A New Estimate of Transaction Costs

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Transaction costs are important for a host of empirical analyses from market efficiency to international market research. But transaction costs estimates are not always available, or where available, are cumbersome to use and expensive to purchase. We present a model that requires only the time series of daily security returns to endogenously estimate the effective transaction costs for any firm, exchange, or time period. The feature of the data that allows for the estimation of transaction costs is the incidence of zero returns. Incorporating zero returns in the return-generating process, the model provides continuous estimates of average round-trip transaction costs from 1963 to 1990 that are 1.2% and 10.3% for large and small decile firms, respectively. These estimates are highly correlated (85%), with the most commonly used transaction cost estimators.

How much does it cost to trade common stock? The Plexus Group (1996) estimated that trading costs are at least 1.0–2.0% of market value for institutions trading the largest NYSE/AMEX firms. Such trades account for more than 20% of reported trading volume. Stoll and Whaley (1983) reported quoted spread and commission costs of 2.0% for the largest NYSE size decile to 9.0% for the small decile. Bwardwaj and Brooks (1992) reported median quoted spread and commission costs between 2.0% for NYSE securities with prices greater than $20.00 and 12.5% for securities priced less than $5.00. These costs are important in determining investment performance and “can substantially reduce or possibly outweigh the expected value created by an investment strategy” [Keim and Madhavan (1995)].

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Despite the increasingly prominent role of transaction costs in both practice and research, estimates of transaction costs are not always available or, where available, subject to considerable expense and error.

This article presents a new method of obtaining estimates of transaction costs regardless of time period, exchange, or firm. The primary advantage of this model is that it requires only the time-series of daily security returns, making it relatively easy and inexpensive to obtain estimates of transaction costs for all firms and time periods for which daily security returns are available. This estimate of transaction costs mitigates the problems of incorporating transaction costs into empirical studies that address issues such as market efficiency, market structure analysis, and international market research.[1] Further, security traders can use the model to judge the competitiveness of their realized trading costs and expected profits.

Researchers who needed transaction cost estimates generally used either proxy variables or spread plus commission. Studies such as Karpoff and Walkling (1988) and Bhushan (1994) used the proxy variables of price, trading volume, firm size, and the number of shares outstanding under the assumption that these variables are negatively related to transaction costs. It is generally recognized that proxy variables cannot directly estimate the effects of transaction costs and that these variables may capture the effect of variables that are not related to transaction costs.

The most direct estimate of transaction costs is the spread plus commission (hereafter, $S + C$), which is the sum of the proportional bid-ask spread, calculated using current specialist quotes, and a representative commission from a brokerage firm. However, there are several problems with the $S + C$ as an estimate. First, trades on the NYSE and AMEX are often consummated at prices that are inside the bid-ask quotes.[2] Lee and Ready (1991) and Petersen and Fialkowski (1994) provided evidence that many trades are inside the quoted bid-ask spread. Roll (1984) provided an estimate of the "effective spread," but his model cannot provide estimates for more than half of the firms listed on the NYSE/AMEX exchange [Harris (1990)]. Sec-

[1] For example, transaction cost estimates are often unavailable for markets outside of the United States [Kato and Loewenstein (1995)], transaction costs are difficult to obtain for market efficiency tests that span long time periods before transaction cost data were collected [Karpoff and Walkling (1988) and Bhushan (1994)], and transaction costs availability restrict market structure analysis to recent, single-year periods where NYSE/AMEX cost data are more commonly available [Huang and Stoll (1996)]. In additional, interexchange studies are often hampered because "most trades for NASDAQ listed firms will not carry a commission fee, since the broker/dealer is compensated through the buy-sell spread in the market" (Plexus Group 1996) while NYSE/AMEX listed firms carry a separate commission charge, if applicable. Even with intraday data (ISSM, TORQ, and TAQ) many empirical studies find the data cumbersome, and often impossible, to use due to the sheer volume of data and because it is provided on a year-by-year basis.

[2] Grossman and Miller (1988) argued that the quoted spread cannot serve as a measure of the cost of supplying immediacy for typical trading orders. They cite other "problems" with the spread such as the timing of trades or the likelihood that a buyer and seller will arrive in the market to transact at the same time and at the same price.

ond, the commission schedule of brokers often reflects more than the costs of executing a trade. For example, Johnson (1994) argued that execution costs are often bundled with “soft dollars” that pay for research which may or may not be related to the specific trade. In effect, the S + C estimate can overstate the effective transaction costs.

Despite these problems, S + C is presently the best available estimate of transaction costs. It should be noted that the S + C estimate is a narrow view of transaction costs. Merton (1987) argued that the cost of marginal traders' time used in developing a decision rule when information is released is a transaction cost. Berkowitz, Logue, and Noser (1988) and Knez and Ready (1996) argued that the impact on price when an order is executed is part of transaction costs and important in estimating the performance of trading strategies. However, obtaining continuously quoted bid-ask spreads for all firms and time periods where security returns exist is difficult and, at times, impossible. The intraday Trades, Orders, Reports and Quotes (TORQ) and Trades and Quotes (TAQ) databases only provide quotes on a monthly basis from 1991 to 1993. Other sources, such as Fitch, restrict quotes to only NYSE firms, and the Institute in the Study of Security Markets (ISSM) intraday database provides quotes only from 1987 to 1991.

In this article, we propose a model of security returns that avoids the limitations of the transaction cost proxies and S + C estimates because it reflects the effect of transaction costs directly on daily security returns. In our model, this effect is modeled through the incidence of zero returns. The premise of this model is that if the value of the information signal is insufficient to exceed the costs of trading, then the marginal investor will either reduce trading or not trade, causing a zero return. The estimates from this model are the marginal trader's effective transaction costs.

The model is rooted in the adverse selection framework of Glosten and Milgrom (1985) and Kyle (1985).[3] A key feature of this literature is that the marginal (informed) investor will trade on new (or accumulated) information not reflected in the price of a security only if the trade yields a profit net of transaction costs. The cost of transacting constitutes a *threshold* that must be exceeded before a security's return will reflect new information. A security with high transaction costs will have less frequent price movements and more zero returns than a security with low transaction costs. This article provides evidence that security returns demonstrate the effects of transaction costs through the incidence of zero returns.

We first find that zero returns are very frequent. As much as 80% of the smallest firm's returns are zero and some of the largest firms have 30% zero returns. Using NYSE and AMEX data on individual securities for the period

[3] Constantinides (1986), Merton (1987), and Dumas and Luciano (1991) model similar trading behaviors applied to portfolio returns. In these models, trading volume is used to represent the effects of transaction costs.

1963–1990, we test the relation between zero returns and transaction cost proxies. Consistent with our transaction costs model, we find evidence that the frequency of zero returns is inversely related to firm size, and directly related to both the quoted bid-ask spread and Roll's measure of the effective spread.

We next use the limited dependent variable (LDV) model of Tobin (1958) and Rosett (1959)[4] to estimate transaction costs based on the frequency of zero returns. We apply the LDV model to daily security returns of all individual NYSE/AMEX securities from 1963 to 1990. The LDV model's estimates of average round-trip transaction costs range from 1.2% for the average firm in the largest size decile to 10.3% for the average firm in the smallest size decile. This measure of transaction costs is significantly and positively correlated with the S+C measure used by Stoll and Whaley (1983) over the period 1963–1979 and by Bhardwaj and Brooks (1992) over the period 1982–1986. Time-series analysis indicates that our estimates track these S + C estimates with a correlation coefficient of 85%. However, on average, our estimates are 15–50% smaller than the S+C estimates for small and large size decile firms, respectively. This is consistent with the findings of Lee and Ready (1991) and Petersen and Fialkowski (1994) that trades take place within the bid-ask spread and that the "effective" spread varies with firm size.

This article is organized as follows. In Section 1, we discuss the behavior of security returns in the presence of transaction costs. Section 2 presents the LDV model and introduces the LDV measure. Section 3 describes the data and Section 4 presents the test results of the zero return and transaction cost hypotheses. Tests of the LDV measure of transaction costs are shown in Section 5 and Section 6 concludes.

1. Security Returns and Transaction Costs

In the limiting case of no transaction costs, investors have the opportunity to continually trade in all securities. If transaction costs are not zero, the marginal investor will weigh the costs of trading against the expected gains. We assume the marginal investor is the one with the highest net difference between the value of the information and transaction costs.[5] Following Glosten and Milgrom (1985), we assume that there exists a public information signal that investors use to augment their private information and their consequent decision to trade.

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[4] The LDV model has been used in a variety of empirical studies in finance and accounting. See Maddala (1983, 1991) for a review of the applications.

[5] If all traders have the same information, the marginal trader is the one with the lowest trading costs. If all traders have the same trading costs, the marginal trader is the one with the most valuable information. An additional consideration is liquidity traders, who will limit their trades if the liquidity value exceeds the costs. Our model focuses primarily on marginal information trading which, we assume, is the most telling aspect of security price movement.

The basic hypothesis of our model is that, on average, a zero return is observed if the transaction cost threshold is not exceeded. This implies that zero returns result from the effects of transaction costs on the marginal investors, who may be informed or uninformed. For informed traders, if the value of the public-plus-private information is insufficient to exceed the costs of trading, then these investors will either reduce their desired trades or not trade[6] and there will be no price movement from the previous day. For most liquidity traders, if the need for liquidity is sufficiently low and the transaction costs sufficiently high, they will not trade and we will observe a zero return. However, some liquidity traders may trade regardless of transaction costs and the consequent returns may be nonzero. We assume that the value of their trades is idiosyncratic and over time the average return resulting from their trades will be zero. While we cannot observe whether the marginal traders are informed or uninformed nor directly measure the transaction cost-adjusted return we can observe both the market return and the occurrence of zero returns. We treat zero returns as evidence that the transaction cost threshold has not been exceeded by the marginal trader.

In our model, these zero returns result from transaction costs that include not only the S + C costs, but also the expected price impact costs and opportunity costs. Given that we observe the ex post return of the marginal trade, all the costs encountered by the marginal trader are included in transaction costs.

The effect of transaction costs on daily security returns is visible in Figure 1, which plots security returns versus the market return (equally weighted index) for the calendar year 1989. Each circle represents a 1-day return. Panels A and B show the security return behavior for a small-firm security, Avnet Corporation, and a large-firm security, IBM Corporation, respectively. The striking feature of panel A is the large number of zero returns exhibited by Avnet, especially in contrast to the paucity of zero returns exhibited by IBM in panel B. Of equal note for Avnet is that zero returns appear more frequently for small market returns than for large ones. A weaker version of the same relationship holds for IBM.

In the next section we develop an empirical model of security returns that incorporates the effect of transaction costs as evidenced by zero returns. Our model assumes that the return on a market index is a significant factor used by marginal investors to augment their private information sets. The lower

[6] In most microstructure models, the market maker must determine whether he is trading with an informed or uniformed trader. The market maker makes a probability-weighted guess about whether the trader is informed based on the order flow. Glosten and Milgrom (1985) and Kyle (1985) argue that the flow of orders is not a sufficient statistic for transaction costs because of liquidity traders. Bhushan (1991) extends these models to show that the volume of trading in a security by all types of investors will tend to be inversely related to the investors' transaction costs. While trading volume and transaction costs are related, trading volume is also related to liquidity trading and this confounding effect makes the relationship between trading volume and transaction costs difficult to specify empirically.

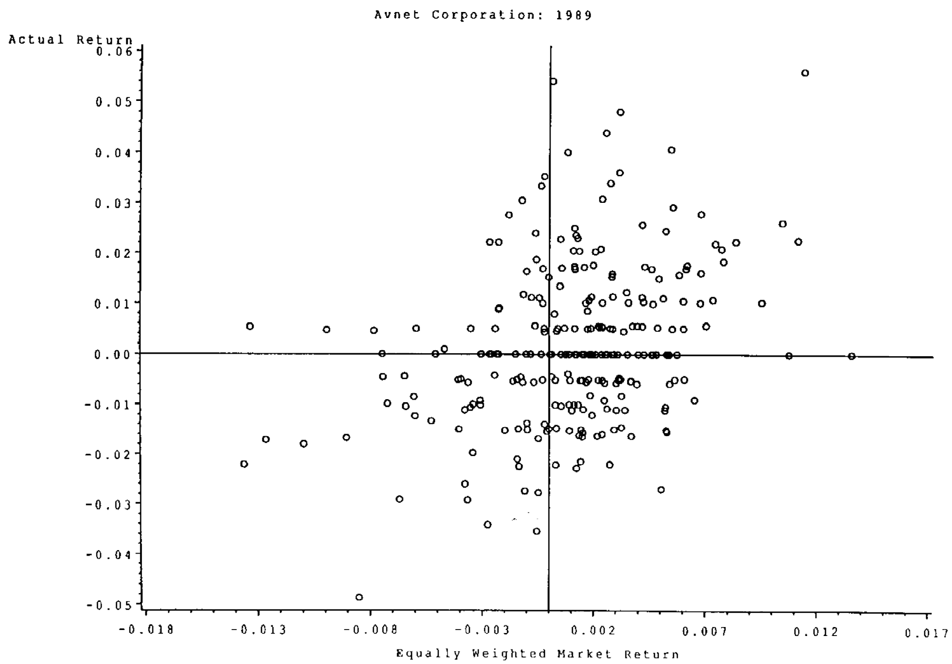

Figure 1
Daily security return behavior
Daily security returns versus daily equally weighted market returns. Each circle represents a daily security return.

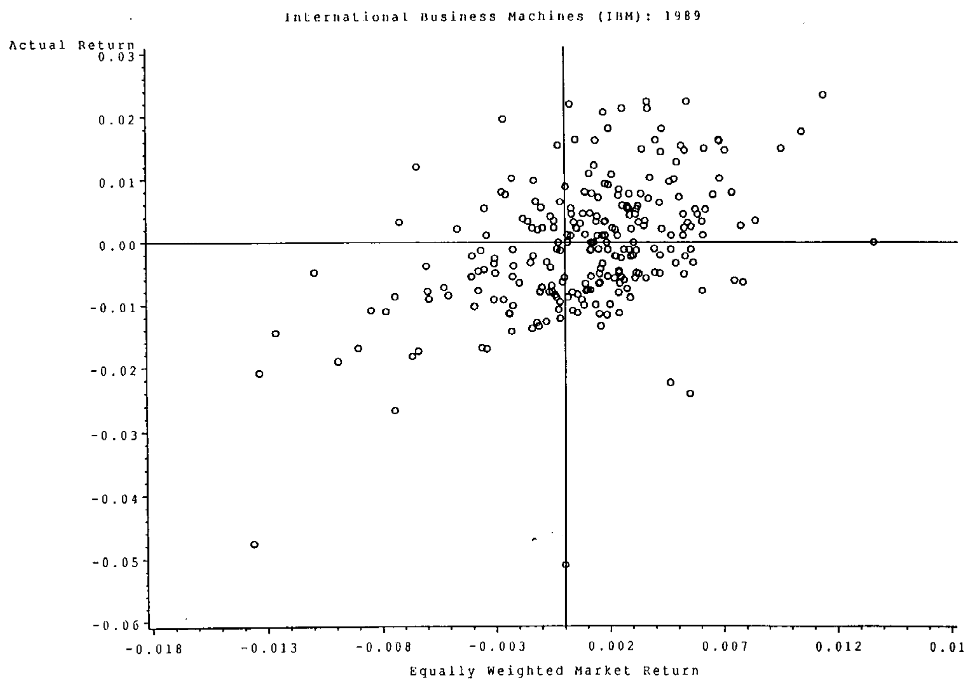

Figure 1
(continued)

the absolute value of the market return, the lower the likelihood that the marginal investor will trade and the greater the probability that we will observe a zero return.

2. The LDV Model

Our proposed model of security returns in the presence of transaction costs is based on the limited dependent variable (LDV) model of Tobin (1958) and Rosett (1959). In this model we assume that the common "market model" (with the intercept suppressed) is the correct model of security returns, but is constrained by the effects of transaction costs on security returns. In the presence of transaction costs, the marginal informed investor will trade only if the value of information exceeds transaction costs.

The intercept term usually included in the market model is now subsumed by transaction cost intercept terms. The intercept in the market model normally captures any misspecification in the market index that may not be mean-variance efficient. Thus any difference in the alpha's across assets may simply be due to an inefficient mean-variance market index and not transaction costs. However, the suppression of the intercept term does not affect our estimate of transaction costs, as a free intercept would be additive to each alpha term. Since we are interested in the difference $\alpha_2 - \alpha_1$ to determine the round-trip transaction costs, any effect of model misspecification on the transaction cost estimates is very small.[7]

The relationship between measured (CRSP provided) and true security returns is illustrated in Figure 2. The bold line relates the measured return to the true return. The measured return does not begin to reveal the true return of the marginal trader until transaction costs are exceeded. In effect, our model asserts that the measured return will only partially reflect the true value of the information because the marginal investor must be compensated for transaction costs. The true return is then gross of transaction costs while investors form expectations on the net-of-cost returns. The curvilinear line of Figure 2 reflects the expected measured return, which is continuous with the true return. As the market return moves away from zero, the transaction cost threshold is approached and there is a greater probability that the measured return will be nonzero and the expected measured return will begin to match the true return. The expected measured return begins to reflect the true return

[7] We verified this by running a "simulation" using a benchmark that was likely to be inefficient. We constructed a benchmark portfolio that was composed of securities based on size decile. For securities in each decile we used a mismatched benchmark that was composed solely of stocks in another decile at the opposite extreme. For example, decile 10 securities were grouped in decile 1, size decile 9 securities were grouped in size decile 2, etc. We then estimated the transaction costs with the LDV model using this misspecified benchmark. For comparison purposes, we used the equally weighted index as a more "proper" benchmark. We found that the LDV estimates of $\alpha_{j2} - \alpha_{j1}$ were different in the third decimal place irrespective of size decile. Thus we do not believe that the results are sensitive to the choice of a broad market index.

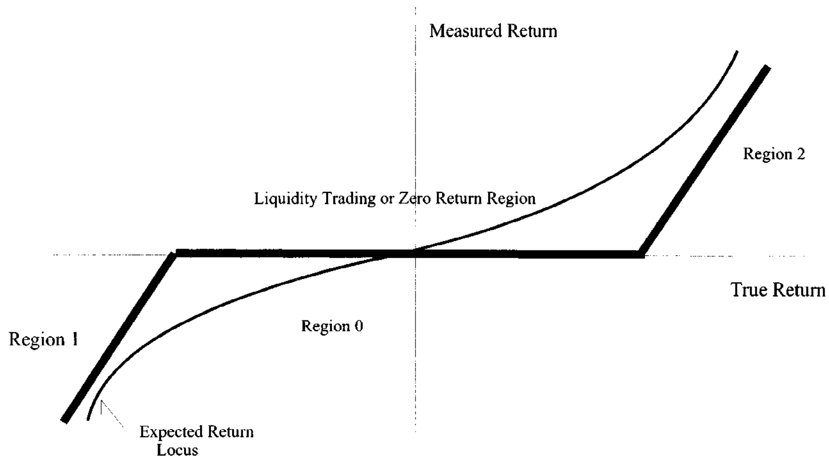

Figure 2
LDV model specification, econometric structure, and nomenclature
Measured (CRSP) return versus "true" return. The expected return locus refers to the ex ante measured return that investors would price given the market return.

once the transaction cost threshold is exceeded, with the true return acting as the asymptote.

The LDV model of the relation between measured returns, R_{jt}, and true returns, R^*_{jt}, is given as

$$R^*_{jt} = \beta_j R_{mt} + \epsilon_{jt}, \tag{1}$$

where

$$\begin{array}{lll} R_{jt} = R^*_{jt} - \alpha_{1j} & \text{if} & R^*_{jt} < \alpha_{1j} \\ R_{jt} = 0 & \text{if} & \alpha_{1j} < R^*_{jt} < \alpha_{2j} \\ R_{jt} = R^*_{jt} - \alpha_{2j} & \text{if} & R^*_{jt} > \alpha_{2j}. \end{array}$$

For firm j, the *threshold* for trades on negative information is α_{1j} and for trades on positive information is α_{2j}. If $\alpha_{1j} < \beta_j R_{mt} + \epsilon_{jt} < \alpha_{2j}$, the measured return on the security will be zero. Thus the marginal investor will make trading decisions on the basis of the observable contemporaneous marketwide information and all "other" information. The "other" information may contain accumulated past marketwide and firm-specific information that has not yet been incorporated into the price. We assume that all information not contained in the contemporaneous market return is captured by the residual term.[8]

[8] This assumption follows Kyle's (1985) model, in which the informed investor's information set "consists of his private information . . . as well as past prices" (p. 1315). Also, Glosten and Milgrom's (1985) Proposition 4 posits that the private information of the informed investor will gradually be incorporated

The resulting likelihood function of the econometric structure of Equation (1) has three components for the measured return: one for decreases, one for increases, and one for zeros.

$$L = \prod_{t \in R_1} \frac{1}{\sigma_j} \phi_1(\zeta_t) \prod_{t \in R_2} \frac{1}{\sigma_j} \phi_2(\zeta_t) \prod_{t \in R_0} \Pr(\text{no change})_t, \qquad (2)$$

where R_1 and R_2 denote the regions where the measured return, R_{jt}, is nonzero in negative and positive market return regions, respectively. R_0 denotes the zero returns. The terms ϕ_1 and ϕ_2 refer to standard normal density functions for decreases and increases in the measured return, respectively. These are the standardized residuals evaluated at $\zeta = \epsilon/\sigma$, where σ^2 is the variance estimate using only the nonzero measured returns. $\Pr(\text{no change})_t$ is the probability of a zero return. Replacing terms of Equation (2) results in

$$\begin{aligned} L(\alpha_{1j}, \alpha_{2j}, \beta_j, \sigma_j \mid R_{jt}, R_{mt}) \\ = \prod_1 \frac{1}{\sigma_j} \phi \left[\frac{R_{jt} + \alpha_{1j} - \beta_j \cdot R_{mt}}{\sigma_j} \right] \\ \times \prod_0 \left[\Phi_2 \left(\frac{\alpha_{2j} - \beta_j \cdot R_{mt}}{\sigma_j} \right) - \Phi_1 \left(\frac{\alpha_{1j} - \beta_j \cdot R_{mt}}{\sigma_j} \right) \right] \\ \times \prod_2 \frac{1}{\sigma_j} \phi \left[\frac{R_{jt} + \alpha_{2j} - \beta_j \cdot R_{mt}}{\sigma_j} \right], \qquad (3) \end{aligned}$$

where $\Phi(\cdot)$ is the distribution function of the standard normal distribution. The first and last terms correspond to nonzero measured returns in negative and positive market return regions, respectively. The second term represents the region of zero returns. The logarithm of the likelihood function in Equation (3) is

$$\begin{aligned} \ln L = & \sum_1 \ln \frac{1}{(2\pi \sigma_j^2)^{1/2}} - \sum_1 \frac{1}{2\sigma_j^2} (R_{jt} + \alpha_{1j} - \beta_j \cdot R_{mt})^2 \\ & + \sum_2 \ln \frac{1}{(2\pi \sigma_j^2)^{1/2}} - \sum_2 \frac{1}{2\sigma_j^2} (R_{jt} + \alpha_{2j} - \beta_j \cdot R_{mt})^2 \\ & + \sum_0 \ln(\Phi_{j2} - \Phi_{j1}). \qquad (4) \end{aligned}$$

The parameters α_{1j}, α_{2j}, β_j, and σ_j are solved by maximizing the likelihood function expressed in Equation (4).[9]

into the price through a sequence of trades. This implies that, for any given trade, the informed trader assesses the extent to which the current price does not yet reflect past information. A potentially useful extension to this model is serially dependent error terms to better capture the effect of past information.

[9] The derivation is more completely outlined in Maddala (1983) and Lesmond (1995).

For our purpose, the critical parameters of the LDV model are the intercept terms, α_{2j} and α_{1j}, which are the proportional transaction costs for buying and selling, respectively. The difference, $\alpha_{2j} - \alpha_{1j}$, is a measure of the proportional round-trip transaction costs for the competitive, marginal investor. The threshold parameters, α_{2j} and α_{1j}, provide a basis to judge whether, on average, the benefits to trading exceed the costs. This does not assume that all price movements that exceed the α_2 threshold are buyer initiated or all price movements that exceed the α_1 threshold are seller initiated. We assume the value of information relative to the transaction costs is what causes price movements. It is plausible that the market maker may possess the most valuable information and will adjust the quotes even if there are no buyers or sellers initiating the trade. With external buyers or sellers initiating the trade, the source of the trade may be liquidity traders, who sell into a rising market or buy into a falling market, or informed traders, who trade because the information value exceeds transaction costs. As a result, we cannot determine the source of the trade, but we can determine if the average "true" returns exceed transaction costs. The maintained hypothesis is that the marginal, informed investor will rationally trade only if the value of the accumulated information exceeds the transaction costs. This assumption allows us to interpret the lower limit as the seller's transaction costs and the upper limit as the buyer's transaction costs. Our testable hypothesis is that $\alpha_{2j} - \alpha_{1j}$ is a measure of the total round-trip transaction costs associated with security j.

3. Data

Data for this study are taken from the CRSP NYSE/AMEX daily master file for the 28-year period 1963–1990. Firms are included in this study for a calendar year if the security was listed on the exchange for the entire year.[10] Unless otherwise stated, we use the CRSP assignment for firm size deciles. These firms are sorted into NYSE/AMEX size deciles according to the total market value of the firm's equity at the end of the previous year. If the previous year's ranking is unavailable, the current year's ranking is used. For separate NYSE size decile classifications, we rank order only NYSE firms using the previous year's equity market value. In addition, we take returns on the CRSP equally weighted index of NYSE/AMEX securities for use in the LDV model.

We use two additional datasets in the analysis. The first set consists of daily closing bid and ask quotes for all NYSE/AMEX securities for the 3-year period 1988–1990, obtained from the Institute for Study of Security

[10] The LDV model requires at least 25 daily security returns for an annual trading period (252 days) for numerical convergence. We delete all missing returns, that is, those less than −1.0 from the estimation process.

Markets (ISSM).[11] The second set includes the estimates of proportional spreads for NYSE securities for the period 1963–1979 that Stoll and Whaley (1983) used in their study. The proportional spread represents the compensation for the dealer on a turnaround transaction (buy and sell) and were collected for each NYSE security for the last trading day of each year from the Fitch database.[12] The commission rates are calculated from the minimum commission rate schedule available in the various issues of the NYSE fact book from 1963 to 1974. Subsequent to 1974, the minimum commission schedule from 1974 is assumed to apply.

4. Empirical Tests on the Frequency of Zero Returns

Table 1 presents tests of the relation between the relative frequency of zero returns and transaction costs using size as an inverse proxy for transaction costs. This is based on evidence that transaction costs are inversely related to the size of the firm [Demsetz (1968), Benston and Hagerman (1974), Copeland and Galai (1983), Stoll and Whaley (1983), Roll (1984)]. We separate firms into size deciles and calculate the proportion of each firm's daily returns for the ensuing year that are equal to zero. Then we calculate the overall proportion of zero returns for all firms in each decile. The results are shown for the period 1963–1990 in panel A of Table 1.

The evidence is consistent with a transaction cost effect on security returns. The proportions of zero returns are inversely related to firm size, and the relationship is monotonic. On average, firms in the smallest size decile experience 36.6% zero returns for an annual trading period. Firms in the largest size decile experience, on average, 11.9% zero daily returns. It is worth pointing out that some of these large decile firms have a substantial number (49%) of zero returns. Given that zero returns are indicative of transaction costs, some large capitalized firms have substantial transaction costs.

We use Roll's (1984) measure of the "effective" bid-ask spread as a second proxy for transaction costs. This measure, $2\sqrt{-\text{cov}}$, is estimated using the first-order autocovariance of security returns. Roll shows that as trade prices bounce between bid and ask quotes, a negative return autocovariance is induced. The magnitude of the autocovariance depends on both the size of the spread and the probability that investors trade with the specialist at the bid or ask quotes, as opposed to trading with others at intermediate prices. Thus Roll's statistic is a measure of the "effective" spread [Stoll (1989)]. A problem using Roll's measure is that the sam-

[11] Although (opening and) closing spreads tend to be slightly higher than midday spreads [Wood, McInish, and Ord (1985)], the difference does not appear to be large enough to compromise the analysis.

[12] We thank Hans Stoll for providing the spread data.

Table 1
Average Proportions of Zero Returns, Specialists' Spreads, and Roll Model Estimates by Firm Size

Panel A: Period 1963–1990

Size decile	Firm-years	Proportion of zero daily returns (%)	Maximum proportion of zero daily returns (%)	Roll's spread (%)
1	5928	36.6	84.5	4.34
2	5867	31.1	77.4	2.88
3	5806	27.8	69.8	1.67
4	5875	25.0	82.5	1.31
5	5851	22.6	67.1	1.16
6	5938	20.2	76.9	0.76
7	6005	18.6	78.6	0.56
8	6173	16.7	69.9	0.52
9	6368	14.6	65.1	0.34
10	6540	11.9	49.2	0.31

Panel B: Period 1988–1990

Size decile	Firm-years	Proportion of zero daily returns (%)	specialists' spread (%)	Roll's spread (%)	Roll's Spread ÷ specialists' spread (%)
1	521	43.7	10.05	5.25	52.24
2	537	36.8	5.03	2.68	53.28
3	533	33.4	3.48	1.76	50.58
4	511	30.8	2.61	1.21	46.36
5	520	27.6	2.20	1.02	46.36
6	508	25.7	1.72	0.68	39.54
7	523	21.7	1.45	0.56	38.62
8	606	19.7	1.14	0.48	42.11
9	581	16.0	0.87	0.35	40.23
10	520	11.8	0.60	0.36	60.00

The results are based on a year-by-year analysis of daily returns for NYSE/AMEX stocks for the period 1963–1990 (panel A) and the period 1988–1990 (panel B). The size decile ranking is taken from CRSP with size deciles 1 and 10 corresponding to the smallest and largest firms, respectively. For each firm and year the proportion of daily returns equal to zero is calculated and the average of these proportions is computed for stocks in each size decile. These zero returns are scaled by the total number of available trading days to determine the proportion of zero returns. Roll's spread is defined as $2\sqrt{-\text{cov}}$, where cov is the first-order serial autocovariance of daily security returns. Roll's "effective" spread is estimated using the serial autocovariance of returns based on data for a full year. The given Roll's spread measure forces all positive serial autocovariance measures negative as outlined in Harris (1990). The specialists' spread of panel B is the average of each day's closing bid and ask quotes, defined as $\frac{(Ask-Bid)}{(Ask+Bid)/2}$ over an annual trading period. Firm-years refers to the number of observations for the proportions of zero daily returns, specialists' spreads, and Roll's estimate.

ple autocovariance (which we calculate for each security using a full year of returns) is frequently positive, rendering the estimate incalculable. To overcome this problem, we adopt the approach of Harris (1990), converting all positive autocovariances to negative. The averages of Roll's estimates are shown in the final column of panel A. As expected, average effective spreads are inversely related to firm size, ranging from 0.31% for firms in the largest size decile to 4.34% for firms in the smallest size decile.

Our third proxy for transaction costs is the specialist bid-ask spread. We calculate the average proportion of zero returns and the average annual spread for individual NYSE/AMEX firms for the 3-year period 1988–1990. The results, sorted by firm size, are shown in panel B. Also reported in panel B are the average values of Roll's spread estimates for each size decile, as well as the average ratio of Roll's spread to the corresponding specialists spread. The proportions of zero returns are inversely related to firm size. The average specialist spreads are also inversely related to firm size, ranging from 0.60% for the largest firms to 10.05% for the smallest firms. Note that for all size deciles, Roll's estimates are approximately half as large as the quoted spreads. These results are consistent with those of Harris (1990) as well as Petersen and Fialkowski (1994).

We test the association between the frequency of zero returns and transaction costs by regressing the zero return proportions on specialist spreads for firms in each size decile. The results are displayed in Table 2 using data for the period 1988–1990. In all of the regressions, the spread coefficient is positive and highly significant for each size decile. The R^2 statistic is significant, rising from 15% for the smallest size decile of firms to almost 40% for the largest. These results suggest that the proportion of zero returns is a useful proxy for transaction costs.

Our count of the number of zero returns relies on the CRSP record of zero returns. This count of the zero returns understates the "true" number of zero returns because CRSP will report a nonzero return for a zero volume day (when the prior day's volume was nonzero) because the recorded closing price is the midpoint of the bid-ask spread. In addition, Conrad, Kaul, and Nimalendran (1991) note that movements between the bid-ask quotes produce a nonzero security return due to the bid-ask bounce when the "true" return is zero. We call the number of zero returns that would have resulted without these two influences the *effective* number of zero returns. Table A of Appendix A presents the analysis for the period 1988–1990.[13]

As shown in Table A, the (CRSP provided) observed number of zero returns (column 9) and the *effective* number of zero returns (last column) are closely related. For instance, the proportion of observed zero returns for the smallest size decile of firms is 43.7%, while the *effective* proportion of zero returns is 54.1%. For the firms in the largest decile, the observed proportion of zero returns is 11.8%, while the *effective* proportion of zero returns is 13.62%. Given the difficulty in obtaining bid-ask spreads for all time periods (1963–1990), these results show that using the CRSP closing daily returns provides an accurate indicator of the number of zero returns.

[13] We wish to thank Joseph Ogden, in part, for this one contribution to the article.

Table 2
Results of Regressions of Zero Returns on Specialists' Spread

Size decile	Firm-years	*Intercept* $\hat{\zeta}_1$	*Spread* $\hat{\zeta}_2$	$\% R^2$
1	520	0.3912**	0.4565**	15.12
		(0.0069)	(0.0471)	
2	536	0.3070**	1.2117**	24.96
		(0.0068)	(0.0912)	
3	532	0.2677**	1.8814**	30.10
		(0.0057)	(0.0134)	
4	510	0.2286**	3.0530**	34.97
		(0.0066)	(0.2038)	
5	519	0.2034**	3.3149**	29.93
		(0.0064)	(0.2490)	
6	507	0.1790**	4.4968**	24.81
		(0.0074)	(0.3856)	
7	521	0.1421**	5.1814**	27.76
		(0.0064)	(0.3667)	
8	605	0.1064**	7.8761**	27.80
		(0.0063)	(0.5167)	
9	580	0.0635**	11.1471**	25.71
		(0.0071)	(0.7876)	
10	519	0.0285**	14.8578**	30.76
		(0.0074)	(0.9791)	
Aggregate	5359	0.2093**	1.9454**	37.50
		(0.0011)	(0.0341)	

** Significant at the 1% level.
Regressions of the proportion of zero returns on the average proportional specialist spread. The results are based on the aggregate as well as size decile rankings of all NYSE/AMEX firms for the period 1988–1990. The specialist's spreads are based on closing bid and ask quotes obtained from ISSM. Firms are analyzed on a daily basis from January to December to obtain the proportion of zero returns (*Propzero*) and the average proportional spread (*Spread*). *Spread* is the average daily proportional spread, defined as $\frac{(Ask-Bid)}{(Ask+Bid)/2}$. The size decile ranking is taken from CRSP with size deciles 1 and 10 corresponding to the smallest and largest firms, respectively. Any firm-year that had a zero market capitalization or either began or ceased trading midyear was deleted. The regression equation is $Propzero_{jf} = \zeta_1 + \zeta_2\, Spread_{jf} + \epsilon_{jf}$, where j and f are size decile and firm-year indicators, respectively. Standard errors are in parentheses.

5. LDV Empirical Estimates of Transaction Costs

5.1 LDV Estimates of Transaction Costs

We use the LDV model, developed in Section 2, to estimate transaction costs for NYSE and AMEX firms for the period 1963–1990. Panel A of Table 3 shows the average costs of sell trades, α_{1j}, buy trades, α_{2j}, and the round-trip transaction costs, $\alpha_{2j} - \alpha_{1j}$. All results are shown for firms sorted by NYSE/AMEX size deciles.

As expected, the average values of the estimates of α_{1j} and α_{2j} are negative and positive, respectively. The average round-trip transaction cost

Table 3
Average Values of LDV Model Estimates for NYSE/AMEX Stocks

Panel A: NYSE/AMEX firms combined

Size decile	Firm-years	$\hat{\alpha}_1$ (%)	$\hat{\alpha}_2$ (%)	$\hat{\alpha}_2 - \hat{\alpha}_1$ (%)	$t(\hat{\alpha}_2 - \hat{\alpha}_1)$
1	4365	−5.34	4.31	10.35	28.3
2	5911	−3.68	3.41	7.09	24.6
3	5888	−2.92	2.67	5.59	25.7
4	5945	−2.35	2.14	4.49	30.1
5	5963	−1.97	1.86	3.83	29.9
6	6074	−1.65	1.54	3.19	32.6
7	6118	−1.43	1.33	2.76	31.2
8	6256	−1.19	1.09	2.28	35.6
9	6191	−0.97	0.87	1.84	33.1
10	5356	−0.73	0.50	1.23	27.7

Panel B: NYSE and AMEX firms separated

NYSE/AMEX size decile	firm years	Only AMEX $\hat{\alpha}_2 - \hat{\alpha}_1$ (%)	Firm years	Only NYSE $\hat{\alpha}_2 - \hat{\alpha}_1$ (%)	NYSE size decile	firm years	NYSE $\hat{\alpha}_2 - \hat{\alpha}_1$ (%)
1	4076	10.26	289	15.91	1	3656	6.97
2	5101	6.94	810	8.58	2	3881	4.12
3	4076	5.56	1812	5.78	3	3885	3.45
4	2996	4.67	2949	4.41	4	3847	3.02
5	1999	4.06	3964	3.73	5	3808	2.69
6	1299	3.57	4775	3.11	6	3781	2.43
7	864	3.21	5254	2.71	7	3732	2.15
8	547	2.81	5709	2.28	8	3637	1.91
9	329	2.35	5862	1.90	9	3481	1.70
10	156	1.94	5200	1.55	10	2916	1.46

The results are based on a year-by-year analysis of firm data for NYSE/AMEX stocks for the period 1963–1990. The size decile ranking is taken from CRSP with size deciles 1 and 10 corresponding to the smallest and largest firms, respectively, for combined and separated NYSE/AMEX firms of panels A and B. Panel B also uses a NYSE firm grouping that relies on only NYSE firms that are sorted into decile rankings for each year from 1963–1990. The LDV model intercept estimates, $\hat{\alpha}_1$ and $\hat{\alpha}_2$, are based on a full year of data, regressing stock returns on the equally weighted market index. If a firm began or ceased trading during the year that firm was deleted for that year.

estimates, $\alpha_{2j} - \alpha_{1j}$, are significant for every size decile.[14] Furthermore, as firm size increases, the sell, buy, and round trip transaction costs all decrease, as expected.

The average values of $\alpha_{2j} - \alpha_{1j}$ for the firms in the largest size decile are 1.23% and 10.35% for firms in the smallest size decile. Note that for each size decile the absolute, average value of α_{1j} is very close to, but tends to slightly exceed, the corresponding average value of α_{2j}, indicating that transaction costs are slightly greater for selling than for buying.[15] These results are consistent with those of Berkowitz, Logue, and Noser (1988) and Huang and Stoll (1994), who also find that transaction costs are greater for selling than for buying.

[14] We also used the equally weighted portfolio of all firms with a size decile as a benchmark for firms in the decile. The results were identical. We also ran the model using the *effective* number of zero returns of Appendix A. The LDV estimates were slightly increased for small firm deciles and virtually identical for larger firm deciles.

[15] For all size deciles, the t-statistic of the difference in $\alpha_{2j} - \alpha_{1j}$ is highly significant.

Since most empirical studies focus only on NYSE firms [e.g., Stoll and Whaley (1983) and Bhardwaj and Brooks (1992)], we separately examine the LDV transaction cost estimates for firms listed on the NYSE exchange or AMEX exchange. AMEX firms are generally smaller than NYSE firms and we expect that AMEX firms will have greater transaction costs compared to NYSE firms. The results are displayed in panel B of Table 3.

The firm-year totals for the firms listed on the AMEX and NYSE exchanges are shown in columns 2 and 4, respectively. These totals reflect the prevalence of relatively smaller firms listed on the AMEX exchange than on the NYSE exchange. For both exchanges, the average values of $\alpha_{2j} - \alpha_{1j}$ are again inversely related to firm size. But contrary to our prior expectations, smaller AMEX listed firms, size deciles 1–3, demonstrate lower LDV transaction cost estimates than NYSE listed firms. Our prior suppositions are supported for larger firms, size deciles 4–10, that demonstrate smaller transaction costs for NYSE securities than AMEX securities. These transaction cost differences are driven primarily by share price. The small size decile NYSE listed firms have lower share prices, but more shares outstanding, than the comparison AMEX listed firms. Firm size computed as market capitalization camouflages the price difference and the resulting transaction cost comparison.[16] Using firm size for different exchange listed firms, without regard for share price, represents a potentially flawed transaction cost proxy.

A finer means of examining the total round-trip transaction costs, $\alpha_{2j} - \alpha_{1j}$, for only NYSE firms is done by sorting against other NYSE firms. The results are shown in the right-most columns of panel B. Again, the average values of $\alpha_{2j} - a_{1j}$ are inversely related to firm size, ranging from 1.46% to 6.97% for the largest and smallest firms, respectively. For each size decile, the transaction cost estimates based on NYSE firms only are much smaller than the estimates obtained for both NYSE/AMEX firms. This is due to the relatively larger size of NYSE firms as compared to combined NYSE/AMEX firms.

5.2 Comparisons of LDV Estimates with Spread-Plus-Commission Estimates

In this section we compard the LDV transaction cost estimates to the commonly used S+C used by Stoll and Whaley (1983) and Bhardwaj and Brooks (1992). These comparisons serve several purposes. First, we can determine if the LDV estimates of transaction costs are correlated with the commonly used S+C estimates. Second, given that most trades occur within the quoted

[16] This is confirmed by segmenting the sample by share price deciles, with ranges of $1.00 per share up to $5.00 per share, and price quintiles, with ranges of $5.00 per share up to $20.00 per share. The sample was unbounded for share prices greater than $30.00 per share. For share prices less than $5.00, the AMEX-only LDV transaction cost estimates were, at most, 70 basis points lower than NYSE-only firms. For share prices greater than $5.00, the LDV transaction cost estimates for NYSE-only firms were, at most, 75 basis points lower than AMEX-only firms.

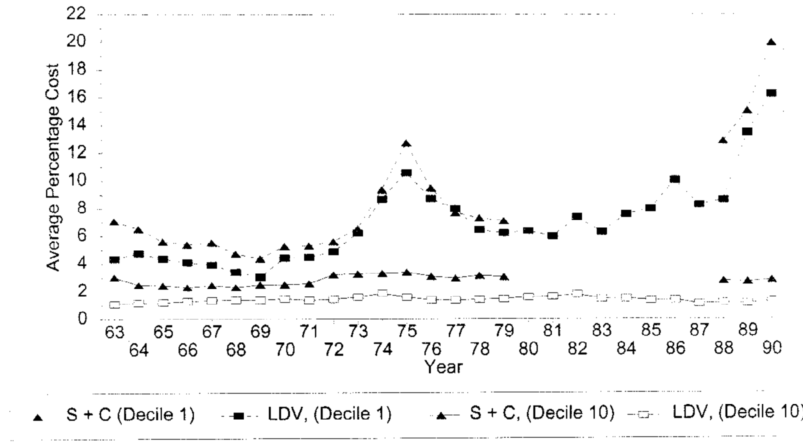

Figure 3
Transaction cost comparisons, LDV estimates, spreads and commissions
Mean percentage estimated transaction cost rates, using three measures, for selected size decile sorted NYSE common securities, annually from 1963–1990. The first measure is the limited dependent variable (LDV) estimate calculated from 1963–1990, the second is the sum of the average proportional bid-ask spreads and round-trip commission rates (S + C) calculated from 1963–1979, and the third is the proportional bid-ask spreads and round-trip commission rates (S + C) calculated from 1988 to 1990. Firms are sorted annually into deciles by total market value of common NYSE equity and the figure shows results for firms in decile 1 (smallest) and decile 10 (largest).

spread [Roll (1984) and Petersen and Fialkowski (1994)], the S + C may generally overstate the direct transaction costs facing the marginal investor. The LDV estimates of transaction costs suggest to what degree the S + C estimates overstate the transaction costs for the marginal investor. We begin with a comparison of Stoll and Whaley's (1983) estimates and conclude with Bhardwaj and Brooks' (1992) estimates.

The proportional spreads, obtained from Stoll and Whaley, include only NYSE securities and cover the period from 1963–1979. The commission is calculated in the same manner as Stoll and Whaley (1983). We use the (fixed) minimum-commission schedules provided in various issues of the NYSE Fact Book. We doubled each estimate of the commission to represent a round-trip commission cost and added it to the proportional spread. Firms were then sorted each year into size deciles using only other NYSE firms.

The graphical comparison of the time series for LDV estimates for the smallest (decile 1) and largest firms (decile 10) is shown in Figure 3. The Stoll and Whaley (1983) S + C are restricted to the period 1963–1979, while the LDV estimates are shown for the entire period 1963–1990. For comparison with the LDV estimates for the period 1988–1990, we use the ISSM data for the spread and use a price-based commission schedule as provided by Scott (1983).

The most striking aspect of the results is the close correspondence of these estimates over time, especially for the smallest firms. For firms in size deciles 1 and 10, the correlation of the yearly values of the Stoll and Whaley (1983) and ISSM-based S + C with the LDV estimates is 85% (significant at the 1% level). For size decile 1 firms, both estimates rose and then fell considerably in the mid-1970s, a period that corresponds with the switch from a flat (only price dependent) commission rate to a commission rate predicated on both the share price and the number of shares traded. An additional source of pressure on trading costs for the period 1973–1974, as reported in the NYSE Fact Book, was a drop in the average share price from \$33.80 to \$26.20. Share prices prior to 1973 were approximately \$40.00. In particular, for size decile 1 firms, the average price fell from \$13.68 in 1970 to \$2.55 in 1975. Average share prices subsequent to 1975 rose from \$2.55 to \$6.95 in 1979. The dramatic rise in transaction costs from 1972 to 1975 for firms in the smallest size decile appears to be principally due to decreasing share prices.[17] A similar effect is also noted for the transaction costs for the period 1988–1990. Average prices for all NYSE small decile shares was \$5.25 in 1988 and then fell to \$2.34 in 1990. Subsequent to 1990, average share prices fluctuated from \$2.34 to as low as \$2.10.

Numerical results for the period 1963–1979 are provided in panel A of Table 4. Table 4 shows the average values of the LDV estimates and S + C estimates for firms in each size decile. Note that for all firms the average LDV estimates are considerably smaller than the corresponding S + C estimates. The t-statistics shown in the last column of the panel indicate that the differences between these estimates are all highly significant. These results suggest that typical S + C estimates generally overestimate the effective transaction costs for NYSE firms. The S + C estimate acts as an upper bound for the total effective transaction costs facing the marginal trader. Peterson and Fialkowski (1994) document a similar result when using the quoted spread versus the effective spread.

Panel B of Table 4 shows regression test results, for firms in each size decile, measuring the association between the LDV estimates and corresponding estimates of the bid-ask spread and commission costs. In all regressions the coefficients of both spread and commission are positive and significant at the 1% level, indicating that LDV estimates are significantly associated with both the spread and commission costs. The adjusted R^2 statistics fall with firm size. The R^2 statistics for the smallest size decile are 78.31% and decrease to 31.56% for the largest firm decile.[18] The reduction

[17] A more technical reason for the increase in the transaction costs for this period was increased pressure on computer facilities due to rising volume facing the NYSE. These pressures were alleviated with the development of a high-speed market data transmission line in January 1976 and the Designated Order Turnaround (DOT) System in March 1976.

[18] Regression tests were also run using 1/price as an additional independent variable. The R^2 statistics increased for all size deciles ranging from 81.13% for the small firm size deciles to 35.70% for the large

of the R^2 statistic with firm size is generally consistent with Petersen and Fialkowski (1994) who find that the ratio of the effective spread to the quoted spread (based only on the market value of equity for NYSE listed firms) is more than 83% for small NYSE firms and only 57% for large NYSE firms. Market orders for large firms appear to have many more trades within the spread than do market orders for small firms. This finding is exhibited in the regression results of panel B of Table 4. The quoted spread is a better proxy of the effective spread for smaller firms than for larger firms and consequently our R^2 statistic is higher for smaller firms than for larger firms.

Within each size decile the coefficient for the spread is approximately 0.5, which is consistent with Roll's (1984) effective spread estimate, and is due to the large number of trades that are executed within the quoted spread irrespective of size decile. The spread coefficient ranges from 57.65% (standard error of 2.71%) for size decile 1 firms to 51.48% (standard error of 3.13%) for size decile 10 firms. This can be compared to a coefficient of 63.26% (standard error of 2.88%) and 69.33% (standard error of 3.07%) for firms in size deciles 4 and 7, respectively. Of interest, Petersen and Fialkowski (1994) report that the mean ratio of the effective spread to the posted spread for both retail and TORQ-supplied market orders is roughly 55%, which is comparable to our results.

The coefficient for the commission cost component is much more variable with firm size than the spread coefficient. For the smallest firms, the coefficient is 162.75% (standard error of 4.33%), while for the largest firms the coefficient is 34.02% (standard error of 1.92%). The patterns of the commission coefficient suggest that commission costs were a larger portion of the cost of transacting for small firms than large firms. The commission schedule for large firms may be discounted for institutional traders who concentrate their trading efforts in larger firms. The large and significant intercept suggests that for smaller firms other excluded explanatory variables, such as price impacts and opportunity costs, have a larger influence on the regression results than for larger firms.

Berkowitz, Logue, and Noser (1988) find that for the largest 100 securities in 1985, commissions actually paid to brokers were only \$0.07 per share. The regression results in Table 4 for the large firm size decile appear to show that commission costs are a smaller portion of the transaction costs than the (effective) spread. For small firms the price impact of trades is much greater, and these effects are loaded into both the commission (which is principally price based) and the intercept.

Finally, Table 5 provides a comparison of LDV and S + C estimates for NYSE securities sorted by price for the periods 1982–1986 and 1988–1990.

firm size deciles. The regression's spread coefficient remained of the same sign, slightly reduced, and significant at the 1% level. The commission coefficient was reduced by a factor of five, but had the same sign and was significant at the 1% level for all but the smallest firm size decile.

Table 4
Spread-plus-Commission and LDV Transaction Costs Comparisons, 1963–1979

Panel A: Comparisons of Spread-plus-Commission and LDV Estimates of Total Transaction Costs

NYSE size decile	Mean (%) spread (S)	Mean (%) round-trip commission (C)	Mean (%) S + C	Mean (%) $\alpha_2 - \alpha_1$ LDV estimate	Difference t-statistic
1	3.23	3.66	6.89	5.82	33.14
2	2.23	3.01	5.24	4.02	46.31
3	1.85	2.78	4.64	3.34	44.19
4	1.62	2.65	4.28	2.95	61.45
5	1.45	2.54	3.98	2.64	71.52
6	1.29	2.44	3.73	2.35	73.80
7	1.16	2.33	3.50	2.12	58.54
8	1.02	2.29	3.31	1.87	69.49
9	0.90	2.23	3.12	1.69	59.97
10	0.76	2.10	2.86	1.43	70.97

Overall correlation: 85%

Panel B: Regressions of LDV Estimates of Transaction Costs on the Specialists' Spread and Commission Estimates

Size decile	Firm-years	*Intercept* $\hat{\zeta}_1$	*Spread* $\hat{\zeta}_2$	*Commission* $\hat{\zeta}_3$	$\%R^2$
1	1980	−2.0013**	0.5765**	1.6275**	78.31
		(0.1162)	(0.0271)	(0.0433)	
2	2090	−2.2252**	0.5773**	1.6442**	70.61
		(0.1089)	(0.0251)	(0.0453)	
3	2125	−2.2087**	0.5079**	1.6549**	62.39
		(0.1157)	(0.0279)	(0.0478)	
4	2121	−2.0731**	0.6326**	1.5061**	62.42
		(0.1064)	(0.0287)	(0.0467)	
5	2129	−1.7168**	0.4256**	1.4706**	52.56
		(0.1050)	(0.0232)	(0.0444)	
6	2124	−0.9610**	0.5837**	1.0501**	49.31
		(0.0874)	(0.0269)	(0.0385)	
7	2116	−0.4779**	0.6933**	0.7676**	44.74
		(0.0740)	(0.0307)	(0.0337)	
8	2076	−0.1682**	0.5295**	0.6515**	36.58
		(0.0655)	(0.0287)	(0.0291)	
9	1995	0.1076*	0.5287**	0.5015**	32.94
		(0.0543)	(0.0314)	(0.0240)	
10	1614	0.3487**	0.5148**	0.3402**	31.56
		(0.0427)	(0.0313)	(0.0192)	
Aggregate	20370	−1.2546**	0.6131**	1.0645**	80.85
		(0.0192)	(0.0088)	(0.0091)	

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

Panel A shows mean percentage spreads (S), round-trip commissions (C), and LDV estimates of transaction costs based on a year-by-year analysis of data for NYSE firms for the period 1963–1979. The size decile rankings are computed using only NYSE firms where size deciles 1 and 10 correspond to the smallest and largest NYSE firms, respectively. Shown as Stoll and Whaley's (1983) proportional spread (S) data and the NYSE stated minimum round-trip commission (C) expressed in percentages for each size decile. The mean percentage spread are a point estimate taken at December 31 of each year from 1963–1979. It should be noted that in Stoll and Whaley's (1983) article they present one-half of the round-trip commission, whereas we present the full round-trip commission. The LDV model estimates, $\alpha_2 - \alpha_1$, are based on a full year of data, regressing stock returns on the equally weighted market index. The t-statistic of panel A is from a means test for the difference between spread (S) plus round-trip commissions (C) and the LDV transaction costs estimates for each size decile. The regressions of panel B for each size decile are stated as $\alpha_{2f} - \alpha_{1f} = \zeta_1 + \zeta_2\, Spread_{jf} + \zeta_3\, Commission + \epsilon_{jf}$.

Table 5
Spread-plus-Commission and LDV Transaction Costs Comparisons, 1982–1990 and 1988–1990

Price range group	Median (%) spread (S)	Median (%) round-trip commission(C)	Median (%) S + C	Median (%) $\alpha_2 - \alpha_1$
Panel A: Period 1982–1986 Comparisons of Spread-plus-Commission and LDV Estimates of Total Transaction Costs				
$P \leq \$5$	5.128	7.407	12.535	10.121
$\$5 < P \leq \$10$	2.548	2.674	5.222	4.809
$\$10 < P \leq \$15$	1.827	2.917	4.744	3.311
$\$15 < P \leq \$20$	1.389	2.027	3.416	2.623
$\$20 > P$	0.806	1.289	2.095	1.789
Panel B: Period 1988–1990 Comparisons of Spread-plus-Commission and LDV Estimates of Total Transaction Costs				
$P \leq \$5$	6.441	7.407	13.848	12.056
$\$5 < P \leq \$10$	2.299	2.674	4.973	4.404
$\$10 < P \leq \$15$	1.603	2.917	4.520	3.006
$\$15 < P \leq \$20$	1.278	2.027	3.305	2.330
$\$20 > P$	0.724	1.289	2.013	1.522

Panel A shows median percentage spreads (S), commissions (C) as given by Bhardwaj and Brooks (1992) for five price groupings and 20 NYSE firms for the period 1982–1986. Median values, as opposed to means, are given as the distributions are skewed. The commissions stated are round-trip commission costs (C). The LDV model estimates of total transaction costs, $\alpha_2 - \alpha_1$, are based on a full year of data, and are determined by regressing stock returns on the equally weighted market index. Panel B shows the period 1988–1990 where the Bhardwaj and Brooks (1992) commission schedule from 1982–1986 is used along with NYSE spread data from the period 1988–1990 to determine the spread plus round-trip commission cost.

We use the same price categories as Bhardwaj and Brooks (1992). For the 1982–1986 period, we use their estimates of the median specialist spread and round-trip commission for each price category. Panel A of the table shows the price ranges for 1982–1986, including the sum of the median spread and commission costs. These total transaction costs are inversely related to price, ranging from 12.53% for securities priced at less than $5 to 2.09% for securities priced greater than $20. The last column of panel A shows the average values of the LDV estimates of transaction costs for firms in the indicated price range. The average LDV costs are also inversely related to price level, ranging from 10.12% for the lowest priced firms to 1.78% for the highest priced firms. For every price range the average LDV estimate is smaller than the corresponding S + C estimates. These results are similar to those reported for the Stoll and Whaley (1983) comparisons based on size decile rankings.

Similar results are obtained in panel B, where the analysis is extended to the 1988–1990 period. Here we calculate the median specialist spread for all NYSE firms in each price category, and again use Bhardwaj and Brooks' (1992) estimates of the median round-trip commission cost. As found in panel A, for each price category, the sum of the median estimates of spread and commission for this period is greater than the median LDV estimate.

In summary, we find that the LDV estimates of transaction costs closely correspond to the S + C estimates over time and cross-sectionally. Although the LDV estimates tend to be smaller than the S + Cs, they are highly correlated. Researchers and traders who use the S + C estimate of transaction costs should therefore consider the possibility that they are overestimating the effective transaction costs facing the marginal investor.

5.3 Comparisons of LDV Estimates with Specialists' Spread

The association between the LDV estimates of $\alpha_{2j} - \alpha_{1j}$ and the average specialist proportional bid-ask spread is tested by regressing the LDV estimates of transaction costs for all NYSE/AMEX securities on the average specialist proportional bid-ask spread. These tests cover the period 1988–1990 for which we have complete daily spread data. We run separate regressions for the observations in each NYSE/AMEX size decile, as well as an aggregate regression that uses all the observations. The results are displayed in Table 6.

For every size decile, the slope coefficient of the regression is positive and significant at the 1% level. The adjusted R^2 for all regressions range from 46.46% to 91.76%. The aggregate regression also yields a highly significant positive slope coefficient and an adjusted R^2 of 88.47%. These results indicate that the LDV estimates of transaction costs are very closely related to specialist proportional bid-ask spreads. For all firm size deciles, the slope coefficient is reliably greater than 1 (though never greater than 2.3). Similar results are obtained from the aggregate regression. These findings indicate that the LDV model is an accurate estimate of the bid-ask spread.

The regression results in Table 6 contrast sharply with those of Table 2. In both regression tests, we use NYSE/AMEX data for the period 1988–1990 with the average specialist spread as the independent variable. Thus the only difference is the dependent variable; zero returns for the Table 2 regressions, and LDV estimates for Table 6. For each size decile, the adjusted R^2 is much higher in Table 6 than in Table 2. This indicates that the LDV estimates correspond much more closely to spreads than do the proportions of zero returns. These results suggest that the LDV model extracts from the data a measure that is much more closely related to transaction costs than the simpler characteristic of zero return proportions. This is true even though both measures are related to transaction costs.[19]

[19] We also regressed Roll's (1984) estimates on specialist spreads for firms in each size decile using the data for 1988–1990. The aggregate regression had an R^2 of only 77%. In each size decile the LDV model's R^2 statistics were much higher than Roll's estimate. This was especially true for size deciles 8–10. The regression using Roll's effective spread estimate produced an R^2 that ranged from 27.1%, 3.53%, and 1.45% for size deciles 8–10, respectively.

Table 6
Results of Regressions of LDV Model Estimates on the Specialists' Spreads

Size Decile	Firm-years	*Intercept* $\hat{\zeta}_1$	*Spread* $\hat{\zeta}_2$	$\%R^2$
1	520	0.0054	1.5595**	82.15
		(0.0040)	(0.0319)	
2	536	−0.0049**	1.9097**	84.72
		(0.0023)	(0.0351)	
3	532	−0.0072**	2.0531**	91.76
		(0.0012)	(0.0267)	
4	510	−0.0020	1.9595**	83.79
		(0.0012)	(0.0382)	
5	519	0.0004	1.9589**	74.86
		(0.0013)	(0.0499)	
6	507	−0.0043**	2.1608**	82.99
		(0.0008)	(0.063)	
7	522	−0.0029**	2.2371**	78.89
		(0.0008)	(0.0507)	
8	605	−0.0028**	2.2763**	70.75
		(0.0008)	(0.0595)	
9	580	0.0040**	1.6734**	46.46
		(0.0007)	(0.0743)	
10	519	0.0053**	1.4664**	47.72
		(0.0004)	(0.0674)	
Aggregate	5359	0.0047**	1.6495**	88.47
		(0.0004)	(0.0081)	

** Significant at the 1% level.
Regression tests of $\alpha_2 - \alpha_1$ on the average proportional spread. The results are based on the aggregate as well as size decile rankings of all NYSE/AMEX firms for the period 1988–1990. The specialists' spreads are based on closing bid and ask quotes obtained from ISSM. The resulting firms are analyzed on a daily basis from January to December to obtain an average proportional spread. The proportional spread, shown as *Spread*, is the average of each day's spread, and defined as $\frac{(Ask - Bid)}{(Ask + Bid)/2}$ over an annual trading period. The size decile ranking is taken from CRSP with size deciles 1 and 10 corresponding to the smallest and largest firms, respectively. Any firm-year that had a zero market capitalization or either began or ceased trading midyear was deleted. The regressions for each size decile and in aggregate are stated as $\alpha_{2f} - \alpha_{1f} = \zeta_1 + \zeta_2\, Spread_{jf} + \epsilon_{jf}$. Standard errors are in parentheses.

6. Conclusions

In this article we develop a model to estimate transaction costs using only the time series of daily security returns for all firms listed on the NYSE and AMEX exchange over the time period 1963–1990. The model of transaction costs is based on the number of zero returns. For some of the smallest firms, more than 80% of the daily security returns are zero during a year. Even for some of the largest firms, 40% of the annual daily security returns are zero. This transaction cost-based model of security returns uses an LDV specification that endogenously estimates transaction costs through the incidence of zero returns.

The estimates of transaction costs obtained from the LDV model range from 10.3% for small firms to 1.2% for large firms. For the period 1963–

1990, these estimates have an 85% correlation coefficient with the most commonly used estimate of transaction costs, spread plus commissions. Regressions for the bid-ask spread on the LDV measure have aggregate R^2 statistics of 88%. By comparison, the Roll estimate produces R^2 statistics of only 77%. The LDV estimates tend to be smaller than the spread plus commissions. This suggests the effective trading costs encountered by the marginal trader are smaller than the quoted spread and a single commission schedule. Based on our findings, studies that use the spread plus commissions as estimates for transaction costs will overstate the effective trading costs by 15% for small firms and by as much as 50% for large firms. This extends the results of Petersen and Fialkowski (1994), who find the effective spread is smaller than the quoted spread.

This model of security returns is relatively easy to employ and the estimates of transaction costs are obtainable for any time period and firm where daily security returns are available. This is unlike bid-ask spreads which are *unobtainable* for a host of applications. The need for comprehensive and complete transaction cost estimates in international, market efficiency, and market structure analysis studies underscores the importance of this model.

Appendix A: A Closer Examination of the Behavior of Daily Returns

This appendix presents evidence that CRSP daily closing prices provides a conservative estimate of the number of zero returns. CRSP returns do not reflect all potential zero returns as a result of two situations. One is the bid-ask bounce [Conrad, Kaul, and Nimalendran (1991)]. The second is zero trading volume days.

A specialist acts as a monopolistic dealer for each security, and occasionally trades are executed with the specialist at either the bid or ask price. For constant bid and ask quotes, when closing trades occur at the bid one day and at the ask the next day, or vice versa, the recorded return for the day is nonzero. This is true even though it is likely that no value relevant information was incorporated into the price, since the specialist did not change the quote. Also, when a security does not trade for an entire trading day, there is no trade price to calculate the return on the security for that day. In such cases, CRSP uses the average of the specialist's closing bid and ask quotes in place of a trade price for the purpose of calculating the return on the security. This convention also affects the frequency of zero returns.

For a clearer picture of the zero returns, we delineate the following categories of daily returns on individual securities. The categories are created by first separating the trading days for a given security into two classes: days with positive volume and days with zero volume. Focusing initially on the days with positive volume, we identify four categories of daily returns on a security:

(1) The observed return is nonzero and successive closing bid and ask prices are different. This case is consistent with the presence of new information.

(2) The observed return is nonzero, but closing prices move from bid to ask or vice versa and successive closing bid and ask prices are unchanged. This case is consistent

with the absence of new information and evidence of a “true” return of zero [Conrad, Kaul, and Nimalendran (1991)].

(3) The observed return is zero as a result of successive closing trades at the bid price or ask price, where the bid and ask prices are unchanged. This case also indicates the absence of new information or trading between liquidity traders and the specialist.

(4) The observed return is zero, but successive closing trades are not at the bid or ask prices. This case also indicates the absence of new information and trading between liquidity traders.

Next, we consider the cases with zero volume. The three possible categories are determined by the CRSP convention noted above and the tendency of the specialist to change bid and ask quotes in response to new information even in the absence of trading:

(5) The return is nonzero and successive bid and ask prices are changed. This case indicates that the specialist changed their quotes in response to new information.

(6) The return is nonzero, but successive day’s bid and ask prices are unchanged. The nonzero return occurs because the prior day’s trading volume was nonzero and the closing price was not at the midpoint of the spread, but there was no new information. This is evidence of a “true” return of zero because there was no trading volume, the quotes were not revised, nor was there any new information.

(7) The return is zero; this case occurs only when volume on the previous day is also equal to zero, and the specialist did not change the bid and ask quotes.

We examine the frequency of cases in each of these categories using data on NYSE and AMEX securities for the period 1988–1990. As before, we sort securities into size deciles, and for securities in each decile we compute the proportion of all returns that fit into each of the seven categories listed above. The results are shown in Table A. Shown in columns 2–8 are the proportions of all returns that conform to categories (1)–(7), respectively.[20] To determine the “effective” number of zero returns we sum the columns that correspond to the measured zero returns and those returns that would be zero if we accounted for the bid-ask bounce. The proportions in categories (2), (3), and (4) correspond to the positive volume cases and categories (5) and (7) correspond to the zero volume cases. Categories (2) and (5) correspond to those cases where the measured return is nonzero, but would be zero if we accounted for the bid-ask bounce. Adding categories (2), (3), (4), (5), and (7) determines the “effective” number of zero returns.

As shown in the last column of Table A, the “effective” number of zero returns is always greater than the measured CRSP reported number of zero returns. However, the measured zero returns is a good indicator of the number of “true” zero returns. The difference between these two proportions is inversely related to firm size, ranging from 1.82% for the largest firms to 10.40% for the smallest firms. Remarkably, for the smallest firms the “effective” proportion of zero returns is greater than 50% (54.09%).

[20] To provide internal validity for the results, we verify the proportion of zero returns that we derived using the measured (CRSP provided) returns of Table 1 for the period 1988–1990. This result is contained in the second to last column of Table A and given as the absolute proportion of zero returns, which is the sum of categories (3), (4), and (7). These results are identical to those of Table 1.

Table A
Daily Security Return Behavior: Bid and Ask Quote Basis

	Categories of daily return proportions							Categories of zero return proportions	
	Positive trading volume				Zero trading volume				
Size decile	Nonzero (1) (%)	Nonzero (Zero) (2) (%)	Zero (3) (%)	Zero (4) (%)	Nonzero (5) (%)	Nonzero (Zero) (6) (%)	Zero (7) (%)	Observed proportion of zero returns (3) + (4) + (7) (%)	*Effective* proportion of zero returns (2) + (3) + (4) + (6) + (7) (%)
1	40.53	3.82	8.52	18.71	4.77	6.58	16.46	43.69	54.09
2	50.52	4.46	9.58	19.28	3.44	4.38	7.94	36.80	45.64
3	56.90	4.57	9.61	20.12	2.12	2.70	3.61	33.34	40.61
4	60.81	4.56	9.08	19.90	1.27	1.78	1.79	30.77	37.11
5	64.64	4.63	8.66	18.02	0.79	1.38	0.90	27.58	33.59
6	65.79	3.95	7.22	17.11	0.56	3.86	1.34	25.67	33.48
7	70.53	3.36	5.75	15.16	0.52	2.69	0.78	21.69	27.74
8	75.23	3.53	6.00	13.39	0.39	0.84	0.31	19.70	24.07
9	81.11	2.49	4.34	11.64	0.15	0.16	0.06	16.04	18.69
10	87.27	1.73	2.94	8.85	0.00	0.09	0.01	11.80	13.62

This table presents the proportions of zero and non-zero returns that are based on the movements of the bid and ask quotes. Seven categories are presented. The first four correspond to non-zero daily trading volume while the last three correspond to zero daily trading volume. Within the first four categories, category (1) contains non-zero returns that pertain to successive trades at different bid and ask quotes and category (2) pertains to returns that reflect the bid-ask bounce. Category (3) is measured zero returns due to successive closing trades at the bid or ask prices, while category (4) contains zero returns due to successive closing trades that are not at the bid or ask prices. Categories (5) and (6) correspond to non-zero returns (but zero volume). Category (5) results from the specialist changing the quotes. Category (6) results from the trades at either the bid or ask prices the previous day and the average spread price recorded today. Category (7) corresponds to observed zero returns that result because of zero volume. The last two zero return calculations correspond to the sums of separate categories. The first zero return calculation is the sum of categories (3), (4), and (7). These are the observed zero returns as observed on the CRSP database, but aggregated from different daily volume cases. The last zero return calculation is termed the *effective* zero returns because it contains the proportions of zero returns that would result if in addition to the measured zero returns we included those days that exhibited non-zero returns related to the bid-ask bounce, category (2), and zero volume returns, category (6). A (Zero) is included in categories (2) and (6) to signify an *effective* zero return. The size deciles correspond to NYSE/AMEX firms.

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