Launching Successful E-Markets: A Broker-Level Order Routing Analysis of Two Options Exchanges

(Authors' names blinded for peer review)

New e-markets try in a number of ways to attract a critical mass of participation and usage. Two innovative, all-electronic options exchanges, the International Securities Exchange (ISE) and the Boston Options Exchange (BOX), opened for trading in 2000 and 2004. In contrast to rival floor markets, they offered immediate order execution, direct user access, and reduced costs. ISE and BOX grew trading volumes and won market share from four incumbent exchanges in the U.S. We observe significant differences between broker order routing practices across ISE and BOX leading to the markets' different growth patterns. We develop and test hypotheses about new market growth using a panel of six years of quarterly disclosures from 24 major brokerage firms. We find that membership affiliations are the dominate force in predicting brokers' order routing patterns. In contrast to prior research, network externalities, as measured by an exchange's previous quarter market share, are not significant predictors after controlling for temporal heterogeneity. Managerial implications are discussed.

Key words: competitive impacts of IS, electronic financial markets, electronic markets and auctions, electronic market design and assessment, IT impacts on industry and market structure, longitudinal research, network economics

1. Introduction

The first all-electronic exchange for trading equity options, the International Securities Exchange (ISE) opened for trading in 2000, and the Boston Options Exchange (BOX), opened for trading in 2004. Compared to the incumbent floor markets, ISE and BOX offer technical advances such as immediate trading, direct user access, and reduced costs. The new exchanges gained trading volumes in competition with four incumbent markets in the U.S. including the largest and oldest, the Chicago Board Options Exchange (CBOE), founded in 1973.

Previous attempts such as the Arizona Stock Exchange, BondConnect, Intex, Jiway, Optimark, Tradepoint and many others offered new, fully electronic trading platforms but failed to reach sustainable market shares and were shut down. ISE and BOX were both relatively successful compared to these exchanges. However, little is known about what sets ISE and BOX apart as successful entrants. Furthermore, while ISE reached 30 percent market share after three years, BOX only achieved 6 percent in the three years from its launch. This raises a natural question: why was ISE so successful compared to BOX?

Previous research recognizes that interdependent adoption decisions and network effects can delay the diffusion of new information technologies and prevent organizations from realizing Information Technology (IT)'s value. When technological progress does diffuse into the operational processes of acquiring firms and with success of the introduction of a new technology hinging on attracting a sustainable number of users, researchers have sought to identify the drivers of adoption. The economics literature suggests that users adopt a new technology as the perceived or anticipated benefit of doing so increases. The benefits, termed network effects, have been identified in numerous settings (Brynjolfsson and Kemerer 1996, Griliches 1957, Weber 2006).

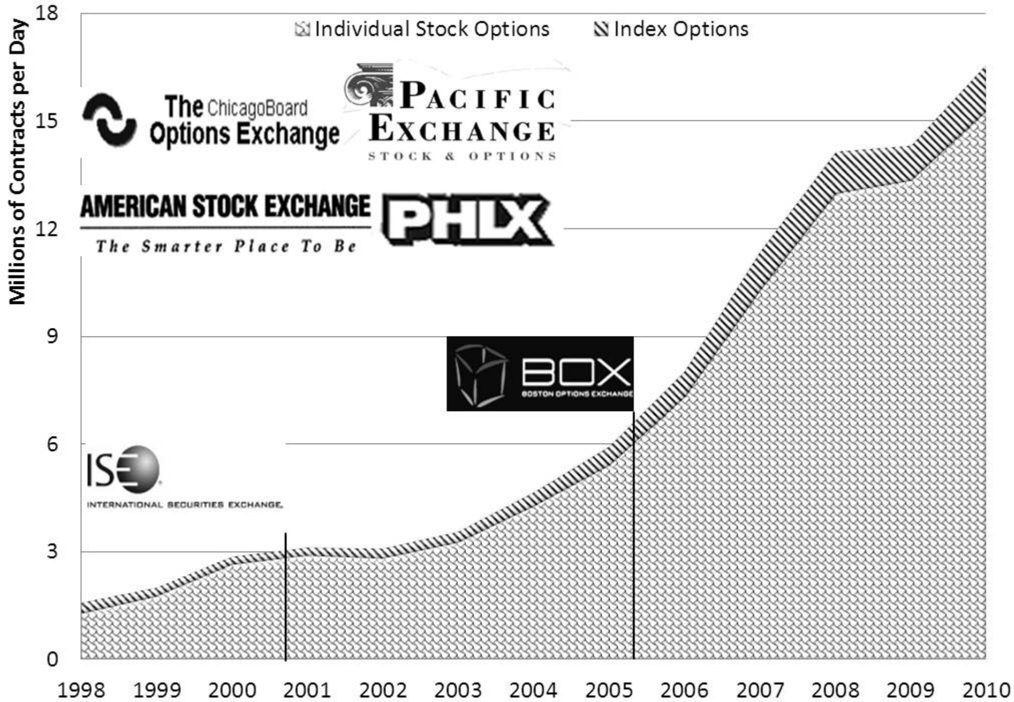
Also at work are sociological drivers of adoption such as know-how or experience with an innovation. As a technology diffuses among consumers or firms, non-economic forms of institutional pressure or "keeping up with the Joneses" effects can accelerate adoption (Abrahamson and Rosenkopf 1997). These forces can help or hinder diffusion of the new technology.

While the introduction of technologically enabled markets is solidly within the Information Systems (IS) domain, IS research traditionally focuses on pricing, transactions costs, and auction mechanisms (Bakos 1997, Ghose and Yao 2011, Overby and Jap 2009, Tang et al. 2010). A survey of e-markets papers appearing in top journals from 1997 to 2008 found that 90, or nearly half of the 196 papers covered, were on auctions alone (Standing et al. 2010). Early empirical research into electronic markets generally compared new electronic markets to traditional, manual markets (Clemons and Weber 1990, Hess and Kemerer 1994). This paper addresses the gap in the literature by comparing two electronic markets competing with one another, and with the traditional floor markets they challenged. We examine the factors influencing options exchange usage among U.S. brokerage firms that led to differing growth patterns for two new e-markets. Exchange markets depend on the participation of multiple, heterogeneous firms and users, and the liquidity and value of a market grow with its user base.

The history and scale of options markets make them a particularly interesting setting in which to research e-market competition.[1] Options contracts can be either a put or a call. A put (call) option is the right, but not the obligation, to sell (buy) the underlying security at option expiration for a pre-determined price. Each equity contract is for 100 shares of the underlying security. Options contracts began to trade on the Chicago Board Options Exchange in 1973. Three other exchanges for options opened in the next three years. From 1990 to 2000, when the ISE launched, daily average options trading volume grew at a compound annual rate of 13.3 percent. From 2000-2010, volumes rose at a compound annual rate of 18.4 percent, reaching 15.6 million contracts and $3.4 billion in value per day by the end of 2010 (Figure 1).

[1] Appendix A summarizes the importance of financial markets in general and the role of IT in particular.

Figure 1 Average Daily Equity and Index Options Volume on all U.S. Exchanges, 1998 - 2010



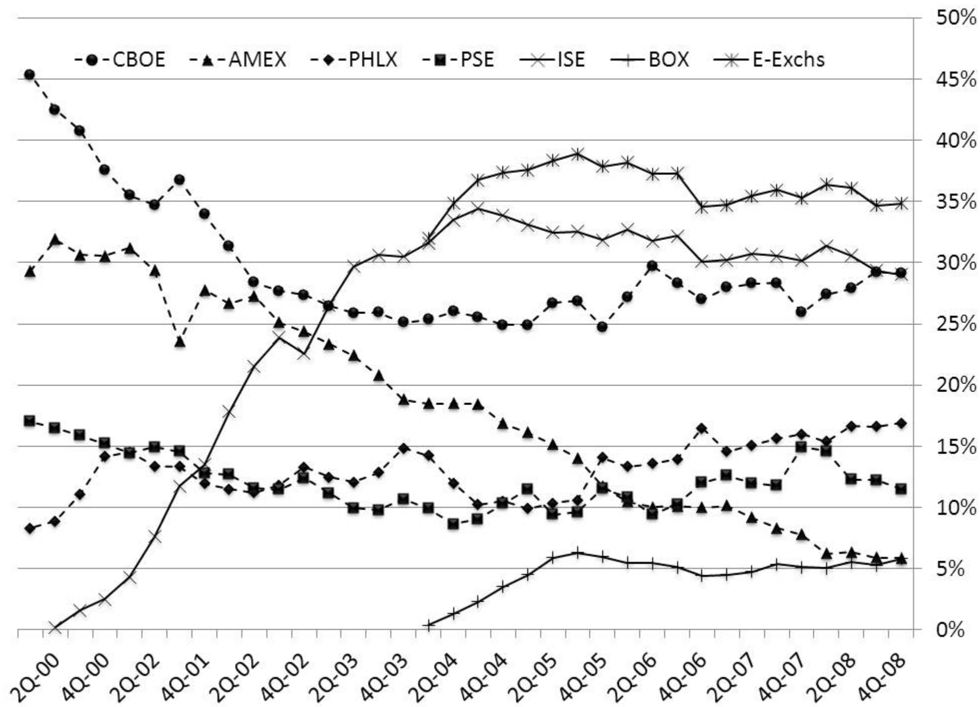
Note. Trading volumes to the markets grew at a compound annual rate of 13.3 percent from 1990 to 2000 and 18.4 percent from 2000 to 2010.

Once an investor decides to trade an option, the order is delivered electronically or via phone to the broker. Brokers are obligated to sell at the highest price and buy at the lowest price. However, with many exchanges matching prices at current exchanges, brokers may need to be incentivized to send orders to ISE and BOX. The decision of the allocation of orders sent to each exchange, called the "order routing" decision, is potentially automated to route orders to a certain exchange under certain conditions. Furthermore, brokers can sign up for one or multiple affiliations with the exchanges which entitle them to some benefits for routing orders to and participating in trading on that exchange. Affiliation in this context represents institutional pressure/persuasion to route orders to a particular exchange.[2] In that sense, they are a sociological factor influencing brokers' order routing decision.

Failure to attract enough orders is what caused previous attempts to launch e-markets to shut down. ISE and BOX illustrate the critical mass challenges. In their first four years of operation, the two exchanges slowly gained market share from the incumbent floor exchanges. ISE reached a

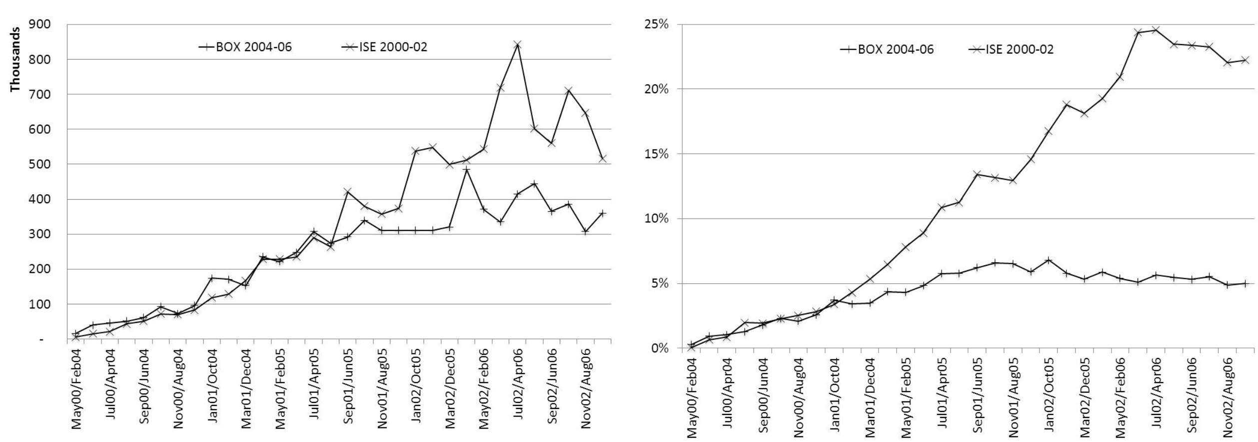
[2] Brokers' exchange affiliation should not be confused with affiliation in a sociological sense such as North American or European. Indeed it is more closely related to a two-part tariff where there is an upfront fixed cost and subsequent variable cost. We use the term affiliation throughout this paper to keep in line with the terminology used between brokers and exchanges.

Figure 2 Market shares of U.S. Exchanges, 2000-2008



Note. ISE and BOX are electronic competitors to four traditional floor exchanges: Chicago Board Options Exchange (CBOE), American Stock Exchange (AMEX), Philadelphia Stock Exchange (PHLX), and Pacific Stock Exchange (PSE). Traditional floor exchanges are shown with dashed lines while the new electronic exchanges are shown with solid lines. E-Exchs is the total market share for electronic exchanges after BOX entered.

Figure 3 Broker categorization



(a) Average contracts per day (b) Options contracts market share

Note. ISE and BOX had similar initial growth in terms of average contracts per day during the first 30 months after launch. However market shares for the two exchanges were only similar in the first eight months.

market share of 30 percent after three years. While BOX achieved 6 percent market share within two years, it has not increased from that level (Figure 2).

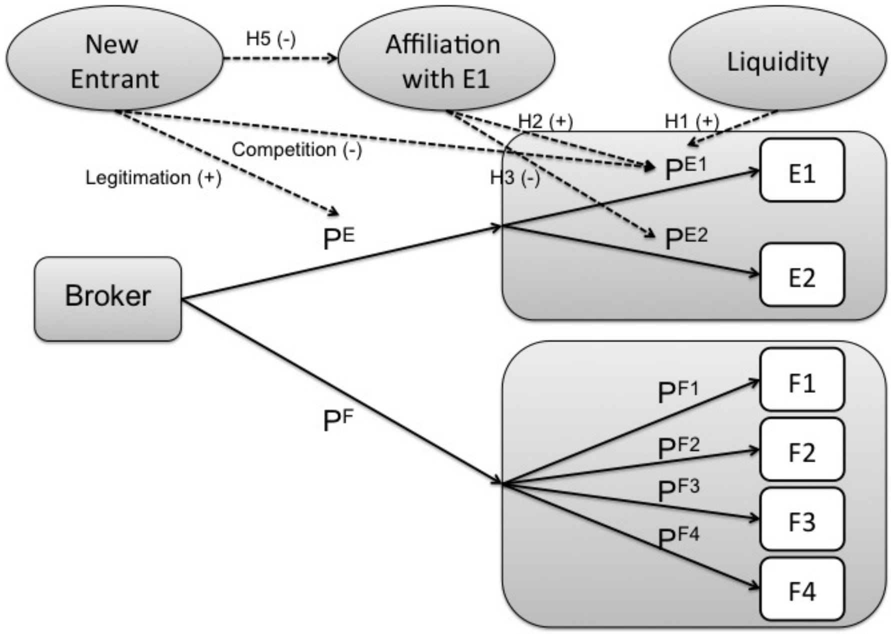
Figure 3(a) shows the growth in the initial months at ISE and BOX were similar in terms of the number of contracts traded per day. However, when viewed in terms of the market share of the exchanges as in Figure 3(b), ISE continued to grow after its first twelve months, while BOX growth stagnated.

With so much at stake financially, there are several critical questions to understand how to introduce electronic markets in competition with traditional floor exchanges and rival electronic exchanged. Specifically, are economic (network) or sociological (affiliation) effects both important for introducing new electronic exchanges? If so, which is the more important force? How does the introduction of a second electronic exchange impact the market share of an incumbent electronic exchange?

To answer these questions, we first formally develop hypotheses regarding broker order routing to competing electronic exchanges in the presence of affiliation benefits and network effects. Before explicitly testing these propositions, we examine differences in brokers' adoption and attrition across the two exchanges. Then using a panel of six years of quarterly disclosures from 24 major brokerage firms, we model the broker's order routing patterns at the firm level. Estimating fractional regression models of the new markets' growth, we find that "sociological" factors (affiliations) outweigh the importance of economic factors (network effects) in brokers' order routing decisions to the new markets.

Our competing markets setting, and the issue of IT diffusion across firms, are broadly important in the IS field. Many new IT platforms derive their value from the level of usage and the network benefits they generate (e.g. social media websites, packaged software, online auctions). Succeeding in the initial start-up phase is therefore crucial. This paper contributes to our knowledge of the factors that can lead to the successful diffusion of electronic markets. Our results are important for three reasons. First, we find a counterintuitive result in the data that suggests network effects, measured as an exchange's previous quarter market share, are not significant predictors of brokers' order routing levels after controlling for unobserved temporal heterogeneity. Strategies that target a broad base of brokers may not benefit from the network effects as much as previously thought. Second, the results highlight the key role of exchange affiliations in achieving broad market usage. Combined with the previous result, our findings have implications for operators of new e-markets and participants in the financial trading industry. Specifically, technological advantages will not lead to economic benefits unless the adoption decisions and usage patterns of target participants collectively facilitate a successful launch. Third, we advance the academic literature by empirically studying competition between rival electronic exchanges. Prior work generally examined electronic markets versus physical markets leaving comparison of alternative IT-enabled institutions a relatively understudied area of the IS literature (Koh et al. 2010).

Figure 4 Summary of hypotheses



Note. Summary of hypotheses. E represents an electronic exchange and F represents a traditional floor exchange. P is the percent of orders routed to that exchange by a broker. H4 is the net effect of legitimation and competition.

2. Literature and Hypotheses

A large body of research has sought to understand the sociological and economic processes underlying the diffusion of new technologies. This section ties together these two literature streams to develop hypotheses on how brokers decide where to route orders. Figure 4 provides an overview of the brokers' choice of where to route orders. It also serves as a framework within which to describe each of the hypotheses below.

2.1. Economics of Diffusion

The economics literature principally considers how consumers or firms adopt when they *anticipate* benefits from other consumers or firms using the same technology. The economic benefits may be direct, such as for a unified electronic records system or word processing user gaining when others acquire the records system or buy software with the same document format. Or there may be indirect benefits, arising from the technology that is widely selected being more likely to survive and have more products compatible with it in the future. For instance, once Blu-Ray went ahead in the format battle for High Definition DVDs, your neighbor can lend you a Blu-Ray disk to play on your machine, generating an indirect benefit an HD-DVD player would not. The first three hypotheses aim to measure whether network or affiliation effects dominate in brokers' decision of where to route orders.

Empirical data has been used to understand the diffusion process of technological innovations. The seminal work of Griliches (1957) found the diffusion pattern of new, hybrid corn seeds varied by region within the central United States in the period 1932-1956. The adoption of hybrid corn, a new technology, was shown to be a series of interdependent developments involving seed producers and farmers that occurred at different rates in different areas that had different characteristics.

Empirical research on IT innovations generally confirms the presence of network effects that influence the expected benefits from a new technology, and thus drive adoption decisions by users. The role of network effects was identified in a study of ATM adoption by banks in the period 1971-1979 (Saloner and Shepard 1995). At the time, technology was proprietary and ATMs were not yet linked into multi-bank networks. After controlling for a bank's deposit base, it turns out the size of the bank's branch network explains a bank's speed in rolling out ATM machines. More branches lead to less rapid ATM adoption. The results suggest predictability in diffusion across firms, and confirm that anticipated network value leads firms to be earlier adopters of a new technology. A more recent study looks at internet banking adoption and finds that customers are more likely to adopt when local online banking penetration levels are higher (Xue et al. 2011). Another study identified features of spreadsheet software that commanded premium prices, but also identified "positive network externality effects from installed base and from compatibility [that are] as important as any of the intrinsic product features" of the 93 competing software packages in the sample (Brynjolfsson and Kemerer 1996). A study of ISE in the period 2001-2004 showed brokers' use was positively related to whether the firm is an online broker, its ISE affiliation status, and the prior period's overall ISE market share (Weber 2006).

One challenge for research studying the take up of new IT is that analyses based on sales of an IT product often overstate the true diffusion process (Fichman and Kemerer 1999). An "assimilation gap" exists between the acquisition of software and its deployment. This leads to the conclusion that IT innovations may enjoy robust sales, yet are "not genuinely diffusing in the sense of having a significant impact on the operational processes of acquiring firms" (Fichman and Kemerer 1999, p. 273). Examining the assimilation of software process innovations in 608 corporate IT departments, Fichman develops a model with six variables including department size, education, and internal training activity. The model explained 49 percent of the variance in firms' use of software process innovations (Fichman 2001). Evidence of benefits are shown to be more strongly linked to the actual usage of technology than to its mere availability in a sample of decision support systems (DSS) usage in eight hospitals (Devaraj and Kohli 2003). Pac et al. (2010) extended the Bass diffusion model to a competitive environment in which the rival "platforms" have differing network externalities. The optimal adoption times for users are solved for as Nash equilibria, and the paper shows that under competition, the dominance of an incumbent platform translates into lagged response by users to an entrant's innovation.

The above studies document the historic importance of network effects in the diffusion of new technologies. Network effects are also perceived to be important in the context of financial exchanges. Exchanges with a larger number of orders routed to them, termed higher liquidity, tend to have more competitive quotes (higher sell prices and lower buy prices) and lower spreads (the difference between current buy and sell prices) (Harris et al. 2008). Therefore, as the liquidity of the exchange increases, quotes become more competitive and brokers will increase the percentage of orders routed to that exchange leading to further reductions in trading costs. We expect this effect to be apparent in the electronic exchange setting we study here. After all, as the old trader adage goes "liquidity begets liquidity." This is reflected in Figure 4 where increased liquidity in one exchange leads to a larger percentage of orders routed to that exchange at the expense of the competing exchanges.

Hypothesis 1. *Network effects play an important role in e-market use: As an exchange grows its market share and overall liquidity, the percentage of orders that brokers subsequently route to that exchange will increase.*

2.2. Sociological Factors of Diffusion

In contrast to the diffusion economics literature, sociological research emphasizes how know-how or experience with an innovation can be spread across users and become the mechanism that drives network effects (Rogers 1976, 2003). Abrahamson and Rosenkopf (1997) propose a theory of how the structure of social networks affects the extent of an innovation's diffusion among members. According to the theory, success is a result of knowledgeable advocates, experts and technology vendors promoting early adoption of an innovation. As it becomes more widespread, other forms of institutional pressure — business partners, consultants, etc. — persuade other, similar firms to adopt. They propose that as innovations gain managerial attention, becoming fads and fashionable, their diffusion accelerates, perhaps more so than would be justified on economic benefits alone.

Sociological effects are not merely important for physical products but can play a significant role in the diffusion of e-markets. A study based on surveys of 90 senior managers and traders across 25 financial institutions found that interfirm relationships play a major role in limiting the proliferation of electronic trading systems in the fixed-income markets (Montazemi et al. 2008). In this case, sociological effects have maintained the status quo with merely 10% of fixed income trades transacted via the electronic channel.

Broker affiliations with an exchange are sociological effects in the context of electronic exchanges. Firms which operate closely together by continual interaction develop a sense of obligation toward the other party; nurturing ties that lead to the formation of mutually beneficial alliances (Gulati 1995). Similar to the relationships Gulati examined in fixed income markets, affiliations will drive the successful or unsuccessful launch of the new electronic exchanges as orders are routed to the exchanges with which the brokers have formed the closest ties. We hypothesize that broker affiliations will impact order routing in two ways. First, brokers that affiliate with an exchange route more orders to that exchange.

HYPOTHESIS 2. *Brokers with membership affiliation(s) with electronic exchange E1 will route a higher percentage of their customer orders to exchange E1 than brokers without membership affiliation(s) with electronic exchange E1.*

Second, affiliating with an electronic exchange has a significant impact on order routing to the competing electronic exchange. Increased order routing to exchange E1 could come at the expense of the competing electronic exchange E2 or it could come at the expense of one (or all) of the floor exchanges with no reduction in order routing to E2. However, affiliating with electronic exchange E1 could potentially lead to an increased percentage of orders routed to E2. If brokers develop or purchase new technologies to take advantage of the affiliation benefits with E1, they may see a benefit to routing more orders to electronic exchanges in general. In this case, the increase in P^E would lead to an increase in the percentage of orders routed to E2 as well as to E1. These types of spillover effects have a positive impact on a firm's long-run productivity (Chang and Gurbaxani 2012).

HYPOTHESIS 3. *Brokers with membership affiliation(s) with electronic exchange E1 will differentially route a percentage of their customer orders to electronic exchange E2 than brokers without membership affiliation(s) with exchange E1.*

2.3. Competitive Forces in Action

In addition to affiliation and network effects, competitive forces impact brokers' order routing decisions. When BOX enters as a new electronic market, there are four possible outcomes for order routing to ISE. The first is that BOX receives no orders and the status quo is maintained. A related outcome is that BOX receives orders that were previously routed to the floor exchanges. This would also have no impact on the percent of orders that are routed to ISE. The third potential outcome is that orders are routed away from ISE to BOX. This is in line with classic market competition models that predict the introduction of a rival will reduce the market share of closely related competitors (Hotelling 1929). Finally, ISE could experience an increase in order routing. BOX's entry could signal to brokers that electronic trading is not a fad or increase public knowledge of the benefits of electronic trading. In doing so, BOX's entry would "legitimize" the new trading technology. The exact mechanism through which legitimation occurs is outside the scope of this paper. We merely note that, for whatever reason, a second mover, in technological terms, may in fact lead to increased market share for the first mover at the expense of existing non-technological competitors. While we do not know which of these four outcomes will eventually transpire, we expect that BOX's entry will have some impact on the orders routed to ISE.

HYPOTHESIS 4. *The opening of a new electronic exchange will impact the percentage of orders routed by brokers to existing electronic exchanges.*

One possible way in which BOX entry can impact order flow to ISE is through changing relative incentives for brokers affiliated to ISE. After BOX opens, brokers are faced with different benefits and costs. The attractiveness of BOX affiliations could cause ISE-affiliated brokers to change their order routing decisions. It is unlikely that the BOX affiliation structure would make the ISE affiliation structure *more* attractive as this would imply that brokers were not correctly evaluating the relative benefits and costs of affiliating with ISE and the traditional floor exchanges correctly before BOX was introduced. We therefore expect that the relative benefits of being affiliated with ISE are reduced when BOX opens and therefore ISE-affiliated brokers will route a lower percentage of their orders to ISE after BOX opens.

HYPOTHESIS 5. *The opening of a new electronic exchange will lower the percentage of orders routed to the existing electronic exchange through brokers affiliated with the incumbent exchange.*

3. Data

We test the hypotheses developed using a panel dataset made up of quarterly observations for 24 major U.S. brokerages from third quarter 2001 through fourth quarter 2006, inclusive. Since our sample does not contain a complete collection of brokers in the U.S. market, we must ensure it is representative of the industry as a whole. We collected commission revenue data from each broker's annual reports for 2001 to 2006 in addition to aggregate industry commission revenue over the same period.[3] The revenue from 21[4] of the brokers in our sample made up 70 percent of the entire industry's commission revenue in 2004, the midpoint of our data. Over the 2001 to 2006 period these brokers made up between 69 percent and 78 percent of the industry's annual aggregate commission revenue. Our sample therefore covers the most important U.S. brokers at the time of our analysis.

[3] Data on aggregate total commission revenue was obtained from `http://www.sifma.org/uploadedFiles/Research/Statistics/StatisticsFiles/FI-US-Industry-Financial-Results-SIFMA.xls` on January 27, 2011.

[4] Three brokers were not included in this calculation because appropriate data was not available. However, aggregate industry commission includes these brokers. Available data for these brokers would only increase the total revenue of the brokers in the sample and therefore improve the industry coverage of the brokers in the sample.

Table 1 Summary of affiliation structures

ISE	BOX
• Launched May 2000	• Launched February 2004
• Market makers must purchase a membership	• No seats for brokers to purchase/lease
• Membership costs: Primary market makers (PMM): $7.9 million in 2006 Competitive market makers (CMM): $1.5 million in 2008	• Unlimited competing market maker participants
• One PMM and 16 CMMs in each of 10 option bins	• Four designated "Price Improvement Process" (PIP) market makers
• Firms are affiliated with ISE as PMM, CMM or Electronic Access Member (EAM)	• Firms are affiliated with BOX as Investors, Market Makers, or Participants

The data on these brokers come from four disjoint sources. First, Securities and Exchange Commission's (SEC) Rule 606 (formerly called Rule 11Ac1-6) requires brokers to publish their routing of equity and option orders on a quarterly basis starting with the third quarter of 2001. The requirement stipulates that every broker must publish the percentage of orders routed to each exchange. This is reported quarterly beginning 3Q 2001 through 4Q 2006 for our sample of 24 of the largest U.S. brokerage firms.[5] The authors collected this data from brokers' websites as the publications were made available.

Second, the total number of contracts traded on each exchange for each quarter was collected from the Options Clearing Corp. We use this data to calculate the market share for each exchange in each quarter. An exchange's market share is a measure of the liquidity in that exchange relative to liquidity in all of the other exchanges.

Third is the brokers' affiliation information. The authors hand collected this data from the ISE and BOX websites and through correspondence with managers at the exchanges to determine dates at which firms became affiliated with that exchange. Table 1 summarizes the affiliation categories in each exchange. A detailed description of exchange affiliation requirements and benefits is given in the next subsection.

The fourth source is Barron's annual survey of online brokers from 2002 to 2005, which classifies brokers into online (OLBs) and full-service categories (FSBs). We use this variable to determine if online brokers, which have adopted a high-technology strategy in the broker space, routed orders differently to the two exchanges. While we have no hypothesis that would suggest differences in order routing, observing a significant difference in order routing for these brokers would provide evidence that one exchange facilitated electronic trading better than the other through better

[5] Rule 606 mandates that from third quarter 2001 firms must disclose the identity of the market centers that receive 5% or more of customers' orders for: i) NYSE-listed securities, ii) Nasdaq-listed securities, iii) Amex-listed and regional exchange-listed securities, iv) exchange-listed options. The specific disclosures apply are the "Percentage of Customer Orders Having a Market Value Less Than $200,000" for securities, and for listed options, the "Percentage of Customer Orders Having a Market Value Less Than $50,000."

Table 2 Descriptive Statistics

Variable	Description	Mean
	Dependent Variables	
ISE	Percent of orders routed to ISE	0.242
BOX	Percent of orders routed to BOX	0.026
	Independent Variables	
OLB	Online Broker Indicator	0.424
ISEPMM	ISE Primary Market Maker Indicator	0.306
ISECMM	ISE Competitive Market Maker Indicator	0.515
ISEEAM	ISE Electronic Access Member Indicator	0.874
BOXINV	BOX Investor Indicator	0.299
BOXPRCT	BOX Participant Indicator	0.743
BOXMM	BOX Market Maker Indicator	0.187
BOXOPEN	BOX Open Indicator	0.536
PREVQTRMSISE	ISE Previous Quarter Market Share	0.280
PREVQTRMSBOX	BOX Previous Quarter Market Share	0.040

Mean of the dependent and independent variables used in our analysis. Averages for OLB and ISE related variables are calculated over 462 observations. Averages for BOX related variables are calculated over 257 observations due to the later timing of BOX entry.

connectivity, timelier support, etc. Table 2 reports the mean of the dependent and independent variables in our sample.

3.1. Exchange Affiliation Structures

At the midpoint of our data collection in 2004, the ISE listed options on 646 securities. Its market is organized into 10 bins with about 60 stock options in each. A bin has one Primary Market Maker (ISEPMM), and as many as 16 Competitive Market Makers (ISECMMs). An ISEPMM must purchase or lease one of the 10 ISEPMM trading rights. In 2004, eight firms operated as ISEPMMs, with two firms covering two bins each. The second ISE affiliation category is Competitive Market Maker. In 2004, 23 firms operated as ISECMMs. An ISECMM must purchase or lease one of 160 ISECMM trading rights, entitling them to enter quotations in the options in a bin. ISECMM trading privileges for Bin 3 were bought for $1.5 million each on December 18, 2003. ISECMM rights were sold for $1.5 million again in 2008. ISEPMMs have greater obligations, but also greater privileges in ISE trading than ISECMMs. The third ISE affiliation type is an "Electronic Access Member" (ISEEAM). An ISEEAM is a broker/dealer that acts as an order flow provider, and – unlike ISEPMMs and ISECMMs – is not required to purchase affiliation. There are no limits on the number of ISEEAMs, who pay a monthly access fee to route orders in all of the options traded on the ISE. ISEEAMs cannot enter quotations or otherwise engage in market making activities on the exchange. In 2004, there were 126 ISEEAMs, and in 2009 there were 187.

In contrast, BOX places no limits on the number of brokers within its affiliation designations, nor does it require brokers to purchase affiliations. BOX Market Makers (BOXMM) are responsible

Table 3 Trading fees across exchanges

Exchange	Execution Fee (per contract)	Match / Comparison Fee	Exchange Floor Broker Fee	Total
ISE	\$0.15	\$0.03	\$0.00	\$0.18
BOX	\$0.20	\$0.00	\$0.00	\$0.20
AMEX	\$0.19	\$0.04	\$0.03	\$0.26
Pacific	\$0.26	\$0.00	\$0.00	\$0.26
CBOE	\$0.24	\$0.00	\$0.04	\$0.28
Philadelphia	\$0.20	\$0.04	\$0.05	\$0.29

Fees per contract traded in 2006 are comparable across the six exchanges and cost differentials are not significant in explaining market share gains at ISE or BOX.

for providing liquidity in the options they have been assigned to, but can freely enter or exit. The market makers on BOX are competing with any number of other market makers. The second BOX affiliation type is called a participant (BOXPRCT). Similar to the ISEEAM affiliation type, the BOXPRCT is not purchased but a registration requirement for trading on the exchange. The third BOX affiliation type is an investor (BOXINV). This is different to the other two affiliation types. An investor is a broker that also has an equity stake in BOX.

Data on explicit per trade exchange costs were collected, but the small differences turned out to have no relation to market share changes (Table 3). We also learned that volume discounts and rebates made published fees less than reliable measures of actual costs.

4. Analysis of Brokers' Adoption and Attrition

Before formally testing our hypotheses through an econometric analysis of broker order routing, we first examine the pooled data. At the broker level, there are alternative explanations for why BOX did not achieve market share levels comparable to ISE including: (1) fewer brokers used BOX than ISE, (2) brokers used BOX but with not enough volume, and (3) brokers used BOX for a time but then stopped using BOX.

In order to examine adoption and attrition in the highly sensitive post-launch period, we first categorize the brokers into four types:

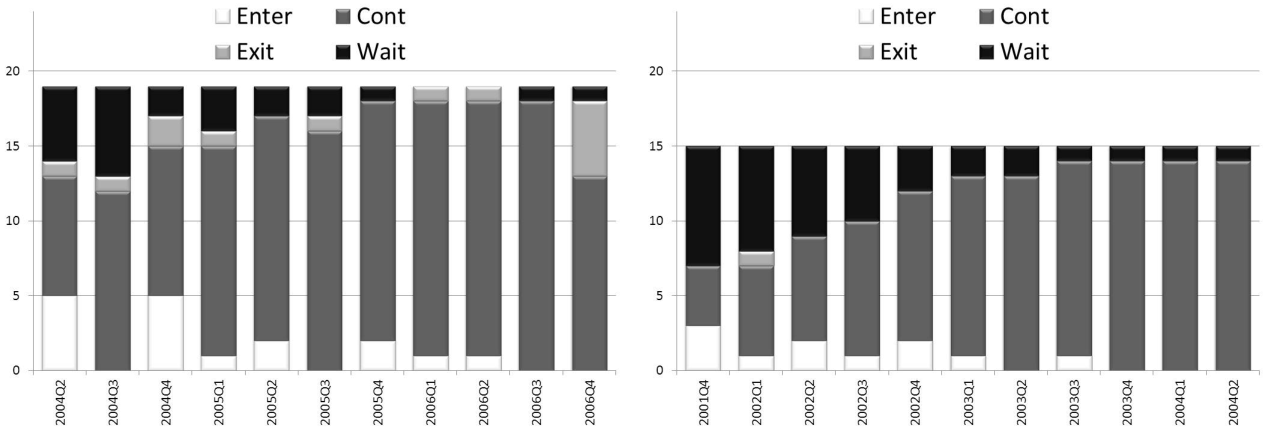
1. Continuing brokers are those which submitted orders to the exchange in both the previous and the current quarter.

2. Entering brokers are those which did not submit orders in the previous quarter but did in the current quarter.

3. Exiting brokers are those which submitted orders to the exchange in the previous quarter but not in the current quarter.

4. Waiting brokers are those which did not submit orders in either the previous or the current quarter.

Figure 5 Broker categorization



(a) BOX (b) ISE

Note. Number of brokers in each category for ISE and BOX in the 12 quarters following exchange opening. ISE had fewer exiting brokers than BOX but BOX had more continuing brokers than ISE.

Table 4 Categorization of brokers

	Category			
Exchange	Continuing	Entering	Exiting	Waiting
ISE	116	11	1	37
	(70.3%)	(6.7%)	(0.6%)	(22.4%)
BOX	156	17	13	23
	(74.6%)	(8.1%)	(6.2%)	(11.0%)
POOLED	272	28	14	60
	(72.7%)	(7.5%)	(3.7%)	(16.0%)

Number and percentage of broker-quarters in each category for each exchange. Percentages in a row may not sum to zero due to rounding.

An exchange failing to attract sustainable order flow could be the result of brokers not continuing usage (too many brokers exiting the user group), or brokers not entering the user group (too many brokers delaying adoption), or a combination of the two. Starting from when an exchange opened and continuing for 12 quarters, we categorize brokers in this way. This enables us to compare the exchanges on equivalent time spans. In addition, we only consider brokers for which we have order information for all 12 quarters following exchange opening. This prevents overestimation of the impact of each category due to missing data. Figure 5 shows the breakdown of brokers in each category for both exchanges. Immediately evident is that ISE has fewer exiting brokers than BOX in almost all except one quarter. However, with the exception of the final quarter, BOX has more continuing brokers than ISE.

Table 4 shows the number and relative percentage of broker-quarters in each category for each exchange as well as for the two exchanges pooled together. Using this information, we perform chi-

Table 5 Brokers' transition in usage

Panel A: ISE			Panel B: BOX		
	Previous Quarter			Previous Quarter	
Current Quarter	Zero	Positive	Current Quarter	Zero	Positive
Positive	22.9%	99.1%	Positive	42.5%	92.3%
Zero	77.1%	0.9%	Zero	57.5%	7.7%

Probability of a broker using ISE (Panel A) and BOX (Panel B) in the current quarter conditional on the previous quarter's usage. Note that columns sum to 100% while rows do not.

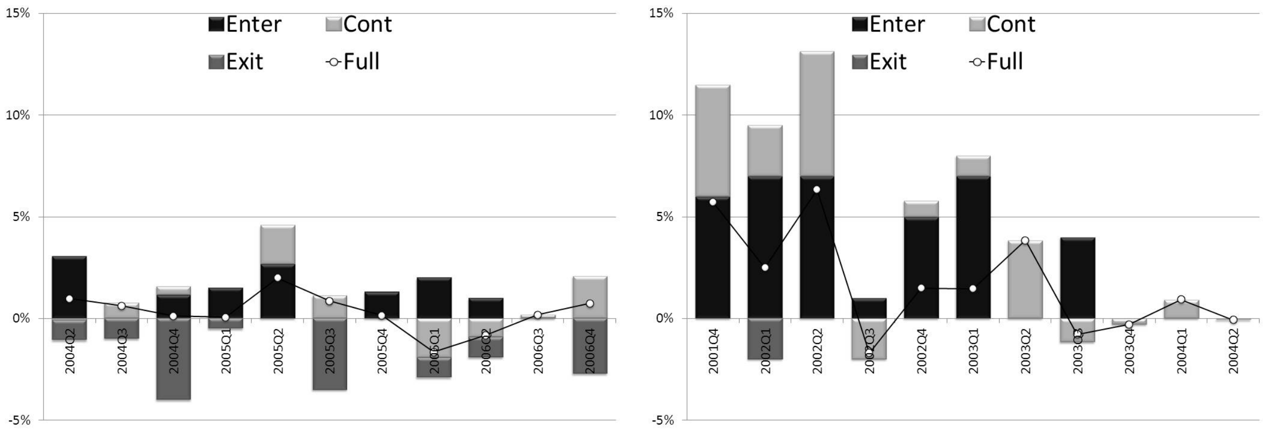
squared tests to determine if the number of broker-quarters in each category for the exchanges is significantly different from the number of broker-quarters in each category for the pooled data. The results of the tests confirm that both ISE and BOX broker categorizations are statistically different than the pooled broker categorizations ($\chi^2 = 100.35$, $p < 0.001$ for ISE and $\chi^2 = 147.01$, $p < 0.001$ for BOX). We conclude that the overall distribution of broker-quarters across the categories is different between the two exchanges.

We also use the data in Table 4 to calculate the probability of a broker switching their usage in the current quarter given their usage in the previous quarter. For example, a broker who routed a positive percentage of their orders to an exchange in the previous quarter is either a continuing broker (if their usage is positive in the current quarter) or an exiting broker (if their usage is zero in the current quarter). Similarly, a broker who did not route any orders to an exchange in the previous quarter is either an entering broker (if their usage is positive in the current quarter) or a waiting broker (if their usage is zero in the current quarter). Table 5 shows these probabilities for ISE and BOX. The calculations emphasize the substantial differences between the two exchanges that are apparent in Figure 5. In particular, the chance of an ISE user remaining an ISE user the next quarter is 99.1 percent but it is only 92.3 percent for BOX as 7.7 percent of brokers fail to use BOX the quarter after reporting positive use of BOX. Lower retention levels for BOX could signal lower benefits for the brokers.

It is not simply the number of brokers in the categories that determines why ISE reached the market share levels it did while BOX failed to achieve these levels but also the percent of orders routed to an exchange by the brokers. If brokers route orders to an exchange, but only in small amounts, then the exchange may fall short of critical mass. A similar argument applies to brokers that already route orders to the exchange. If these brokers stop routing orders to the exchange or decrease the percentage of orders routed to the exchange, then the volume could have difficulty attaining a sufficient mass of orders to remain profitable. In both cases the positive feedback loop of exchange volume was better engaged for ISE than for BOX.

Figure 6 shows the breakdown of changes in average percent of orders routed in each of the broker categories as well as the overall change in average percent of orders routed to ISE and BOX.

Figure 6 Change in percent of orders routed by category



(a) BOX (b) ISE

Note. Changes in percent of orders routed from quarter to quarter for entering, continuing, and exiting brokers as well as overall change in percent of orders routed to ISE and BOX.

Table 6 Differences in order routing across broker categorizations

	Mean ISE	Mean BOX	t-stat	p-value (one tailed)
Entering Broker	0.0555	0.0196	3.86	0.001
Continuing or Exiting Brokers	0.0105	0.0007	1.45	0.074

Results of a one-tailed two-sample t-test for differences in the change in average percentage of orders routed to each exchange for entering and continuing or exiting brokers.

It seems that the average percentage of orders routed to ISE by entering brokers is higher than the average percent of orders routed to BOX by entering brokers. In addition, the average percent of orders routed to ISE by either continuing or exiting brokers is higher than the average percent of orders routed to BOX by either continuing or exiting brokers.

Table 6 shows the results of two-sample t-tests assuming unequal variances for differences between the change in percentage of orders routed for different categories of brokers across exchanges. The results confirm that brokers using BOX for the first time route a smaller percentages of their orders compared to those using ISE. Furthermore, continuing or exiting brokers route a smaller percentage of their orders to BOX. These two results combine to show that ISE had larger routing percentages and a greater chance of continuing usage, which provided the liquidity advantages needed in order for the exchange to succeed.

BOX had a larger number of users than ISE. However, brokers' lower usage levels and higher exits from usage resulted in BOX not achieving the market share levels reached by ISE. These results suggest new electronic exchanges should aim to attract a small number of highly committed users to achieve a successful launch.

5. Econometric Specification

While the previous section demonstrates that brokers' use of ISE was different than BOX, there are many broker-specific and temporal effects that are not controlled for. To address these issues, we turn to a robust econometric analysis to determine how broker characteristics impact their order routing to the two competing electronic exchanges. In the context of electronic exchanges, we explain the percentage of orders routed to a given exchange by a broker in each time period as a function of firm characteristics (broker affiliation with an exchange and whether the broker is an online or full-service broker), and external factors (whether BOX is open and the market share of an exchange).

Broker order routing to an exchange is, by definition, bounded between 0 and 1. Two seminal papers demonstrate the econometric issues with estimating a model with a bounded dependent variable (Papke and Wooldridge 1996, 2008). These so-called fractional regression models have been gaining momentum in the academic literature as of late. These models take into consideration the bounded nature of the dependent variable and resolve the drawbacks of estimating a linear model such as OLS regression. Additionally, fractional regression models are preferred over alternatives (such as modeling the log-odds ratio in a linear manner) because they allow for observations at the boundary. This is a crucial consideration in our model as there are numerous observations where a broker has not routed any orders to a particular exchange.

The analysis conducted in Weber (2006) failed to take into account these econometric issues. We therefore first verify that these results are robust to a fractional regression model of the form:

$$p_{it} = \alpha_i + \beta_1 ISEPMM_{it} + \beta_2 ISECMM_{it} + \beta_3 ISEEAM_{it} + \tau_t + \epsilon_{it} \tag{1}$$

where p_{it} is the percentage of orders routed to ISE by broker i to ISE in quarter t, $ISEPMM_{it}$ is a dummy variable taking the value of one when a broker is an ISE Primary Market Maker and zero otherwise, $ISECMM_{it}$ is a dummy variable taking the value of one when a broker is an ISE Competitive Market Maker and zero otherwise, $ISEEAM_{it}$ is a dummy variable taking the value of one when a broker is an ISE Electronic Access Member and zero otherwise, α_i are broker fixed effects and τ_t are dummy variables for each quarter.[6] The broker fixed effects control for any unobserved, time-invariant differences across brokers. The quarter dummy variables control for quarterly differences that impact all brokers including the previous quarter market share of ISE and any measure of the distribution/concentration of orders across exchanges in a quarter. In addition, they control for any unobserved temporal heterogeneity that may influence a brokers decision to affiliate with an exchange such as changes in competitive strategy enacted by the traditional floor

[6] When a broker affiliates during a quarter, we scale the dummy variable to reflect the portion of the quarter remaining, e.g. 0.5 if a ISEPMM seat was acquired midway through the quarter.

exchanges and customer's demand for near immediate execution. The inclusion of quarter dummy variables prevents identification of the network effect using the previous quarter market share for ISE, but is used because it is robust to arbitrary differences in macroeconomic factors and changes in the competitive landscape through time.

After testing previous results related to the impact of affiliation on brokers' order routing decisions in the robust fractional regression specification with controls for both broker level and temporal heterogeneity, we examine affiliation and network effects under electronic exchange competition. The benefit of observing order routing for both exchanges simultaneously is the ability to identify the impact of network effects, over and above idiosyncratic quarterly shocks controlled for by the quarterly dummy variables, due to differences in the previous quarter market share for the two exchanges. Furthermore, although we cannot determine if online brokers routed more orders to the electronic exchanges than full service brokers because of the broker fixed effects, we can examine whether online brokers routed orders differentially between the two exchanges. Finally, we can examine what impact being affiliated with one electronic exchange has on the routing to the other electronic exchange and whether the increased competition or legitimation effect dominates. To do so, we estimate a fractional regression model of the form:

$$\begin{aligned} p_{ijt} = \alpha_i &+ \beta_1 BOX_j + \beta_2 OLB_i \times ISE_j + \beta_3 ISEPMM_{it} \times ISE_j + \beta_4 ISECMM_{it} \times ISE_j \\ &+ \beta_5 ISEEAM_{it} \times ISE_j + \beta_6 BOXINV_{it} \times ISE_j + \beta_7 BOXMM_{it} \times ISE_j \\ &+ \beta_8 BOXPRCT_{it} \times ISE_j + \beta_9 ISEPMM_{it} \times BOX_j + \beta_{10} ISECMM_{it} \times BOX_j \\ &+ \beta_{11} ISEEAM_{it} \times BOX_j + \beta_{12} BOXINV_{it} \times BOX_j + \beta_{13} BOXMM_{it} \times BOX_j \\ &+ \beta_{14} BOXPRCT_{it} \times BOX_j + \beta_{15} MS_{j,t-1} + \beta_{16} BOXOPEN_t \times ISE_j + \tau_t + \epsilon_{ijt} \end{aligned} \quad (2)$$

where $p_i jt$ is the percentage of orders routed to exchange j by broker i in quarter t, BOX_j is a dummy variable taking the value of one when the orders are being routed to BOX and zero otherwise, ISE_j is a dummy variable taking the value of one when the orders are being routed to ISE and zero otherwise, OLB_i is a dummy variable taking the value of one when the order being routed is from an online broker and zero otherwise, $BOXINV_{it}$ is a dummy variable taking the value of one when a broker is a BOX Investor and zero otherwise, $BOXMM_{it}$ is a dummy variable taking the value of 1 when a broker is a BOX Market Maker, $BOXPRCT_{it}$ is a dummy variable taking the value of one when a broker is a BOX Participant and zero otherwise, $BOXOPEN_t$ is a dummy variable taking the value of one when BOX is open and zero otherwise and $MS_{j,t-1}$ is the aggregate market share of exchange j in the previous quarter. All other variables are as described above. The exchange dummy variables are mutually exclusive meaning that coefficients on the interactions with broker affiliations are differences relative to order routing to that exchange by a broker without that affiliation level.

Finally, we examine how the introduction of BOX impacts broker order routing by brokers that are affiliated to ISE. As hypothesis 4 elaborates on, after BOX opens, the relative benefits of the ISE affiliations are re-evaluated and brokers may change their order routing to ISE as a result. To identify the effect, we interact ISE affiliation levels with BOX opening:

$$\begin{aligned} p_{ijt} = \alpha_i &+ \beta_1 BOX_j + \beta_2 OLB_i \times ISE_j + \beta_3 ISEPMM_{it} \times ISE_j + \beta_4 ISECMM_{it} \times ISE_j \\ &+ \beta_5 ISEEAM_{it} \times ISE_j + \beta_6 BOXINV_{it} \times ISE_j + \beta_7 BOXMM_{it} \times ISE_j \\ &+ \beta_8 BOXPRCT_{it} \times ISE_j + \beta_9 ISEPMM_{it} \times BOX_j + \beta_{10} ISECMM_{it} \times BOX_j \\ &+ \beta_{11} ISEEAM_{it} \times BOX_j + \beta_{12} BOXINV_{it} \times BOX_j + \beta_{13} BOXMM_{it} \times BOX_j \\ &+ \beta_{14} BOXPRCT_{it} \times BOX_j + \beta_{15} MS_{j,t-1} + \beta_{16} BOXOPEN_t \times ISE_j \\ &+ \beta_{17} ISEPMM_{it} \times ISE_j \times BOXOPEN_t + \beta_{18} ISECMM_{it} \times ISE_j \times BOXOPEN_t \\ &+ \beta_{19} ISEEAM_{it} \times ISE_j \times BOXOPEN_t + \tau_t + \epsilon_{ijt} \end{aligned} \tag{3}$$

where all variables are as described above. The three way interactions between ISE affiliations, ISE and $BOXOPEN$ measure changes in order routing to ISE by ISE-affiliated brokers after the introduction of BOX.

In all three models, we allow for an error structure with arbitrary autocorrelation within a broker and heteroskedasticity across brokers. Clustering errors at the broker level is especially important in models (2) and (3) where both exchanges are modeled simultaneously. When a larger percentage of orders are routed to ISE there is a lower perentage of orders left to be routed to BOX and vice versa. Failure to account for this could result in incorrect standard errors and conclusions may not be correct.

The astute reader will recognize that brokers are not randomly assigned to affiliation levels with the two exchanges. Instead, a broker may choose to affiliate with an exchange in anticipation of heavy usage and then route a higher percentage of orders to this exchange once the choice has been made. While we cannot completely rule out this source of endogeneity of exchange choice, we are not overly concerned for two reasons related to order flows under endogeneity. First, if exchange choice was endogenous, order routing would follow in a "winner-take-all" manner where each broker routes all of their orders to the one exchange they are affiliated with. This is not the case as evidenced by order routing levels that are routinely less than 100%. Second, order routing would remain unchanged until a competitor offers an affiliation structure that provides an incentive for a broker to move all order flow to that exchange. Brokers would route orders to an exchange in one quarter and then fail to route orders to that exchange in another quarter. Low BOX retention and brokers affiliating with the exchanges several quarters after they opened as seen in Section 4 demonstrates that this is not the case. Both of these facts combine to suggest that while affiliation and order routing may not be perfectly separable, they are different decisions for brokers and we are not overly concerned that this is driving the results that follow.

6. Results

We begin this section by testing the results of Weber (2006) under the more robust fractional regression specification. In addition to the alternative estimation procedure, we include quarter fixed effects instead of lagged exchange market share to control for any temporal heterogeneity that impacts all brokers in a quarter. Column (1) of Table 7 shows the results from Model (1). Given the inclusion of broker fixed effects in our specification, the best comparison model from Weber's analysis is the firm fixed effects model. In his analysis, Weber found that PMMs and EAMs but not CMMs submitted a significantly larger percentage of their orders to ISE than non-affiliated brokers. In contrast, the current specification finds that only PMMs route a significantly larger percentage of orders to ISE. The change in significance for the EAM affiliation level demonstrates the importance of a correct specification. Instead of high and medium levels of affiliation resulting in significantly higher order routing levels, only the highest levels are important. The inclusion of quarter fixed effects in our specification controls for but does not allow us to separately identify network effects.

6.1. Affiliation Effects Under Competition

We now utilize the entry of BOX as a competitor in the e-market space to analyze how affiliations and competition interact as in Model (2). The results, in Column (2) of Table 7, demonstrate that broker-exchange affiliations are still significant predictors of broker order routing. ISEPMMs route a larger percentage of their orders to ISE but ISECMMs and ISEEAMs do not, suggesting that only brokers with the most expensive affiliation levels take their affiliation status into consideration when deciding where to route their orders.

Interestingly, ISE-affiliated brokers do not seem to route a smaller or larger percentage of their orders to BOX at across all levels of affiliation. ISEEAMs route a smaller percentage of their orders to BOX. However, ISEPMMs route a larger percentage of their orders to BOX, although the effect is only significant at the 10% level. The results suggest the ISEPMMs are heavy users of electronic trading in general and do not simply rely on a single platform. The increased order routing of ISEPMMs to both electronic exchanges must come at the expense of the traditional floor exchanges. Identifying these heavy users early in an electronic exchange introduction can be the difference between a successful launch and closing operations within a few months.

Table 7 Regression results for all models

VARIABLES	(1) Routing	(2) Routing	(3) Routing
BOX		-0.0629	-0.550
		(1.048)	(1.033)
OLB×ISE		-0.211	-0.238
		(0.692)	(0.670)
ISEPMM×ISE	0.735**	1.013***	1.309***
	(0.349)	(0.308)	(0.345)
ISECMM×ISE	-0.0327	-0.125	-0.0784
	(0.419)	(0.353)	(0.418)
ISEEAM×ISE	-0.887	-0.0336	-0.254
	(0.746)	(0.633)	(0.700)
ISEPMM×BOX		0.547*	0.601*
		(0.316)	(0.311)
ISECMM×BOX		-0.799	-0.983*
		(0.600)	(0.598)
ISEEAM×BOX		-1.983**	-2.137**
		(0.815)	(0.906)
BOXOPEN×ISE		1.273	0.436
		(0.853)	(0.921)
BOXINV×ISE		-0.537**	-0.497**
		(0.240)	(0.224)
BOXMM×ISE		-1.449***	-1.297***
		(0.353)	(0.352)
BOXPRCT×ISE		0.635*	0.760**
		(0.328)	(0.366)
BOXINV×BOX		-0.271	-0.284
		(0.324)	(0.282)
BOXMM×BOX		-0.750	-0.656
		(0.526)	(0.493)
BOXPRCT×BOX		1.597	1.699*
		(0.994)	(0.993)
$MS_{j,t-1}$		4.669	5.125
		(3.475)	(3.152)
ISEPMM×ISE×BOXOPEN			-0.336
			(0.349)
ISECMM×ISE×BOXOPEN			-0.362
			(0.453)
ISEEAM×ISE×BOXOPEN			-0.483*
			(0.257)
Constant	-18.85***	-19.59***	-19.34***
	(1.174)	(1.386)	(1.420)
Observations	462	719	719
Quarter FEs	YES	YES	YES
Broker FEs	YES	YES	YES
Log pseudolikelihood	-155.3	-176.7	-176.2

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Unlike ISE-affiliated brokers routing a larger percentage of orders to ISE, BOX-affiliated brokers do not route a larger percentage of their orders to BOX than unaffiliated brokers. However, BOXINVs and BOXMMs route a significantly smaller percentage of their orders to ISE. Similar to the results for order routing of ISEPMMs to BOX, BOXPRCTs route a marginally significant larger percentage of their orders to ISE. This demonstrates the difficulty of developing the correct affiliation structure and identifying heavy initial users. ISEPMMS, brokers the most significant affiliation level for ISE, are also heavy users of BOX. However, BOXPRCTs, brokers with the least significant affiliation level for BOX, are also heavy users of ISE. One cannot identify the heavy users of electronic trading in general simply by identifying their affiliation with one or the other exchange.

The coefficient on BOX indicates the extent to which orders are routed to one or the other exchange after controlling for affiliation effects, network effects, and broker and temporal heterogeneity. The coefficient can be interpreted as the difference between the percentage of orders an unaffiliated broker routes to BOX relative to the percentage of orders an unaffiliated broker routes to ISE. The coefficient is not significant indicating that unaffiliated brokers did not route orders to one exchange over the other. Combining all of the affiliation results together, we conclude that exchanges must carefully decide on a mutually beneficial broker affiliation structure in order to attract a critical mass of participation. Failure to provide the correct incentives will result in low use and could result in complete failure of the exchange.

In contrast to the affiliation levels, previous quarter market share, a measure of network effects, which has traditionally been considered the most important factor for e-market success, is not a significant predictor of broker order routing practices. An important implication of this result is that managers of e-markets cannot rely on network externalities to drive continued use. This conclusion supports the results of the adoption and attrition analysis in Section 4 showing a larger number of brokers routing orders to BOX but in lower amounts. The lack of benefits due to network effects suggests that electronic exchanges must solely focus their efforts on identifying and maintaining the correct affiliation structure. Furthermore, this reinforces earlier conclusions that relying on a broad user base with relatively low usage is not a sustainable model for growth.

Weber (2006) presented suggestive evidence that OLBs route a larger percentage of their orders to ISE than full service brokers. Targeting OLBs may therefore be a successful strategy. However, OLBs do not route more to ISE or to BOX as evidenced by the insignificant coefficient on $OLB \times ISE$. This is evidence that the broad e-market platform and connectivity was not better at one exchange over the other. Neither exchange can gain a relative advantage by attracting these brokers. However, ignoring OLBs is not an optimal strategy as these brokers may submit a larger portion of their orders to the electronic exchanges in general.

The opening of BOX had little direct impact on ISE after controlling for affiliation as evidenced by an insignificant coefficient on $BOXOPEN \times ISE$. BOX order flow could have come at the expense of the floor exchanges. Alternatively, ISE order flow could have increased due to the legitimation effect and decreased due to competitive forces. The two effects would combine to show unchanged order flow as in our regression results. Unfortunately, we cannot determine the specific reason why the coefficient is not significant. Future research can collect necessary data to identify the two effects separately to determine how the two factors interact.

6.2. Affiliation Effects Under Increased Competition

The previous results do not identify an aggregate effect of increased competition on ISE order flow. However, it is possible that ISE-affiliated brokers changed their order routing as a result of BOX's entry. Column (3) of Table 7 contains the results of the regression for Model (3). The results for affiliation, network and competition effects are qualitatively unchanged from the previous specification with the exception of a marginally significant coefficient on $BOXPRCT \times BOX$. We therefore focus exclusively on order routing changes to ISE once BOX has opened for brokers affiliated with ISE. When BOX opens, the relative benefits of submitting orders to ISE must be re-evaluated by these brokers. The results show that ISEEAMs route a smaller percentage of their orders to ISE after BOX opened for business. Order routing by ISEPMMs and ISECMMs was unchanged following BOX's entry. This further supports the conclusion that retaining heavily affiliated brokers is important to e-market success. When switching costs are low, as in this technology setting, the marginal benefit of low-level affiliations can be easily compromised with the introduction of a closely related competitor.

6.3. Managerial Implications

Combined results of the three models highlight the importance of developing and maintaining incentives for brokers to route orders to an exchange. Failure to retain affiliated brokers or loss of a relative affiliation incentive advantage can result in a significant reduction in order routing to an exchange. We conclude that at the time of launch electronic exchanges should spend significant resources to ensure a mutually beneficial affiliation structure. Furthermore, exchanges must react to new competitor entry and changes in competitors' affiliation structures so as to retain an incentive structure that is beneficial for brokers.

Failure to offer the correct affiliation structure can have devastating consequences. A broad use strategy that aims to drive order flow from many different brokers may inevitably fail. E-markets cannot rely on the network effects to maintain order flow from unaffiliated brokers as evidenced by a lack of significance on the previous quarter market share for an exchange. Catering to the unaffiliated masses can be a costly strategy for e-markets as these brokers do not appear to route different amounts of orders to the two exchanges or react to the introduction of new exchanges. Attempting to identify technically capable users, such as online brokers in our setting, will not provide a sustainable competitive advantage over other electronic exchanges.

Finally, exchanges must react to new competitor entry and changes in competitors' affiliation structures so as to retain an incentive structure that is beneficial for brokers. The effects of not responding to market entry are evident in Model 3. ISE failed to offer an affiliation level at a cheap price. Because ISE did not react to BOX's entry in terms of matching or at least adjusting its affiliation structure, BOX was able to attract order flow from many of the low-affiliation ISE users. While this did not result in an overall reduction in ISE market share it undoubtedly led to lower levels of market share than ISE could have achieved with the correct response to BOX entry. One such response would have been to offer an even lower cost or possibly free affiliation tier below the EAM affiliation.

7. Discussion and Conclusions

New electronic exchanges have significant advantages over traditional floor exchanges due to direct user access, faster trading speeds and reduced trading costs. However, electronic exchanges must differentiate from each other in different ways. This papers examines the roles networks effects and broker affiliations in determining brokers' order routing practices to two new electronic options exchanges in the U.S.

We analyze the propensity of a broker to stop using ISE or BOX, and find withdrawals were high at 8 percent per quarter for BOX but less than 1 percent for ISE, which was more "sticky." The commitment of ISE users to continue use of the exchange more than made up for the initially smaller number of ISE users in our sample. This reinforces the conclusion that exchanges require a base of dedicated users to compete successfully, and that a smaller number of heavy users can more than compensate for a low number of users.

Based on our panel of 462 quarterly disclosures from 24 major brokerage firms, we find the growth of new exchanges can be attributed to the characteristics of individual broker-users. We also identify significant differences in brokers' order routing practices to two new electronic options exchanges. The models we estimate allow us to test hypotheses that explain individual firms' usage levels and the drivers of new electronic markets' growth. Brokers' order routing to the more successful electronic exchange and the less successful electronic exchange can be attributed to differences between the exchanges' affiliation structures.

We believe we are the first to compare two competing electronic markets by contrasting order routing estimated from an empirical data set. We find support for sociological factors influencing diffusion, such as whether it has an e-exchange affiliation or ownership role. After controlling for broker and temporal heterogeneity, affiliation status is found to be the only significant predictor of broker order routing levels. Unexpectedly, economic measures of the network externality effect, which have traditionally been important factors in the diffusion of new technologies, have no influence on the markets' growth. There is no a priori reason to believe that affiliation effects dominate network effects solely in the e-market context examined here. Investigation of the relative impact of affiliation versus network effects in competitive market spaces merits further examination.

Unaffiliated brokers did not significantly change their order routing to ISE once BOX opened, indicating that competitive effects of a new introduction are seen only through affiliations to the exchanges. We confirm that this is the case but only for low levels of affiliation. From our results, executives of new e-exchanges should allocate their resources strategically at the time of launch. Identifying broker exchange affiliation and incentive schemes is important to building overall liquidity. We can conclude that exchanges should focus on developing a structure that provides brokers with appropriate incentives in order to achieve sustainable order levels. Furthermore, keeping a keen eye on the competitive landscape and reacting to changes in current and prospective competitors' affiliation structures may prove the most beneficial way to ensure continued success. Top management must identify the relative advantages of new entrants' affiliation structures and respond accordingly. A new entrant that provides incentives through a novel affiliation structure can be routed significant orders if the incumbent exchange does not react swiftly and effectively. Catering to the masses does not appear to be beneficial as unaffiliated brokers are largely unaffected by the introduction of a new e-market.

In our multi-firm setting with network effects, we believe the empirical methods presented are promising for management researchers who want to explain cross-organizational responses to IT innovation, and generate insights. The results are not limited to analyzing electronic exchanges but, we expect, to many situations where competing IT platforms also benefit from user affiliation and network effects.

References

Abrahamson, Eric, Lori Rosenkopf. 1997. Social Network Effects on the Extent of Innovation Diffusion: A Computer Simulation. *Organization Science* **8**(3) 289–309.

Amihud, Yakov, Haim Mendelson. 1988. Liquidity and Asset Prices: Financial Management Implications. *Financial Management* **17**(1) 5–15.

Bakos, J. Yannis. 1997. Reducing Buyer Search Costs: Implications for Electronic Marketplaces. *Management Science* **43**(12) 1676–1692.

Brynjolfsson, Erik, Chris F Kemerer. 1996. Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market. *Management Science* **42**(12) 1627–1647.

Chang, Young Bong, Vijay Gurbaxani. 2012. The Impact of IT-Related Spillovers on Long-Run Productivity: An Empirical Analysis. *Information Systems Research* **23**(3-Part-2) 868–886.

Clemons, Eric K., Bruce W. Weber. 1990. London's Big Bang: A Case Study of Information Technology, Competitive Impact, and Organizational Change. *Journal of Management Information Systems* **6**(4) 41–60.

Devaraj, Sarv, Rajiv Kohli. 2003. Performance Impacts of Information Technology: Is Actual Usage the Missing Link? *Management Science* **49**(3) 273–289.

Fichman, Robert G. 2001. The Role of Aggregation in the Measurement of IT-Related Organizational Innovation. *MIS Quarterly* **25**(4) 427–455.

Fichman, Robert G., Chris F. Kemerer. 1999. The Illusory Diffusion of Innovation: An Examination of Assimilation Gaps. *Information Systems Research* **10**(1) 255–275.

Ghose, Anindya, Yuliang Yao. 2011. Using Transaction Prices to Re-Examine Price Dispersion in Electronic Markets. *Information Systems Research* **22**(2) 269–288.

Griliches, Zvi. 1957. Hybrid Corn : An Exploration in the Economics of Technological Change. *Econometrica* **25**(4) 501–522.

Gulati, Ranjay. 1995. Social Structure and Alliance Formation Patterns: A Longitudinal Analysis. *Administrative Science Quarterly* **40**(4) 619–652.

Harris, Frederick H. Deb., Bruce W. Weber, Elroy Dimson, Frank Hatheway, Paul Bennett, Giovanni Petrella. 2008. Execution Costs and Market Design Worldwide: A Panel Discussion. *The Journal of Trading* **3**(1) 9–24.

Hess, Christopher M., Chris F. Kemerer. 1994. Computerized Loan Origination Systems: An Industry Case Study of the Electronic Markets Hypothesis. *MIS Quarterly* **18**(3) 251–275.

Hotelling, Harold. 1929. Stability in Competition. *The Economic Journal* **39**(153) 41–57.

Koh, Tat Koon, Mark Fichman, Michael D. Smith. 2010. Multi-homing Users Preferences for Two-Sided Exchange Networks. *Working Paper* 1–21.

Montazemi, Ali Reza, John J. Siam, Akbar Esfahanipour. 2008. Effect of Network Relations on the Adoption of Electronic Trading Systems. *Journal of Management Information Systems* **25**(1) 233–266. doi: 10.2753/MIS0742-1222250109.

Overby, Eric, Sandy Jap. 2009. Electronic and Physical Market Channels: A Multiyear Investigation in a Market for Products of Uncertain Quality. *Management Science* **55**(6) 940–957.

Pac, Mehmet Fazil, Sergei Savin, Chander Velu. 2010. Adoption of Technological Innovation in Competitive Network Markets. *Working Paper* .

Papke, Leslie E., Jeffrey M. Wooldridge. 1996. Econometric Methods for Fractional Response Variables with an Application to 401(K) Plan Participation Rate. *Journal of Applied Econometrics* **11** 619–632.

Papke, Leslie E., Jeffrey M. Wooldridge. 2008. Panel Data Methods for Fractional Response Variables with an Application to Test Pass Rates. *Journal of Econometrics* **145** 121–133.

Rogers, Everett M. 1976. New Product Adoption and Diffusion. *Journal of Consumer Research* **2**(4) 290–301.

Rogers, Everett M. 2003. *Diffusion of Innovations*. The Free Press, New York, NY.

Saloner, Garth, Andrea Shepard. 1995. Adoption of Technologies with Network Effects: An Empirical Examination of the Adoption of Automated Teller Machines. *The RAND Journal of Economics* **26**(3) 479–501.

Standing, Susan, Craig Standing, Peter E. D. Love. 2010. A Review of Research on e-Marketplaces 1997 2008. *Decision Support Systems* **49** 41–51.

Tang, Zhulei, Michael D. Smith, Alan Montgomery. 2010. The Impact of Shopbot Use on Prices and Price Dispersion: Evidence from Online Book Retailing. *International Journal of Industrial Organization* **28**(6) 579–590.

Weber, Bruce W. 2006. Adoption of Electronic Trading at the International Securities Exchange. *Decision Support Systems* **41** 728–746.

Xue, Mei, Lorin M Hitt, Pei-yu Chen. 2011. Determinants and Outcomes of Internet Banking Adoption. *Management Science* **57**(2) 291–307.

Appendix A: Financial Market Operations

Financial markets perform a number of basic economic functions. First, they consolidate supply and demand for securities, currencies, and derivatives contracts, and process orders and execute trades. They also disseminate price information. By providing information and price discovery for standardized instruments — stocks, bonds, foreign currencies, and futures contracts — markets play an important role in facilitating capital raising and the transfer of risks. IT makes pricing information widely available and reduces latencies for market communications, which enhances liquidity and provides more choices to investors. As a result, transactions costs have fallen and volumes have risen in most major markets in the past 10 years (Harris et al. 2008).

Second, markets provide infrastructure for transferring ownership and payments, and for enforcing rules and legal contracts. Conflicts of interest and opportunities for fraud arise in markets, so investors require assurance that financial information is reliable (e.g., has been audited), and that trading rules will be enforced. Third, markets intermediate between sources of capital (savers) and users of capital (borrowers), and provide immediacy and liquidity. This means that, for instance, a 'saver' that purchases bonds or call option contracts on a company's stock does not need to hold the bonds or options until their maturity or expiration date. The buyer can reverse the investment decision by selling the bonds or the call options back to buyers in the market. The liquidity of traded financial assets makes them more valuable than other assets that can not be readily converted into cash (Amihud and Mendelson 1988).

Finally, markets are inter-organizational systems whose success depends on their participant firms, particularly at the time of launch. In such settings, economic forces such as adoption decisions and network effects can determine the impacts of technology as much as technical advantages. The empirical question we answer is how the dynamics of an interrelated, multi-firm environment can support the launch of two electronic options exchanges. Furthermore, we investigate the roles broker affiliation and network effects play in brokers' order routing decisions.

Appendix B: Data Tables

Table 8 Full Service Broker Order Routing Data

	Panel A: Percentage of contracts routed to ISE												
	AGE	BOFA	BSC	CITI	CSFB	DB	GS	JPMS	LEHM	MER	MS	PRU	UBS
20013Q	0	NA	08	0	NA	NA	7	39	0	0	0	NA	0
20014Q	0	NA	NA	2	NA	NA	13	56	0	0	0	NA	0
20021Q	0	NA	NA	0	26	NA	27	48	0	0	7	0	0
20022Q	0	NA	NA	0	26	NA	36	49	0	0	23	0	0
20023Q	0	NA	NA	0	24	19	42	28	0	0	32	0	0
20024Q	0	NA	NA	0	23	20	37	32	0	5	32	5	0
20031Q	0	NA	37	0	28	11	35	49	7	6	37	7	0
20032Q	0	29	34	0	32	0	38	44	10	7	40	9	0
20033Q	0	23	30	0	30	0	35	41	09	14	42	0	4
20034Q	0	25	35	0	25	0	35	18	10	15	44	6	4
20041Q	0	26	37	0	23	8	33	15	10	24	42	5	5
20042Q	0	31	39	0	28	22	34	17	10	18	41	5	6
20043Q	0	32	32	0	31	23	42	22	13	19	42	9	3
20044Q	0	32	36	29	35	23	42	24	20	30	43	10	3
20051Q	0	32	29	36	38	30	41	27	29	29	53	14	3
20052Q	0	31	34	33	48	31	38	25	28	40	56	24	7
20053Q	0	26	32	31	51	33	36	23	26	41	57	39	13
20054Q	0	27	36	32	50	48	35	24	29	41	41	44	13
20061Q	0	24	36	30	42	43	41	23	30	42	45	40	13
20062Q	0	25	36	34	36	40	31	17	31	39	47	41	9
20063Q	0	25	39	35	40	40	27	11	29	39	56	37	23
20064Q	0	30	44	38	30	39	39	14	31	38	57	40	23

	Panel B: Percentage of contracts routed to BOX												
	AGE	BOFA	BSC	CITI	CSFB	DB	GS	JPMS	LEHM	MER	MS	PRU	UBS
20041Q	0	1	0	0	4	0	0	2	2	0	4	2	0
20042Q	0	0	0	7	2	4	1	2	2	1	3	1	0
20043Q	0	0	0	9	2	4	1	1	2	0	3	2	0
20044Q	0	0	1	9	5	0	1	2	2	3	2	3	0
20051Q	0	0	2	1	1	0	2	3	3	3	2	2	0
20052Q	0	0	3	3	2	4	2	3	3	3	2	8	2
20053Q	0	0	1	4	6	0	5	5	1	2	2	7	1
20054Q	0	0	3	3	8	3	6	4	1	2	2	7	0
20061Q	0	2	3	2	8	2	6	3	0	2	2	8	0
20062Q	0	1	3	2	5	2	5	3	1	3	4	2	0
20063Q	0	3	3	2	6	2	4	2	2	3	0	4	4
20064Q	0	0	0	2	2	5	0	9	2	4	13	2	0

Percent of orders full service brokers routed to ISE (Panel A) and BOX (Panel B) in our dataset. NA means the data was not available.

Table 9 Online Broker Order Routing Data

	Panel A: Percentage of contracts routed to ISE										
	AMTD	BROWN	DATK	ETRD	FID	IB	JBOX	OX	SCH	SCOT	TDW
20013Q	0	NA	0	59	0	63	0	NA	0	0	0
20014Q	5	NA	5	59	0	62	0	NA	0	11	0
20021Q	29	NA	6	51	0	61	0	NA	0	5	0
20022Q	35	NA	5	61	0	62	6	NA	8	5	0
20023Q	30	NA	6	47	0	60	7	NA	16	5	1
20024Q	38	NA	17	41	5	55	8	NA	16	16	1
20031Q	33	6	33	45	4	57	5	29	19	5	3
20032Q	40	8	NA	51	6	54	24	39	19	5	17
20033Q	40	8	NA	43	9	51	12	34	20	9	15
20034Q	36	11	NA	41	11	58	16	34	19	20	13
20041Q	39	22	NA	44	14	54	21	40	23	17	12
20042Q	48	23	NA	42	15	48	23	44	23	15	12
20043Q	57	29	NA	42	15	54	NA	56	30	29	15
20044Q	67	32	NA	52	19	57	NA	57	37	31	19
20051Q	63	31	NA	55	26	47	NA	58	38	32	23
20052Q	55	32	NA	49	29	40	NA	51	38	29	26
20053Q	51	35	NA	51	16	41	NA	49	37	NA	28
20054Q	42	36	NA	52	15	20	NA	49	26	NA	18
20061Q	33	38	NA	50	15	22	NA	47	34	NA	18
20062Q	27	NA	NA	44	18	20	NA	29	27	NA	7
20063Q	31	NA	NA	32	15	18	NA	38	26	NA	31
20064Q	28	NA	NA	28	14	16	NA	44	26	NA	28
	Panel B: Percentage of contracts routed to BOX										
	AMTD	BROWN	DATK	ETRD	FID	IB	JBOX	OX	SCH	SCOT	TDW
20041Q	1	0	NA	0	0	1	4	0	0	1	0
20042Q	2	0	NA	1	2	3	3	0	0	1	0
20043Q	3	0	NA	4	3	5	NA	0	0	0	0
20044Q	3	0	NA	0	3	5	NA	1	1	2	1
20051Q	3	0	NA	2	10	6	NA	1	0	4	1
20052Q	5	0	NA	3	19	10	NA	2	0	2	3
20053Q	8	0	NA	4	29	11	NA	2	0	NA	4
20054Q	12	0	NA	2	31	7	NA	1	0	NA	2
20061Q	2	0	NA	2	12	4	NA	1	1	NA	2
20062Q	2	NA	NA	2	6	4	NA	0	1	NA	2
20063Q	2	NA	NA	1	6	4	NA	0	1	NA	2
20064Q	8	NA	NA	3	4	0	NA	0	0	NA	8

Percent of orders online brokers routed to ISE (Panel A) and BOX (Panel B) in our dataset. NA means the data was not available.