The Impact of E-Commerce on Competition in the Retail Brokerage Industry

Yannis Bakos **Henry C. Lucas, Jr.** **Wonseok Oh**
Gary Simon **Siva Viswanathan** **Bruce Weber**[+]

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ABSTRACT

This paper analyzes the impact of e-commerce on markets where established firms face competition from Internet-based entrants with focused offerings. In particular, we study the retail brokerage sector where the growth of online brokerages and the availability of alternate sources of information and research services have challenged the dominance of traditional brokerages. We develop a stylized game-theoretic model to analyze the impact of competition between an incumbent full-service brokerage firm with a bundled offering of research services and trade execution and an online entrant offering just trade execution. We find that as consumers' willingness-to-pay for research declines, the incumbent finds it optimal to unbundle its offering when competing with the online entrant. We also find that the online entrant chooses a lower quality of trade execution when faced with direct competition from the incumbent's unbundled offering. The analytical model motivates a unique field experiment placing actual simultaneous trades with traditional full-service and online brokers, to compare order handling practices and the quality of trade execution. In keeping with our analytical results, our empirical findings show a significant difference in the quality of execution between online brokerages and their full-service counterparts. We discuss the relevance of our findings for quality differentiation, price convergence and profit decline in a variety of markets where traditional incumbents are faced with changes in the competitive landscape as a result of e-commerce.
Keywords: E-commerce, impact of IT, unbundling, execution quality.

[+] Affiliations: Bakos and Simon are at the Stern School of Business, New York University; Lucas and Viswanathan are at the Robert H. Smith School of Business, the University of Maryland, Oh is on the faculty of Management at McGill University, and Weber is at the London Business School.

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INTRODUCTION

This paper analyzes the impact of e-commerce on markets where established full-service firms offering a broad range of goods and services face competition from Web-based entrants with narrower product offerings. In particular, we study the retail brokerage market, which experienced rapid growth in the share of online brokers providing low-priced trade executions. Retail brokerage represents one of the most successful applications of e-commerce; for instance, the number of online accounts grew from 7 million in 1998 to over 31 million in 2003, with online brokers responsible for 28% of U.S. retail trades in 2002.

Traditional, full-service brokerage firms used to bundle trade execution with associated investment services and research, while online entrants typically focused on trade execution through easy-to-use interfaces that linked individual investors to the trading venues. The dramatically lower commissions of online brokers and the large amount of financial information available online, which enabled retail investors to conduct their own research, significantly reduced the appeal of the full-service brokers' bundled offerings of research and trade execution. The Web is widely credited with making trade execution more affordable and attractive for retail investors, stimulating the growth of the "self-directed" market segment for brokerage services. Thus, the advent of the Web has radically shifted the competitive environment by enabling the growth of online brokers, who focused on trade execution and charged significantly lower commissions than traditional brokers.

An important feature of retail stock trading is that it is difficult for a typical investor to verify if a trade was executed at the best possible price. The same order may be executed at different prices when handled by different firms; thus in addition to the explicit commissions they pay, investors face potential costs from differences in execution quality. This cost is hidden, in the sense that the actual price of the trade and any "price improvement[1]" becomes known only after a trade is executed. While brokers provide information on which market the trade occurred in (e.g., the New

York Stock Exchange, or the Boston Stock Exchange), information on the actual quality of execution compared to what was possible at the time of trading typically is not available to investors.

Online brokers argue that their significantly lower commissions reflected their cost advantage over traditional brokers burdened with significant investments in legacy systems, physical assets and expensive human brokers. On the other hand, traditional brokers and industry analysts have questioned the quality of execution of online brokerages and their order-handling practices:

> "*It costs just a few bucks to make an online stock trade. The growing concern is that investors are getting what they pay for. Regulators and industry participants worry that online investors, without know it, are sometimes getting poor trade executions in return for low commissions"* (Wall Street Journal, April 23, 1999).

> "*Everybody's happy with $9.95 trades, but they're not looking at what their broker really costs them*," (Business Week, May 22, 2000).

Despite the growing market share of online brokerages and the concerns regarding their quality of trade execution, there has been little systematic research examining the execution quality of the different types of retail brokerage firms. Our paper fills this void by studying the quality of trade-execution in full-service and online brokers. We first develop a stylized game-theoretic model of competition between an incumbent full-service broker offering research and other services bundled with trade execution, and an online entrant offering just trade execution. The results of our analytical model show that under certain conditions, an incumbent full-service broker would find it optimal to unbundle its previously bundled offerings when competing with an online entrant offering just trade execution. We also find that the online entrant's quality choice depends on whether the incumbent retains a bundling strategy or changes to a component-pricing strategy. In particular, the online entrant chooses a lower quality when the incumbent pursues component pricing. While all consumers benefit from lower prices resulting from greater competition, online consumers may be faced with a lower quality offering compared to their counterparts.

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[1] A price improvement occurs when an investor is able to buy a stock for less than the asking price or sell it for more

Our analytical model provides insights about the impact of competition on the quality choices of the different brokerages. The model motivates our empirical study, a unique field experiment to compare the execution quality and order-routing choices of full-service and online brokerage firms. The results of our experiment show that online brokers indeed offer a lower quality of trade-execution compared to traditional full-service brokers. However, higher commission costs of full-service brokers are not offset by the differences in execution qualities between full-service and online brokers.

Our paper presents one of the first studies of execution quality in financial markets based on simultaneous trades placed with different categories of brokerages. Our findings are particularly significant given the difficulty of measuring execution qualities in the retail brokerage market. In contrast to past studies of electronic commerce that focus on price transparency, this research identifies other components of a transaction that are important, in this case, trade quality. Our study shows that a unitary focus on "price-transparency" can be misleading, and our findings highlight the significance of hidden costs and the need for greater transparency on other dimensions of importance. Finally, the results of our analytical model and empirical study contribute to our understanding of developments in other industries where incumbents with bundled offerings are faced with competition from online entrants with low-cost component-offerings.

RESEARCH CONTEXT

The U.S. securities industry generated $26 billion in brokerage commissions in both 2003 and 2004 according to the Securities Industry Association (SIA), and is the third largest component of the financial sector after banking and insurance. Government regulations in the U.S. require that a registered brokerage firm act as an agent or a "tollgate" between the investor and the financial markets; in other words, investors are prohibited from accessing the NYSE, the Nasdaq, or the regional exchanges directly. Although the end of fixed brokerage commissions on May 1, 1975 led

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than the bid price, i.e. the execution of the order occurs within the spread between the bid/ask prices.

to the entry of discount broker such as Charles Schwab, the brokerage sector remained dominated by large full-service brokerage houses that provide a bundle of investment services including research, advice, and trade-execution for a single price. Commissions for a 100-share trade with a full-service broker were $75-$150 through the mid-1990s. These traditional full-service brokerage firms are, in most cases, full members of the principal stock markets, NYSE and Nasdaq, maintaining a staff of floor traders and proprietary market makers for Nasdaq stocks. The full-service brokerage firms have also invested heavily in technologies linking their trading desks to the NYSE and Nasdaq systems, making it easier and cheaper for them to trade on these exchanges.

Information technology and the growth of e-commerce in the 1990s have brought about significant changes in the retail brokerage industry (Konana et al., 2000). The Internet in particular, led to the rapid growth of online brokerages that offered just trade execution to retail investors, resulting in an explosion of online trading by "self-directed investors" who primarily valued trade execution. Unlike traditional brokerages, online brokerage firms typically have no stock brokers or branch offices, and the entire process is automated (Chen and Hitt, 2002)

Concomitant with the growth of retail brokerages there has also been a growth of trading venues (Clemons and Weber, 1997). While most trading is still concentrated in the primary exchanges, information technology brought about an explosion of alternate trading venues such as Electronic Communications Networks (ECNs) that match buyers and sellers. These alternate trading venues serve as cheaper alternatives, particularly for smaller brokerage firms that are not members of the main exchanges. In addition, several of these trading venues offer "payments for order flow" (POF) for orders that add liquidity, making them more attractive to new entrants[2].

After a customer places an order, a broker can route it to the floor of the NYSE, the Nasdaq, or any of the regional stock exchanges. Alternatively, the broker can route the order to a third market

[2] For instance, as of 2004 most ECNs (such as INET, Archipelago, and Brut) charged fees/commissions in the range of $0.10 to $0.50 for a 100-share trade. In certain ECNs, an order that adds liquidity would receive a POF rebate in the range of $0.10 to $0.30 instead of being charged a commission.

maker or to an ECN that automatically matches buy and sell orders. These different trading venues can vary in their cost of order execution for different brokers, and limited discretion is allowed by Securities and Exchange Commission's regulations[3]. Thus, although brokers are obligated to get investors the best possible price, a broker may have an incentive to route an order to a specific venue rather than to the best possible market at the time.

The growth of online brokerages with different cost structures as well as the emergence of trading venues with different execution costs and payment policies has raised a number of interesting and important issues. Added to these developments, the availability of cheaper online alternatives poses significant challenges for traditional brokerages as well as regulators. As noted earlier, there are concerns regarding choice of trading venues as well as execution quality that have not been systematically addressed. The implications of these developments for competition between online entrants and traditional full-service brokerages and their choice of execution qualities is the main focus of our study.

BUNDLING PRODUCT OFFERINGS

Prior research on bundling is of particular relevance to our study. Most bundling-related research focuses on the profitability and efficiency of bundling compared to component pricing strategies. Adams and Yellen (1976) compare component-pricing, pure-bundling and mixed-bundling pricing strategies and show that the package-selling strategy generally increases a seller's profit and extracts consumer surplus. Varian (1995) identifies the basic factors affecting the economics of bundling for information goods and finds that commodity bundling can increase seller profits by reducing the heterogeneity of the consumers' willingness to pay. Bakos and Brynjolfsson (1999) derive the optimal bundling strategy for selling a large number of unrelated information goods, while Bakos and Brynjolfsson (2000) study the effects of large-scale bundling strategies for

[3] The SEC requires that when a broker acts on behalf of a customer in a transaction, the agent is under duty to exercise reasonable care to obtain the most advantageous terms for the customer. Thus, the duty of best execution requires

information goods in a competitive setting. Their results show 1) the conditions under which larger bundlers outperform their smaller counterparts, and 2) when bundling information goods allows incumbents to be more profitable than less-established competitors. In contrast to earlier studies on bundling that focus primarily on the price-discriminatory implications of bundling, Nalebuff (2004) finds that bundling can also serve as an effective entry deterrent strategy for incumbents. Recent studies have also identified conditions under which component pricing can be more profitable than bundling strategies. Chuang and Sirbu (1998) find that in a monopoly lacking significant economies of scale, pure unbundling can dominate pure bundling. Fay and MacKie-Mason (2003) show that when consumers' preferences are heterogeneous duopolistic-competition reduces the effectiveness of a firm's bundling strategy and makes component-pricing optimal. Parker and Van Alstyne (2003) also find that unbundling, rather than bundling, maximizes a firm's profit when network externalities lead firms to develop complementary products.

While there is a growing stream of research on the implications of bundling goods and services, the growth of the Web has also led to the emergence of online firms selling individual components of previously bundled offerings. Very little is known about the implications of competition between an incumbent with a bundled offering and an entrant with a focused (component) offering. More importantly, the implications of such competition for the quality choices of these firms are also unclear. Our theoretical model and empirical findings add to these studies, by examining the strategic interdependence between bundling strategies and the quality choices of competing firms.

A MODEL OF COMPETITION BETWEEN FULL-SERVICE AND ONLINE BROKERS

Full-service brokerage firms use a broker as the client contact point to recommend investment opportunities, provide research reports and offer customer service in addition to executing trades,

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brokers to route their customers' orders to market centers that execute trades at the NBBO (National Best Bid and Offer) quoted prices or better. .

while online brokers like Ameritrade offer basic trade execution for as little as \$8. In this section we model competition between an incumbent full-service brokerage firm and an online entrant that offers just trade execution. In particular, we focus on two important Web-related developments in the brokerage industry: the entry of online brokers, and the reduction in consumers' willingness-to-pay (WTP) for added services, due to the availability of cheaper online alternatives. We consider a stylized one-period setting with two firms and a unit mass of consumers. Firm A is the incumbent full-service broker and offers a bundle of two goods, trade execution E and additional services R (such as equity research, advice, etc.). Firm B is an online entrant and offers just component E, the trade execution. We use a game-theoretic model of competition along the lines of Nalebuff (2004)[4] to examine the firms' optimal quality choices and pricing strategies.[5] Both firms are assumed to face identical fixed and variable costs, which are normalized to zero without loss of generality.

Each consumer (investor) is in the market for one unit of trade execution E and/or one unit of additional services R. Consumers are heterogeneous, with types for trade execution E and additional services R independent and uniformly distributed over a range normalized at [0,1] for E and [0, ρ] for R. Firms have a choice of the quality of trade execution E, with the maximum feasible quality level determined by the technology available to each firm.[6] We denote the execution quality chosen by A and B as α and β respectively, and the maximum feasible quality levels as $\hat{\alpha}$ and $\hat{\beta}$, with the corresponding intervals of feasible quality levels being [0, $\hat{\alpha}$] and [0, $\hat{\beta}$]. Quality of trade execution is defined so that a consumer of type e for E has WTP for trade execution of quality x equal to ex. A consumer's type for R indicates her willingness to pay for additional services. Figure 1 shows the distributions of consumer types for E and R.

Monopoly Case

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[4] Unlike Nalebuff (2004), we endogenize the quality choices of both firms and derive closed form solutions for a Stackelberg game.

[5] While the actual quality of execution is determined by the trading venue or exchange to which the order is routed, as noted earlier brokers can choose where their orders are routed for execution.

In the monopoly case firm A can charge a higher price when it provides higher execution quality and thus it will offer its highest available quality level $\hat{\alpha}$. We show that in this case it is advantageous for firm A to bundle additional services R with order execution E.

Proposition 1: *A monopolistic full-service broker providing trade execution E and additional services R will have higher profits under pure bundling than under separate sales of R and E.*

Proof: Proofs are in Appendix A unless otherwise specified.

Duopoly Case

In the duopoly case firm A, the full-service broker, is faced with competition from firm B, an online entrant. The analysis is based on a three-stage non-cooperative game. In the first stage, firm A (the full-service firm) chooses α, its execution quality. In the second stage firm B (the online entrant) chooses its execution quality β, having observed A's choice. In the third stage both firms choose their prices simultaneously[7]. We solve for a sub-game perfect Nash equilibrium in pure strategies.

Incumbent Bundles R and E

When firm A chooses to bundle additional services R with trade execution E, it is optimal for A and B to offer their highest possible level of execution quality $\hat{\alpha}$ and $\hat{\beta}$ respectively. This is because with other things being equal, each firm's profit increases as its execution quality is higher and as the other firm's execution quality is lower. Specifically:

Proposition 2: *In a duopoly setting with an incumbent full-service firm selling a pure bundle of R and E and an online entrant selling E, both firms offer their highest feasible quality of execution.*

As an example based on the analysis in Appendix A, in the case where ρ = 1.5 and $\hat{\alpha} = \hat{\beta} = 1$, the optimal prices for firms A and B are, $p_A^* = 0.8816$ and $p_B^* = 0.3117$, with corresponding profits $\pi_A^* = 0.7772$ and $\pi_B^* = 0.1222$. Both firms choose the highest feasible quality level, however their

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[6] These technology ranges are exogenous to our model and the corresponding technology costs are sunk.

[7] As is normal in such games, the choice of quality is a long-run decision that is difficult to change in the short-run, while prices are less costly to change in the short-run. Thus, although the first mover A chooses its quality and price before firm B, firm A can alter its prices (but not its quality) in reaction to firm B's choices.

execution qualities could still differ because $\hat{\alpha} \neq \hat{\beta}$, for instance due to differing technologies available to the two firms.

As illustrated in Figure 1, the full-service brokerage finds it optimal to target investors that have a higher WTP for added services. On the other hand, the online entrant finds it optimal to target investors that have a lower WTP for additional services R, and its profit π_B^* is only a fraction of the incumbent's profit π_A^*. While we assumed that entry costs are negligible, a potential online entrant facing significant entry costs could find entry unprofitable.

There is an increasing amount of investment information available on the Web, often for free, making investors less reliant on full-service brokerage firms for added services like equity research. Thus, while investors are still dependent on brokerages for trade execution, their WTP for added services has declined significantly. In our setting, this decline corresponds to a decrease in ρ, the parameter that defines the range for investors' WTP for added-services R. The following proposition shows that the result is increased competition between firms A and B, and thus lower prices, lower profits for both firms, and increased price convergence.

Proposition 3: *As investors' relative WTP for added-services declines, both online and full-service brokers' profits decline substantially, resulting in lower prices for investors and greater price convergence.*

Figure 2 illustrates these results for the special case where $\hat{\alpha} = \hat{\beta} = 1$, i.e. when both firms provide the same quality of trade execution (normalized to 1). Our analysis in the separate Technical Appendix (available on request) shows that in this case prices and profits are given by

$$p_A(\rho) = \frac{2\rho + 2p_B - p_B^2}{4}, \qquad p_B(p_A) = \frac{(1+p_A) - \left(\sqrt{1 + p_A(p_A - 1)}\right)}{3};$$

$$\pi_A(\rho) = \left(\rho - p_A + p_B - \frac{p_B{}^2}{2}\right) p_A, \qquad \pi_B = (1 - p_B)(p_A - p_B) p_B;$$

Thus, the prices and profits of both firms decrease as ρ decreases, and the rate of decline is more rapid for firm A. The sensitivities of the firms' prices and profits are further illustrated in

Table 1, which shows the optimal prices and corresponding profits and market shares of the two firms as ρ drops from 1.5 to 0.50, with firm A continuing to provide a bundled offering.

Incumbent Unbundles R and E

The full-service brokerage can always choose to unbundle the trade execution and associated service offerings, resorting to component pricing for E and R. In this scenario, firm A prices R as a monopolist, setting price equal to $\rho/2$ and realizing profit $\rho/4$. We analyze the competitive market for E using the same notation and timing as before, with p_{AE} and π_{AE} denoting firm A's price and corresponding profit for component E, and $\pi_V = \pi_{AE} + \rho/4$ its total profit. As in the bundled case, we solve for sub-game perfect Nash equilibria in pure strategies. We find that when the incumbent unbundles trade execution, the online entrant chooses to offer a lower quality of trade execution than the incumbent:

Proposition 4a: *When the full-service firm adopts component pricing, the online broker finds it optimal to offer a lower quality of trade execution than the full-service firm.*

Proposition 4b: *The full-service brokerage firm finds it optimal to adopt component pricing (unbundling execution and additional services) when investors' WTP for additional services decreases relative to their WTP for execution.*

Specifically, the proof of proposition 4 in Appendix A shows that $\alpha^* = \hat{\alpha}$ and $\beta^* = 4\hat{\alpha}/7$ (or $\hat{\beta}$ if $\beta^* < 4\hat{\alpha}/7$). When the incumbent offers trade execution as an individual component, the entrant prefers to avoid head-on competition with the incumbent's offering, which would lead to no profits for either firm. The incumbent, being the first mover, chooses the more profitable higher quality offering, thus forcing the entrant to choose a lower quality offering[8,9]. This result is in line with conventional wisdom that firms competing on two dimensions find it optimal to maximally differentiate on one, while differentiating minimally on the other.

8 This is in line with earlier work on vertical differentiation (Shaked and Sutton 1982, Moorthy 1988) which concludes that the equilibrium strategy for each firm in a duopoly is to differentiate its offering from the other. The first-mover, is able to preempt the choice of higher quality and price, as well as control the entrant's choice.

Comparing the profits for firm A across the two cases (i) where it chooses to bundle and (ii) where it chooses to unbundle R and E, we find that when ρ decreases below a certain threshold, it becomes more profitable for firm A to unbundle R and E. The reason is that when ρ is high, bundling allows firm A to leverage its monopoly in R by selling E to consumers with a high valuation for R. As the WTP for R decreases, however, it no longer allows firm A to differentiate its bundled offering, and hence it is optimal for A to unbundled R and E.

Normalizing $\hat{\alpha}$ to 1 for comparison with the bundled case gives us $\beta^* = \frac{4}{7} = 0.5714$ and corresponding profits $\pi^*_{AE} = 0.146$ for firm A and $\pi^*_B = 0.021$ for firm B. We now compare the optimal profits[10] with the optimal profits in the unbundled case, where total profit for firm A is $\pi^*_A = \pi^*_{AE} + \pi^*_{AR} = 0.146 + \frac{\rho^2}{4}$. Table 1 shows the sensitivity of the two firms' prices and profits as α changes from 1.5 to 0.50. The relative profits are also shown in Figure 2, which illustrates that while for high values of ρ it is optimal for firm A to bundle R and E, as ρ decreases both firm's profits decrease and as some point it becomes optimal for A to unbundle.

We assumed in our analysis that investors' WTPs for the two components R and E are independent. These WTPs could be positively correlated, for instance because of technological complementarities such as cost savings for the investors or the firm, or because of correlation to an underlying trait such as investor wealth or frequency of transactions. Such a correlation would increase the profitability of the pure bundling strategy for firm A compared to separate sale of the individual components (Bakos and Brynjolfsson 2000, Nalebuff 2004). As noted by Nalebuff (2004) a negative correlation in consumer valuations makes bundling a potent strategy when used as a price discrimination device. However, when used as a competitive (entry-deterrent) device positive correlation of buyer valuations improves profitability from bundling. Thus in this

[9] In the Technical Appendix (available from the authors) we show that the practice of payment for order flow (POF) does not alter these results. In fact, the higher the POF, the lower is the execution quality chosen by the online entrant.

competitive setting positive correlation would make bundling optimal for firm A over a wider range of values for ρ and it would correspondingly decrease the profitability of firm B.

Hypotheses Development for the Experimental Study

Two results of our theoretical analysis are of particular interest: the choices of execution quality by the brokers, and their pricing strategy and corresponding profits. When investors' WTP for added-services is high, Proposition 2 finds that the online broker and the full- service broker would each offer the highest quality of execution available to them, $\hat{\alpha}$ and $\hat{\beta}$ respectively, which are not necessarily the same. Furthermore, as shown in the proof of Proposition 2, in the resulting equilibrium each firm's profits are higher as its execution quality increases and as the other firm's execution quality decreases. When investors' WTP for added services declines, Proposition 3 finds that the prices and profits of both firms also decline. Proposition 4b finds that a decline in investors' WTP for added services can induce the incumbent full-service broker to unbundle its offering, leading to greater price convergence. Furthermore, Proposition 4a shows that when the full-service broker unbundles trade execution from added services, the online broker will choose to offer a lower quality of execution β, and a lower price p_B, compared to the full-service broker.

These findings directly motivate the hypotheses in our empirical study regarding the relative execution qualities of online and traditional brokerages and the price convergence resulting from changes in the competitive landscape. The analysis in our stylized setting shows that independent of their bundled services, full-service brokers benefit when consumers believe that they offer higher quality trade executions than online brokers. Such an outcome could arise due to differences in the technology infrastructures of the two types of firms, or due to different order routing policies. Brokerage firms have the option of routing their orders to different trading venues that may provide different execution qualities; the choice of a lower quality trading venue would result in lower execution quality for customers. Our experimental study directly addresses these issues by testing

[10] Comparison of the closed form solutions is available in the separate Technical Appendix.

for differences in execution quality in a controlled setting, and for significant differences in the trading venues to which different brokerages route their orders. Specifically, we test the following hypotheses:

H-1: *There is no difference among markets (trading venues) in price improvements on retail securities trades.*

In null form, this hypothesis states that the different markets and trading venues provide the same level of price improvements. If this hypothesis is true, then any propensity of one type of broker to use a particular type of market will not result in differences in the quality of trade execution for investors (i.e., $\beta^* = \alpha^*$).

H-2: *There is no difference among brokers on which markets they choose for executing trades.*

If different markets offer different levels of price improvement (and resulting trade execution qualities), then for trade execution quality to be identical across types of brokers, these brokers must not favor a particular type of market.

H-3: *There are no differences among brokers on price improvements.*

If there are either no differences in the choice of markets, or no differences among markets on price improvements for both NYSE and Nasdaq listed securities, there should be no differences among brokers on price improvement (i.e., $\beta^* = \alpha^*$).

Testing the above hypotheses will allow us to determine whether online and full-service brokers offer similar or different qualities of trade execution. As noted earlier, this is also a question of great interest to investors and regulators.

H-4: *The total trading costs of full-service and electronic brokerage firms are comparable; more expensive commissions in full-service firms are offset by better trade execution.*

Although the product offerings of the online and full-service firms are not directly comparable, our analysis suggests that as ρ declines, the primary factor supporting differences in the prices charged at equilibrium would be the differences in the quality of trade execution between the two types of firms. It is thus important to examine the extent to which any significant differences in execution qualities ($|\alpha - \beta|$), offset differences in the explicit commissions ($|p_A - p_B|$), charged by the two types of brokerages. This is particularly important given that retail investors have very little information about the relative trade execution qualities between full-service incumbents and the online entrants.

RESEARCH DESIGN

While past papers have used simulations to estimate the impact of different trading strategies (Battalio, et al., 1999), a more realistic analysis requires actual stock trades in a controlled experimental setting. Comparing execution prices implies that one must execute identical trades at different brokers simultaneously so that each broker faces the same market conditions and bid/ask spread executing the trade.

The Salomon Center for Research in Financial Institutions and Markets at the Stern School at NYU agreed to provide financing and working capital, $60,000 in total, for a controlled experiment. We opened six accounts with three different kinds of brokers: 1) two full-service "voice brokers" who take orders the traditional way with the investor interacting with a human broker, 2) two "higher-than-average-commission brand-name" online brokers, and 3) two "below-average-commission deep-discount" online brokers. In the paper, the voice brokers are designated as A and B, the brand-name online brokers as J and K, and the inexpensive online brokers as Y and Z. Commissions for trading 100 shares averaged $47 for the voice brokers, $23 for the brand-name electronic brokers, and $7.50 for the inexpensive electronic brokers.

The experimental design involved 64 trials, each placing 3 simultaneous buy or sell orders for 100 shares of the same stock, using a traditional, voice broker, a medium-priced "brand-name" online broker and an inexpensive "deep-discount" online broker. In other words, each trial involved one of brokers A and B, one of brokers J and K and one of brokers Y and Z. Out of the total 64 trials in the experiment, 32 were buy orders and 32 were sell orders for 32 different stocks. (Note that we had to sell the same stocks that we had previously purchased.) The design was completely balanced with respect to brokers and NYSE-listed and Nasdaq stocks. For any dependent variable, say price improvement, there are 192 values, which consist of 16 buys and 16 sells for each of 6 brokers ($(16+16) \times 6 = 192$). The ANOVA model corresponding to the design has fixed effects for the 6 brokers, for the two listing exchanges and for buy versus sell. The model has random effects for the 32 individual stocks and for statistical noise. The blocked design and associated analysis of variance can be found in Appendix B.

We conducted the experiment over an eleven-day period during July and August, 1999. The experimenters worked in a room with a telephone and two computers with high-speed connections to the Internet. In the morning between 10:00 and 10:30, we selected stocks to purchase as specified in the experimental design. The selection came from the stocks in Standard and Poor's Platinum and Fair Value Portfolios as listed in their newsletter, *Investor's Monthly.* We chose securities priced under $50 so as not to exhaust our working capital at any one broker on a given day, and we selected stocks that showed active trading volume, but that had a bid-ask spread of at least $1/8th, so that there was some potential for price improvement[11]. (After switching from 1/8 price increments in 1997, the smallest pricing increment in U.S. stock markets in 1999 was 1/16th. Note that if a bid ask spread is 1/16th, there is no room for improvement.) All transactions were for a lot of 100 shares, which retail customers frequently trade.[12] Each trial comparing three brokers involved a different stock to remove any variation caused by the security being purchased, and all trades were "at market." There were a total of 64 trials involving 3 brokers per trial for a total of 192 trades.

Three experimenters conducted each trial. An experimenter at each computer completed the purchase screen for the two online brokers, stopping just before clicking on the button to submit the trade. The experimenter talking to the voice broker signaled when the broker indicated he had submitted the order, and the experimenters at each computer clicked to submit their trades. All three transactions were thus identical ("buy 100 shares of PRQ Corporation at the market") and were as close as humanly and electronically possible to being simultaneous.

Beginning at approximately 3:30 PM, we simultaneously sold the stocks purchased in the morning so that we held no position longer than six hours. We recorded data identifying each broker, the bid/ask spread from the online brokers' real-time quotes and the voice broker's bid/ask spread just before the transaction. We also recorded the execution price and the commissions, which were verified when we received the printed trade confirmations.

[11] In 2001, the U.S. stock markets converted to decimal pricing, reducing the minimum price increment to 1 cent.
[12] In the first quarter of 2001, the average order size for on-line broker was 195 shares. "Special Report: On-line Investing", The Wall Street Journal, June 11, 2001.

Bloomberg data service provides a detailed "Time of Sales" transactions report on the consolidated market ticker, and this was logged for each of our trading sessions. Using this trace, it was possible to identify all 3 trades in 60 out of our 64 trials and to verify that they had been executed as closely together as possible. Table 2 shows the distribution of the time taken for order execution for the 64 trials, each involving 3 brokers. Of the trades, 66% occurred within one minute of submission, and 87% within two minutes. There were no changes in the bid/ask quotes from the time we entered our trades until they executed, except for two outlier trades noted later in the paper. The experiment was successful in achieving nearly simultaneous trade execution for the three brokers in each trial. On all but the two trades noted, the three orders in each trial faced identical market conditions as reflected by identical bid/ask spreads.

RESULTS

Market Differences: Our first hypothesis H-1, postulates that there are no differences among markets on price improvement. The results of our experiment in Table 3 reject this null hypothesis for NYSE listed stocks, but *not* for Nasdaq listed securities. For NYSE-listed stocks, price improvement was related to the executing market. The NYSE market had the highest rate of price improvement on our orders, and provided the greatest amount of improvement, averaging 8.69 cents. The occurrence of price improvement for orders to buy or sell Nasdaq stocks, at 14.6%, was far lower than that for NYSE-listed stocks. As a result, trading costs for the 96 orders in Nasdaq stocks in our sample were greater than for the NYSE stocks. For Nasdaq stocks, the small number of price improvements (14 of 96) implies that the equivalent analysis for Nasdaq stocks has no significant differences to report, and is not reproduced here. Table 3 also reports the price improvements just for the trades that had a price improvement.

Order Routing Differences: Hypothesis H-2, states that there are *no differences* among brokers on where they route orders for execution. The data in Table 4 leads to the rejection of this null hypothesis. Orders to buy or sell NYSE-listed stocks placed with traditional voice brokers were overwhelmingly routed to the NYSE, while orders handled by the two brand-name online brokers were most likely to execute on one of the five regional stock exchanges (Chicago Stock Exchange, the Pacific S.E., the Boston S.E., the Philadelphia S.E., and the Cincinnati S.E.). Deep discount electronic brokers predominately used third market dealers to execute our orders. Using the regionals and the third market enables the broker to receive additional payments for order flow. Third market dealers typically make this payment from trading revenues they realize by buying shares on average at lower prices than they subsequently sell them. [13]

A conclusion to be drawn from the data in Tables 3-4 is that the online brokers in our sample that charge the lowest commissions predominantly route their orders electronically to the third market. Thus, we find that the online brokers faced with very low profit margins and increasing costs route their orders to alternate trading venues, although such trading venues provide few price improvements, resulting in lower execution quality for investors.

Overall Price Improvement by Brokers: The experimental design matches one voice broker with two online brokers (one a more expensive "brand-name" broker, and the other a inexpensive deep discount broker) for 16 trials, 8 buys and 8 sells. While each broker is involved in 32 trials in all, we only have 16 comparisons among specific brokers, all with the same stocks, market conditions, bid/ask spreads, day and time of the week. Table 5 shows statistical comparisons based on these head-to-head pair-wise comparisons of the brokers.[14] This table has no pair-wise differences that

[13] This point was made in a comment letter to the SEC that referenced the results from an earlier working paper version of the our paper. Blume, Marshall E., Howard Butcher III Professor of Financial Management, Wharton School of the University of Pennsylvania, , "Comment on Proposed Recession of NYSE Rule 390", SEC, SR-NYSE-99-48, www.sec.gov/rules/sro/ny9948/blume1.htm, April 26, 2000.

[14] For two of the electronic brokers, J and Y, one trade for the same stock actually resulted in a negative improvement! In this instance, the trade executed outside of the quoted bid/ask spread as the NASDAQ market maker changed the spread as the order was received. Because these prices are what an individual trading would have received, we did not adjust the data. It appeared to us that the market maker saw the orders coming and lowered the bid price for our two trades, raising it immediately afterwards.

are statistically significant, at the .05 level, suggesting that we should accept hypothesis H-3 of no difference among brokers on overall price improvements.[15]

It is also possible to compare price improvement across the 32 transactions for each broker. Comparisons between particular brokers involve trials in which they both participated as well as trials in which only one of them participated. As shown in Figure 3, voice brokers on average provided the most improvement, and the deep discount e-brokers provided the least improvement. In the context of the full experiment, the broker differences produced an F value of 2.24, on (5, 123) degrees of freedom. The associated p value is 0.054. This analysis used fixed effects for the brokers and random effects for the triplets. There were no differences at the .05 level using Tukey's pairwise comparison. These results suggest that we should accept hypothesis 3 of no difference among brokers on price improvements.

How is it possible to reconcile the results for hypotheses 1 and 2 with acceptance of hypothesis 3? Tests of the first two hypotheses indicate that there *are* differences in price improvements by market, but only for NYSE listed securities, and differences among brokers in their use of the NYSE, regional and third markets. Tests of the first two hypotheses found differences in price improvements among markets and differences between price improvements among brokers *for NYSE listed stocks only*. Adding Nasdaq stocks reduced these differences in price improvements to insignificance in the full sample. In this experiment, voice brokers routed more orders for NYSE listed securities to the NYSE and the NYSE offered more price improvements than other markets; however, these differences were not large enough to make up for the lack of price improvement on Nasdaq listed securities. For trading, which involves a mix of NYSE and Nasdaq listed securities,

[15] Groups of values would generally be compared with the two-group (unpaired) t test. This test however requires at least approximate normal distributions. Data in which there are extensive ties cannot possibly satisfy this requirement. The price improvement data were nearly all zero or $\frac{1}{8}$ or $\frac{1}{4}$. The nonparametric test which operates in the spirit of the two-group (unpaired) t test is the Wilcoxon test. For the normal-approximated W, values near 0 suggest that one ought to accept the null hypothesis of no-group differences.

in our case 50% each, we find no statistically significant difference among the three types of brokers on price improvements.

We designed the experiment with a sample size that was reasonable for finding moderate-to-large differences, despite the statistical power being eroded by the discreteness of stock prices ($1/16^{th}$ of \$1 price increments in the U.S.) and the resulting prevalence of tied values, i.e., instances in which two brokers in a comparison had identical prices (see Table 5).[16]

Total Trading Cost: Our final hypothesis H-4, states that the trading costs of full-service and online brokerage firms are the same because more expensive commissions are offset by better trade executions. Price improvement is the mechanism for measuring the quality of execution, but exactly how to arrive at the total trading cost given trades with and without price improvements is not immediately obvious. Following Battalio et al. (1999) and Lee (1993), we computed the total cost of a trade as the commission plus the liquidity premium. This premium is defined as the difference between the mid-price of the bid/ask spread and the execution price. For a buy, the premium is the execution price—the mid-price and for a sell, it is the mid-price—the execution price. A price improvement moves the execution price closer to the mid-price, and thus results in a lower liquidity premium and lower total trade cost. Table 6 presents the pair-wise comparisons of costs by broker for the 16 paired trades.[17]

The mean differences in the table (Table 6) result from subtracting the total cost of the broker in the column from the total cost of the broker in the row for the 16 trials in which the pair participated together in simultaneous trades for NYSE-listed stocks. It is clear from the table that there are statistically significant differences among the brokers on total trade cost, and we can reject

[16] If the true means are γ standard deviations apart, the power of such a test, done at significance level α, is approximately $\Phi(\gamma\sqrt{n} - z_{\alpha/2})$, where Φ is cumulative normal distribution function. For our $n = 16$, $\gamma = 0.8$ (say), and $\alpha = 0.05$, this would be $\Phi(1.24) \approx 0.89$, which is reasonable power. However, in the actual data, the brokers nearly always provided identical price improvements, and it appears that the actual γ value is near zero. For total trading costs the differences are substantial and power is more than adequate.

[17] Broker B provided a 10% rebate on commissions for July and August. There was no explanation of the basis for this rebate, or whether one could count on receiving it over time. As a result, we have used the actual commissions Broker B charged at the time of trade and have not subtracted the later rebate.

H4. The magnitude of the differences shows that the total costs of a trade for 100 shares with more expensive "brand" online brokers is less than the total costs of voice brokers, except for broker B versus broker J. Total trading costs for inexpensive online brokers are significantly less than total trading costs either for the two voice brokers or the two more expensive online brokers. All differences except broker B versus J are highly significant statistically. The differences in mean trading cost for each of the 32 trades by broker are highly statistically significant using an analysis of variance ($F = 67.57$, $p < 0.01$; Chi-Square of 133.97, $p < 0.01$).[18] Please see Figure 4.

Our results are clear: for NYSE listed stocks online brokers disproportionately route orders to regional and third-party exchanges offering fewer price improvements, compared to traditional brokers. Traditional brokers, routing a large proportion of their orders to the NYSE, were able to obtain a price improvement averaging 8.9 cents/share. The differences in commissions charged by offline and online brokerages could not be fully accounted for by the differences in their execution qualities. This indicates that traditional brokers were successful in differentiating themselves from low-cost online rivals.

DISCUSSION

Our analytical results as well as our experimental findings show that online brokers offering primarily trade execution significantly under-price full-service brokerage firms. Clearly, e-commerce has had a significant impact on the retail brokerage industry and triggered an industry transition to a new pricing equilibrium. Commissions that had ranged from under $10 to almost $100 for a 100 share trade at the time of our experiment have narrowed since this experiment. Table 7 illustrates the narrowed range, which has continued in recent years.

While full-service brokerage firms are forced to lower their prices when faced with competition from online brokers, they still manage to price significantly higher than their online rivals. For instance, Merrill Lynch, in what was considered a radical shift, started offering online

[18] Comparisons between particular brokers involve trials in which they both participated as well as trials in which only

trading at $29.95 per trade beginning in December 1999, along with a new, "Unlimited Advantage" account for high net worth individuals, offering essentially unlimited trades for a fixed annual fee of 0.3% to 1% of the account's balance, with a $1500 minimum (*Business Week* 11/15/99; Altschuler et. al, 2002). This, while much lower than their traditional commissions for their bundled offerings, is significantly higher than the commissions charged by online brokerages. As highlighted by our theoretical model, when the mix of "delegators" to "self-directed investors" changes, full-service firms find it optimal to unbundle their previously bundled offerings when competing with online brokers. In addition, online brokerages have also triggered market expansion, thereby increasing consumer welfare.

However, while online brokers are cheaper than full-service firms, their lower prices come at a *cost*. The quality of execution of online brokers is significantly lower than those of traditional full-service brokers. This is an interesting finding considering that the two primary drivers of the differences in execution costs—information technologies and unbundling—are considered to be unambiguously beneficial to consumer welfare, as they promote transparency and competition. When faced with head-on competition from the component offerings of the incumbent, lowering execution quality provides a means for online entrants to differentiate themselves from the established incumbents. In addition, as pricing pressure intensifies and profit margins are squeezed, online brokerages are forced to seek alternate sources of revenue. As highlighted by our findings in Tables 3-4, although online brokers charge much lower commissions than traditional brokers, they disproportionately route their orders for NYSE securities to *third markets*. While this provides additional revenues through payments for order flow benefiting both the brokerages and the marketplaces, this choice of markets results in fewer price improvements and higher trade execution costs for customers of online brokerages relative to the other brokers in our study. Thus, while

one of them participated.

investors of full-service brokerages are more likely to benefit from price improvements on their trades, customers of online brokerages face higher *execution costs* for essentially the same trade.

IMPLICATIONS

Unbundling and Increased Competition: Traditionally, bundling has enabled firms to leverage their monopoly power in one market to related markets, helping them differentiate themselves from their rivals and, maintain high margins. Bundling has also enabled firms to leverage supply as well as demand-side economies of scale and scope, and structure complex offerings that make direct price or cost comparisons difficult. However, as new technologies reduce information, search, and agency costs, online consumers increasingly find it efficient to create customized bundles by purchasing components from specialized firms, rather than purchase a bundled offering at a higher price. Consequently, traditional firms that use bundling strategies to sustain high margins find their markets shares eroding. Our theoretical model indicates that up to a point, a bundling strategy might still be optimal for such firms when faced with competition in selective component markets. In fact, such a strategy could be beneficial if traditional firms can force a high-cost entrant out of the market. However, when the incumbent's monopoly power (for instance, in research services) is eroded significantly, bundling ceases to be optimal, and the incumbent is forced to compete head-on with the online entrant, which leads to an interesting outcome. The online entrant facing intense competition from an unbundled incumbent is now forced to lower its quality and commissions in order to differentiate itself from its rival.

Technology and Transparency: The proliferation of online trading and the rapid growth of alternate trading venues including ECNs offer testimony to the ability of new technologies to radically impact environments that have typically been resistant to change. While these technological innovations are commonly perceived as promoting the transparency and efficiency of existing systems, our experimental findings offer a note of caution, particularly for unsuspecting investors. The Internet promotes greater price transparency; but the same cannot be said of other product/service attributes. Online markets can make it more difficult for customers to discern quality. For instance, by facilitating price comparison, the Web can cause consumers to focus on price and neglect other variables of importance, creating an illusion of efficiency. Our findings illustrate how online brokers and trading venues can take advantage of information asymmetries and pass on additional costs to consumers.[19] Our study quantifies the magnitude of such *implicit* costs and draws attention to the significance of these costs for uninformed consumers who might be lured solely by the low commissions of online brokerages. As noted by Konana et al (2000), and as highlighted by our findings, it is important to separate the efficiency perceived by investors from the *real* efficiency of transactions.

Implications for Brokerage Firms: The inherent structural differences in the trading venues as well as the differences in the order-routing practices of brokerage firms serve as effective mechanisms to segment the market. As noted by Easley et al. (1996), the characteristics of these new trading venues cause profitable small retail trades to be diverted to them, leaving the bigger exchanges with larger, less profitable, information-based trades. The higher expected profits from uninformed traders, in turn compensates the market-maker for payments for order flow. As they note, segmentation of the market, based on the type of order can lead to adverse selection and impose costs on existing markets. A segmentation strategy can be profitable for these new trading venues. Also, given the limited avenues for differentiation, these alternate trading venues might be crucial for the survival of low-priced online brokerages.

Incumbent firms might find it difficult to deter new entrants that capitalize on alternative revenue streams and cost-reduction opportunities. As the mix of self-directed investors and delegators changes in response to new technologies, traditional firms find it increasingly difficult to

[19] As stated earlier (see Hypothesis 3), we find significant differences in execution quality only for NYSE-listed stocks. It is interesting to note that the commissions of some online brokerages differ for NYSE and NASDAQ related stock trades, reflecting their differing ability to benefit from information asymmetries and hidden costs in the two cases. *"E*Trade touts its base rate of $14.95, but has revealed only in the fine print of its ads and brochures that placing a trade for a Nasdaq stock -- which represents the bulk of its business -- costs $19.95. Similarly, Ameritrade trumpets its rock-bottom commission of $8, but its average commission is higher."*

sustain their highly profitable bundling strategies. Competition with low-cost online brokerages could force the full-service broker to choose to compete in evolving markets at the cost of cannibalizing existing profits. Clearly, technology-driven channels like the Web are a potent force requiring radical rethinking of existing business models and strategies. Existing firms would do well to be proactive in their use and adoption of these technologies.

Implications for Public Policy: Are online brokers failing in their responsibility of obtaining best execution for their customers, by accepting payments for order flow from electronic trading venues? Brokerage services and market making functions are separable and investors should be able to mix and match these services to get the lowest commissions as well as lowest execution costs, rather than having to trade one for the other. While it may seem that the differences in the costs of execution are negligible, our research suggests that this is not the case and the investors may benefit by choosing brokerage firms as well as trading venues, rather than delegating the choice to their brokerage firms. Our study is a first step in providing measures of comparative execution costs across different types of brokerages. Reliable metrics for other factors of interest to consumers such as the speed of execution, liquidity and the likelihood of execution should be developed and published. Government regulators have recognized that the current levels of disclosure are insufficient and have required brokerage firms to disclose their average trade execution performance[20], leading to at least one deep discount broker raising commissions from $8 to $11 a trade in October of 2002.[21]

Implications for Other Industries: There are several markets that share some of the characteristics of retail brokerages. For example, real estate, insurance, home mortgages, travel services, and auto-retailing, typically feature 1) agents that intermediate transactions for the consumer, 2) associated

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[20] The SEC's client disclosure rule, SEC Rule 11 Act-6, now requires all broker/dealers that route orders in equity and option securities to make available quarterly reports that present a general overview of their routing practices. The reports must identify the significant venues to which the client orders were routed for execution and disclose the broker/dealer's relationship with such venues.

[21] See http://www.ameritrade.com/html/be_stats.html

goods and services bundled with the core product, and most importantly, 3) the potential for *hidden* costs of quality, and 4) "full-service" traditional firms facing significant competition from online rivals. The Internet has enabled rivals to develop low cost business models for some core components and is believed to promote price transparency in these markets. For instance, traditional real estate brokers are facing significant challenges competing against online counterparts who offer services at deeply discounted commissions *(USA Today*, July 6, 2000). Major Web-based brokers such as erealty.com and zipRealty.com charge 4% to 5% of a home's selling price, 2 to 3% lower than the commission charged by traditional real estate brokers. In response to the threat from lower-priced Web-based rivals, established brokerages such as Century 21 and Coldwell Banker are considering offering an a la carte menu of options, similar to strategies implemented by full-service stock-brokers, that allows home sellers to pay lower commissions for less service. According to a recent survey, average commissions charged by traditional real estate brokers have dropped to 5.5% from 6.1% as a result of price pressure created by Internet-based brokerages (*The Wall Street Journal*, 12/21/2001). Similarly, online insurance brokers offering customers significantly lower premiums have forced their traditional rivals to lower prices substantially.[22]

Auto-retailing, another sector characterized by information asymmetries (with consumers lacking information about invoice prices and true dealer margins), has also witnessed a significant growth of online intermediaries. These intermediaries, by providing consumers with higher quality and more-timely information about prices and hidden-costs associated with traditional intermediaries, have altered the industry structure and value chain.

Online intermediaries in markets with thin margins are likely to exploit information asymmetries to boost their bottom line, resulting in higher costs for consumers. For instance, online book and CD retailers offer discounts on the core products (books & CDs) to attract consumers, but

[22] Morgan Stanley & Co. estimated that Internet-based insurers offer premiums roughly 10% lower than do traditional

the margins on shipping costs and packaging are often higher, resulting in higher total costs that are not immediately obvious to most customers. For incumbent firms, the lessons from e-commerce in the brokerage industry are clear. Be prepared to compete with online firms that have a lower cost structure than you do. It is likely that you will have problems sustaining bundled products and services, especially when new entrants provide customers with focused offerings. While it may be possible to segment the market, it is more likely that the incumbent will have to compete in the same market with online rivals. An incumbent firm, by structuring its offerings in a way that leverages its infrastructure, reputation, and its existing customer base, can compete more effectively with online entrants. Most importantly, first-mover advantages imply that incumbents can maintain higher quality, leaving the entrants with a choice of lower quality.

LIMITATIONS

There are a number of limitations to the empirical study. A rival hypothesis that would cast doubt on some of our results is that price dispersion between brokers is less for larger order sizes. We obtained the commission rates from the brokers in the study for trade sizes up to 2500 shares, which is above the size of the typical retail trade, and we extrapolated the trade results from the experiment. We concluded that it would be very difficult even at these trade sizes for the full-service brokers to provide as low trading cost as electronic brokers. Also, our results do not apply to limit orders since the investor sets the share price and waits for the market to reach the set price. In early 2001, the NYSE and the Nasdaq respectively converted to decimal prices. It would be interesting to examine the impact of decimalization on the outcomes[23]. Price improvement is just one of the several dimensions of quality and performance. Speed of execution, liquidity, likelihood of execution, reliability, among other variables can also be important in determining quality.

insurers. (Source: "The Internet and Financial Services", January 31, 2000, Morgan Stanley)

[23] Recent changes in the financial markets, including decimalization, have resulted in significantly narrower spreads, which could reduce the inter-broker differences in execution quality.

Experimental designs are subject to bias. The fact that we placed our own orders, however, should not introduce bias. For four of the six brokers, we clicked on a “submit” order button, which could be done by anyone. For the two voice brokers we placed orders without seeking any advice. Our choice of securities was not random, but was dictated by the price of the security and its trading activity; however, the stocks came from a variety of companies and industries, and we chose a different security for each buy order.

SUMMARY AND FUTURE RESEARCH

This paper developed a model of competition between an incumbent full-service broker offering a bundled product and an online entrant offer trade execution only. The results of the model show that under certain conditions the full-service broker finds it optimal to unbundle its offering, and the online entrant chooses to compete with lower quality execution. Our empirical study found that online brokers offer lower quality trade execution, but that the higher commission costs of full-service brokers are not offset by these quality differences.

Securities trading involves observable and hidden costs; future research might look at the impact of electronic markets on such information asymmetries in other sectors. Conventional wisdom suggests that electronic markets increase efficiency by promoting price transparency; however the same is not necessarily true of quality transparency. Will e-commerce lead to greater overall transparency or will its impact be limited to advertised prices?

Online intermediaries, by reducing the information asymmetries and removing the inefficiencies of the traditional value chain, play an important role in the evolving competitive landscape in a variety of markets. The results of our study highlight the need for a careful examination of these intermediated markets to understand the direct as well as indirect impacts of emerging technologies, and more importantly, to identify implicit costs that are difficult or impossible for consumers to predict.

The impact of online brokers on the securities industry should be a harbinger of the impact that electronic commerce will have on other industries, especially those which feature tollgate intermediaries, information asymmetries and associated products and services bundled with core products. One extension of this work is to look at e-commerce across other industries to evaluate its impact. Are industries with certain types of intermediaries more likely to face restructuring than others? Is there a difference in how e-commerce affect services like brokerage compared to the distribution of physical products like books?

While we cannot generalize from one study, our analytical derivations as well as empirical results suggest that online brokers destabilized the market for trading by expanding the self-directed market segment, and forced new marketing and pricing strategies on traditional brokerages. We believe that e-commerce has the potential to bring about dramatic changes in other industries as well.

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APPENDIX A

Additional proofs may be found in a separate technical appendix available on request.

Proof of Proposition 1

If R and E are offered separately, it is easy to see that their optimal prices are $p_R^* = \frac{\rho}{2}$ and $p_E^* = \frac{1}{2}$; the corresponding profits are $\pi_R^* = \frac{\rho}{4}$ and $\pi_E^* = \frac{1}{4}$. The total unbundled profit is $\pi_U^* = \frac{1+\rho}{4}$. If the full-service broker sets a price p_A for the bundle of R and E, and if $p_A \le \frac{1+\rho}{2}$, the corresponding quantity is $q_A = 1 - \frac{2{p_A}^2}{(1+\rho)^2}$, and profit $\pi_A = p_A - \frac{2{p_A}^3}{(1+\rho)^2}$. Solving for first order conditions (FOC), we have $p_A^* = \frac{1+\rho}{\sqrt{6}}$. If $p_A > \frac{1+\rho}{2}$, then $q_A = \frac{2(1+\rho-p_A)^2}{(1+\rho)^2}$, and $\pi_A = \frac{2p_A(1+\rho-p_A)^2}{(1+\rho)^2}$. Solving for FOC, we have, $p_A = \frac{1+\rho}{3}$, which does not satisfy the condition $p_A > \frac{1+\rho}{2}$. Thus, the optimal bundle price is $p_A^* = \frac{1+\rho}{\sqrt{6}}$, and the corresponding profit is $\pi_A^* = \frac{2(1+\rho)}{3\sqrt{6}}$. Since $\pi_A^* > \pi_U^*$, it is optimal for the full-service broker is to bundle R and E.

Proof of Proposition 2

The utility for a consumer of type (e, r) from a trade with execution quality x is $r + ex$. Thus when firm A bundles, the corresponding utility for the consumer is $r + e\alpha - p_A$ when buying from A, and $e\beta - p_B$ when buying from B.

As illustrated in Figure 1 firm B sells to investors in the cross-shaded region, i.e., to investors whose valuation for E is greater than p_B/β as well as to investors whose valuation for R is less than $(p_A - \frac{p_B\alpha}{\beta})$. Firm A sells to investors in the shaded region, which has area

$$\frac{1}{2}\left(1-\frac{p_B}{\beta}\right)\left(2\rho-2p_A+p_B-\frac{\alpha}{\beta}p_B+\alpha-\beta\right)+\frac{1}{2}\frac{p_B}{\beta}\left(2\rho-2p_A-\frac{\alpha}{\beta}p_B\right)=\rho-\frac{\beta}{2}+\frac{\alpha}{2}-p_A+p_B-\frac{{p_B}^2}{2\beta}.$$

The corresponding profit functions are

$$\pi_B = \frac{(\beta-p_B)(\beta(\beta-\alpha+2p_A)-(\beta+\alpha)p_B)p_B}{2\beta^2} \text{ and } \pi_A = \left(\rho-\frac{\beta}{2}+\frac{\alpha}{2}-p_A+p_B-\frac{{p_B}^2}{2\beta}\right)p_A.$$

Both firms choose prices simultaneously in stage-3. Solving for first order conditions we get,

$$p_B^*(\beta) = \frac{2\beta(\beta+p_A)-\beta\left(\sqrt{3\alpha^2+\beta^2+2p_A(\beta-3\alpha+2p_A)}\right)}{3(\alpha+\beta)}, \qquad p_A^*(\alpha) = \left(\frac{\beta(\alpha+2\rho-\beta)+2p_B\beta-p_B^2}{4\beta}\right)$$

Given the prices in stage-3, firm B chooses its quality. Substituting the prices from stage-3 back into firm B's profit function and solving for optimal quality, we find that firm B's profits increases monotonically with its quality β. We denote with $\hat{\beta}$ the maximum level of quality available to (and chosen by) firm B. Solving for firm A's choice of quality we find that firm A's profit function also increases monotonically with its quality α. We denote the maximum quality available to (and chosen by) firm A with $\hat{\alpha}$. In the illustrative case with $\rho = 1.5$ and $\hat{\alpha} = \hat{\beta} = 1$, the optimal prices and profits for both firms are given by $p_A^* = 0.8816$, $p_B^* = 0.3117$, $\pi_A^* = 0.7772$, and $\pi_B^* = 0.1222$. A more detailed proof is available in the separate technical appendix.

Proof of Proposition 4

Proof: There are two possible cases[24]: $\beta \leq \alpha$, or $\beta > \alpha$. We begin by analyzing the case where $\beta \leq \alpha$. Let $\hat{\theta}$ be the consumer type indifferent between the offerings of firms A and B. Then, $\alpha\hat{\theta} - p_A = \beta\hat{\theta} - p_B$, or $\hat{\theta} = \frac{p_A - p_B}{\alpha - \beta}$. If $\hat{\hat{\theta}}$ is the consumer type indifferent between purchasing from firm B and not buying at all, then, $\beta\hat{\hat{\theta}} - p_B = 0$, or $\hat{\hat{\theta}} = p_B / \beta$. Then, firm A sells to types from $\hat{\theta}$ to 1, and firm B sells to types from $\hat{\hat{\theta}}$ to $\hat{\theta}$. Thus the profit for Firm B is $\pi_B = (\hat{\theta} - \hat{\hat{\theta}})p_B$, or $\pi_B = \left(\frac{p_A - p_B}{\alpha - \beta} - \frac{p_B}{\beta}\right)(p_B)$. We first compute the price equilibrium for the given quality choices and then compute the optimal quality choices. Solving for FOC, we have, $p_B^* = \frac{\beta p_A}{2\alpha}$. Firm A's profit from E is $\pi_{AE} = (1 - \hat{\theta})p_A = \left(1 - \frac{p_A - p_B}{\alpha - \beta}\right)(p_A)$. Solving for FOC, we get firm A's price $p_A^* = \frac{(\alpha - \beta + p_B)}{2}$. Substituting, we get $p_A^* = \frac{2\alpha(\alpha - \beta)}{(4\alpha - \beta)}$, and $p_B^* = \frac{\beta(\alpha - \beta)}{(4\alpha - \beta)}$, and the corresponding profits for firm B is $\pi_B^* = \frac{(\alpha - \beta)\beta\alpha}{(\beta - 4\alpha)^2}$. Given prices p_A and p_B, we solve for optimal qualities. Firm B chooses quality β, taking α as given. Solving for FOC, we have $\beta^* = \frac{4\alpha}{7}$. Substituting the optimal β^* in the profit function for firm A we have, $\pi_{AE}^* = \frac{7\alpha}{48}$. In other words, firm A chooses the maximum quality feasible,[25] while B chooses a lower quality.

The proof for the case where $\beta > \alpha$ can be found in the separate technical appendix.

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[24] Considering both cases, we find that the profits of both firms are maximized when $\beta < \alpha$. The results of the 2nd case are omitted for sake of brevity, but are available in a separate technical appendix.

[25] This is in line with earlier work (Shaked and Sutton, 1982) where the highest possible quality is restricted – the focus, then being on the relative quality choices of the firms.

Appendix B: Experimental Trials

Note that the days were not executed in order due to delays in opening accounts at several brokers. We conducted the trials indicated for each day.

DAY 1

Broker A	Broker J	Broker Z	NYSE
Broker B	Broker K	Broker Y	NASDAQ
Broker A	Broker K	Broker Z	NASDAQ

DAY 2

Broker B	Broker J	Broker Y	NYSE
Broker A	Broker J	Broker Y	NYSE
Broker B	Broker K	Broker Z	NASDAQ

Day 3

Broker A	Broker K	Broker Y	NASDAQ
Broker B	Broker J	Broker Z	NYSE
Broker A	Broker K	Broker Y	NYSE

Day 4

Broker B	Broker J	Broker Z	NYSE
Broker A	Broker J	Broker Y	NASDAQ
Broker B	Broker J	Broker Y	NASDAQ

Day 5

Broker A	Broker K	Broker Z	NASDAQ
Broker B	Broker K	Broker Z	NYSE
Broker A	Broker J	Broker Z	NYSE

Day 6

Broker B	Broker K	Broker Y	NYSE
Broker A	Broker K	Broker Z	NYSE
Broker B	Broker K	Broker Y	NYSE

Day 7

Broker A	Broker J	Broker Z	NASDAQ
Broker B	Broker J	Broker Y	NASDAQ
Broker A	Broker J	Broker Y	NASDAQ

Day 8

Broker B	Broker J	Broker Z	NASDAQ
Broker A	Broker K	Broker Y	NYSE
Broker B	Broker K	Broker Z	NASDAQ

Day 9

Broker A	Broker J	Broker Z	NASDAQ
Broker B	Broker J	Broker Z	NASDAQ
Broker A	Broker K	Broker Y	NASDAQ

Day 10

Broker B	Broker K	Broker Y	NASDAQ
Broker A	Broker J	Broker Y	NYSE
Broker B	Broker J	Broker Y	NYSE

Day 11

Broker A	Broker K	Broker Z	NYSE
Broker B	Broker K	Broker Z	NYSE

ρ	p_A	π_A	π_A Unbundled	p_B	π_B Bundled	π_B Unbundled	π_B	Market Shares (%) Firm A	Firm B
1.50	0.8816	**0.7771**	0.7085	0.3117	**0.1222**	0.0210	0.1222	58.77	26.13
1.40	0.8277	**0.7340**	0.6710	0.3006	**0.1187**	0.0210	0.1108	59.12	26.33
1.30	0.7734	**0.6901**	0.6335	0.2884	**0.1148**	0.0210	0.0995	59.49	26.53
1.20	0.7186	**0.6456**	0.5960	0.2752	**0.1106**	0.0210	0.0885	59.89	26.78
1.10	0.6634	**0.6001**	0.5585	0.2607	**0.1058**	0.0210	0.0776	60.31	27.06
1.00	0.6075	**0.5538**	0.5210	0.2449	**0.1006**	0.0210	0.0671	60.78	27.37
0.90	0.5509	**0.5059**	0.4835	0.2278	**0.0947**	0.0210	0.0568	61.21	27.72
0.80	0.4937	**0.4569**	0.4460	0.2092	**0.0882**	0.0210	0.0471	61.71	28.11
0.70	0.4356	0.4066	**0.4085**	0.1891	0.0810	**0.0210**	0.0378	NA	NA
0.60	0.3767	0.3547	**0.3710**	0.1673	0.0729	**0.0210**	0.0292	NA	NA
0.50	0.3168	0.3010	**0.3335**	0.1439	0.0639	**0.0210**	0.0213	NA	NA

* Firm profits are normalized total market demand of 1.5 for ease of comparison.

Table 1: Computed Market Profitability (α=1, *β*=1)

Delay (minutes)	Count	Percentage
0 < x <= 1	42	65.6%
1 < x <= 2	14	21.9%
2 < x <= 3	2	3.1%
3 < x <= 4	1	1.6%
4 < x <= 5	1	1.6%
Unable to identify	4	6.3%
x = time delay	64	100%

Table 2: **Time Distribution of Executions**

Exchange	Percentage of orders receiving price improvement relative to best bid or ask quote	Price improvement per Share(¢) Average improvement for orders that received price improvement	Average price improvement for all orders	Bid-ask spread at time of order placement (¢)	n	Average Price
NYSE	74.2%	8.69	6.45	19.8	31	$26.76
Regionals	62.5%	6.67	4.17	16.9	24	$24.02
Third Market	39.0%	7.02	2.74	19.1	41	$26.35
All Listed	56.3%	7.64	4.30	18.8	96	$25.90
Nasdaq	14.6%	14.13	2.06	31.1	96	$27.55

$\chi 2$= 9.380, 2 degrees of freedom, p <.01

Table 3: Price improvements by market for NYSE-listed Stocks.

(Nasdaq price improvement data is provided in the bottom row for comparison.)

BROKER TYPE	NYSE	Regionals	Third Market	Percentage of orders receiving price improvement relative to best bid or ask quote	Price improvement per Share (¢)		Added Cost (¢/share) relative
					Average improvement for orders that received price improvement	Average improvement for all orders	
Voice Broker	87.5%	12.5%	0.0%	68.8%	8.23	5.66	0.00
Brand-Name Online	9.4%	59.4%	31.3%	59.4%	7.24	4.30	1.36
Deep Discount Online	0.0%	3.1%	96.9%	40.6%	7.21	2.93	2.73
All Brokers – Listed Stocks				56.3%	7.64	4.30	--

$\chi 2$ = 105.626, 4 degrees of freedom, p <.001 for broker and market

Table 4: Percentage of orders routed to the NYSE, Regionals, and the Third Market for NYSE-listed stocks along with the percentage of orders receiving price improvement by broker type.

(The average improvement per share is also shown for the three broker types along with the additional execution cost of using the two online brokers, relative to the voice broker.)

	vs. Broker *A*	vs. Broker *B*	vs. Broker *J*	vs. Broker *K*	vs. Broker *Y*	vs. Broker *Z*
Better price for Broker *A*			1 *W*=2.0	1 *W*=1.5	2 *W*=7.5	3 *W*=8.0
Better price for Broker *B*			1 *W*=2.0	5 *W*=15	3 *W*=6.0	4 *W*=10
Better price for Broker *J*	2 *W*= –2.0	1 *W*= –2.0			3 *W*=8.0	5 *W*=15
Better price for Broker *K*	1 *W*= –1.5	0 *W*= –15			0 *W*=0.0	1 *W*=2.0
Better price for Broker *Y*	3 *W*= –7.5	0 *W*= –6.0	1 *W*= 8.0	1 *W*= 0.0		
Better price for Broker *Z*	1 *W*= – 8.0	0 *W*= –10	0 *W*= –15	1 *W*= –2.0		

Table 5: Price Improvement Broker Comparisons

The table shows the results of 16 direct comparisons for each pair of brokers. For instance, in comparisons of *A* vs *Z*, *A* had the better price improvement 3 times and *Z* had the better price improvement 1 time. The remaining 16 – 3 – 1 = 12 trades involving *A* and *Z* had identical price improvements.

Table 5 assesses the six brokers through pairwise comparisons. Pairs of values would generally be compared via the *t* test. This test however requires at least approximate normal distributions. Data in which there are extensive ties cannot satisfy this requirement. The price improvement data were nearly all zero or $\frac{1}{8}$ or $\frac{1}{4}$. The nonparametric test used here is the Wilcoxon rank-sum, and there are no comparisons significant at the .05 level.

	J	K	Y	Z
A	-30.69 [2.77] (-44.39)***	-42.80 [2.78] (61.66)***	-51.86 [5.80] (-35.74)***	-52.08 [4.09] (-50.88)***
B	-0.82 [12.7] (-0.26)	-13.32 [3.57] (-14.91)***	-21.20 [12.65] (-6.71)***	-24.55 [3.76] (-26.09)***
J			-20.39 [5.35] (-15.24)***	-21.00 [3.00] (-28.07)***
K			-9.84 [2.65] (-14.85)***	-10.84 [3.50] (-12.40)***

* p<=.10, **p<= .05, ***p<= .01
Mean differences for 16 matched trades, [standard deviation], (t statistic)
Positive differences favor the broker in the row
Negative differences favor the broker in the column

Table 6: Comparison of Mean Total Trading Costs

Full-Service Brokers	Online Commissions (as of May 29, 2001)	Online Commissions (as of Sep 10, 2004)
American Express Financial Advisors	19.95	19.95
Bank Of America	24.95	24.95
Bank One Corporation	19.95	24.95
Benson York Group Inc.	9.99	NA (out of business)
Bluestone Capital Partners LP	29.95	NA (out of business)
Burke Christensen &Lewis Secs Inc.	13.00	9.95 (HarrisDirect)
Cales Investments Inc.	15.00	15
Donaldson Lufkin & Jenrette/DLJ Direct	20.00	9.95
Empire Financial Group Inc.	5.00	8.99
Everen Securities Inc.	32.99	29.95 (Wachovia)
FleetBoston Financial/Quick & Reilly	14.95	19.95
Howe Barnes Investments Inc.	20.95	NA
Investors Capital Corporation	24.99	29.95
Merrill Lynch Pierce Fenner & Smith	29.95	29.95
Morgan Stanley Dean Witter & Co.	29.95	Asset-based only
Nesbitt Burns Securities Inc.	25.00	BMO (Canadian)
Principal Financial Securities Inc.	29.99	27.99
Southwest Securities Inc.	12.00	NA
U S Bancorp Piper Jaffray Inc.	29.95	Asset-based only
Wells Fargo Securities Inc.	24.95	20.45
	Mean = $21.67	**Mean = $20.92**
	Source: www.weissratings.com Note that some of these commissions may be based on assets under management, not shares traded.	Source: Phone quotes & Websites

Table 7: Full-Service Brokerage Firms - Online Brokerage Commissions (2001 & 2004)[26]

[26] The mean for on-line trades for six brokers ranging from deep discount to full-service in the fall of 2002 averaged $20.39 for a 100 share order.

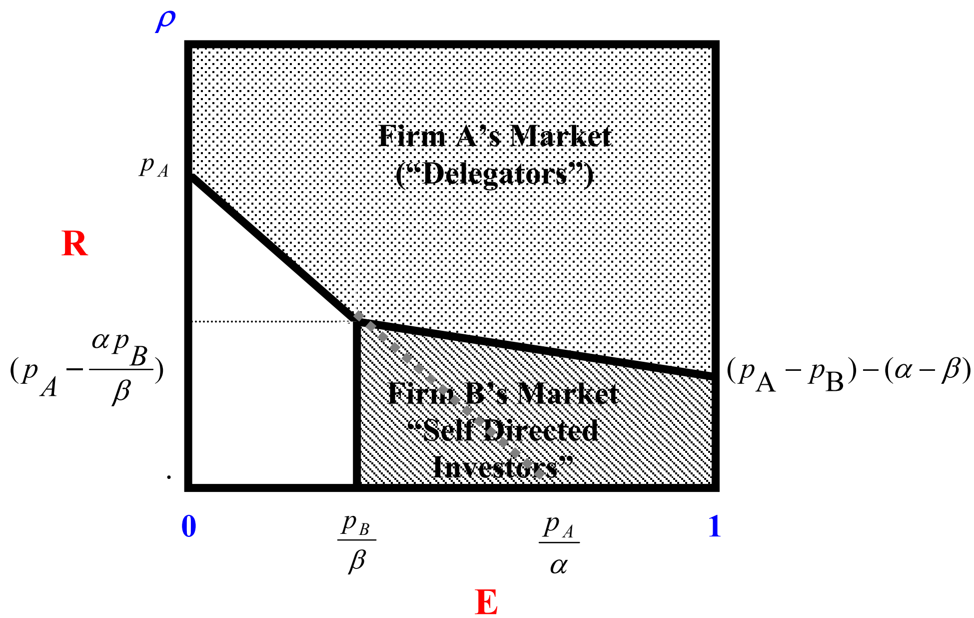
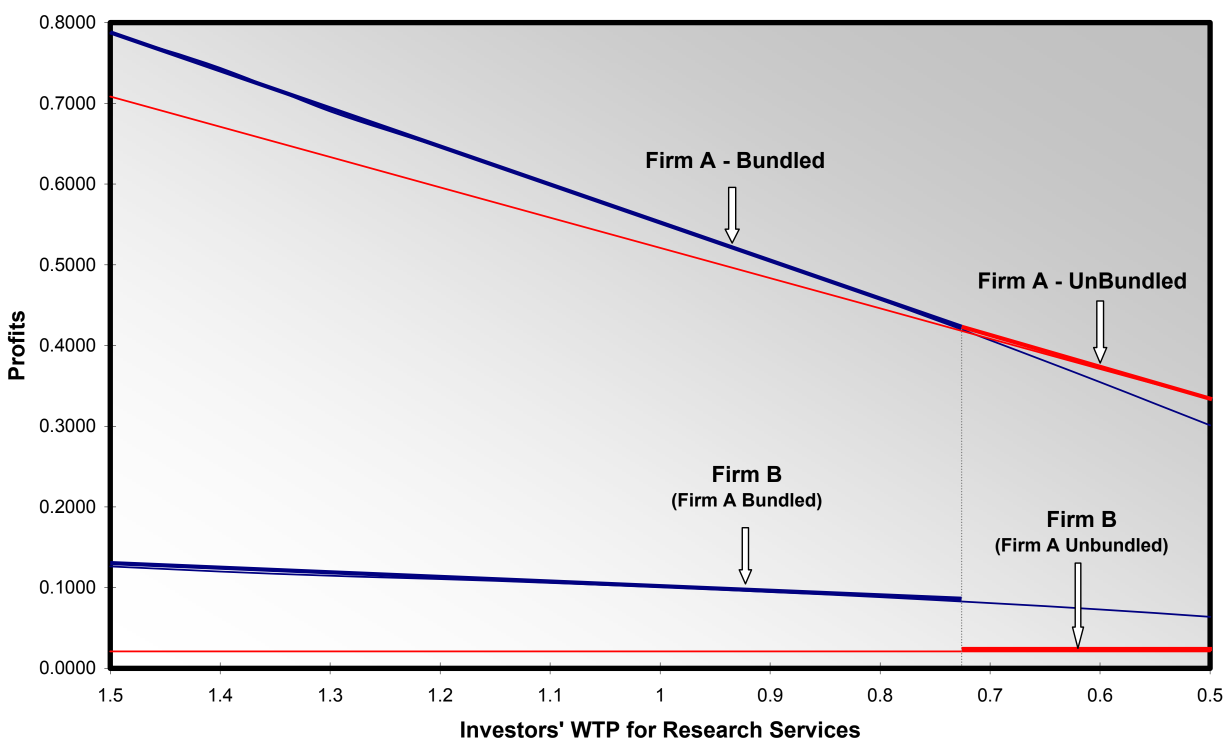


Figure 1: A stylized model of competition between full-service and online brokers

Figure 2: Firm Profits with Decreasing WTP for R



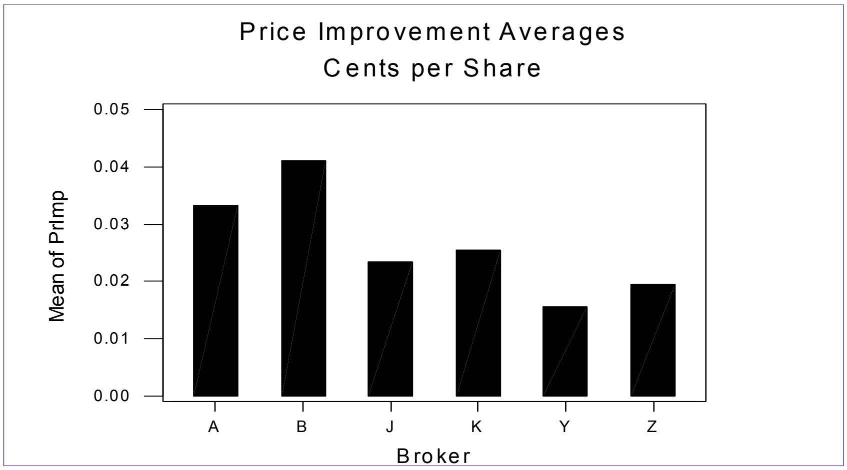


Figure 3: Average Price Improvement by Broker Across all 32 Trials

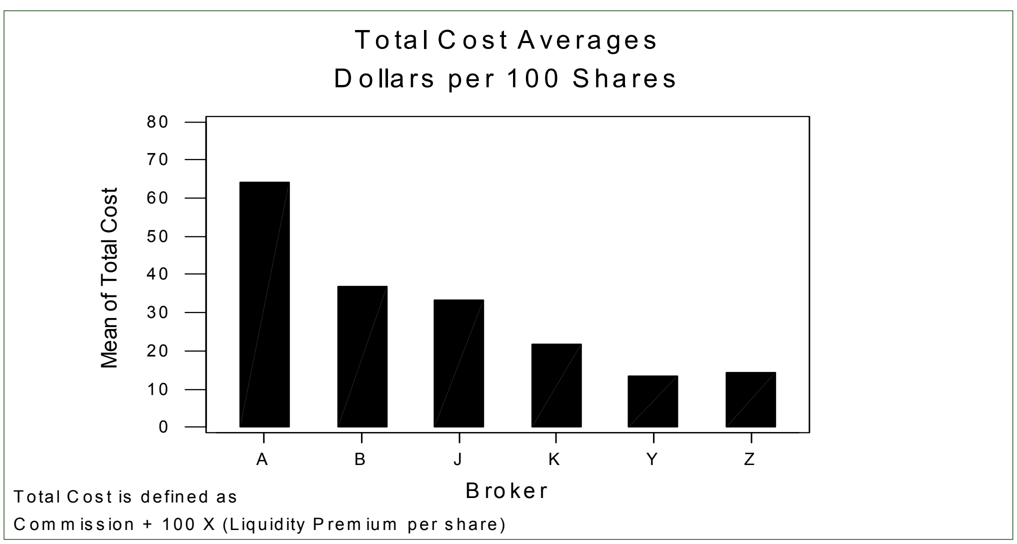


Figure 4: Mean Trading Cost by Broker