Brokerage Commissions and Institutional Trading Patterns

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"I kept my buy rating, but I told my favorite investors to sell"
-anonymous sell-side analyst quoted in Business Week 3/20/2000.

1. Introduction

Why do brokers charge per share commissions for execution of institutional trades? The choice of per share commissions as a payment method is puzzling, as they are not the most natural way to charge for order execution. A per-share commission is not driven by marginal cost considerations because execution costs are not proportional to the trade size, and as a transactions cost, commissions are supposed to deter trading.[1] We contend that commissions, rather than representing a per share price of execution, constitute a convenient way of charging fixed fees for broker services provided to institutional clients. These services include difficult order execution, access to initial public offerings and information provision.

We assume that institutions prefer to hide their trading strategies from the market. Consequently, in the absence of other considerations, institutions would like to disperse their total trading volume rather widely among many brokers. Empirically, however, we find that this conjecture does not hold. Using a proprietary data set of institutional trades we report that institutions concentrate the bulk of their trading with a small fraction of the brokers they deal with. The largest clients in our data use an average of 78 brokers, but execute 47.6 percent of their trades with their top five brokers. Smaller institutions concentrate their trades even more. The smallest institutions in our data execute 75.3 percent of their trades with their top five brokers. We refer to this phenomenon as the bunching of institutional trading.

We develop a model of the broker-client contract where the brokers provide a higher level of service to clients that provide them with the greatest total revenue. What makes the implications of the model interesting is the fact that there is a fixed supply of valuable broker services such as access to sell-side analysts information or IPO access. Brokers allocate these services based on the total revenue provided by the client. The

[1] See for example, Amihud and Mendelson (1986), Constantinides (1986), Vayanos (1998), and Barclay, Kandel, and Marx (1998).

largest institutions such as Fidelity Investments provide enough total revenue to receive a high level of services from many brokers. But most institutions are faced with the decision to trade off the benefits of hiding their trading strategy by trading with many brokers against the benefits of concentrating their trading with a small set of brokers; becoming important clients to these brokers. The smaller the institution, the more they must concentrate their trades. The model outlines the conditions under which a bunching equilibrium can exist and provides analytical solutions for the equilibrium for a simple static example. In our framework, per share commissions are just a convenient way of determining the broker's total revenue.

The implications of the model are tested by examining institutional trading at the time when the broker's sell-side analysts' information is likely to be particularly valuable; when they change their recommendation (Elton, Gruber and Grossman, 1986; Womack, 1996).

Section 2 outlines our view of the per-share commission contract as a vehicle to account for the broker's total revenue from a client. Section 3 describes the model. Section 4 discusses the empirical tests and section 5 concludes.

2. The commission contract

Brennan and Chordia (1993) model per share commissions as an optimal risk-sharing contract. In their model, brokers wish to sell information to clients but the value of the information to the client is uncertain *ex-ante*. As a solution to this problem Brennan and Chordia (1993) postulate that the less risk-averse broker gives the information away to the more risk-averse client. If, *ex-post*, the information is useful to the client, the resulting trades reward the broker through commission dollars. However, this explanation is unlikely to explain institutional commission contracts. In the absence of forcing contracts, the high cost of monitoring every client's trade makes it easy for clients to cheat and execute the trades with the cheapest available provider of execution services, such as discount brokers. Moreover, this argument is unlikely to apply to institutions: optimal risk sharing may actually involve a large institution bearing most of the risk. Thus, the question as to why brokers charge per share commissions, particularly to institutions, remains an open one.

Perhaps one can view commissions as a linear incentive contract. In many principal-agent environments, the principal pays a commission based on performance measures that inform him *ex-post* of the effort being exerted by the agent *ex-ante* (Holmstrom 1979). Linear contracts are optimal in situations where effort is multi-dimensional and contracts are long-lived (Holmstrom and Milgrom 1987). However, the incentive provision is unlikely to be the explanation for commission contracts, since the transaction size is determined solely by the principal (client) and is unlikely to serve as a performance measure of the agent (broker).

Linear contracts are used as payment for services when the impact of these services is hard to quantify, and thus hard to base on an objective performance measure: one example is advertising. In these cases, payments are based on an easily measurable variable that is under the full control of the client, so that the client determines the total payment. Then the agent chooses the quality of the service and the client chooses the amount he pays for it. These two strategy choices must be optimal in equilibrium. This concept is very similar to the product quality assurance argument of Klein, Crawford, and Alchian (1983). In their paper, the equilibrium is such that a firm prices the product above its marginal cost, while maintaining high quality. People are willing to overpay (relative to cheaper competitors), as long as the quality is above some predetermined level. The firm has no incentives to save on quality provision, since it will ruin the stream of positive profits for the future.

We contend that if the level of broker services replaces product quality, the institutional commissions contract fits nicely into the Klein, Crawford, and Alchian (1983) framework. Equilibrium in this framework ensures that full service brokers provide the required level of service, and eliminates the possibility in the Brennan and Chordia' (1993) solution that clients could free ride on the brokers' services. In this framework commissions represent a simple and convenient way to pay for services provided by the brokers. Such services include basic execution service, execution service for more difficult trades, information provision, and access to IPOs underwritten by the broker.

Basic execution is a commodity, thus must be competitively priced. Discount brokers and electronic networks (ECNs) dominate the market for basic execution. This market is highly competitive: commissions in this market are 1-2 cents per share. In many cases institutions can even get even cheaper fixed-fee execution.

For other trades, the potential price impact is greater and the quality of execution depends on the amount of resources, such as the capital committed or trader search costs, the broker expends on execution. The broker's inherent quality, the skill of the trading desk, could also affect execution quality. Consequently, this segment of the industry provides a differentiated service, in a less competitive environment. While measures of execution quality are available (we will use some of them), these measures rely on assumptions about the trading environment, which can be disputed by the parties.

Information quality is even more difficult to define. On one hand, information quality certainly depends on the analysts' talent, for which the broker must pay the ongoing market rates. However, once the analyst works for the broker, the cost of generating information and dissipating it is small. On the surface it would appear that information is a public good, and thus no single individual would be willing to pay enough for its generation. This impression, however, is misleading. From any single client's perspective, the *value* of information he receives crucially depends on the *timing* of its transmission from the broker. Since information is supplied sequentially, not all clients are called at the same time. As a result, the broker has *discretion* on whom to call first. In financial markets, information is most valuable to those who receive it the earliest. Indeed, since prices adjust to reflect information imbedded in trades (see Glosten and Milgrom (1985), Kyle (1985), Easley and O'Hara (1987)), information loses its value upon receipt by additional market participants (Kyle 1985). Thus, the scarce resource in this context is the client's place in the queue: the client who is called first by the broker gets the most valuable information, and should be willing to pay more for getting it.

Access to IPOs can be viewed in this context as a simple rebate program. Larger clients get larger allocations of better IPOs, and since these usually yield significant short-term returns, larger clients get larger rewards.

While brokers could charge each client explicitly for the scarce resources utilized in his providing these services, this might not be the most efficient contract. As an alternative, we present a static model of broker services, such as information provision, in which brokers compete for clients by setting explicit fees for places in the queue, while clients optimally self-select. We show that in equilibrium clients who value information the most, get it first, thus the equilibrium is efficient.

The efficient solution does not, however, explain why commissions dominate the payment of a lump-sum fee for a place in the queue for information. There are fixed fee alternatives to commissions in the market for information. One example is the multitudes of newsletters that are distributed to subscribers. Value Line offers several subscription rates: higher subscription fee ensures earlier information delivery. However, commissions have strong historical and regulatory roots. Minimal per share commissions were mandated first by the NYSE, and then by the SEC for over 100 years, until the industry was deregulated in 1975. The consequences of deregulation have been profound in the retail brokerage industry. Two alternative contracts, the fixed fee per trade charged by the discount broker and the percentage of assets managed fee employed by full-service brokers successfully coexist with the commission contract. Surprisingly, the fixed-fee execution contract provided by the discount broker and their institutional counterparts has not driven out commission contract in either the institutional market or the full-service retail market.

Another potentially important reason for the survival of the commission contract is the regulatory treatment of commissions paid by the buy-side institutions. Institutions compete, among other parameters, on their management fees. If an institution pays fixed payments for auxiliary services received from brokers, it must increase its management fees to cover them. Commissions, on the contrary, are deducted directly from the funds under management, thus do not necessitate raising management fees. This rationale is the driver behind the soft-dollar market, where commissions explicitly used as a payment for services that are unrelated to the execution of specific transactions.

Finally, psychology may play a role. Prospect theory (Kahneman and Tversky 1980) applied to marketing suggests that a seller of a product or a service should present it in such a way that the buyer sees aggregate losses (one price) but segregated gains. Charging a single price, that is small on a per share basis, and providing a slew of services in return is consistent with maximization of the buyer's perception of the broker's value added.

2.1. Our view of the commission contract

In our interpretation of the commission contract, commissions provide a convenient substitute for fixed fees. The average per share commission paid by an institution is just the ratio of the total payment required to obtain the chosen service level to the total share volume directed by this institution to the broker. Bunching or aggregating trades with a few brokers increases these brokers' revenues through the volume component of total revenue. Thus, there will be relatively little variation in the average per share commission charge. Figure 1, which presents cross-sectional average of commissions per share confirms this speculation. The majority of institutional trades pay 5 or 6 cents per share.

This result does not preclude the possibility that the average commission component can vary to some extent across clients. Large volume clients can pay smaller average commissions and still maintain a position as one of the broker's most important clients. On the other hand, smaller institutions may voluntarily agree on greater average commission payments because their total volume is not large enough to insure them access to the level of broker services they desire.

We find that average commissions vary across clients' depending on the clients' size. Empirically, small institutions pay higher commissions to the broker with whom they trade the most. The largest clients pay the lowest commissions to their largest volume broker; they provide adequate compensation to the broker through their large trading volumes. Total commission revenue from the largest institutions to their most active broker is roughly 140 times larger than the overall commission from the smallest institutions to their most active broker.

Any transaction cost induces inefficiencies and reduces the volume of trading. But the effect of commissions on the volume of trade by institutions is minimal, given that basic execution is always available at competitive prices. As long as an institutional client can trade (their marginal shares) with a discount broker or ECN, his desired trading volume should be set using the ECN's low transaction costs, since the higher commissions that include the payment for other services are inframarginal for the institution. Consequently, the detrimental effect of charging for broker services through higher commissions is small. In fact, it is possible commissions may actually increase the volume of trading to the detriment of the investors. If institutional investors do not bear the cost of trading directly, they might trade too much to get the desired amount of service.[2] This problem is particularly relevant for smaller institution that may want to increase their service above the level they would receive based on their size. Conrad, Johnson and Wahal (2001) find that soft-dollar trades receive inferior execution; thus excessive soft-dollar trading could negatively impact performance.

We proceed by presenting a simple model of competition between brokers, who must allocate their service capacity among institutional clients. Then we postulate and test empirical hypotheses derived from our view of commissions.

3. The Model

This purpose of this model is to show the existence of equilibria where brokers of different quality compete on fees, and clients select and pay for the amount of service they desire. Existence is shown in a one-period model, but any equilibrium that can be supported in a one-shot game can also be supported in a dynamic game. We outline the model in a simple 2 by 2 framework for analytical tractability, but we contend that the model could be extended to the case of many clients and brokers. The model also demonstrates that two types of equilibria are possible. In the first, the largest client dominates both brokers. Bunching exists is this equilibrium if the largest client chooses to use one broker proportionately more than the other. The second equilibrium proves the existence of a stricter definition of bunching; in this case each client is the largest trader with a particular broker. This case requires localized economies of scale.[3] Economies of scale can arise if: there is a fixed cost of dealing with each broker, or if broker's fees are concave in the level of service, or if the benefits of receiving a high level of broker services exhibit increasing returns to scale.

Finally, we contend that the payment for broker's services is not paid as a lump sum, but charged on a per share basis. Then the number of shares sent to a particular broker by a particular client determines the level of service the client receives from that broker.

3.1. Model setup: the institutions choice of services

There are two institutions, A and B, with different portfolio sizes. We assume that portfolio size is positively correlated with the value they derive from broker services. These differential valuations are represented by $Q_A > Q_B > 1$. We also assume that there exist two brokers, who differ in terms of the quality of service they can provide. This

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[2] Institutions lose on performance if they spend too much on commissions, but it may be of minor importance relative to what they gain from getting extra services.

[3] This result can be obtained in a model where all brokers provide the same service (perfect substitutes), but due to economies of scale they provide quantity discounts. Clients, on the other hand, prefer to trade through many brokers so as to prevent front running and conceal their trades. The tradeoff between the two creates bunching for some clients.

quality is denoted by α_j: j = [1,2] such that $\alpha_1 > \alpha_2 \geq 1$. The level of service provided by broker j to client i is denoted by s_{ji}

The total value of the services for client i is as follows:

$$V_i = Q_i\left[\alpha_1 \ln(s_{1i}) + \alpha_2 \ln(s_{2i})\right] - s_{1i}s_{2i} \quad (1)$$

Notice that:

$$\frac{\partial V_i}{\partial s_{1i}} = \frac{\alpha_1 Q_i}{s_{1i}} - s_{2i,} \quad (2)$$

which is positive if we assume that $\alpha_2 Q_B > s_{1i}s_{2i}$ and $\frac{\partial^2 v_i}{\partial s_{1i}\partial s_{2i}}$ = -1 < 0. This implies that the services provided by the competing brokers are substitutes. We also assume that brokers have limited capacities, S_1 and S_2, which they have to allocate among all the demanders for their services. Thus:

$$s_{1A} + s_{1B} = S_1 \quad and \quad s_{2A} + s_{2B} = S_2 \quad (3)$$

We further assume that brokers are limited in charging a fee per unit of service provided. We denote these fees, $F_{1,}F_2$, for the first and second broker respectively.

The first step is to figure out what would be the equilibrium in this market, if brokers could charge specific prices for their services. The demand for services from each institutional client is determined by the following optimization problem:

$$\max_{S1i\,S2i} \quad Q_i\left[\alpha_1 \ln(s_{1i}) + \alpha_{2\ln}(s_{2i})\right] - s_{1i}s_{2i} - F_1 s_{1i} - F_2 s_{2i} \quad (4)$$

The FOC are:

$$\frac{\alpha_1 Q_A}{s_{1A}} - s_{2A} - F_1 = 0 \quad (5a)$$

and

$$\frac{\alpha_2 Q_A}{s_{2A}} - s_{1A} - F_2 = 0 \quad (5b)$$

If we assume, as before, that $\alpha_2 Q_B - s_{1i}s_{2i} > 0$ then the indifference curves are convex in the relevant range, ensuring the existence of the maximum.

Solving for the optimal choices, we obtain:

$$s_{1A}{}^{2}F_1 + \left[(\alpha_2 - \alpha_1)Q_A + F_1F_2\right]s_{1A} - \alpha_1 Q_A F_2 = 0,$$

or

$$s_{1A} = \frac{(\alpha_1 - \alpha_2)Q_A - F_1F_2 + \sqrt{\left[(\alpha_1 + \alpha_2)Q_A + F_1F_2\right]^2 - 4\alpha_1\alpha_2 Q_A{}^2}}{2F_1}, \qquad (6a)$$

and

$$s_{2A} = \frac{-(\alpha_1 - \alpha_2)Q_A - F_1F_2 + \sqrt{\left[(\alpha_1 + \alpha_2)Q_A + F_1F_2\right]^2 - 4\alpha_1\alpha_2 Q_A{}^2}}{2F_2}. \qquad (6b)$$

Similarly:

$$s_{1B} = \frac{(\alpha_1 - \alpha_2)Q_B - F_1F_2 + \sqrt{\left[(\alpha_1 + \alpha_2)Q_B + F_1F_2\right]^2 - 4\alpha_1\alpha_2 Q_B{}^2}}{2F_1} \qquad (7a)$$

$$s_{2B} = \frac{-(\alpha_1 - \alpha_2)Q_B - F_1F_2 + \sqrt{\left[(\alpha_1 + \alpha_2)Q_B + F_1F_2\right]^2 - 4\alpha_1\alpha_2 Q_B{}^2}}{2F_1} \qquad (7b)$$

3.2. The broker's optimization

The brokers must decide on the fees for their respective services in a simultaneous one-shot game. Brokers maximize their fees given the solution to the institutions choice problem and subject to the capacity constraints:

$$\begin{aligned} \max_{p_1} \quad & F_{1_1}\left[s_{1A}(F_1;F_2) + s_{1B}(F_1;F_2)\right] \\ s.t. \quad & s_{1A}(F_1;F_2) + s_{1B}(F_1;F_2) = S_1 \end{aligned} \qquad (8a)$$

$$\begin{aligned} \max_{p_2} \quad & F_2\left[s_{2a}(F_2;F_1) + s_{2B}(F_2;F_1)\right] \\ s.t. \quad & s_{2A}(F_2;F_1) + s_{2B}(F_2;F_1) = S_2 \end{aligned} \qquad (8b)$$

It is clear that without explicitly measuring the brokers' cost functions, the capacity constraint must be binding in equilibrium. This implies that the shadow prices of the capacity constraints must be equal 1, and both capacity constraints are satisfied as equalities. In other words, the brokers must solve the optimal capacity allocation problem. It is possible to model an additional stage in the game where brokers first choose their capacity. However, given the complete information nature of the game choice, a broker would never choose excess costly capacity. Thus we restrict our attention to the second stage of the game.

Consequently:

$$s_{1A}(F_1; F_2) + s_{1B}(F_1; F_2) = S_1 \qquad (9a)$$

$$s_{2A}(F \ ; F_1) + s_{2B}(F_2; F_1) = S_2 \qquad (9b)$$

Equation (9a) specifies the reaction function of the first broker and (9b) that of the second broker. We set $S_1 = S_2 = 1$, so that we interpret each client's allocations as shares of the total broker's capacity. Substituting (6a,b) and (7a,b) into (9a,b) we conclude that in the equilibrium

$$F_1^* = F_2^* + (\alpha_1 - \alpha_2)(Q_A + Q_B). \qquad (10)$$

The equilibrium difference between the broker's fees is directly proportional to the difference in broker quality. The next step is to prove the existence of the equilibrium. First we evaluate the reaction function of the first broker (9a) at $F_2=0$, which yields:

$$F_1(F_2 = 0) = (\alpha_1 - \alpha_2)(Q_A + Q_B). \qquad (11)$$

We can show that $F_1(F_2)$ is a monotonically increasing concave function, which converges asymptotically to $\hat{F}_1 = \alpha_1(Q_A + Q_B)$ as $F_2 \to \infty$.

We cannot evaluate the reaction function of the second broker, (9b), at $F_1 = 0$, but we can evaluate it at $F_2 = 0$ which yields:

$$F_2\left(F_1 = \frac{\alpha - \alpha_2}{2\alpha_2}\right) = 0 \qquad (12)$$

Notice, that: $\frac{\alpha_1 - \alpha_2}{2\alpha_2} < (\alpha_1 - \alpha_2)(Q_A + Q_B)$. We can show that the reaction function $F_2(F_1)$ is a monotonically increasing concave function that converges asymptotically to $\hat{F}_2 = \alpha_2(Q_A + Q_B) \quad as \quad F_1 \to \infty$. These results imply that there exists a unique Nash equilibrium of the game between the two brokers.

In this equilibrium, the largest client dominates both brokers. This is quite intuitive, since the marginal benefit of any combination is proportional to the client's size. This is the only equilibrium type possible given our current set of assumptions. This equilibrium exhibits bunching when the largest client uses less of the second broker's capacity than he does of the first broker's capacity.

It is possible to derive an alternative equilibrium in which bunching is so extreme that each client is the largest trader with a particular broker. The clearest way to show this is to prove the existence of an equilibrium in which the smaller client (B) would prefer to completely forego the services of the first broker and instead, concentrate all of their trading with the second broker. In the process B may become the largest client of the second broker. To obtain this equilibrium requires the assumption of increasing returns to scale in broker services. The simplest way to model increasing returns is through the fixed fee each client has to pay for dealing with the broker.[4] This fee can be exogenous, or chosen by the broker. We model the first case for simplicity.

3.3. A fixed cost equilibrium

If there were a non-trivial fixed cost of using a broker, the ensuing equilibrium could be such that the second client chooses not to buy from the first broker.[5]
Since, in this case: $s_{1B} = 0$, thus $s_{1A} = S_1$, broker two's services would be given by:

$$s_{2A} = \frac{\alpha_2 Q_A}{S_1 + F_2}, \tag{13a}$$

and

$$s_{2B} = \frac{\alpha_2 Q_B}{F_2}. \tag{13b}$$

This yields:

$$\frac{\alpha_2 Q_A}{S_1 + F_2} + \frac{\alpha_2 Q_B}{F_2} = S_2, \tag{14a}$$

[4] Conceptually, increasing returns to scale can be represented in other ways, such as the increasing returns to scale in broker services discussed above.
[5] He could also forego the services of the second broker, and instead focus on the firs, but he will be able to buy much less services there, due to more intense competition from client A.

or

$$S_2^{'}P_2^{2}+\left(S_1S_2^{'}-\left(Q_A+Q_B\right)\right)F_2-Q_AS_1=0, \tag{14b}$$

where: $S_2^{'}\equiv S_2/\alpha_2$. Solving, we obtain:

$$F_2=\frac{\left(Q_A+Q_B\right)-S_1S_2^{'}+\sqrt{\left(S_1S_2^{'}-\left(Q_A+Q_B\right)\right)^2+4Q_AS_1S_2^{'}}}{2S_2^{'}}. \tag{15}$$

Let $S_1=S_2=S_2^{'}=1$, then

$$F_2=\frac{\left(Q_A+Q_B\right)-1+\sqrt{\left(1-\left(Q_A+Q_B\right)\right)^2+4Q_A}}{2} \tag{16}$$

Substituting into the demand functions, we obtain:

$$s_{2B}=\frac{2Q_B}{\left(Q_A+Q_B\right)-1+\sqrt{\left(1-\left(Q_A+Q_B\right)\right)^2+4Q_A}} \tag{17}$$

Next we determine the condition under which client B demands more than half of the second broker's services: $s_{2B}>0.5$. This is equivalent to:

$$2Q_B>0.5\left(Q_A+Q_B\right)-0.5+0.5\sqrt{\left(1-\left(Q_A+Q_B\right)\right)^2+4Q_A} \tag{18}$$

or $2Q_B>Q_A$.

Thus, given the increasing returns induced by the fixed fee, the second client will take more than half of the capacity of the second broker, while foregoing the services of the first broker altogether. This can occur when the two clients are not too different in their valuations $\{Q_B, Q_A\}$. Conceptually, any form of increasing returns, whether exogenously determined as in this example, or endogenous, could result in a bunching equilibrium. Brokers may prefer one equilibrium to the other. The first equilibrium involves more competition between brokers, but also more competition between the clients. The second equilibrium is a less competitive environment.

3.4. Commissions in our framework

In the equilibria presented above, a per-share commission can be easily calculated as the per share amount required to generate the service fee given the client's equilibrium trading volume. Denote by q_{ij} the equilibrium share volume sent by client *i* to broker *j*, which is the decision variable of client *i.* The per-share commission each client pays is computed from the total payment required for the service, and the volume allocated to each broker. The per share commission paid by client *i* to broker *j*, which we denote by c_{ji} is therefore, just the ratio of the required payment for the service, and the volume sent by the client to the broker:

$$c_{ji} = F_j\, s_{ij} / q_{ij} \; . \tag{19}$$

Notice that while the commission is expressed in per share terms, it represents the average payment, rather than the marginal cost of execution. This is a new way of looking at the commission contract. The empirical evidence presented below supports our alternative view of commissions.

We contend that equilibria with more brokers and clients will exhibit similar features to this simple 2 by 2 case. A bunching equilibrium could exist in a world with many clients and many brokers. The largest institutions will tend to be important clients to many brokers. But large institutions will not necessarily be the most important clients for every broker. Smaller institutions must concentrate their trades with a few brokers in order to obtain their desired level of broker services. Brokers rank clients in a queue; allocating the best services to those clients who choose to pay the fee. Because fee payments are tracked by per share commissions, in a bunching equilibrium small institutions will trade relatively more with their top brokers than large institutions do. We test this implication of the model using a proprietary database of institutional trades. This data and the accompanying tests are described in the next sections.

4. Data, hypotheses and empirical results

The data used to test our hypotheses consists of 651,183 trades by 305 institutional investors executed between January 1, 1997 and March 31, 1997.[6] The data is obtained from Abel-Noser Corporation, as NYSE member firm and a leading provider of transaction cost analysis to institutional investors. Information in the database consists of several unique items including: identification of the executing broker, identification of the institutional client, and a trade indicator (Buy or Sell). In addition, the database contains the per-share commission cost of each trade the trade date, size, and the execution price.

4.1. Descriptive statistics

Institutional commissions are quoted on a per share basis; their levels vary, but the vast majority are denominated in terms of round cents per share. Figure 1 presents the distribution of commissions per share based on the trade size. We see that the majority of institutional commissions are 5-6 cents per share. There is a relative paucity of trades at 4 cents per share, however many trades are charged between 0-3 cents per share. The frequency of both 3 and 5 cents-per-share commissions increases with the trade size. Sixty percent of all block trades (above 50,000) are charged these two commissions. We speculate that the distribution of commissions suggests that there are essentially two types of trades in the database. Full service trades, usually charging 5 or 6 cents per share and execution-only trades charging 3 cents per share or less.[7] We examine the breakdown of these trades across different size brokers and clients in section 4.2.

The size of the institutional client is important to several of our hypotheses. To understand more about the different institutions in the database, we first sort the clients into five quintiles, ranked by trading volume, and examine aggregate trading statistics by

[6] We are unsure whether this database, although it is very large, contains all the trades by every client, and it certainly does not contain all the trades by every broker. Thus there may be a bias in the data towards particular brokers. Nevertheless, as we examine the clients' trading patterns, as long as the majority of trades for each client are reported or the sampling mechanism is unbiased, our results should be represented of the entire market

quintile. What is immediately evident in Table 1 is that trading activity is skewed towards the largest clients. The high-volume quintile dominates the other quintiles in terms of total trading volume, total trades and total commissions paid to brokers. The trading activity of the smallest 80 percent of all institutions is only 21 percent of the total number of transactions, with the largest quintile executing the bulk of all transactions. As trade size also rises with client size, from a total share volume perspective, these discrepancies are even larger. Clearly, the largest institutions are going to be desired customers for all brokers.

From our perspective, this brings up the interesting question of how the smallest 80 percent of all institutions compete for broker services. We postulate that the smaller brokers will tend to bunch their trades among fewer brokers, perhaps concentrating their full-service trades among the smaller brokers where they obtain adequate levels of broker services from relatively small trading volumes.

4.2. Client trading by broker size

Table 2 examines aggregate trading statistics for our five client quintiles against five broker quintiles, sorted by total broker volume. Table 2 presents aggregate trading statistics for twenty-five cells, five for client size and five for broker size. In addition, we analyze the importance of each cells trading volume relative to the total volume separating trades into those that charge 5 cents or more per share (full-service trades) and those trades that charge less than five cents per trade (execution-only trades).

The most striking result in Table 2 is that trading volume is strongly skewed toward the largest clients executing with the largest brokers. Over sixty-five percent of total volume is trades by the largest institutions with the largest brokers where the commission cost is at least five cents per share. An additional twenty five percent of all volume is accounted for by the execution-only trades of this group. In terms of aggregate volume, all institutional trading on Wall Street is essentially the largest institutions trading with the largest brokers.

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[7] We confirmed the accuracy of our speculation in conversations with institutional trading desks.

Nevertheless there are some interesting patterns in overall full-service volume that are evident in the table. Consider, for example, the full-service trades of the smallest institutions. The three smallest client quintiles all do less trading with the largest broker quintile than they do with some other broker quintiles. This result is counterintuitive, because total trading volume increases as broker quintiles go from 1 to 5. However, this result is consistent with our hypotheses. Smaller clients choose to concentrate their trades with the smaller brokers. With little chance of competing in the queue for services with the larger brokers, the smaller institutions tend to concentrate their trades with brokers to which they are relatively important. This tendency to bunch trading with particular brokers is explicitly documented in Table 3.

Average commission costs are relatively constant across the twenty-five cells. One notable exception is that the largest client-broker quintile per-share commissions are the lowest average in the table. This finding tends to support our contention that the largest clients provide enough volume-based revenue to the brokers that large clients can achieve some cost per share discount.

4.3. Evidence on institutional clustering of trades

Table 3 presents evidence on the bunching or clustering of trades for each client quintile. The first panel presents the average amount of trading done with each quintiles highest volume (Top) broker, their top 3 brokers, their top 5 brokers, their top 10 brokers and the total number of brokers employed.

The data in Table 3 indicate a very skewed allocation of client trades among brokers. The largest institutions send 20% of their total volume to their top broker, 17% to the next two, 11% to the following two, and 17% to the next five. The smallest institutions concentrate their trading even more, they send 38% of their trading volume to their top broker, 25% to the next two largest brokers, 12% to the next two, and 18% to the next five. These results contradict the naïve assumption that clients want to hide their trading strategies by maximizing the number of brokers they use. There must be a strong reason to deviate from that strategy, namely the benefits from moving up higher in the queue for broker services. These results are consistent with our model. Notice that the existence of fixed costs of dealing with every broker would also prompt smaller clients to reduce the number of brokers they engage. However, this simple story would not explain the asymmetry of dealings with brokers that we document.

The middle panel of Table 3 presents average commission costs for each client quintile. The average commission costs for the top-ranked broker confirm our intuition that smaller institutions that cannot move up the broker's queue with higher volume might choose to do so by paying higher per share commissions. In fact, in each of the smallest three client quintiles the average commissions paid to the largest broker are larger than the average commissions paid to all other groups of brokers. These results are contrary to the evidence of volume discounts in the retail market presented in Brennan and Chordia (1993), but they are consistent with smaller clients increasing their revenues with their most important broker. In contrast, larger clients receive volume discounts and pay less in average commissions to their top broker than they do to other brokers.

4.4. Determinants of commissions per share

Table 4 presents regression results using the commissions per share on each trade as the dependent variable. The regression specification is:

$$Commission = \alpha + \beta_1 Shares + \beta_2 Price + \beta_3 Percentmarket + \beta_4 QVOL + \beta_5 BQVOL + \eta \quad (20)$$

In Equation (20) Commission is commissions per share on a single trade, Shares is the trades size, Price is the trade price, Percent market is the trade size as a percentage of the daily trading volume in the stock, QVOL is the quintile rank of the client and BQVOL is the quintile rank of the executing broker.

Table 4, panel A presents Equation (20) regression results for 644,492 trades. All trades in this regression had commissions of less than 8 cents per share.[8] The trade size, the percent of daily market volume and the price are all variables that represent the marginal costs of transacting. Larger trades, measured as both the number of shares and by the dollar volume (Price) are widely used to represent the cost of trade execution. The percent of the market (Percent market) is an additional and useful measure of trading costs, because it controls for differences in trading volume across stocks. The coefficients of the number of shares and the percent of the market have the predicted signs: the greater the number of shares and percent of the market, the higher the commission costs. The coefficient on Price has a negative sign, which is not predicted by the standard execution cost arguments.

The striking result in this table is that these standard measures of transactions costs do not explain much of the variation in commissions per share. Much more effective are the controls for the size of the client, QVOL and the size of the broker, BQVOL. Particularly relevant to our argument is the explanatory power of QVOL, the quintile rank of the client. We make the argument that larger client's can easily reach their desired fixed fees because their total trading volumes are so large. We speculate in our discussion of Table 3 that the commissions per share charged to the largest clients could be lower than the commissions for smaller clients for this reason. We view the fact that client size is the most important variable in this regression as further confirmation of our hypothesis.

Panels B and C present commissions per share regressions that separate the data into execution-only transactions, 0-3 commissions per share, and research transactions, which charge between 3 and 8 cents per share. In Panel B, execution-only trades, the size of the client adds very little explanatory power to the regression. This result is consistent with our contention that the execution-only market is competitive and priced at marginal cost. We do not expect to see volume discounts in this sub-sample. In contrast to these results, QVOL is the variable with the greatest explanatory power in Panel C; a regression using only the research trades. For research trades commissions per share

[8] Commissions per share are truncated at 8 cents to minimize the effect of outliers on the regression

exhibit volume discounts that are consistent with our hypotheses.

4.5. Trading efficiency around information events

If our hypothesis on the client-broker relationship is correct, we should expect to find some tangible benefit from a higher position in the queue for information. To investigate this we have collected a sample of brokerage-specific analysts' recommendation changes that previous research has shown to be informative events (Elton, Gruber and Grossman, 1986, Womack, 1996, and Barber, Lehavy, McNichols and Trueman, 2001). We examine the pattern of client trading at the time of these information events. If certain clients are preferred and get earlier or more complete information prior to other clients, then trading gains are possible for these clients. We test if the trading patterns in our data are consistent with this hypothesis by examining the profitability of client trades at the time the analyst report is released.

Our sample of analysts' recommendation changes consists of 441 upgrades or downgrades on NYSE-listed stocks that were recorded by the Dow Jones News Service in the first quarter of 1997. The Dow Jones News Service analysts' reports are time-stamped so that we know when the reports became public, although public dissemination may occur after dissemination to important clients. The analysts' reports are issued exclusively by brokers in our largest quintile.

Table 5 presents the average event-day abnormal returns for the analysts' recommendation changes. Our purpose is not to examine the market reaction to these events, but rather to confirm that they are information events, as measured by abnormal returns, and that the market reaction is consistent with previous research. The event day is defined as the day the report was released if the report is time-stamped before the close of trading and the following day if the report is time-stamped after the NYSE 4:00 close. Abnormal returns are estimated using market excess returns on the event day. CRSP provides the raw security returns and the value-weighted market returns for the

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coefficients.

calculation of market excess returns. Our sample of analysts' upgrades and downgrades produces significant abnormal returns. Upgrades produce an average abnormal return of 2.27% (t-statistic = 10.14) and downgrades produce and average abnormal return of 2.98% (t-statistic = -7.80). The only statistically insignificant analysts' recommendations are upgrades to a hold recommendation.

This background analysis allows us to state that we find analyst recommendations to be information events as measured by abnormal returns and therefore trading in these stocks on these days may provide better than average profit or loss avoidance opportunities. With the daily closing price as a benchmark, we can determine the trading efficacy of institutions that execute trades on these high-information days. Further, we can examine whether trading profits, if they exist, are related to the nature of the client-broker relationship.

4.5.1. Institutional trading on analysts' information

Table 6 presents an analysis of client trades on the day analysts' change their recommendations. We compare the execution costs of trades through the broker that issues the analyst's recommendation against trading through other brokers.[9] This is a powerful and direct test of the informational value of being a client of a research broker. Clients who traded that day through the recommending broker are by definition clients of that broker.

We find that trades through the initiating broker on the day of the recommendation change paid higher commissions (5.56 cents), while trades in the same stock on the same day through any other broker paid lower commissions (4.68 cents). This difference is statistically significant at the 1% level. We use the buy and sell indicator variables in our data and the price of the trade to calculate trade profitability. Only trades through the initiating broker are profitable. On average, all institutional client trading in the stock on the recommendation day beat the volume weighted-average price

(VWAP), though the gains relative to the VWAP are modest. The transaction price relative to the close presents the most striking evidence of profitability. Clients who trade through the recommending broker have an execution price 24.55 cents per share better than the close, while trades through the non-recommending broker received only modest price improvement of 1.70 cents per share relative to the close. For clients trading through the recommending broker the price improvement received represents a gross per-trade profit, based on the average trade size of $3,618.92. Thus, clients of the initiating broker paid more for their commissions but made profitable trades, while trades done through other brokers paid less but lost money relative to the commissions paid. These results are strongly consistent with the model's suggestion that for broker services such as information, the place in the queue matters, and that brokers inform some clients earlier than others.

5. Conclusion

Timmons (2000) claims that brokers treat their preferred institutional clients to privileged information. If her assertion is true, then brokers must have a mechanism that determines the relative importance of an institutional client. We start from the natural premise that the broker's preferred clients will be those providing the largest revenues to the brokerage firm. We model the total revenue paid to a broker as a fixed fee, clients optimally select their desired level of broker services and pay the associated fixed fee through commissions per share on their trades. Thus, commission per share represents an average per share cost of broker services. This result contrasts with the prevailing view of per share commissions as a transaction cost that is priced at marginal cost.

One example of a brokerage service that is allocated across clients is access to information, not all information reaches all parties at the same time. Thus, the receipt of information earlier provides the opportunity for profit to those who receive it. Commissions represent a way for clients to pay the brokers not only for the information, but also for the its timely receipt. As position in the queue to receive information is a

[9] The sample size in table 6 is 433. Eight Dow Jones analysts' recommendations could not be matched to

scare resource, brokers are more likely to provide this scarce resource to those that will pay the most. In response, clients who would otherwise try to disguise their trades by using many brokers will instead try to buy their way up the queue by concentrating their trades across a few brokers.

We present a model of the allocation of brokers' services, such as a place in the queue for information, and show that a fixed payment mechanism is both an equilibrium and efficient. Empirical results indicate that clients, consistent with attempts to buy their way up the queue, bunch or concentrate their trades, and that smaller firms pay higher commissions than larger firms to their top brokers. Other empirical results indicate that brokerage recommendations do affect stock prices, and that clients who trade through initiating brokers on the day of the recommendation make profitable trades while clients who trade elsewhere do not. These results are consistent with the model and with information being disseminated to brokers' best clients first, with clients paying more for the privilege of being higher in the queue and receiving information earlier than the rest of the market.

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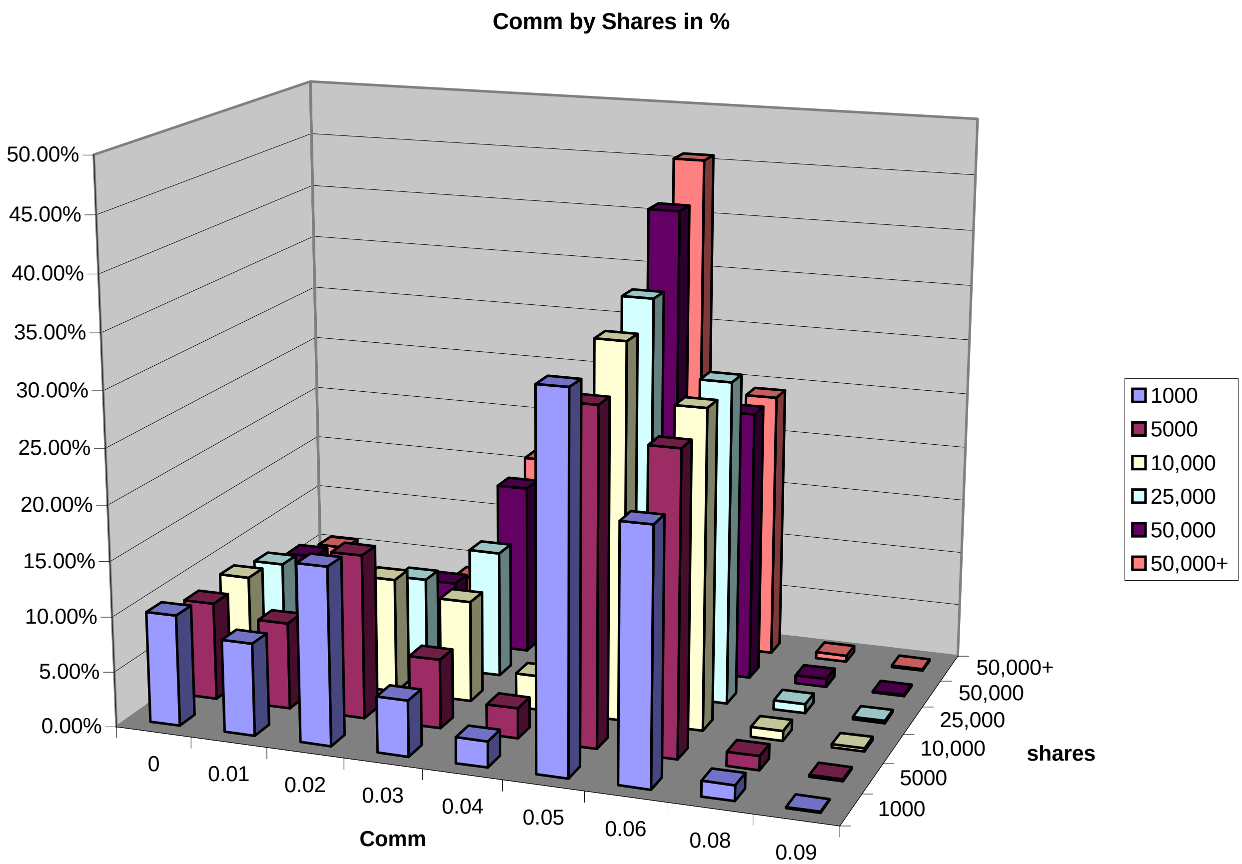
Figure 1



Comm by Shares in %
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
0
0.01
0.02
0.03
0.04
0.05
0.06
0.08
0.09
Comm
50,000+
50,000
25,000
10,000
5000
1000
shares
1000
5000
10,000
25,000
50,000
50,000+

Table 1

Description of institution (client) trading activity in the sample

This table presents summary trading information for the trading activity of 305 institutional clients in the first quarter of 1997. Clients are sorted into 5 quintiles by total trading volume. Total volume, total commission and the number of trades are totals for each client quintile. Average commissions per share, per trade, trade size and stock price per share are averages of all trades for each quintile. Price – VWAP is the buy trade price less that day's value-weighted average price; or the value weighted price less the sell trade price. Price – open is the same relative to that day's opening price. Price-vwap and price – open quintile averages and medians are reported. Trade direction (Buy or Sell) information provided by the client is used to calculate these execution cost measures.

	Client quintile by trading volume				
	1 = low	2	3	4	5 = high
Total volume (000's) $	16,698	51,943	120,754	274,761	5,505,833
Total commission (000's) $	962	2,904	6,421	10,370	257,105
trades	12,425	23,564	41,082	59,222	514,890
Average commission c/share	5.82	5.57	5.01	5.33	4.33
Average commission $/trade	77.42	123.23	156.30	242.24	499.34
Average trade size	1,344	2,204	2,939	4,639	10,693
Average price $/share	48.2	47.4	49.7	48.4	47.1
Price impact – VWAP cents	1.3	0.7	2.9	3.7	-0.9
(median)	(0)	(1)	(1)	(1)	(-0.1)
Price impact – Open cents	-2.2	3.1	2.4	2.8	3.8
(median)	(0)	(0.2)	(0)	(0)	(0)

Table 2
Institutional Trading by Broker and Client Quintile

This table presents client quintile by broker quintile summary trading information describing the commissions and trading activity of 305 institutional clients in the first quarter of 1997. Clients are sorted into quintile by client volume, brokers are sorted into quintiles by broker volume. For example, trades in the (1,1) group represent trades by the smallest volume clients with the smallest volume brokers. Variables are described in table 1, except for Total volume => 5 (< 5) cents per share which represents the percentage of total volume in each quintile paying high commissions (=> 5 cents per share) or paying low commissions (< 5 cents per share).

Client quintiles	**Broker quintile by broker trading volume**				
	1 = low	2	3	4	5 = high
Quintile 1					
Average commission cents per share	5.53	5.77	6.37	5.91	5.79
Average commission $ per trade	62.61	66.20	73.11	75.49	78.17
Total volume = >5 cents per share (% of sample)	0.02	0.02	0.02	0.02	0.01
Total volume < 5 cents per share (% of sample)	<0.01	<0.01	<0.01	<0.01	<0.01
Average trade size	1,225	1,218	1,239	1,370	1,348
Price impact – VWAP $	-0.004	0.007	0.045	-0.009	0.015
Price impact – Open $	-0.062	0.009	0.039	-0.059	-0.021
Quintile 2					
Average commission cents per share	5.41	5.23	5.32	5.60	5.57
Average commission $ per trade	69.78	181.73	146.74	115.71	122.90
Total volume = >5 cents per share (% of sample)	0.05	0.07	0.08	0.08	0.06
Total volume < 5 cents per share (% of sample)	<0.01	<0.01	0.01	<0.01	0.01
Average trade size	1,235	3,301	2,722	1,993	2,201
Price impact – VWAP $	-0.091	-0.029	0.013	0.023	0.005
Price impact – Open $	-0.211	-0.079	-0.063	0.037	0.034
Quintile 3					
Average commission cents per share	5.20	5.06	5.63	4.90	5.00
Average commission $ per trade	126.36	119.50	202.60	160.91	155.68
Total volume = >5 cents per share (% of sample)	0.07	0.19	0.27	0.25	0.25
Total volume < 5 cents per share (% of sample)	<0.01	0.01	0.02	0.02	0.02
Average trade size	2,317	2,205	3,814	3,313	2,904
Price impact – VWAP $	0.033	0.005	0.030	0.027	0.029
Price impact – Open $	-0.093	-0.047	0.091	-0.008	0.026
Quintile 4					
Average commission cents per share	5.57	6.42	5.50	5.36	5.31
Average commission $ per trade	259.72	172.85	340.22	275.14	237.88
Total volume = >5 cents per share (% of sample)	0.07	0.27	0.66	0.94	1.19
Total volume < 5 cents per share (% of sample)	0.01	0.03	0.06	0.09	0.15
Average trade size	5,038	3,090	6,273	5,025	4,584
Price impact – VWAP $	-0.067	0.058	0.007	0.013	0.040
Price impact – Open $	0.063	-0.166	-0.008	-0.001	0.033
Quintile 5					
Average commission cents per share	10.31	5.19	4.99	5.71	4.25
Average commission $ per trade	262.85	329.05	395.80	644.15	494.48
Total volume = >5 cents per share (% of sample)	0.06	0.22	0.68	2.50	65.44
Total volume < 5 cents per share (% of sample)	<0.01	0.05	0.23	0.71	25.08
Average trade size	4,840	6,161	8,105	13,024	10,630
Price impact – VWAP $	-0.758	0.683	0.083	-0.005	-0.011
Price impact – Open $	-0.699	0.586	0.059	-0.043	-0.061

Table 3

Evidence on broker clustering by institutional clients

This table presents information on broker choice, commissions paid and execution cost for the trading activity of 305 institutional clients in the first quarter of 1997. Clients are sorted into quintile by total trading volume. Broker concentration reflects the percentage of client trading that the average client in the quintile does with each brokerage group. Commissions (and price impact) are the average commissions paid (and execution costs) by the clients in each quintile for each brokerage group. VWAP is the value-weighted average trading price for a stock on the same day the client transactions were recorded.

	Client quintile by trading volume				
	1 = low	2	3	4	5 = high
Broker Concentration (% of client volume)					
Top broker	38.7	26.4	23.3	21.3	20.0
Top 1-3	63.4	46.3	40.4	39.0	36.8
Top 1-5	75.3	57.9	50.9	49.2	47.6
Top 10	93.3	76.6	68.1	67.2	64.3
Total brokers used	25.5	38.1	52.0	57.0	78.0
Commission Cost (cents per share)					
Top broker	6.14	5.94	5.85	5.53	4.88
Top 1-3	6.07	5.86	5.56	5.96	5.05
Top 1-5	6.04	5.84	5.57	5.78	5.03
Top 1-10	5.97	5.84	5.56	5.72	5.16
Price Impact – VWAP (cents)					
Top broker	-2.1	0.6	-0.0	1.6	13.8
Top 1-3	-1.6	-0.5	1.6	2.4	16.6
Top 1-5	-0.7	-0.1	0.6	2.6	12.8
Top 1-10	13.6	-0.6	2.8	2.6	9.6

Table 4
Institutional Commissions

This table presents the results of regressions using commissions per share as the dependent variable. Commissions per share are truncated at 8 cents a share; which leaves a sample size of 644,492. Shares is the trade size, price is the trade price. Percent market is the size of the trade divided by the daily volume in the traded stock. QVOL is the client's quintile rank from Table 2, BQVOL measures the broker-client relationship, and it is measured as the rank of the executing broker across all trades from that client. Panel A uses all observations. Panel B estimates the determinants of per share commissions for 146,210 trades where the commission per share is less than or equal to three cents per share (Execution Only trades). Panel C estimates the determinants of commissions for 498,281 trades where the where commission per share is between three and eight cents per share (Research trades). All commission per share figures are rounded to the nearest 1/10 of a cent.

Panel A: All trades

Intercept	Shares	Price	Percent market	QVOL	BQVOL	Adj. R^2
0.043***	0.0000000319***					0.0028
0.045***		-0.000023				0.0014
0.044			0.000059***			0.0007
0.060***				-0.00439***		0.0499
0.061***					-0.00430***	0.0085
0.045***	0.0000000306***	-0.000021***				0.0040
0.044***	0.0000000297***		0.000022***			0.0029
0.045***	0.0000000298***	-0.000021***	0.000009**			0.0040
0.061***	0.0000000398***	-0.000019***	0.000047***	-0.00456***		0.0570
0.073***	0.0000000403***	-0.000018***	0.000041***	-0.00442***	-0.00321***	0.0617

Panel B: Execution only trades

Intercept	Shares	Price	Percent market	QVOL	BQVOL	Adj. R^2
0.016***	0.0000000174***					0.0016
0.016***		-0.00000792***				0.0020
0.016***			0.000044***			0.0024
0.014***				0.000455***		0.0022
0.017***					-0.000209**	0.0000
0.016***	0.0000000161***	-0.00000744***				0.0034
0.016***	0.0000000117***		0.000037***			0.0031
0.016***	0.0000000117***	-0.00000654***	0.000031***			0.0044
0.015***	0.0000000109***	-0.00000658***	0.000031***	0.000442***		0.0065
0.016***	0.0000000108***	-0.00000662***	0.000030***	0.000445***	-0.000291***	0.0066

* Significant at the 5% level
** Significant at the 1% level
*** Significant at the 0.01% level

Panel C: Research trades

Intercept	Shares	Price	Percent market	QVOL	BQVOL	Adj. R^2
0.052***	0.0000000210***					0.0047
0.052***		0.00001246***				0.0012
0.052***			-0.00011***			0.0085
0.060***				-0.00223***		0.0464
0.054***					-0.000388***	0.0003
0.052***	0.0000000205***	0.00001117***				0.0056
0.053***	0.0000000126***		-0.000090***			0.0100
0.052***	0.0000000126***	0.00000705***	-0.000086***			0.0104
0.060***	0.0000000071***	0.00000741***	-0.000064***	-0.00213***		0.0517
0.059***	0.0000000071***	0.00000741***	-0.000064***	-0.00213***	0.0000277	0.0517

*Significant at the 5% level
** Significant at the 1% level
*** Significant at the 0.01% level

Table 5
Analyst recommendation changes

This table presents the abnormal returns for 441 NYSE-listed analyst recommendation changes that appeared in the Dow Jones News Service in the first quarter of 1997. The abnormal returns are market-adjusted returns: the difference between the raw stock return on the day the analyst recommendation is reported and the value-weighted market return on that day.

Panel A: Abnormal returns: analyst recommendation changes

	N	Mean	T-statistic	Minimum	Maximum
All upgrades	237	2.27%	10.14	-7.61%	23.68%
upgrades to strong buy	35	3.28%	4.09	-1.90%	23.68%
upgrades to buy	187	2.21%	9.90	-5.23%	14.23%
upgrades to hold	15	0.71%	0.66	-7.61%	13.18%
All downgrades	204	-2.98%	-7.80%	-28.72%	18.58%
downgrades to buy	52	-1.60%	-2.75	-22.42%	6.87
downgrades to hold	136	-3.26%	-6.83	-28.72%	18.58%
downgrades to sell	16	-5.12%	-5.71	-12.24%	0.05%

Table 6
Client trading and broker recommendation changes

This table presents average statistics on the execution of client trades at the time a brokerage analyst issues a recommendation upgrade of downgrade. The sample of brokerage recommendation changes consists of 433 analysts' recommendation changes in NYSE-listed stocks. The sample is gathered from the Dow Jones News Service Broad Tape for the first quarter of 1997. BVOL is the average broker's quintile rank.

	Trade Through Other Broker	Trade through Changing Broker	Difference
Improvement over VWAP (cents)	1.52	2.73	-0.012
Improvement over Close (cents)	1.70	24.55	-22.80**
Commissions per share (cents)	4.68	5.56	-0.0088***
Commissions paid ($)	796	788	7.37
Number of trades	6,011	326	
Share volume	16,462	14,741	1,720
Price ($)	55.73	60.71	-4.98*
Trade as % of daily volume	1.01%	1.51%	-0.50%*
QVOL	4.51	4.56	-0.05
BVOL	4.91	5.00	-0.091***

* significant at the 5% level for both equal and unequal t-tests
** significant at the 1% level for both equal and unequal t-tests
*** significant at the 0.01% level for both equal and unequal t-tests