market-making business is concentrated on select stocks or distributed evenly across stocks. The second component measures whether dealer j makes markets in a large number of stocks or just a few stocks. We include $PINS_{i,j,t}$, $PINSA_{i,j,t}$, $RELSP_{i,j,t}$, and $RELQS_{i,j,t}$ in the model to test whether dealer quote aggressiveness affects survival probability.

AFAN is an indicator variable which equals one if the stock is followed by at least one analyst who is affiliated with the dealer's company, and zero otherwise. Schultz (2003) suggests that investors usually buy a stock through the broker that provides information about it and affiliated analysts provide such information. We include AFAN in the model to test whether the order flow and informational advantages provided by affiliated analysts increase the survival probability of dealers.

SSTATE is an indicator variable which equals one if the headquarters of the dealer and the firm are located in the same state, and zero otherwise. Schultz (2003) suggests that location matters to dealers at regional brokerage companies because their brokerage customers are more likely to invest in stocks of local companies than in stocks of other companies. Schultz (2003) also suggests that dealers are more likely to obtain information about a company through conversation with the company's employees or customers if it is a local one than if it is in another state. To the extent that dealers with order flow and informational advantages are more likely to survive, we expect the coefficient on SSTATE to be positive.

WS is an indicator variable which equals one for wirehouses and zero otherwise, WH is an indicator variable which equals one for wholesalers and zero otherwise, and IB is an indicator variable which equals one for institutional brokers and zero otherwise. We include these variables in the regression model to control for the effect of dealer type on survival probability.

We estimate the above model for each month and calculate the average regression coefficients across months and the z-statistics. We calculate the z-statistic by adding individual regression t-statistics across months and then dividing the sum by the square root of the number of regression coefficients. We provide the regression results in Table 5.

The results show that survival probability is negatively related to both components of the dealer Herfindahl index, indicating that dealers were more likely to survive when their market-making businesses were evenly distributed across stocks and when they made markets in a larger number of stocks. The result for the first component may suggest that dealers with diversified market-making operations across stocks suffered less from the shrinking market than dealers whose market-making businesses were concentrated on select stocks. The result for the second component indicates that dealers with market-making operations in a larger number of stocks were more likely to survive perhaps because of their economies of scale.

Not surprisingly, survival probability increases with dealer quote aggressiveness. Dealers who were at the inside market longer and/or dealers who quoted larger depths exhibit a higher survival probability. We interpret these results as evidence that dealers that posted more competitive quotes attracted more order flow and thus had larger market shares, increasing their probability of survival. Indeed, we show later in the paper that dealer market share is positively related to quote aggressiveness using our study sample of stocks.

Survival probability is higher for dealers with affiliated analysts who followed the same stock. This result supports the conjecture that the order flow and informational advantages provided by affiliated analysts increase the survival probability of dealers. The regression coefficients on SSTATE are all positive and significant at the 1% level. This result supports the notion that geographical proximity provides dealers with the order flow and informational advantages and thus increases survival probability. The results show that wirehouses, wholesales, and institutional brokers had a higher survival probability than regional broker-dealers, perhaps because of the economies of scale.

The factors that affect dealer survival or exit in each stock are also likely to determine the probability that a dealer exits the market entirely, quitting its market-making operation in all stocks. To test this conjecture, we estimate the following probit regression model using the data that are aggregated across stocks for each dealer:

$$S_{j,t} = \delta_0 + \delta_1 \text{H-COMPO1}_{j,t} + \delta_2 \text{H-COMPO2}_{j,t} + \delta_3 \log(\text{PINS}_{j,t}) \text{ [or } \delta_3 \log(\text{PINSA}_{j,t}) \text{ or } \delta_3 \log(\text{RELSP}_{j,t})] + \delta_4 \log(\text{RELQS}_{j,t}) + \delta_5 \text{WS} + \delta_6 \text{WH} + \delta_7 \text{IB} + \varepsilon_{j,t}; \quad (2)$$

where $S_{j,t}$ is a binary variable which equals one for dealers that belong to Group $\text{SURVIVE}_{i,t}$ and zero for dealers that belong to Group $\text{EXIT}_{i,t}$, and all other variables are the same as previously defined. The results (see Panel B of Table 5) are qualitatively identical to those presented in Panel A of Table 5, indicating that the factors that affect dealer survival or exit in each stock also affect the probability that a dealer exits the market entirely.

3.3. Determinants of dealer survival length

To determine whether our results are sensitive to different model specifications, we replicate regression analysis in Section 3.2 using a different measure of dealer survival. Instead of the binary dependent variable used in the previous section, we employ a continuous dependent variable that measures dealer survival length. For this, we determine the month that dealer j quits making a market in stock i and count the number of months ($\tau_{i,j}$) from January

1999 to that month. Similarly, we determine the month that dealer j quits market-making business entirely and count the number of months (τ_j) from January 1999. Then, we re-estimate regression model (1) using $\log(\tau_{i,j})$ (instead of $S_{i,j,t}$) as the dependent variable and regression model (2) using $\log(\tau_j)$ (instead of $S_{j,t}$) as the dependent variable. We measure all explanatory variables using the data during the period that the dealer makes market in the stock. The regression results (see Table 6) are qualitatively identical to those presented in Table 5–note that the sign and statistical significance of the estimated regression coefficient on each and every explanatory variable are identical between Table 5 and Table 6. These results indicate that the variables that explain a dealer's survival probability at a given point in time also explain how long the dealer has survived.

4. Determinants of dealer market share

In the previous section we show that both dealer survival probability and survival length are significantly related to quote aggressiveness and other dealer and stock attributes. Presumably, dealer survival probability and length are related to these variables because they reflect competitive advantages and thus affect dealer market share. Dealers with no competitive advantages are likely to lose market shares and they will ultimately be driven out of the market. In this section, we examine whether the variables that explain dealer survival probability and length also explain cross-sectional variation in dealer market shares.

We calculate dealer j's market share in stock i during month t, $MS_{i,j,t}$, by dividing the trading volume of dealer j in stock i during month t, $V_{i,j,t}$, by the total volume across all dealers in stock i during the month, $\sum jV_{i,j,t}$. We then estimate the following regression model using only those dealers who have survived up to month t:

$$MS_{i,j,t} = \varphi_0 + \varphi_1 \text{H-COMPO1}_{j,t} + \varphi_2 \text{H-COMPO2}_{j,t} + \varphi_3 \log(PINS_{i,j,t}) \text{ [or } \varphi_3 \log(PINSA_{i,j,t}) \text{ or } \varphi_3 \log(RELSP_{i,j,t})] + \varphi_4 \log(RELQS_{i,j,t}) + \varphi_5 WS + \varphi_6 WH + \varphi_7 IB + \varphi_8 AFAN + \varphi_9 SSTATE + \varepsilon_{i,j,t}; \quad (3)$$

where all the independent variables are the same as previously defined in regression model (1). We estimate the above regression model for each month and calculate the average regression coefficients across months and the z-statistics.

We report the regression results in Panel A of Table 7. The results show that the sign and statistical significance of the estimated regression coefficients on all the explanatory variables are qualitatively identical to corresponding values in Table 5 and Table 6. These results indicate that the variables that explain dealer survival probability and length also explain cross-sectional variation in dealer market shares. Overall, our findings suggest that dealers that exited the market did so because they lost their market shares due to the lack of competitive advantages in quote aggressiveness, economies of scale, access to order flow, or access to information.

Finally, we estimate the following regression model using the data that are aggregated across stocks for each dealer as we did in regression model (2):

$$MS_{j,t} = \theta_0 + \theta_1 \text{H-COMPO1}_{j,t} + \theta_2 \text{H-COMPO2}_{j,t} + \theta_3 \log(PINS_{j,t}) \text{ [or } \theta_3 \log(PINSA_{j,t}) \text{ or } \theta_3 \log(RELSP_{j,t})] + \theta_4 \log(RELQS_{j,t}) + \theta_5 WS + \theta_6 WH + \theta_7 IB + \varepsilon_{j,t}; \quad (4)$$

where $MS_{j,t}$ denotes the average market share of dealer j across all stocks in month t defined as $(1/n)\sum iMS_{i,j,t}$, and all other variables are the same as previously defined. We do not include AFAN and SSTATE in this regression because they cannot be meaningfully defined. We estimate the regression model for each month using only those dealers who have survived up to that month and calculate the average regression coefficients across months and the z-statistics.

The results (see Panel B of Table 7) are qualitatively identical to those in Panel A, indicating that the factors that determine a dealer's market share in each stock are also likely to determine the dealer's average market share across stocks

5. Summary and conclusion

In this study we perform a survival analysis of stock market dealers using the data for the eight-year period from 1999 to 2006 that entailed major changes in market and competitive environments. Our study period provides a natural experiment which allows us to analyze the effect of exogenous shocks on dealer exit, survival, and competitive equilibrium. Specifically, we investigate how NASDAQ dealers responded to sudden decreases in both the number of stocks (i.e., market size) and the bid-ask spreads (i.e., profitability). We show that many dealers exited the market as both market size and profitability declined, and this led to a significant reduction in the total number of dealers. Those dealers with competitive advantages survived and each of these survived dealers handled an increasingly larger number of stocks to make up the reduced market-making revenues (smaller spreads) from each of these stocks. As a result, the mean number of dealers for each stock actually increased, despite the considerable decrease in the total number of dealers.

Our results indicate that dealers with diversified market-making operations across stocks suffered less (and survived longer) from the shrinking market than dealers whose market-making businesses were concentrated on select stocks, and dealers with market-making operations in a larger number of stocks survived better because of their economies of scale. Dealers that posted more competitive quotes (i.e., better prices and larger depths) exhibited larger market shares and survived longer. Survival probability is higher for dealers with affiliated analysts, suggesting that the order flow and informational advantages provided by affiliated analysts increased survival probability. We show that geographical proximity also provided dealers with the order flow and informational advantages and thus increased survival probability. On the whole, our results suggest that the Darwinian survival of the fittest applies to dealer markets as well.

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Table 1
Descriptive statistics on the number of dealers per stock, the number of stocks per dealer, and trading volume

Panel A shows descriptive statistics on the number of dealers per stock. For each stock, we first obtain the number of dealers that make a market in each month. We then aggregate the number of dealers in each stock across months to obtain the number of dealers in each year. Panel A also shows the number of newly entered dealers, the number of dealers who exited the market, and the total number of (survived) dealers on NASDAQ across all stocks in each year. Panel B shows descriptive statistics on the number of stocks per dealer. For each dealer, we first obtain the number of stocks in each month. We then aggregate the number of stocks across months to obtain the number of stocks handled by each dealer in each year. Panel B also shows the number of newly listed stocks, the number of stocks that are delisted, and the total number of remaining stocks on NASDAQ that are handled by all dealers in our study sample in each year. Panel C reports the total dollar trading volume across our sample stocks and dealers, the average dollar trading volume per stock, and the average dollar trading volume per dealer for each year from 1999 to 2006.

Panel A. Number of dealers for a stock

	Mean	Percentile					Number of entries	Number of exits	Total number of dealers
		Max.	75th	Median	25th	Min.			
1999	10	76	13	8	5	1	54		516
2000	11	89	14	9	5	1	48	83	481
2001	12	101	15	9	5	1	61	99	443
2002	13	99	16	9	6	1	41	120	364
2003	13	87	16	9	6	1	31	94	301
2004	14	78	19	10	6	1	28	68	261
2005	14	70	19	11	6	1	22	37	246
2006	14	65	18	11	7	1	20	45	221

Panel B. Number of stocks for a dealer

stocks	Mean	Max.	Percentile				Number of new stocks	Number of delisted stocks	Total number of stocks
			75th	Median	25th	Min.			
1999	112	4,412	62	15	5	1	923		5,931
2000	132	4,549	74	18	6	1	788	1,152	5,567
2001	156	4,375	97	21	5	1	260	901	4,926
2002	172	3,881	129	27	6	1	209	867	4,268
2003	183	3,535	157	32	8	1	168	625	3,811
2004	215	3,270	211	41	9	1	280	498	3,593
2005	225	3,221	226	45	8	1	292	351	3,534
2006	248	3,109	252	47	7	1	324	349	3,509

Panel C. Total trading volume, trading volume per stock, and trading volume per dealer

	Total trading volume ($ in billions)	Trading volume per stock ($ in billions)	Trading volume per dealer ($ in billions)
1999	8,376	1.41	16.23
2000	14,446	2.59	30.03
2001	7,511	1.52	16.95
2002	4,376	1.03	12.02
2003	3,560	0.95	11.83
2004	2,590	0.72	9.92
2005	3,129	0.88	12.72
2006	7,460	2.12	33.76

Table 2
Stock H-index, dealer H-index, and their two components

The first three columns in Panel A show the H-index and its two components for the NASDAQ Stock Market as a whole. The next three columns show the mean value of the H-index and its components for individual stocks. The H-index of stock i in month t is defined as: $\text{H-index}_{i,t} = \sum_j [V_{i,j,t}/\sum_j V_{i,j,t}]^2$, where $V_{i,j,t}$ is stock i's volume accounted for by dealer j during month t and $\sum_j$ denotes the summation over j. Note that $\text{H-index}_{i,t}$ can be decomposed into two components. The first component ($\text{H-COMPO1}_{i,t}$) is the sum of squared deviations of dealer market share in stock i from the mean, $\sum_j[(V_{i,j,t}/\sum_j V_{i,j,t}) - (\sum_j V_{i,j,t}/N_i)]^2$, and the second component ($\text{H-COMPO2}_{i,t}$) is $1/N_i$, where N_i is the number of dealers in stock i. We calculate the $\text{H-index}_{i,t}$, $\text{H-COMPO1}_{i,t}$ and $\text{H-COMPO2}_{i,t}$ for each month from January 1999 to December 2006 and obtain their mean values for each year. Similarly, we calculate the H-index and its two components for the NASDAQ market as a whole using the aggregate market share of each dealer across all stocks. The H-index of dealer j in month t is defined as: $\text{H-index}_{j,t} = \sum_i [V_{i,j,t}/\sum_i V_{i,j,t}]^2$, where $V_{i,j,t}$ is stock i's volume accounted for by dealer j in month t and $\sum_i$.is the summation over i. Note that $\text{H-index}_{j,t}$ can be decomposed into two components. The first component ($\text{H-COMPO1}_{j,t}$) is the sum of squared deviations of dealer j's trading volume in each stock from the mean, $\sum_i[(V_{i,j,t}/\sum_i V_{i,j,t}) - (\sum_i V_{i,j,t}/N_j)]^2$, and the second component ($\text{H-COMPO2}_{j,t}$) is $1/N_j$, where N_j is the number of stocks handled by dealer j. Panel B shows the yearly mean values of $\text{H-index}_{j,t}$, $\text{H-COMPO1}_{j,t}$, and $\text{H-COMPO2}_{j,t}$ from 1999 to 2006.

Panel A. Stock H-index and its two components

	Whole market			Individual stocks		
	H-index	Component 1	Component 2	H-index	Component 1	Component 2
1999	367	345	22	2,808	1,257	1,551
2000	377	353	24	2,628	1,229	1,399
2001	383	355	28	2,617	1,275	1,342
2002	436	402	34	2,574	1,364	1,210
2003	593	552	41	2,552	1,412	1,140
2004	651	606	45	2,538	1,423	1,115
2005	667	617	50	2,524	1,433	1,091
2006	686	630	56	2,453	1,439	1,014

Panel B. Dealer H-index and its two components

	H-index	Component 1	Component 2
1999	2,850	1,216	1,634
2000	2,804	1,177	1,627
2001	2,752	1,153	1,599
2002	2,674	1,148	1,526
2003	2,622	1,143	1,479
2004	2,531	1,063	1,468
2005	2,482	1,070	1,412
2006	2,463	1,059	1,404

Table 3
Quoted, effective, and realized bid-ask spreads

We calculate the quoted, effective, and realized spreads of stock i at time t using the following formulas: Quoted $spread_{i,t} = (Ask_{i,t} – Bid_{i,t})/M_{i,t}$; Effective $spread_{i,t} = 2D_{i,t}(P_{i,t} – M_{i,t})/M_{i,t}$; and Realized $spread_{i,t} = 2D_{i,t}(P_{i,t} - P_{i,t+5})/M_{i,t}$; where $Ask_{i,t}$ is the best ask price of stock i at time t, $Bid_{i,t}$ is the best bid price of stock i at time t, $M_{i,t}$ is the quote midpoint $((Ask_{i,t} + Bid_{i,t})/2)$ of stock i at time t, $P_{i,t}$ is the transaction price of stock i at time t, $P_{i,t+5}$ is the first transaction price at least five minutes after the trade for which the realized spread is measured, and $D_{i,t}$ is a binary variable which equals +1 for customer buy orders and -1 for customer sell orders. We estimate $D_{i,t}$ using the algorithm in Lee and Ready (1991) as modified by Bessembinder (2003c). For each stock, we then calculate the time-weighted average quoted spread and trade-weighted average effective and realized spreads for each month from January 1999 to December 2006. We then calculate the yearly mean values of these variables.

	Quoted spread		Effective spread		Realized spread	
	Mean	Median	Mean	Median	Mean	Median
1999	0.0390	0.0285	0.0329	0.0255	0.0205	0.0135
2000	0.0352	0.0246	0.0299	0.0217	0.0182	0.0127
2001	0.0376	0.0243	0.0314	0.0213	0.0191	0.0122
2002	0.0313	0.0200	0.0281	0.0175	0.0170	0.0099
2003	0.0224	0.0123	0.0195	0.0108	0.0108	0.0054
2004	0.0177	0.0115	0.0126	0.0079	0.0059	0.0036
2005	0.0151	0.0088	0.0105	0.0057	0.0049	0.0024
2006	0.0128	0.0071	0.0084	0.0042	0.0036	0.0016

Table 4
Comparison of quote aggressiveness between survived and exited dealers

We measure dealer j's quote aggressiveness in stock i during month t by (1) the percentage of dealer j's time at the inside market, $PINS_{i,j,t}$; (2) the percentage of dealer j's time at the inside market *alone*, $PINSA_{i,j,t}$; (3) the ratio of dealer j's spread in stock i to the average spread of all dealers in stock i, $RELSP_{i,j,t}$; and (4) the relative magnitude of dealer j's quoted depth to the average quoted depth of all dealers at the inside for stock i, $RELQS_{i,j,t}$. For each stock, we identify two groups of dealers in each month. Group $SURVIVE_{i,t}$ includes all dealers that made a market in stock i in month t and continued their market making in the stock in the following month. Group $EXIT_{i,t}$ includes all dealers that made a market in stock i in month t but exited the market in stock i after month t. We then calculate mean quote aggressive measures for each group during two years, one year, six months, and one month preceding the exit. We repeat the process for each month from January 1999 to December 2004 and for each stock in our study sample and aggregate the quote aggressive measures over months and stocks. This table shows the mean quote aggressiveness measures of the survived and exited dealer groups and the difference in each quote aggressiveness measure between the two groups. Numbers in parentheses are t-statistics testing the equality of the mean values between the survived and exited dealers.

	Group SURVIVE	Group EXIT	Difference (SURVIVE – EXIT)
Quote aggressiveness measures during two years preceding the exit			
$PINS_{i,j}$	0.2630	0.1614	0.1016** (133.36)
$PINSA_{i,j}$	0.0803	0.0608	0.0195** (76.61)
$RELSP_{i,j}$	1.3097	2.2902	-0.9805** (-114.20)
$RELQS_{i,j}$	0.8261	0.6494	0.1767** (57.79)
Quote aggressiveness measures during one year preceding the exit			
$PINS_{i,j}$	0.2511	0.1519	0.0992** (149.90)
$PINSA_{i,j}$	0.0795	0.0605	0.0190** (83.20)
$RELSP_{i,j}$	1.5558	2.3208	-0.7650** (-136.23)
$RELQS_{i,j}$	0.7984	0.6713	0.1271** (54.51)
Quote aggressiveness measures during six months preceding the exit			
$PINS_{i,j}$	0.2427	0.1429	0.0998** (162.45)
$PINSA_{i,j}$	0.0781	0.0582	0.0199** (89.30)
$RELSP_{i,j}$	1.6488	2.3564	-0.7076** (-97.19)
$RELQS_{i,j}$	0.7676	0.6660	0.1016** (42.41)
Quote aggressiveness measures during one month preceding the exit			
$PINS_{i,j}$	0.2401	0.1269	0.1132** (181.07)
$PINSA_{i,j}$	0.0777	0.0547	0.0230** (103.45)
$RELSP_{i,j}$	1.7206	2.4859	-0.7653** (-125.72)
$RELQS_{i,j}$	0.7533	0.6537	0.0996** (49.11)

**Significant at the 1% level.

Table 5
Quote aggressiveness and attributes of survived dealers

Panel A shows the results of the following probit regression model:

$$S_{i,j,t} = \gamma_0 + \gamma_1\text{H-COMPO1}_{j,t} + \gamma_2\text{H-COMPO2}_{j,t} + \gamma_3\log(PINS_{i,j,t})\ [\text{or } \gamma_3\log(PINSA_{i,j,t}) \text{ or } \gamma_3\log(RELSP_{i,j,t})] + \gamma_4\log(RELQS_{i,j,t}) + \gamma_5 WS + \gamma_6 WH + \gamma_7 IB + \gamma_8 AFAN + \gamma_9 SSTATE + \varepsilon_{i,j,t}; \quad (a)$$

where $S_{i,j,t}$ is a binary variable which equals one for dealers that belong to Group $SURVIVE_{i,t}$ and zero for dealers that belong to Group $EXIT_{i,t}$, $\text{H-COMPO1}_{j,t}$ is the sum of squared deviations of dealer j's trading volume in each stock from the mean, $\sum_i[(V_{i,j,t}/\sum_i V_{i,j,t}) - (\sum_i V_{i,j,t}/N_j)]^2$, and $\text{H-COMPO2}_{j,t}$ is $1/N_j$, where N_j is the number of stocks handled by dealer j. $PINS_{i,j,t}$ is the percentage of dealer j's time at the inside market, $PINSA_{i,j,t}$ is the percentage of dealer j's time at the inside market *alone*, $RELSP_{i,j,t}$ is the ratio of dealer j's spread in stock i to the average spread of all dealers in stock i, and $RELQS_{i,j,t}$ is the relative magnitude of dealer j's quoted depth to the average quoted depth of all dealers at the inside for stock i. WS is an indicator variable which equals one for wirehouse and zero otherwise, WH is an indicator variable which equals one for wholesaler and zero otherwise, IB is a binary variable which equals one for institutional broker and zero otherwise, AFAN is an indicator variable which equals one if the stock handled by the dealer is followed by an analyst who is affiliated with the dealer's company and zero otherwise, and SSTATE is an indicator variable which equals one if the headquarters of the dealer and the firm are located in the same state and zero otherwise. Panel B shows the results of the following probit regression model:

$$S_{j,t} = \delta_0 + \delta_1\text{H-COMPO1}_{j,t} + \delta_2\text{H-COMPO2}_{j,t} + \delta_3\log(PINS_{j,t})\ [\text{or } \delta_3\log(PINSA_{j,t}) \text{ or } \delta_3\log(RELSP_{j,t})] + \delta_4\log(RELQS_{j,t}) + \delta_5 WS + \delta_6 WH + \delta_7 IB + \varepsilon_{j,t}; \quad (b)$$

where $S_{j,t}$ is a binary variable which equals one for dealers that belong to Group $SURVIVE_{i,t}$ and zero for dealers that belong to Group $EXIT_{i,t}$, and all other variables are the same as previously defined. We estimate these models for each month and calculate the average regression coefficients across months and the z-statistics. We calculate the z-statistic by adding individual regression t-statistics across months and then dividing the sum by the square root of the number of regression coefficients. Numbers in parentheses are z-statistics.

Panel A. Results for regression model (a)

	$S_{i,j,t}$	$S_{i,j,t}$	$S_{i,j,t}$
Intercept	3.0039**	1.6920**	1.4978**
	(206.84)	(56.42)	(195.36)
$\text{H-COMPO1}_{j,t}$	-2.2487**	-2.3480**	-2.3259**
	(-39.42)	(-45.68)	(-44.86)
$\text{H-COMPO2}_{j,t}$	-1.4125**	-1.4230**	-1.4388**
	(-56.99)	(-59.08)	(-59.55)
$PINS_{i,j,t}$	0.6160**		
	(143.17)		
$PINSA_{i,j,t}$		0.0796**	
		(39.31)	
$RELSP_{i,j,t}$			-0.1386**
			(-43.31)
$RELQS_{i,j,t}$	0.0923**	0.0939**	0.0997**
	(39.37)	(42.71)	(43.31)
WS	0.7699**	0.7881**	0.7928**
	(29.05)	(35.35)	(36.34)
WH	0.9249**	1.0334**	0.9615**
	(48.73)	(57.55)	(53.72)
IB	0.7081**	0.7235**	0.7108**
	(45.89)	(50.49)	(47.74)
AFAN	0.9367**	0.9415**	0.9520**
	(23.74)	(23.14)	(25.18)
SSTATE	0.4696**	0.4967**	0.4934**
	(29.23)	(31.72)	(31.67)

**Significant at the 1% level.

Table 5 (continued)

Panel B. Results for regression model (b)

	$S_{j,t}$	$S_{j,t}$	$S_{j,t}$
Intercept	2.3116** (48.78)	1.8063** (16.04)	0.2780** (11.08)
H-COMPO1$_{j,t}$	-0.7960** (-8.46)	-0.8300** (-9.42)	-0.8560** (-9.74)
H-COMPO2$_{j,t}$	-0.6865** (-11.91)	-0.7029** (-14.37)	-0.7227** (-14.84)
PINS$_{j,t}$	0.9035** (49.37)		
PINSA$_{j,t}$		0.4920** (15.18)	
RELSP$_{j,t}$			-0.1569** (-12.17)
RELQS$_{j,t}$	0.1585** (8.50)	0.1592** (10.65)	0.1605** (9.15)
WS	1.1253** (9.63)	1.1408** (9.83)	1.0640** (9.30)
WH	0.6508** (8.76)	0.6290** (7.67)	0.6401** (7.93)
IB	0.4628** (7.27)	0.4551** (7.85)	0.4803** (8.28)

**Significant at the 1% level.

Table 6
Survival length, quote aggressiveness, and dealer attributes

Panel A shows the results of the following regression model:

$$\log(\tau_{i,j}) = \omega_0 + \omega_1\text{H-COMPO1}_j + \omega_2\text{H-COMPO2}_j + \omega_3\log(\text{PINS}_{i,j}) \text{ [or } \omega_3\log(\text{PINSA}_{i,j}) \text{ or } \omega_3\log(\text{RELSP}_{i,j})] + \omega_4\log(\text{RELQS}_{i,j}) + \omega_5\text{WS} + \omega_6\text{WH} + \omega_7\text{IB} + \omega_8\text{AFAN} + \omega_9\text{SSTATE} + \varepsilon_{i,j}; \quad \text{(a)}$$

where $\tau_{i,j}$ denotes the number of months dealer j makes market in stock i, H-COMPO1$_j$ is the sum of squared deviations of dealer j's trading volume in each stock from the mean, $\sum_i[(V_{i,j}/\sum_i V_{i,j}) - (\sum_i V_{i,j}/N_j)]^2$, and H-COMPO2$_j$ is $1/N_j$, where N_j is the number of stocks handled by dealer j. PINS$_{i,j}$ is the percentage of dealer j's time at the inside market, PINSA$_{i,j}$ is the percentage of dealer j's time at the inside market *alone*, RELSP$_{i,j}$ is the ratio of dealer j's spread in stock i to the average spread of all dealers in stock i, and RELQS$_{i,j}$ is the relative magnitude of dealer j's quoted depth to the average quoted depth of all dealers at the inside for stock i. WS is an indicator variable which equals one for wirehouse and zero otherwise, WH is an indicator variable which equals one for wholesaler and zero otherwise, IB is a binary variable which equals one for institutional broker and zero otherwise, AFAN is an indicator variable which equals one if the stock handled by the dealer is followed by an analyst who is affiliated with the dealer's company and zero otherwise, and SSTATE is an indicator variable which equals one if the headquarters of the dealer and the firm are located in the same state and zero otherwise. Panel B shows the results of the following regression model:

$$\log(\tau_j) = \eta_0 + \eta_1\text{H-COMPO1}_j + \eta_2\text{H-COMPO2}_j + \eta_3\log(\text{PINS}_j) \text{ [or } \eta_3\log(\text{PINSA}_j) \text{ or } \eta_3\log(\text{RELSP}_j)] + \eta_4\log(\text{RELQS}_j) + \eta_5\text{WS} + \eta_6\text{WH} + \eta_7\text{IB} + \varepsilon_j; \quad \text{(b)}$$

where τ_j denotes the number of months dealer j makes market and all other variables are the same as previously defined. We estimate these models for each month and calculate the average regression coefficients across months and the z-statistics. We calculate the z-statistic by adding individual regression t-statistics across months and then dividing the sum by the square root of the number of regression coefficients. Numbers in parentheses are z-statistics.

Panel A. Results for regression model (a)

	$\tau_{i,j}$	$\tau_{i,j}$	$\tau_{i,j}$
Intercept	3.2742**	3.1368**	2.1008**
	(316.60)	(141.94)	(314.52)
H-COMPO1$_j$ x 10^4	-0.6957**	-0.7263**	-0.7001**
	(-19.93)	(-21.27)	(-19.85)
H-COMPO2$_j$ x 10^4	-0.6739**	-0.7165**	-0.8238**
	(-54.29)	(-61.97)	(-66.00)
PINS$_{i,j}$	0.5264**		
	(132.77)		
PINSA$_{i,j}$		0.3170**	
		(46.41)	
RELSP$_{i,j}$			-0.0803**
			(-18.75)
RELQS$_{i,j}$	0.1938**	0.2329**	0.3058**
	(46.44)	(68.62)	(72.31)
WS	0.2715**	0.2960**	0.3481**
	(28.52)	(30.33)	(42.69)
WH	0.3556**	0.3936**	0.4121**
	(32.21)	(37.47)	(38.12)
IB	0.4699**	0.4933**	0.4849**
	(44.02)	(48.82)	(47.39)
AFAN	0.8919**	0.9269**	0.9333**
	(19.34)	(22.39)	(19.46)
SSTATE	0.3803**	0.4196**	0.4099**
	(25.98)	(29.40)	(27.36)
Adjusted-R^2	0.23	0.19	0.16

**Significant at the 1% level.

Table 6 (continued)

Panel B. Results for regression model (b)

	τ_j	τ_j	τ_j
Intercept	4.3659**	4.1253**	3.8361**
	(20.21)	(9.37)	(23.93)
H-COMPO1$_j$ x 10^4	-1.4340**	-1.6101**	-1.4201**
	(-4.11)	(-4.51)	(-4.39)
H-COMPO2$_j$ x 10^4	-0.7160**	-0.7330**	-0.6972**
	(-5.41)	(-5.93)	(-5.40)
PINS$_j$	0.8375**		
	(7.73)		
PINSA$_j$		0.9131**	
		(6.76)	
RELSP$_j$			-0.4540**
			(-5.68)
RELQS$_j$	0.8713**	0.6903**	0.7674**
	(6.67)	(5.46)	(5.95)
WS	1.3436**	1.5440**	1.5849**
	(3.73)	(3.53)	(4.01)
WH	1.7957**	1.8611**	1.5928**
	(4.62)	(4.68)	(4.47)
IB	1.1924**	1.3421**	1.3998**
	(4.42)	(4.80)	(5.66)
Adjusted-R^2	0.29	0.26	0.33

**Significant at the 1% level.

Table 7
Market share, quote aggressiveness and dealer attributes

Panel A shows the results of the following regression model:

$$MS_{i,j,t} = \varphi_0 + \varphi_1 \text{H-COMPO1}_{j,t} + \varphi_2 \text{H-COMPO2}_{j,t} + \varphi_3 \log(PINS_{i,j,t}) \text{ [or } \varphi_3 \log(PINSA_{i,j,t}) \text{ or } \varphi_3 \log(RELSP_{i,j,t})] + \varphi_4 \log(RELQS_{i,j,t}) + \varphi_5 WS + \varphi_6 WH + \varphi_7 IB + \varphi_8 AFAN + \varphi_9 SSTATE + \varepsilon_{i,j,t}; \quad \text{(a)}$$

where $MS_{i,j,t}$ is dealer j's market share in stock i during month t, $\text{H-COMPO1}_{j,t}$ is the sum of squared deviations of dealer j's trading volume in each stock from the mean, $\sum_i[(V_{i,j,t}/\sum_i V_{i,j,t}) - (\sum_i V_{i,j,t}/N_j)]^2$, and $\text{H-COMPO2}_{j,t}$ is $1/N_j$, where N_j is the number of stocks handled by dealer j. $PINS_{i,j,t}$ is the percentage of dealer j's time at the inside market, $PINSA_{i,j,t}$ is the percentage of dealer j's time at the inside market *alone*, $RELSP_{i,j,t}$ is the ratio of dealer j's spread in stock i to the average spread of all dealers in stock i, and $RELQS_{i,j,t}$ is the relative magnitude of dealer j's quoted depth to the average quoted depth of all dealers at the inside for stock i. WS is an indicator variable which equals one for wirehouse and zero otherwise, WH is an indicator variable which equals one for wholesaler and zero otherwise, IB is a binary variable which equals one for institutional broker and zero otherwise, AFAN is an indicator variable which equals one if the stock handled by the dealer is followed by an analyst who is affiliated with the dealer's company and zero otherwise, and SSTATE is an indicator variable which equals one if the headquarters of the dealer and the firm are located in the same state and zero otherwise. Panel B shows the results of the following regression model:

$$MS_{j,t} = \theta_0 + \theta_1 \text{H-COMPO1}_{j,t} + \theta_2 \text{H-COMPO2}_{j,t} + \theta_3 \log(PINS_{j,t}) \text{ [or } \theta_3 \log(PINSA_{j,t}) \text{ or } \theta_3 \log(RELSP_{j,t})] + \theta_4 \log(RELQS_{j,t}) + \theta_5 WS + \theta_6 WH + \theta_7 IB + \varepsilon_{j,t}; \quad \text{(b)}$$

where $MS_{j,t}$ denotes the average market share of dealer j across all stocks in month t defined as $(1/n)\sum iMS_{i,j,t}$, and all other variables are the same as previously defined. We estimate the regression model for each month using only those dealers who have survived up to that month and calculate the average regression coefficients across months and the z-statistics. We calculate the z-statistic by adding individual regression t-statistics across months and then dividing the sum by the square root of the number of regression coefficients. Numbers in parentheses are z-statistics.

Panel A. Results for regression model (a)

	$MS_{i,j,t}$	$MS_{i,i,t}$	$MS_{i,j,t}$
Intercept	0.1631**	0.5707**	0.1759**
	(379.22)	(577.23)	(270.74)
$\text{H-COMPO1}_{j,t}$	0.0109**	0.0117**	0.0118**
	(16.38)	(16.09)	(14.92)
$\text{H-COMPO2}_{j,t}$	0.0083**	0.0076**	0.0063**
	(23.44)	(22.13)	(19.66)
$PINS_{i,j,t}$	0.0454**		
	(300.51)		
$PINSA_{i,j,t}$		0.1580**	
		(527.56)	
$RELSP_{i,j,t}$			-0.0349**
			(-186.46)
$RELQS_{i,j,t}$	0.0126**	0.0094**	0.0177**
	(99.34)	(73.48)	(118.94)
WS	0.0721**	0.0683**	0.0891**
	(155.28)	(106.10)	(198.82)
WH	0.0121**	0.0151**	0.0091**
	(36.63)	(49.06)	(33.48)
IB	0.0352**	0.0396**	0.0303**
	(61.64)	(88.61)	(56.41)
AFAN	0.0019**	0.0024**	0.0028**
	(16.54)	(18.23)	(19.84)
SSTATE	0.0115**	0.0096**	0.0145**
	(28.40)	(25.11)	(24.25)
Adjusted-R^2	0.43	0.58	0.36

**Significant at the 1% level.

Table 7 (continued)

Panel B. Results for regression model (b)

	$MS_{j,t}$	$MS_{j,t}$	$MS_{j,t}$
Intercept	0.1581** (82.61)	0.4860** (102.64)	0.0641** (62.93)
$H\text{-}COMPO1_{j,t}$	0.0252** (13.11)	0.0223** (11.74)	0.0262** (11.42)
$H\text{-}COMPO2_{j,t}$	0.0316** (19.26)	0.0331** (18.73)	0.0287** (17.24)
$PINS_{j,t}$	0.0474** (59.79)		
$PINSA_{j,t}$		0.1361** (92.10)	
$RELSP_{j,t}$			-0.0282** (-37.40)
$RELQS_{j,t}$	0.0084** (27.99)	0.0074** (19.51)	0.0119** (23.88)
WS	0.0673** (13.10)	0.0555** (9.42)	0.0656** (15.35)
WH	0.0127** (11.23)	0.0151** (12.38)	0.0098** (10.57)
IB	0.0319** (17.19)	0.0384** (19.36)	0.0393** (15.84)
Adjsuted-R^2	0.36	0.50	0.28

**Significant at the 1% level.

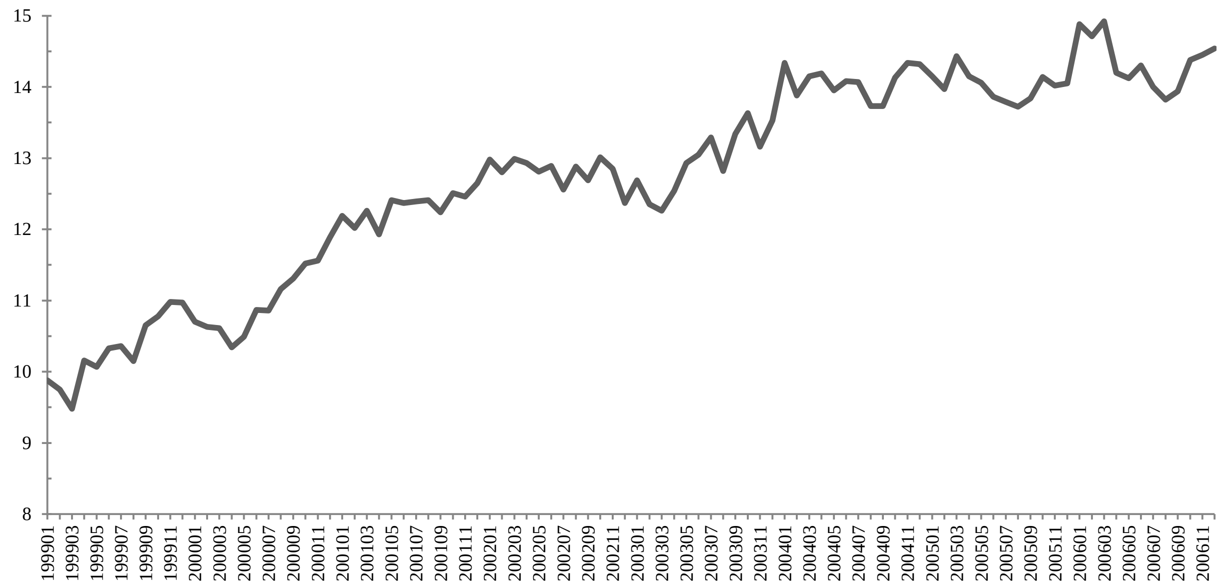

Figure 1. Number of dealers per stock from January 1999 to December 2006

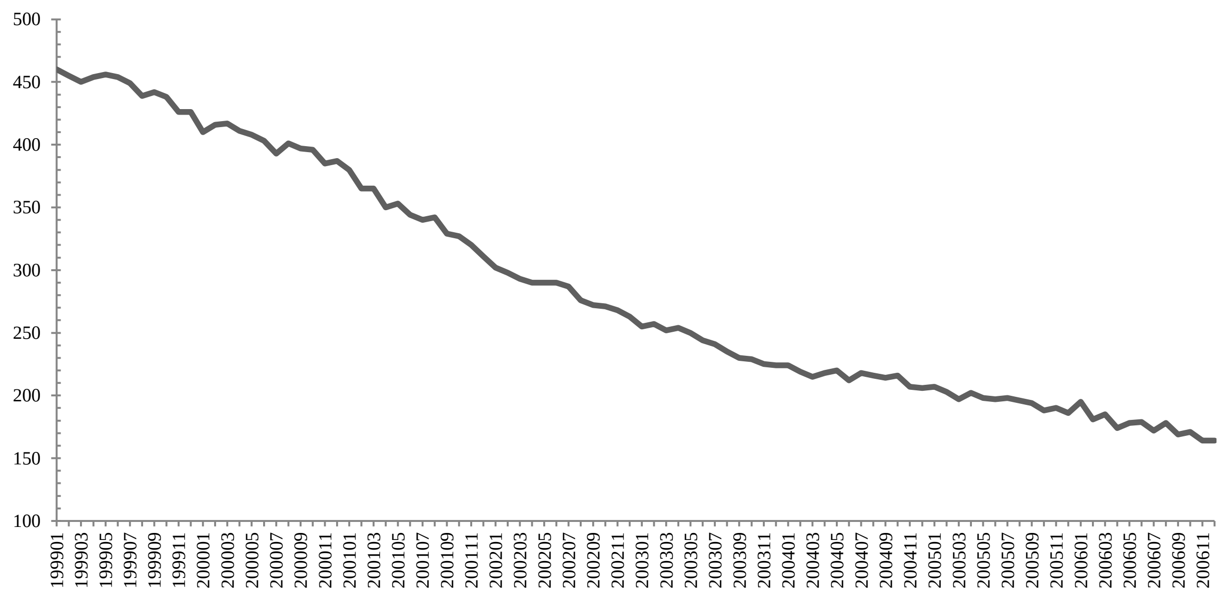

Figure 2. Total number of dealers on NASDAQ from January 1999 to December 2006

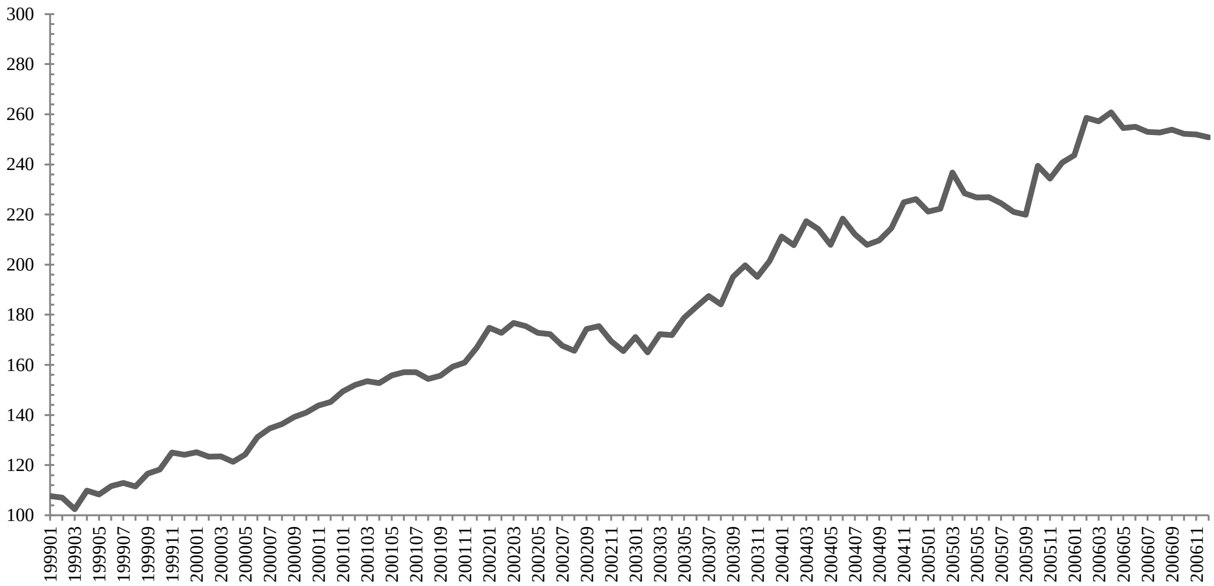

Figure 3. Number of stocks per dealer from January 1999 to December 2006

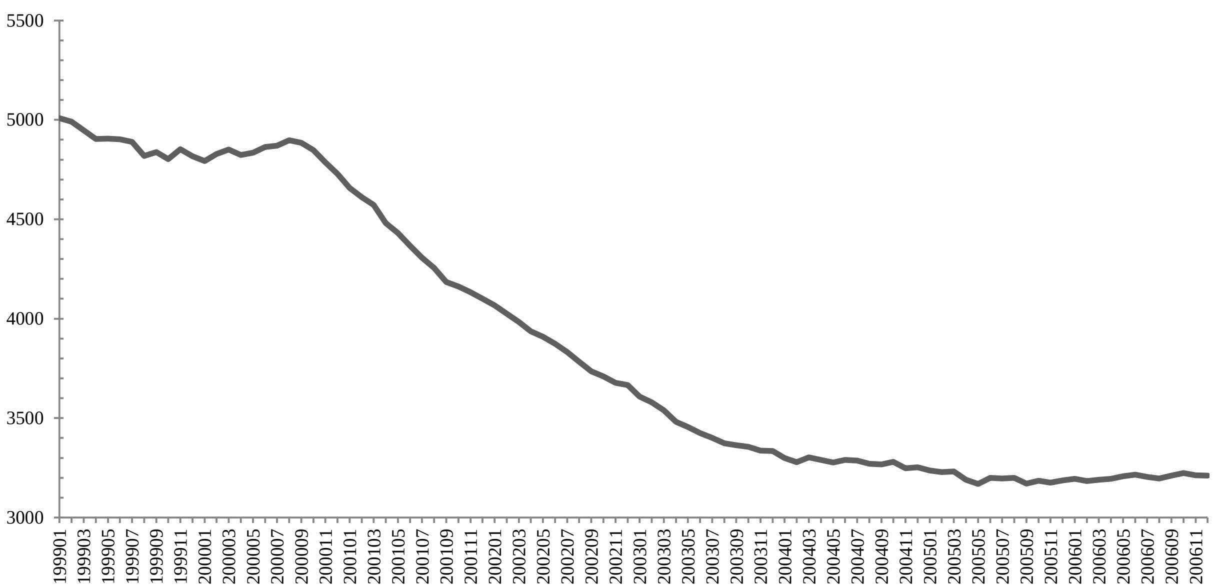

Figure 4. Total number of stocks on NASDAQ from January 1999 to December 2006

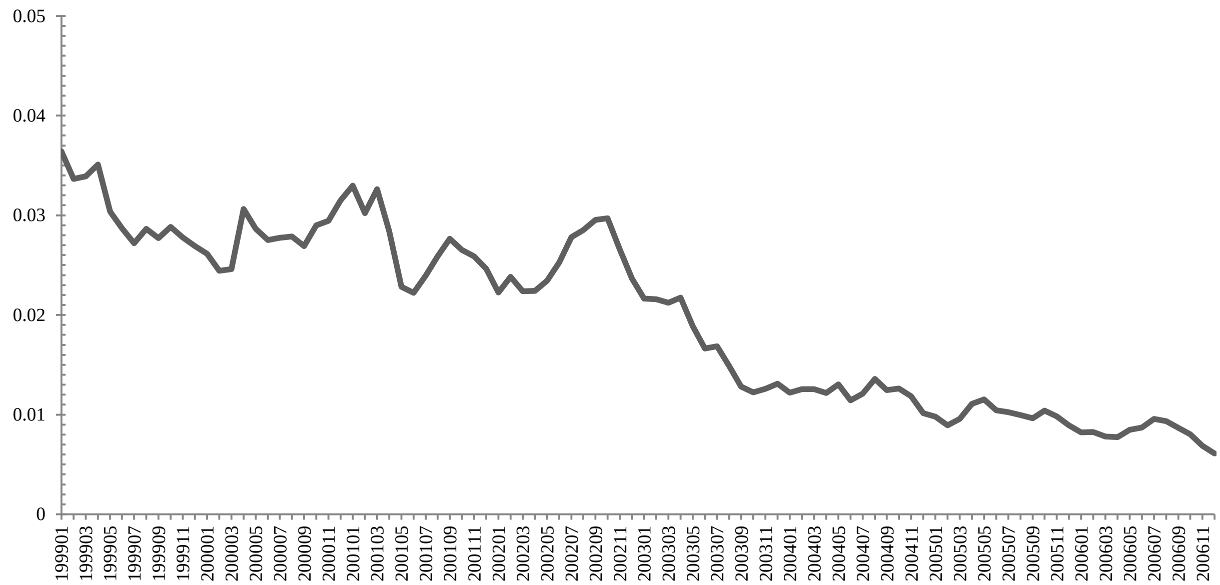

Figure 5. The mean effective spread from January 1999 to December 2006