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The Implicit Costs of Trading in a Jointly Listed Irish Equity

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Abstract: The paper invokes the concept of an implicit bid-ask spread in the Irish Stock Market and measures the consequent cost to traders as the expected gap between the price of sell and buy orders when these have been executed with a high degree of immediacy. Use is made of the spread estimator due to Hsia, Fuller and Kao (1994). The analysis shows that many important empirical tests (including the calculation of a stock's beta coefficient), are distorted by the presence of the implicit spread. A spin-off of a practical nature is the provision of guide-lines for limit-prices.

I INTRODUCTION

The combination of a quoted bid-ask spread and some "order arrival process" implies some particular covariance (and therefore, some time-series econometric representation), of the successive transaction price changes of a quoted stock. Roll (1984), provided a simple method of estimating the effective bid-ask spread from the covariance of transaction price data. Roll's measure is problematic in that it relies on quite restrictive assumptions regarding the order arrival process (assuming it to be random in type and independent of news-type), and also assumes that trade only occurs at either the bid or ask price and not in between these. These restrictions were relaxed in subsequent contributions to the literature.

Following Hasbrouck and Ho (1987), who provided detailed empirical

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evidence of dependence in order type on the New York Stock Exchange,[1] the effect of order-type dependence on measures of effective spread and serial covariance of transaction price changes was explored by Choi, Salandro and Shastri (1988). Bhattacharya (1986), extended the Roll analysis by allowing for trade at values between the quoted bid and ask prices, while estimating the effective bid-ask spread in the presence of news-type/trade-type dependence was considered by Dunne (1994).

Regarding an empirical deficiency, the Roll spread estimator is given as $S = 2\sqrt{-\text{cov}(\Delta P_t, \Delta P_{t+1})}$, which in many circumstances will not be determined due to positive covariance of consecutive price changes. This problem has recently been satisfactorily resolved by Hsia, Fuller and Kao (1994), by applying a time-series econometric approach to infer the effective spread.

The measures referred to above have been applied mainly to the case of dealer type markets in which there exists "firm" quoted bid and ask prices. In the case of an "order-driven"/bargain-matching market (such as the Irish Stock Market), there is, at least, the possibility of the existence of an implicit bid-ask spread. This type of market clearing mechanism usually involves making "soft" bids and offers as a first step towards finding a transaction price (which is likely to be close to one of these indicative prices). Furthermore, the presence of either, asymmetrically informed traders or, liquidity traders, who put a premium on the immediacy of their trade, will ensure that the transaction prices will fluctuate within an implicit spread which compensates for this premium.

The objective of the present paper is to show, both theoretically and empirically, that the modified method of Hsia, *et al.* (1994), is the most appropriate method of measuring the size of the effective spread implicit in the price changes from an order-driven market. In particular, the modified method is shown to be robust to order-type/news-type dependence and the presence of transactions at prices other than the bid and ask. Some weaknesses are shown to apply to the application of the method suggested by Hsia, *et al.*, but these are avoided in the application used in this paper, which takes advantage of the joint listing of the stock examined by using the quoted bid price to remove the news effect from observed price changes.

The results of the empirical application show that an implicit spread does indeed exist in the Irish Stock Market. The spread estimate could prove to be of great practical importance to traders who are wishing to place optimal limit prices on their orders. This is of particular relevance in the order-driven

1. Hasbrouck and Ho (1987), attribute the order type dependence to the practice of "working an order". Working an order refers to the way in which dealers parcel large orders into a number of smaller blocks which are executed over an extended period of time and involve a large number of trading partners.

market because the estimated spread is really a measure of the expected premium for immediate implementation of a trade at a randomly chosen point in time (a premium which is only paid if, by chance, the market is thin at that point in time). As a by-product of the analysis, the empirical results show that the presence of price movement due to order type change, significantly distorts the CAPM "beta" relation between the return on a single stock and the market return. It seems likely that the effect of these movements would render many other tests on stock returns, (e.g., event studies), inappropriate in the case of Irish data. A simple alternative is to use bid or ask prices from the London market.

The remainder of the paper is arranged as follows. Section II contains a discussion of the differences between the "dealership" and "order-driven"/ "bargain-matching" market clearing mechanisms. Here, the idea of an implicit "effective spread" in an order-driven market is introduced. In Section III the Roll spread estimate, along with some generalisations, are introduced. In Section IV it is made clear that most of the weaknesses of the Roll type measure do not apply to the modified spread estimator, due to Hsia, *et al.*, (the most important result is the robustness of the modified estimator to the presence of trades taking place between the limits of the spread). In Section V the empirical application is introduced, the results are presented and interpreted. Concluding remarks then follow in Section VI.

II ISE AND LSE MARKET CLEARING MECHANISMS AND IMPLICIT SPREADS

The analysis below involves the use of closing prices from both the Irish Stock Exchange (ISE) and the London Stock Exchange (LSE). There is just one jointly listed stock considered. The stock in question is simultaneously traded on the London and Dublin markets. It is useful to know that, most large traders have automatic access to the foreign exchange quotations and also to the bid and ask quotes for Irish stocks that have joint listing on the London market. All Irish trades are reported to a monitoring section of the stock exchange.

Some interesting differences exist between the Irish and London markets. Table 1 summarises these differences. The main difference concerns the trading mechanism itself. The London market is a dealership market where quoted bid and ask prices are "firm" in the sense that quoting dealers are prepared to transact a certain size of order at the relevant quoted price. The Irish market, in contrast, is "order-driven". While some brokers quote bid and ask prices from time to time, they are neither obliged to quote, nor to trade at, these prices.

Casual observation of the Irish price alongside the prices from the London market (see Figure 1), indicates that transactions on the Irish market are enacted at a range of values mostly between the bid and ask prices from the LSE but sometimes even outside of these. The reason for this probably lies in the determinants of the bid-ask spread itself. Stoll (1989), was successful in empirically inferring the components of the bid-ask spread, namely, order processing cost, adverse selection/information asymmetry and inventory holding cost.

In the dealership market the spread simply compensates the market maker for these costs. In an order-driven market, the order processing cost is relegated to commission charged to both the seller and the buyer and so could not be affecting the transaction price. However, there may still be room for compensation for inventory holding costs and for the risks associated with trading with a better informed partner. The inventory holding cost component of the spread paid to a market maker is really the cost of immediacy

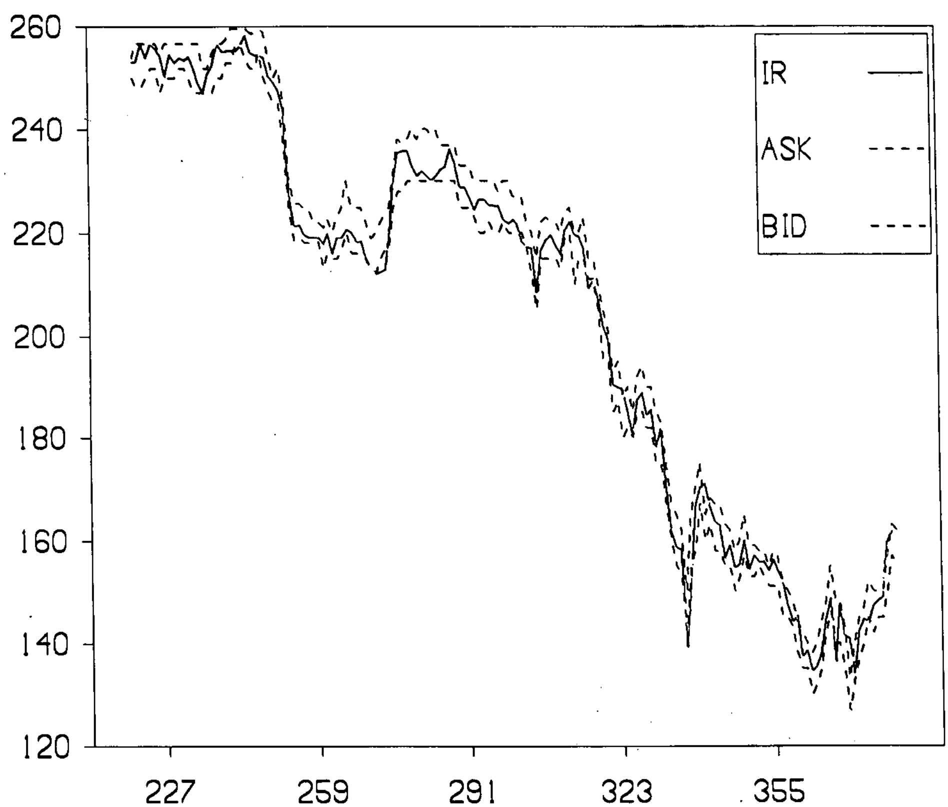

Figure 1: *AIB Stock: BID, ASK and Irish Price*

to liquidity traders. A liquidity trader who finds himself unexpectedly needing to, for example, liquidate a holding can do so at the cost of the difference between the bid price and the underlying value of the stock.

Liquidity traders, in the context of the Irish market, could only be guaranteed immediate liquidation if they were willing to offer their holding at a price that would encourage a prospective trading partner to hold inventory earlier than expected and for an uncertain period of time in a thin trading period. It seems reasonable to suspect that this type of trade on the Irish market will not likely be transacted at the mid-point between the bid and ask on the London market.

A similar type of reasoning applies to the case of asymmetric information. Traders with superior knowledge which is likely to become common knowledge will act like liquidity traders and accept less favourable prices than ordinary traders who are in no particular hurry to complete deals. Thus, the order-driven price from the Irish market is likely to implicitly involve a spread which should, on average, lie well inside both the quoted spread and effective spread earned by a market maker trading in the same stock in the London market.

Table 1: *Salient Differences Between London and Irish Trading Mechanisms*

	Dealership Mechanism	*Order-Driven Mechanism*
1	"FIRM" Quotes	"SOFT"/Indicative Quotes
2	"Working" of large orders	More direct matching of large orders
3	Market makers' costs of order processing are included in the spread	Order processing costs are included in the commission
4	Cost of immediacy almost always paid	Cost of immediacy is a chance variable related to how thin the market is
5	Most trades take place at, or near, the quoted bid and ask	Transactions prices can be anywhere within the implicit spread

III EXTENSIONS OF ROLL'S COVARIANCE AND VARIANCE ESTIMATES

As mentioned above, the combination of a spread and some order arrival process implies a particular covariance, and time-series econometric representation, for successive transaction price changes. This in turn implies that, the covariance and time-series representation of successive transaction price changes could be used to infer the value of the spread and perhaps, reveal information about the order arrival process. Roll (1984), shows, for the case of an efficient market, the extent to which trading costs induce negative serial dependence in observed market price changes due to random fluctuation between bid and ask prices.

Where S is the size of the bid-ask spread, Roll computes the covariance between successive price changes as $-S^2/4$ while, in the absence of news, the variance of ΔP_t is $S^2/2$ and the 1st order autocorrelation coefficient is -0.5. He shows that the measured covariance between successive price changes can then be used to infer the effective bid-ask spread as $S = 2\sqrt{-\text{cov}(\Delta P_t, \Delta P_{t+1})}$.

Bhattacharya's adjustment to the above allows some orders to be executed at the midpoint between bid and ask prices and as a result gives rise to a less negative covariance of successive price changes. The Roll spread estimate would therefore be downwardly biased. A reworked version of this in the correlation form is (using the full formulas for variance and covariance for clarity),

$$\rho_R = \rho_B = \frac{-(.25)S^2(1-\gamma)}{(.5)S^2(1-\gamma)} \tag{1}$$

where γ is the probability of a transaction at the mid-price.

In the case of trade-type/news-type dependence Dunne (1994) shows the covariance between successive price changes as $-(0.25)S^2 + (0.5)(1\text{-}2\beta)SU$, where U is the expected effect of a news shock and β is the conditional probability of a trade occuring at the ask(bid) given that good(bad) news occurred within the period. Disregarding the contribution of news, the variance of ΔP_t is $(0.5)S^2 - (1\text{-}2\beta)SU$ and the 1st order autocorrelation coefficient is -0.5, the same as in the Roll case. Provided that there is no correlation in news type itself there will be zero autocovariance at leads greater than 1. The prominent generalisation is that $\beta > .5$ which amounts to assuming that a buy transaction is more likely to follow good news than a sell transaction. This is what we would expect if there is positive feedback trading.[2] Since the Roll spread estimate is based on the covariance only, it will be an incorrect estimator if there is news-type/trade-type dependence.

Choi, *et al.* (1988), find that the covariance between successive price changes will be less negative than in the Roll case if there is positive serial dependence in transaction type, (i.e., $\delta > 0.5$, where δ is the probability that the trade type will be the same and $(1-\delta)$ is the probability of a change in order type). Specifically they find $\text{cov}(\Delta P_t, \Delta P_{t+1}) = -s^2(1-\delta)^2$. The variance

2. There is a possibility that $\beta < .5$. This relies on an argument put forward by Choi *et al.* (1988), whereby the arrival of bad(good) news causes buy(sell) limit-orders between the bid-ask spread to be immediately transactable after the news.

of ΔP_t in this case is given by the expression $(1-\delta)S^2$ and the 1st order correlation coefficient is given as:

$$\rho_{c(k=1)} = -(1-\delta) \tag{2}$$

To make meaningful use of any econometric analysis of returns based on transaction prices it is necessary to first separate the news related price changes from those due to movement from the ask-price to the bid-price. This is particularly relevant when the size of the bid-ask spread is greater in magnitude than the likely price change due to changes in the "true" underlying value.

IV THE MODIFIED EFFECTIVE SPREAD ESTIMATOR

As described above, observed stock price changes consist of two components, (i) the unobservable value changes and (ii) the effective bid-ask spread. Hsia, *et al.* (1994), show that the presence of the value changes tend to contribute towards the empirical problems associated with the Roll spread estimate. In short there is a tendency for the covariance between successive price changes to be positive and this effectively disables the Roll estimator. The Roll correlation measure, (and the extensions mentioned above), assume that the returns have been cleaned of the news related variance. Thus, if we were to run a regression of returns against underlying value changes then the residuals from the regression would possibly contain the price changes due to switching between bid and ask prices. The problem is however, that such a regression would not be able to filter out the news effect unless a suitable structure is placed on the error term in the regression.

The modified method of Hsia, *et al.* (1994), relies on an appropriate restriction on the error term in just such a regression. In particular, Hsia, *et al.* (1994), consider the following regression,

$$r_t = \alpha + \beta r_{mt} + e_t \tag{3}$$

where r_t is the period t percentage return on the stock and r_{mt} is the percentage return on the market portfolio (representing news related value changes) and e_t is the residual of interest, possibly containing switching between bid and ask prices (and hopefully a small idiosyncratic news effect).

To infer the effective bid-ask spread from the residual term Hsia, *et al.* (1994), identify an appropriate stochastic process for the time series e_t, using the fact that a qth-order serial covariance function is equivalent to a qth-order moving average process. The appropriate stochastic process for e_t is MA(1), i.e.,

$$e_t = a_t - \theta a_{t-1} \tag{4}$$

where θ is the MA parameter and a_t is i.i.d. white noise, $E(a_t) = 0 \forall t$ and $E(a_t a_{t-k}) = \sigma^2$ if k=0 and 0 otherwise.

The modified method is based on the fact that we have prior information about what the MA(1) parameter should be if the error contains only the switching between the bid and ask prices. According to the Roll covariance and variance estimates the error process in the above regression should satisfy

$$COV(e_t e_{t-k}) = \begin{cases} -(0.25)S^2, & k=1 \\ (0.5)S^2, & k=0 \\ 0, & \text{Otherwise} \end{cases} \tag{5}$$

If the e_t process is MA(1) then it is also the case that,

$$COV(e_t e_{t-k}) = \begin{cases} -\theta\sigma^2, & k=1 \\ \left(1+\theta^2\right)\sigma^2, & k=0 \\ 0, & \text{Otherwise} \end{cases} \tag{6}$$

Combining these we have that

$$\begin{aligned} -(0.25)S^2 &= -\theta\sigma^2 \\ (0.5)S^2 &= \left(1+\theta^2\right)\sigma^2 \end{aligned} \tag{7}$$

which implies that θ=1 and S=2σ. This restriction provides a method of forcing the initial regression to separate news effects from switching effects.

The effective spread is estimated by first doing the following restricted regression,

$$r_t = \alpha + \beta r_{mt} + (1-\theta B)a_t \tag{8}$$

where B is the backward shift operator and θ=1 is the restriction. The spread estimate is then calculated as $\hat{S} = \frac{2\hat{\sigma}}{\sqrt{T}}$. It is easy to see that this modified method for inferring the spread is robust to the news-type, trade-type dependence (Dunne, 1994) and to the presence of transactions at intermediate prices (Bhattacharya, 1986) because in these cases the correlation measure is the same. Thus, in both of these cases the restriction on the MA parameter is the same as in the Roll case. However, in the case of (Choi *et al.*, 1988), simple trade-type dependence, it is not certain that the same restriction on the error process is required. Trade-type dependence is not likely to be significant in daily observations and the issue is not addressed in the remainder of this paper.

The important result for the empirical application in this paper is the robustness of the modified method to the presence of trades at intermediate prices. Although the Bhattachary (1986), a generalisation only allows intermediate trade prices to be at the mid-point between the bid and ask prices there is no reason to suspect that the conclusion would be any different if trade prices were allowed to be also at, for example, the bid+(1/4)S and bid+(3/4)S. In fact, so long as the probability of trade at the mid-price is not equal to unity it should be possible to detect whatever spread exists.

V EMPIRICAL APPLICATION

The modified method of Hsia *et al.* (1994), is applied to the Irish market price of Allied Irish Bank plc, with a slight modification. It is shown that the market index does not actually provide a good filter for the news effect (which is not surprising since the idiosyncratic element of news could not be accounted for in this way). An improved method involves using the changes in the bid price from the London market to represent news shocks.

The data used in the application was obtained from Datastream and contained 470 daily observations on closing bid, ask (London) and transaction (Irish) prices running from 14/2/1990 to 3/12/1991. After some initial investigation of the data (and due to the possibility of structural instability in the regression of changes in the Irish price on changes in the bid price), it was decided to use a sub-sample of the data-set for the modified regressions used to estimate the implicit spread. The sub-sample runs from 17/12/1990 to 29/7/91. The initial data analysis revealed that each of the bid, ask and Irish price series were I(1) variables. The variables were pairwise cointegrated.

Results are presented below for 7 Maximum-Likelihood regressions. The implicit spread is calculated from the results of regressions (iv) and (vii). The regressions are as follows:

(i) percentage bid price changes on percentage change in the ISEQ index,

(ii) percentage change in the Irish price on percentage change in the ISEQ index,

(iii) the same as regression (ii) but with an MA(1) error process in which the MA parameter is unrestricted,

(iv) the same as regression (iii) but with the MA parameter restricted to be equal to unity,

(v) the percentage change in the Irish price on percentage change in the bid price,

(vi) the same as regression (v) but with an MA(1) error process in which the MA parameter is unrestricted, and,

(vii) the same as regression (vi) but with the MA parameter restricted to be equal to unity.

Regressions (i) and (ii) indicate the low extent of correlation between the market index movements and the bid and Irish price movements respectively. One is likely to conclude that there is either, no fundamental relationship between these variables or, that the relationship is being obscured by the presence of some other factors. One major factor is the presence of idiosyncratic news effects in the stock prices. The only other factor in the case of the Irish price could be the switching across the implicit spread.

In regression (iii) the inclusion of an unrestricted MA(1) does not appear to change the conclusions drawn from regression (ii). Although the MA parameter looks as though it could be marginally significant, the log-likelihood has not risen significantly. The fourth regression is the same as the regression used by Hsia, *et al.* (1994), and brings about a major change in the estimated coefficients, their significance and the log-likelihood (using a simple likelihood ratio test the MA parameter restriction cannot be supported).

The parameters are now very significant and reveal that, under the assumption that movements across the spread have been removed, there is strong negative correlation between the AIB stock price and the market index. The interesting attribute of the results from the point of view of spread estimation is the fact that the estimated variance has risen substantially. Recall that the spread estimate is then calculated as $\hat{S} = \frac{2\hat{\sigma}}{\sqrt{T}}$. This implies an expected percentage spread of $\hat{S} = 1.047\% \approx 2$ pence.

Turning now to the regressions involving the bid price changes we see in regression (v) that the weak relationship between the stock price and the news variable remains. This is very surprising given the appearance of a high degree of correlation between the bid price and the Irish price of the stock. The only factor which is likely to be responsible for the misleading result, is the random movements within the spread. We should be prepared to accept that these spread movements are large relative to the news related movements otherwise the results would not be so distorted.

When we allow for the MA(1) process with an unrestricted parameter the results change significantly. The slope parameter now shows a marked increase and is marginally more efficiently estimated. The MA parameter is significantly positive although nowhere near to its value in the restricted regressions. The chi-squared, likelihood ratio test of excluding the MA

Table 2

Regression	*(i)*	*(ii)*	*(iii)*	*(iv)*	*(v)*	*(vi)*	*(vii)*
Regression	$\Delta BID_t =$ $\alpha + \beta\Delta ISEQ_t$	$\Delta IRISH_t =$ $\alpha + \beta\Delta ISEQ_t$	$\Delta IRISH_t =$ $\alpha + \beta\Delta ISEQ_T +$ $(1-\theta B)a_t$	$\Delta IRISH_t =$ $\alpha + \beta\Delta ISEQ_t +$ $(1-B)a_t$	$\Delta IRISH_t =$ $\alpha + \beta\Delta BID_t$	$\Delta IRISH_t =$ $\alpha + \beta\Delta BID_t +$ $(1-\theta B)a_t$	$\Delta IRISH_t =$ $\alpha + \beta\Delta BID_t +$ $(1-B)a_t$
Usable Observations	161	161	161	161	161	161	161
Degreees of Freedom	158	158	157	158	158	157	158
Function Value	381.393	356.901	357.307	208.064	357.169	360.049	355.639
$\hat{\sigma}^2$	0.001	0.001	0.001	0.004	0.001	0.001	0.001
(t-stat)	(11.942)	(15.482)	(14.779)	(8.737)	(16.139)	(16.487)	(14.984)
α	–0.003	–0.002	–0.003	–0.003	–0.002	–0.002	0.000
(t-stat)	(–1.477)	(–1.108)	(–1.183)	(–45.382)	(–1.046)	(–1.072)	(2.196)
β	–0.036	–0.092	–0.097	–0.881	0.082	0.367	0.993
(t-stat)	(–0.223)	(–0.419)	(–0.435)	(–12.015)	(1.499)	(6.434)	(39.253)
θ			0.067			0.321	
(t-stat)			(1.604)			(5.610)	

Notes: In all of the results above the $\hat{\sigma}^2$ parameter is the maximum likelihood estimate of the residual variance. The estimation algorithm in each case is Bernt Hall Hall Hausman (BHHH).

Regression (i) involves the Allied Irish Banks plc., bid-price changes from the London Stock Exchange. ΔBID_t as the dependent variable and changes in the Irish Stock Exchange Equity Index, $\Delta ISEQ_t$ as the independent variable. Regressions (ii) and (vii) have the changes in the transaction price from the Irish Stock Exchange as the dependent variable and either $\Delta ISEQ_t$ or ΔBID_t as the dependent variable. Regressions (iii) and (vi) contain an unrestricted 1st Order Moving Average error process, where a_t is the white noise error and θ is the MA parameter. In regressions (iv) and (vii) the MA parameter is restricted to be unity.

process gives a value of 5.76 which compares with a 95 per cent significance level of 3.84 and is therefore rejected. The final regression is by far the most satisfactory since our priors about the relation between the bid and Irish price, (cleaned of the spread effect), is supported. In addition, the MA parameter restriction is supported against regression (v). The value of the likelihood ratio test in this case is 3.0603 which is within the 95 per cent confidence interval of the chi-square (1) distribution.

The fact that the MA(1) restriction is supported, and that the estimated β is so close to unity, confirms that the relationship was indeed obscured by the presence of spread effects. The spread estimate is now calculated in the same manner as before from the variance estimate, which we can see has risen slightly from the regressions (v) and (vi). The expected spread is $\hat{S} = 0.4189\% \approx 0.795$ pence which is a good deal smaller than that implied by the regression on changes in the market index. It therefore seems advisable to give the spread estimate credence if, and only if, the MA restriction is accepted.

VI CONCLUSION

It is argued that an implicit spread exists even in an order-driven market clearing mechanism. The modified spread estimator due to Hsia, Fuller and Kao (1994), is shown to be an appropriate empirical tool capable of measuring this implicit spread provided the application fully caters for news related price changes. The empirical results seem to indicate that, using the market index in the modified estimation does not give satisfactory results due to the left-over idiosyncratic news element. The problem is overcome here by use of the bid price from the dealership market. The empirical investigation shows an implicit spread which is quite small at less than one penny. Further work on some of the more thinly traded stocks would help determine whether the implicit costs of trading, as revealed by the implicit spread, rises with reduced access to immediacy.

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