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Henry Y. K. Yip

David Michayluk

Laurie Prather

Li-Anne Woo
Bond University, lwoo@bond.edu.au

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DECOMPOSING THE BID-ASK SPREAD OF A COMMON STOCK: A CROSS-MARKET APPROACH

Henry Y.K. Yip*
David Michayluk*
Laurie Prather*
And
Li-Anne E. Woo#

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*School of Banking and Finance
University of New South Wales
Sydney 2052
AUSTRALIA

#School of Business
Bond University
Gold Coast Qld 4229
AUSTRALIA

Corresponding Author: Henry Yip
Phone: 61-2-9385 5870
E-mail: h.yip@unsw.edu.au

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DECOMPOSING THE BID-ASK SPREAD OF A COMMON STOCK: A CROSS-MARKET APPROACH

ABSTRACT

Existing trade-indicator models that estimate the components of the bid-ask spread of a common stock fail to utilize the trade flows in the options market as a potential source of adverse information. This paper develops a cross-market model to address this issue by introducing an option trade-indicator variable. Thus, the adverse information about a stock can be inferred from the trade flows of its related options as well as the stock itself. The empirical results support this innovation as there is a significant increase in the magnitude of the estimated adverse information component. This increase is more prominent when the option trade-indicator variable is based on high leverage options. These findings imply that informed trading takes place in the options market and informed traders prefer to transact in high leverage options. Intra-day variations in the distribution of stock bid-ask spread components are observed. The adverse information component is found to be highest when the market opens and declines throughout the day. On the other hand, the estimated inventory component remains steady throughout the day until the last hour of trading when it rises to the highest level. Furthermore, the stock bid-ask spread components are affected by the trade size of the stock and extent of imbalance in information-based option trades. When a large stock trade is observed in the last period, a larger estimated adverse information component of the stock bid-ask spread is obtained. Whereas, when a large imbalance in information-based option trades occurs in the last period, a larger estimated inventory component of the stock bid-ask spread is recorded.

DECOMPOSING THE BID-ASK SPREAD OF A COMMON STOCK: A CROSS-MARKET APPROACH

1. INTRODUCTION

A market maker provides liquidity to the market and facilitates trades by submitting a bid price to indicate how much he is willing to pay for a security, and an ask price to indicate the price at which he is willing to sell the security. The difference between the two prices is known as the bid-ask spread. Following Demsetz (1968) who suggests that the bid-ask spread reflects the price a trader has to pay for immediate execution, a rich volume of research has emerged to suggest that the bid-ask spread is made up of three components, namely, the adverse information, inventory and order processing components. Bagehot (1971), Stoll (1978), Copeland and Galai (1983), Glosten and Milgrom (1985), and Easley and O'Hara (1987) for example, explain the bid-ask spread in terms of adverse information costs associated with the trading loss to informed traders, who possess more information about the security than the market maker and trade only when the security is mispriced.[1] Garman (1976), Stoll (1978), Amihud and Mendelson (1980), Ho and Stoll (1981), and Cohen, Maier, Schwartz, and Whitcomb (1981) on the other hand, introduce inventory holding costs associated with the risk of carrying an inventory of securities required for resolving order imbalances. Finally, Tinic (1972), and Stoll (1978) point out that the market makers have to recover the fixed costs of processing a trade.

Following the theoretical work that thoroughly examines the economic rationale for the market maker to impose a positive bid-ask spread, a number of statistical models have been developed to empirically estimate the three bid-ask spread components and test implications of the theoretical models. These statistical models include among others, the *covariance models* represented by Roll (1984), Choi et al. (1988), Stoll (1989), and George et al. (1991); *vector autoregressive models* represented by Hasbrouck (1988, 1991); and *trade-indicator models* represented by Glosten and Harris (1988), Madhavan et al. (1997), and Huang and Stoll (1997).

Of all the trade-indicator models developed to date, none has looked beyond a single market to measure adverse information. For example, the Huang and Stoll (1997) models suggest that the market makers in the stock market infer adverse information about a stock from the trade flows of the stock only.[2] However, informed traders with positive (negative) news about a stock may buy (sell) the stock, buy (sell) a call option written on the stock, or sell (buy) a put until the information is fully reflected by the securities prices. The choice of alternative trading venues implies that the source of adverse information about a stock may extend beyond the stock market to

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[1] Under information-based models, private information to the informed trader is adverse information to the market maker since the latter always loses to the former. Consequently, the costs arising from the information asymmetry between the informed trader and market maker are known as the adverse information costs.

[2] Huang and Stoll (1997) develop a basic model to reconcile the various covariance and trade-indicator models before extending this model to decompose the bid-ask spread of a stock into all its components on the basis of firstly, the negative serial covariance property in trade flows and secondly, a portfolio approach to inventory management.

the options market, and the trade-indicator models developed to date may have underestimated the adverse information component of the bid-ask spread of a stock by not accounting for the readily available trade information in the options market. This deficiency motivates the construction of a cross-market model in this paper to decompose the bid-ask spread of a common stock into its components. The innovation involves the design and addition of an aggregate option trade indicator variable to the Huang and Stoll (1997) model based on negative serial correlation in trade flows. As the new model relies on information collected from two related markets, it is called a 'cross-market model' to reflect its attempt to fully capture the adverse information about a stock via the simultaneous trade flows in both the stock and options markets.

The Huang and Stoll (1997) model based on serial correlation in trade flows is chosen as the building block of the cross-market model for its versatility.[3] Not only does the model allow decomposition of the bid-ask spread of a stock into all its components that no other existing model is able to achieve, it can also be revised to study a variety of microstructure issues without complicated lag structures or other information requirements.[4]

A brief literature review of options-related literature that examines the issue of information asymmetry between the stock and options markets is presented in section 2 to provide evidence that information-based trading occurs in the options market, and to justify the additional option trade indicator variable to reflect adverse information on a stock that has been overlooked by existing trade-indicator models. Section 3 describes the construction of the cross-market model. Section 4 describes the data. Section 5 discusses the research design. The empirical results of the cross-market model are reported and compared with the Huang and Stoll (1997) model based on negative serial correlation in trade flows in section 6. Section 7 illustrates how the cross-market model may easily be revised to study microstructure issues including the intra-day distribution of stock bid-ask spread components, the relative information content of options with different degrees of leverage, and the effect of stock trade size and option trade imbalance on the distribution of stock bid-ask spread components. The empirical results of these extensions are also reported and discussed in section 7. Section 8 concludes the paper.

2. A REVIEW OF OPTIONS-RELATED LITERATURE

If informed traders prefer to transact in the stock market, information will first be reflected in stock prices. In a perfect market, once stock prices adjust to new information, arbitrage activities will ensure that option prices respond simultaneously to

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[3] The Huang and Stoll (1997) model based on portfolio approach to inventory management is not chosen as the building block as it requires knowledge of the composition of the market maker's portfolio for accurate estimation of the bid-ask spread components.

[4] Huang and Stoll (1997) point out that the trade-indicator models of Glosten and Harris (1988) and Madhavan et al. (1997), for example, combine the order processing and inventory holding costs into one category. For the covariance models, while Roll (1984) includes only the order processing costs, George et al. (1991) ignore the inventory component. Stoll (1989) develops a model that decomposes the bid-ask spread into its constituent components, but the separation of the inventory and order processing components requires the ad hoc assumption that the amount of price continuation as a fraction of the bid-ask spread is one-half.

restore the no-arbitrage equilibrium position dictated by the option-pricing model. However, the presence of market frictions may delay the price adjustment process in the options market in such a way that the change in actual stock price is seen to move ahead of the change in implied stock price.[5,6] On the other hand, if the informed traders are attracted to the options market due to its higher leverage as suggested by Black (1975), the presence of market frictions may similarly delay the price adjustment process in the stock market in such a way that the change in implied stock price is seen to move ahead of the change in observed stock price. Hence, causality models such as the Sims (1972) and Granger (1969) models are commonly employed to investigate the presence of information asymmetry across the two markets by examining the lead/lag relationship between the observed and implied stock price changes, and between stock and option trading volumes.

Although stock price changes are found to lead option price changes by up to twenty minutes in Stephan and Whaley (1990), Chan et al. (1993) show that the result is spuriously related to tick size. After correcting for the tick size effect, stock price changes are found to lead and lag behind option price changes instead. A bi-directional causal relationship between stock and option trading volume is also found in a number of other studies such as Anthony (1988), and Fase (1994). These empirical results therefore imply that informed traders may transact in both markets.

In a more recent study, Easley et al. (1998) develop a market microstructure model to explain why the trading volume of an option reflects information better than its price. In response to the arrival of good (bad) news about the stock, if informed traders buy (sell) calls or sell (buy) puts instead of buying (selling) the stock, they argue that call and put prices, the prices of which are completely determined by that of the underlying stock, will not simultaneously adjust because the information has yet to be incorporated into the stock price. Hence the trading volume of an option is a more timely measure of information than its price. As buyer-initiated (seller-initiated) trades in calls and seller-initiated trades (buyer-initiated) in puts are associated with good (bad) news about the underlying stock, they classify the trading volume associated with these option trades as positive (negative). To examine the extent of information asymmetry between the two markets, Easley et al. (1998) apply the Granger causality test to study the relationships between stock price changes and each of the two definitions of option trading volume. Stock price changes are found to lead positive (negative) option trading volume by up to thirty (ten) minutes. Alternatively, the impact of positive and negative option trading volume on stock price changes is found to be contemporaneous. Given the results, Easley et al. (1998) conclude that option trading volume contains information about future stock price directions and that the information flow from the options market to the stock market is quicker than from the stock market to the options market. In the context of market making, these empirical

[5] Figlewski (1989) shows that the presence of transaction costs dampens arbitrage activities due to the high costs required by continuous rebalancing. Since the transaction costs may more than offset the arbitrage profit, a change in stock price does not necessarily lead to a concurrent change in option price. Furthermore, Chan et al. (1993) point out that despite a change in the stock price, if the theoretical change in option price is less than the minimum tick size, the option price may remain unchanged.
[6] The implied stock price is the theoretical price of a stock given the observed price of the option.

findings suggest that rational market makers in the stock market will consider the readily available trade indicators of not just the stock, but also the related options, for information signals before posting their bid and ask quotes.

3. DEVELOPING THE CROSS-MARKET MODEL

The cross-market model is developed progressively in a three-stage process. While the first stage involves incorporating the adverse information component into the unobserved change in the fundamental value of a stock, the second stage explains how the market maker can use the placement of quote midpoint to encourage trade flows in the preferred direction in an attempt to restore inventories to preferred level, and, the third and final stage, integrates the outcomes of the previous stages to obtain the final model that allows for the decomposition of the bid-ask spread of a stock into all its components.

3.1 MODELING THE CHANGE IN STOCK FUNDAMENTAL VALUES DUE TO ADVERSE INFORMATION

Define:

P_t^s as the transaction price of a stock, s, traded at time *t*,

P_t^b as the bid price of the stock just before the trade is executed at time *t*,

P_t^a as the ask price of the stock just before the trade is executed at time *t*,

M_t^s as the quote midpoint of the stock at time *t*, being the average of P_t^b and P_t^a,

V_t^s as the unobservable fundamental value of the stock just before the bid and ask quotes are posted at time *t*,

Q_t^s as the trade indicator variable for the stock transaction at time *t*. It is assigned a value of +1 if the trade is buyer initiated, or -1 if the trade is seller initiated, and

Q_{t-1}^o as the aggregate option trade indicator that summarizes the trade flows of options written on the stock observed in the last period. It is assigned a value of +1, 0, or -1 if the total value of positive option trades is larger than, equal to, or less than that of negative option trades transacted at the same time as or after the last stock trade at time *t-1* but before the current stock trade at time *t*, respectively.[7]

The change in V_t^s is modeled as follows:

$$V_t^s - V_{t-1}^s = \alpha^s \frac{S^s}{2} Q_{t-1}^s + \alpha^o \frac{S^s}{2} Q_{t-1}^o + \varepsilon_t^s , \qquad (1)$$

where S^s is the constant traded bid-ask spread of the stock to be estimated by the model, α^s is the proportion of the half-spread of the stock attributable to adverse information inferred from the trade indicator of the last stock trade, Q_{t-1}^s, α^o is the proportion of the half-spread of the stock attributable to adverse information inferred

[7] Positive option trades include buyer-initiated trades in calls and seller-initiated trades in puts. Negative option trades include seller-initiated trades in calls and buyer-initiated trades in puts. This classification scheme is due to the work of Easley et al. (1998), who suggest that positive (negative) option trading volume is associated with good (bad) news about the underlying stock.

from the aggregate option trade indicator of the last period, Q^o_{t-1}, and ε^s_t is the public information shock.[8] Further to the private information revealed by the last stock trade, $\alpha^s\left(S^s/2\right)Q^s_{t-1}$, and the public information component, ε^s_t, as in Huang and Stoll (1997), the change in V^s_t is explained by the private information revealed by the option trade flows observed in the last period, $\alpha^o\left(S^s/2\right)Q^o_{t-1}$.

In Equation (1), the trade sign, Q^s_{t-1}, is assumed to be random and totally unexpected by the stock market maker until the stock trade actually takes place. Under the inventory models, market makers are hypothesized to maintain their preferred inventory levels by shifting the bid and ask quotes up (down) following the execution of a public buy (sell) order at the ask (bid) so as to encourage a subsequent sell (buy) order at the bid (ask). This action would lead to a bias towards trade reversals and hence a negative serial correlation in Q^s_t so that:

$$E\left(Q^s_{t-1} \mid Q^s_{t-2}\right) = \left(1 - 2\pi^s\right)Q^s_{t-2}, \qquad (2)$$

where π^s is the probability that the stock trade at *t-1* is opposite in sign to the previous trade at *t-2*. If there are no inventory holding costs, the sign of a trade is unpredictable and π^s equals 0.5. If market orders are influenced by the placement of the bid and ask quotes as suggested by the inventory models, π^s has a value larger than 0.5.

Once inventory holding costs are introduced and known to affect the trade sign as per Equation (2), Huang and Stoll (1997) argue that the expected component must be removed since the revision in fundamental values has to be caused by trade innovations and unexpected public information releases. Hence Equation (1) becomes:

$$V^s_t - V^s_{t-1} = \alpha^s \frac{S^s}{2}\left[Q^s_{t-1} - \left(1 - 2\pi^s\right)Q^s_{t-2}\right] + \alpha^o \frac{S^s}{2} Q^o_{t-1} + \varepsilon^s_t . \qquad (3)$$

where $\left[Q^s_{t-1} - \left(1 - 2\pi^s\right)Q^s_{t-2}\right]$ is the unexpected trade innovation in the stock.

Similarly, if option market makers have target inventory levels and use the placement of the bid and ask quotes to induce inventory-equilibrating trades, the aggregate option trade indicator may be serially correlated. To illustrate, if in any period the total value of positive option trades is in excess of the total value of negative option trades, the market maker may raise the bid and ask prices of the calls, and lower the bid and ask prices of the puts, to encourage traders to sell calls and buy puts. The converse is true if the total value of negative option trades is in excess of the total value of positive option trades. Thus, the negative serial covariance property in option trade flows is modeled below:

$$E\left(Q^o_{t-1} \mid Q^o_{t-2}\right) = \left(1 - 2\pi^o\right)Q^o_{t-2}, \qquad (4)$$

where π^o is the probability that the aggregate option trade indicator in period *t-1* is of opposite sign to that in period *t-2*. When there is not any target inventory level, the sign

[8] Huang and Stoll (1997) point out that the traded spread, S^s, differs from the observed quoted spread, $P^a_t - P^b_t$, in that it reflects trades inside the quoted spread but outside the midpoint. Hence the traded spread is the same as the quoted spread if and only if all trades occur at the posted bid and ask quotes.

of the aggregate option trade indicator is unpredictable and π^o equals 0.5. Under the inventory models, the sign of the aggregate option trade indicator is expected to reverse over time so that π^o has a value larger than 0.5.

Assuming that the market markers in the stock market are aware of the above relationship, the expected portion of option trade direction must be removed from Equation (3) so that:

$$V_t^s - V_{t-1}^s = \alpha^s \frac{S^s}{2}\left[Q_{t-1}^s - \left(1-2\pi^s\right)Q_{t-2}^s\right] + \alpha^o \frac{S^s}{2}\left[Q_{t-1}^o - \left(1-2\pi^o\right)Q_{t-2}^o\right] + \varepsilon_t^s \quad (5)$$

Equation (5) is the cross-market empirical representation of the information-based models. In contrast to the existing trade-indicator models which suggest that the stock market maker infers adverse information solely from the last stock trade, the cross-market model introduces an option trade innovation to reveal the information signal about the underlying stock after the last stock trade at *t-1*, but before the latest stock trade at *t*. Hence the cross-market model uses an augmented set of more timely information to explain the change in the fundamental value of the stock.

The cross-market model may also be used to examine the issue of information asymmetry between the stock and options markets. If informed traders transact in the options market, their trading activities will be captured by the option trade innovation and the estimated value of α^o should be positive in sign and significantly different from zero. Equation (5) differs from the existing causality studies that examine the lead/lag relationships between the two markets in the following aspects. Firstly, *information-based* option trading volume, instead of option transaction prices (see Stephan and Whaley (1990)) or plain option trading volume (see Anthony (1988)), is used to infer information about the underlying stock. As pointed out earlier, Easley et al. (1998) argue that the trading volume of an option is a more timely measure of information than its price. Secondly, the trading volume in different option series written on the same underlying stock are pooled together to collectively generate the option trade innovation and reflect the information content of the options market. Existing causality studies typically consider the trading volume and transaction prices of each option series as separate. They investigate the lead/lag relationships between individual option series and the underlying stock in spite of the fact that the price and volume of an individual option series may not be representative of the collective information on the underlying stock. For example, it is quite common that the price of a call (put) moves in the opposite (same) direction to that of the underlying stock.[9] Additionally, unless information is significant enough to move the price of the underlying stock up or down a few ticks, the price of less sensitive options may not vary despite heavy trading due to the tick size restriction (see Chan et al. (1993)).

[9] Bakshi, Cao and Chen (2000), for example, examine the price movements between the S&P 500 index and its options. Contrary to prior expectations, when the physical asset prices move up and down, the index call (put) option is found to move in the opposite (same) direction in 13.9% (13.4%) of the sample observations collected at hourly intervals.

3.2 MODELING THE PLACEMENT OF QUOTE MIDPOINT DUE TO INVENTORY HOLDING COSTS

Following Huang and Stoll (1997), the inventory models of Stoll (1978) and Ho and Stoll (1981) are used to model inventory holding costs. These models suggest that following a stock trade at time *t-1*, the stock market maker will evaluate his latest inventory position before posting the next set of stock bid and ask prices at time *t* as follows:

$$M_t^s = V_t^s + \beta^s \frac{S^s}{2} \sum_{i=1}^{t-1} Q_t^s \,, \tag{6}$$

where β^s is the proportion of the half-spread of the stock attributable to inventory holding costs. On the assumption of a constant stock trade size of one unit and that the stock market maker does not trade options, $\sum_{i=1}^{t-1} Q_t^s$ measures the cumulative inventory position from the time the market opens up to and including the previous trade at time *t-1*. If $\sum_{i=1}^{t-1} Q_t^s$ is positive (negative), the market maker has accumulated less (more) stocks than his opening position, he is expected to place M_t^s above (below) V_t^s to encourage a sell (purchase) order until the initial inventory position is restored. Hence, the deviation of the quote midpoint from the fundamental value of the stock is only temporary.

3.3 DERIVATION OF THE CROSS-MARKET MODEL

If bid and ask prices of the stock are available, by combining Equation (5) with the first difference of Equation (6) to eliminate the unobservable change in V_t^s, and replacing the traded spread by the observed bid-ask spreads in the corresponding periods, the empirical representation of the cross-market model is formed:[10]

$$\begin{aligned}\Delta M_t^s = \left(\alpha^s + \beta^s\right)\frac{S_{t-1}^s}{2} Q_{t-1}^s - \alpha^s \frac{S_{t-2}^s}{2}\left(1 - 2\pi^s\right) Q_{t-2}^s + \\ \alpha^o \frac{S_{t-1}^s}{2} Q_{t-1}^o - \alpha^o \frac{S_{t-2}^s}{2}\left(1 - 2\pi^o\right) Q_{t-2}^o + e_t^s .\end{aligned} \tag{7}$$

The adverse information, inventory and order processing components of the stock bid-ask spread are measured by (α^o + α^s), β^s, and [1 – (α^o + α^s) - β^s], respectively. The values of these parameters and the two trade-sign reversal probabilities, π^s, and π^o, are obtained by estimating Equations (2), (4) and (7) simultaneously.

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[10] If only transaction prices, but not bid and ask prices, are available, Huang and Stoll (1997) suggest the use of another equation, $P_t^s = M_t^s + S^s/2\, Q_t^s + \eta_t^s$, to remove the unobserved M_t^s, and to decompose the stock bid-ask spread into components. This equation explains the difference between the effective half-spread, $P_t^s - M_t^s$ if Q_t^s = 1, or $M_t^s - P_t^s$ if Q_t^s = -1, and the constant half-spread, $S^s/2$, in terms of an error term, η_t^s, that captures errors such as rounding errors due to price discreteness.

By confining the determinants of quote midpoint changes to the trade indicator variables, the cross-market model retains the simple structure of the Huang and Stoll (1997) and other trade-indicator models.

4. DATA DESCRIPTION

The stock and options data used in this study is extracted from the on-line and real-time Stock Exchange Automated Trading System (SEATS) and CLICK databases of the Australian Stock Exchange (ASX), respectively.[11] The Securities Industry Research Center of Asia-Pacific (SIRCA) maintains these databases and supplies data to its members upon request.

The stock data sample consists of intra-day data for ten stocks with the most active exchange-traded options based on trading volume in the year 2000. Only trades recorded during normal trading by SEATS from 10:00 am to 4:00 pm are used in this study. Normal trading takes place in a continuous market where market orders are executed against limit orders ranked on strict price-time priority. As the market opens and closes with an auction market, opening and closing trades are excluded because of the difference in market structure. Cross trades are also excluded. Cross trades refer to cases where the buying and selling broker is the same. The same broker may be acting on behalf of buying and selling clients, or acting on behalf of a client on one side of the trade and as principal on the other. In either case, both the buyer and seller wish to trade at the same price. Since a cross trade is the result of two simultaneous market orders at the same price but on opposite sides of the trade, the trade indicator is not clearly defined. This explains the exclusion of cross trades in this study.

Furthermore, since the Australian stock market is an order-driven market, an incoming market order to buy (sell) is always matched with the latest best limit order to sell (buy). Hence, the transaction price of a buyer (seller) initiated trade cannot be less (greater) than the best ask (bid) price, this trade is removed.[12] To ensure that the data sample is free from recording errors, trades with unusual transaction prices or quotes are also removed.[13]

Insert Table 1 Here

Table 1 shows the cumulative distribution of stock trades in each trade size category. Among the ten stocks selected, TLS and NAB are the most active with more than two hundred and fifty thousand trades during the year. NDY is the least active and the only stock with less than one hundred thousand trades.

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[11] CLICK originates from the name of the trading program developed by OM Gruppen, a Swedish company that also owns the Swedish Options Exchange. This program was adopted by the ASX to automate the options market from 31 October 1997 to 30 January 1998.

[12] If the trading volume of a market order to buy (sell) is larger than the trading volume of the best ask (bid) at the top of the queue, a number of limit orders in the queue will be matched and executed simultaneously until the market order is filled. This explains the possibility of observing a buyer (seller) initiated trade with a transaction price above (below) the best ask (bid).

[13] A record is considered as unusual if a) the transaction price is greater than \$100 or less than \$0.10 as the stocks selected in this study have never gone beyond \$100 or fallen below \$0.10 during the sample period, b) the difference between price and midpoint is greater than \$5, c) the bid price is equal to or larger than the ask price, or d) the bid-ask spread is greater than \$2 or 25% of the midpoint.

Insert Table 2 Here

Table 2 reports the average quote midpoint and average bid-ask spread for each stock for the entire sample, two size categories and five intra-day periods. A trade is classified as small if its transaction value is less than $100,000, and large if $100,000 or more. The average bid-ask spread is a volume-weighted measure. There is a marginal difference in the size of the bid-ask spread between the two size categories. Among the ten stocks, while the average bid-ask spread of large trades is smaller than that of small trades for two stocks, the opposite is true for three and the remaining five have the same average bid-ask spread for both large and small trades. These observations suggest that the stock market has considerable depth. Since limit order traders keep bid-ask spreads narrow, traders do not necessarily wait for even narrower bid-ask spreads before submitting large market orders.

The average bid-ask spread is largest in the first hour of trading. It then declines gradually during the remaining hours of trading. The larger bid-ask spread in the opening hour is similarly observed in other markets such as the NASDAQ, NYSE and CBOE. For example, Chan, Chung, and Johnson (1995) suggest that the greater price uncertainty at the open causes the bid-ask spread to be widest in the NYSE and CBOE. Similarly, Chan, Christie, and Schultz (1995) postulate that the NASDAQ market-makers post a wider bid-ask spread during this price discovery period to protect themselves from information asymmetry. The gradual decline in bid-ask spreads during the remaining hours of trading is consistent with Madhavan (1992) and indicates that limit order traders are able to gradually infer equilibrium prices and resolve the initial information asymmetry from the history of transaction prices. However, unlike other studies, the average bid-ask spread in the last hour of trading does not decline sharply as observed in the CBOE nor widen significantly as in the NYSE. Previous studies have used the difference in inventory holding costs in different market structures to explain the contrasting narrowing and widening patterns. In a competitive market with multiple market-makers such as the CBOE, Chan, Chung, and Johnson (1995) argue that the bid-ask spread can narrow sharply towards the close as market markers who are short (have excessive) inventories try to outbid one another by posting a higher bid (lower ask) in order to restore their target inventory levels. In the NYSE, since specialists are restricted from executing orders on only one side of the bid-ask spread, Chan, Christie, and Schultz (1995) suggest that severe inventory imbalances may occur towards the close. Consequently, the NYSE specialists may widen their bid-ask spreads approaching market close to discourage further trades that may worsen their inventory imbalances. Therefore, applying the cross-market model to different time periods of the day may help reveal how the observed bid-ask spread pattern is determined by the time-varying inventory and adverse information components of the bid-ask spread.

The next two tables provide summary statistics on the time taken between consecutive trades. Table 3 displays the distribution of consecutive trades in each time category. The stock market is fairly liquid as the majority of consecutive trades, an average of 84.2%, take place within one minute of each other. Consecutive trades at zero second intervals occur when market buy and/or sell orders arrive at the same time.

Insert Table 3 Here

Table 4 shows the average time taken between consecutive trades during different time periods. In general, trading is more frequent during the first and last trading hour, and lighter during the lunch period. Among the ten stocks, TLS is the most frequently traded with an average time of 0.26 minutes between consecutive trades. NDY is the least active and the only stock to have an average time between consecutive trades that exceeds one minute.

Insert Table 4 Here

Table 5 reports the average summary statistics related to trading volume. TLS has the highest turnover in terms of number of trades per day. Whereas NCP has the highest turnover in terms of value of transactions per day. NDY and MIM are the least active and are the only two stocks with less than 500 trades and $7 million worth of shares changing hands per day.

Insert Table 5 Here

5. RESEARCH DESIGN

While the stock market is open for normal trading from 10:00 am to 4:00 pm, the options market is closed from 12:30 pm to 2:00 pm for a lunch break. Hence, the stock data from this period is not used in the empirical analysis because there is no information to compute the value of the aggregate option trade indicator variable, Q_t^o. Additionally, since the far-in and far-out-of-the-money options are traded infrequently, the trade flows of these options are not used to compute Q_t^o.[14] Finally, to ensure that there is a sufficient level of trading activity in the options market to compute the value of Q_t^o, data from inactive option trading days is also removed.[15]

One important institutional difference in market structure is that the Australian Stock Exchange distinguishes buyer-initiated from seller-initiated trades. Hence, for the purpose of assigning a value to Q_t^o and the stock trade-indicator variable, Q_t^s, there is no need to refer to the history of quotes and transaction prices to determine if a trade is initiated by a buyer or a seller (see Lee and Ready (1991)).

[14] Defining M as the difference between the stock price (strike price) and the strike price (stock price) for calls (puts) and I as the strike price interval of the stock option, an option is classified as far-out-of-the-money if $M \leq -2.5I$ and far-in-the-money if $M > 2.5I$. In the year 2000, for the sample stock options selected in this study, these two categories of options accounted for 20% of the total number of option trades.

[15] Ignoring the far-in and far-out-of-the-money options, if there are less than sixty option transactions on a trading day, the day is considered as an inactive option trading day.

When Huang and Stoll (1997) apply their model based on negative serial correlation in trade flows to the stock data, negative values of α^s are obtained and the values of π^s are unexpectedly less than 0.5. They attribute the low values of π^s and the consequent impact on α^s to the effect of positive serial correlation in trade flows as a result of broken-up orders. They then combine all sequential trades with the same transaction price on the same side of the market without any change in bid or ask quotes to form one trade before running the model a second time. The purpose of this bunching of trades is to recover large trades that may be broken-up and reported as a series of smaller trade sizes. To facilitate comparison with the results of Huang and Stoll (1997) and examine the empirical effect of bunching, in this paper, the Huang and Stoll (1997) model is first applied to three sets of stock data with different levels of bunching. No form of aggregation is applied to the first set of data. For the second set of data, all simultaneous stock trades at the same transaction price on the same side of the market without any change in bid or ask quotes are aggregated to form one trade. For the third set, all sequential stock trades at the same transaction price on the same side of the market without any change in bid or ask quotes are aggregated to form one trade.

Following Huang and Stoll (1997), the generalized method of moments (GMM) procedure is chosen to generate all the estimates reported in the next two sections.[16]

6. COMPARISON OF THE CROSS-MARKET MODEL FOR STOCKS AND HUANG AND STOLL (1997)

Table 6 presents the results of the Huang and Stoll (1997) model based on negative serial correlation in trade flows. This model consists of Equation (2) and the following:

$$\Delta M_t^s = \left(\alpha^s + \beta^s\right)\frac{S_{t-1}^s}{2}Q_{t-1}^s - \alpha^s\,\frac{S_{t-2}^s}{2}\left(1-2\pi^s\right)Q_{t-2}^s + e_t^s . \qquad (8)$$

The average estimated value of π^s increases with the degree of bunching and ranges from a low of 0.2215 to a high 0.8537. However, contrary to Huang and Stoll (1997), the average estimated value of α^s does not increase monotonically with bunching. α^s increases from an average estimated value of 7.96% when no trades are aggregated to a high of 19.39% when simultaneous trades are bunched, but decreases to –19.01% when sequential trades are bunched. When negative estimated values of α^s are observed, the estimated values of the inventory component, β^s, exceed one for a number of companies, and the probability of a trade reversal, π^s, approach 1, thus implying that stock bid-ask spreads arise strictly as a result of inventory holding costs.

Insert Table 6 Here

[16] Huang and Stoll (1997) point out that the GMM procedure is preferred to other estimation methods such as maximum-likelihood or least-squares because the GMM procedure requires very weak distributional assumptions and accounts for the presence of conditional heteroskedasticity of an unknown form.

Huang and Stoll (1997) point out that there is not a foolproof procedure to recover partial orders or separate independent trades from trades that belong to a single order. Thus any form of bunching may inadvertently aggregate independent trades. Furthermore, from a theoretical perspective, inventory models postulate that the market-maker uses the placement of the quotes to encourage the submission of orders on the other side of the market to the previous trade so as to avoid an excessive build-up or depletion of inventories. However, the presence of momentum trading, whereby traders chase a trend and continue to submit orders on the same side of the market, means that it is possible to observe a positive serial correlation in trade flows despite the efforts of the market-maker. Consequently, the empirical finding of a positive serial correlation in trade flows suggested by an estimated value for π^s less than 0.5 does not necessarily refute the inventory models. Based on these factors and the results presented in Table 6, the remaining analyses consider the raw data without bunching.

In summary, the parameter estimate of the Huang and Stoll (1997) model presented in Table 6, Panel A indicates that on average 7.96% of the stock bid-ask spread is due to adverse selection with figures that range from a high of 22.53% for CBA to a low of 2.51% for TLS. A further 25.38% of the stock bid-ask spread on average is due to inventory holding costs with a range of 4.85% for MIM to 41.51% for BHP and the probability of a trade reversal is 22.15% on average. In spite of the absence of designated stock market makers in the ASX, these estimates of stock bid-ask spread components are in line with those reported in Huang and Stoll (1997) where the adverse information and inventory components are found to account for an average of 9.6% and 28.7% of the bid-ask spread of NYSE stocks, respectively.

The finding of a significant inventory component in the Australian stock market, being an order-driven market with no officially designated market makers, supports Lindsey and Schaede (1992) argument that due to the demand for and the potential profitability of market-making services, market-making arises regardless of market design and whether design explicitly recognizes the need for market-making.[17]

The parameter estimates for the cross-market model, presented in Table 7, are consistent with those reported in Table 6, Panel A with an average of 8.21% and 22.52% of the stock bid-ask spread attributable to adverse information (due again to the trade flows observed in the stock market alone) and inventory holding costs, respectively. Additionally, the results of the cross-market model indicate that a further 8.20% of the stock bid-ask spread is attributed to adverse information costs due to the trade flows in the options market. Thus, the results from the cross-market model estimates suggest that the earlier trade-indicator spread models, which confine the source of adverse information to the trade flows of the security only, underestimate the adverse information component and overstate the order processing component.

[17] Lindsey and Schaede (1992) provide examples to illustrate how a securities firm in Japan may engage in market-making activities for its customers by submitting a quote on the opposite side of a customer's order in the order-driven Tokyo Stock Exchange. They also argue that large Japanese securities firms with huge inflows of diversified customers' orders can effectively submit simultaneous buy and sell limit orders in order to set an effective bid-ask spread. Hence, it is reasonable to expect that the bid-ask spread of a security traded in an order-driven market will contain an inventory component.

Insert Table 7 Here

On an individual basis, all of the estimated values of α^o, the adverse information component due to the trade flows in the options, are positive and significantly different from zero at the 5% significance level. Hence, information-based option trading volume that is used to compute the aggregate option trade indicator, Q_t^o, provides stock traders with an augmented set of timely information to predict future stock price direction. Furthermore, the similar estimates of the two adverse information components attributed to the trade flows in the stock and options markets suggest that the two markets are of equal importance as a venue for information-based trading.

Table 7 reports an average value of π^o, the probability that Q_t^o is of opposite sign in two consecutive periods, very close to 0.5 and the regression used to estimate the value of π^o has little explanatory power with $\bar{R}^2$ ranging from a low of –0.0132 to a high of only 0.0014. This suggests that Q_t^o moves randomly or that the option market-makers do not use the placement of the quotes to encourage inventory equilibrating trades.

Under the assumption that π^o is close to 0.5, (1 - 2π^o) is close to zero and Q_t^o is unpredictable. Hence, the estimation procedure for the cross-market model can be simplified by dropping π^o or Equation (4) from the model. This leads to a revision of Equation (7) as follows:

$$\Delta M_t^s = \left(\alpha^s + \beta^s\right)\frac{S_{t-1}^s}{2} Q_{t-1}^s - \alpha^s \frac{S_{t-2}^s}{2}\left(1 - 2\pi^s\right)Q_{t-2}^s + \alpha^o \frac{S_{t-1}^s}{2} Q_{t-1}^o + e_t^s . \qquad (9)$$

Table 8 presents the results of the revised cross-market model consisting of Equations (2) and (9). The resulting average estimates for α^s, β^s, and π^s of this model are of similar magnitude, namely, 8.07%, 25.22%, and 0.2215 to those estimates of the original cross-market model presented in Table 7, namely, 8.21%, 25.27% and 0.2252, where π^o is included in the estimation. For the revised model, Table 8 shows that the estimated value of α^o ranges from a low of 6.28% for NDY to a high of 18.18% for NCP. This compares to a low of 2.77% for NDY and a high of 18.02% for NCP reported in Table 7 where π^o is included. Since the exclusion of π^o does not significantly alter the results, the revised cross-market model is used in all subsequent analysis.

Insert Table 8 Here

7.1 INTRA-DAY DISTRIBUTION OF STOCK BID-ASK SPREAD COMPONENTS

To study the intra-day distribution of stock bid-ask spread components, the data is sorted into four intra-day periods and the revised cross-market model is estimated for each time period. The results are reported in Table 9. The values of α^s and α^o, which represent the adverse information components attributed to common stocks and stock options, respectively indicate similar intra-day patterns. Both components post the highest average estimate in the opening hour and the lowest average in the final hour of market trading. In total, the adverse information component of the stock bid-ask spread averages a high of 22.21% in the first hour of trading, declines to 18.81% before lunch and 19.44% after lunch, and attains a low of 16.33% in the last hour of trading.

Insert Table 9 Here

The finding of a larger adverse information component in the first hour of trading supports the argument that greater price uncertainty at the open causes the bid-ask spread to be widest for the NASDAQ, NYSE and CBOE markets (see Chan, Christie, and Schultz (1995) and Chan, Chung, and Johnson (1995)). The gradual decline of the adverse information component during the day is also consistent with the Madhavan (1992) model that market participants are able to gradually infer equilibrium prices and resolve the initial information asymmetry from the history of transaction prices. Moreover, the similar intra-day pattern of α^s and α^o suggests that the trade flows in the options market are also helpful in resolving information asymmetry in the same manner as the trade flows in the stock market.

Table 9 also illustrates that the inventory component of the common stock bid-ask spread remains steady around 25% until the last hour of trading when it rises to 29.19%. Finally, the order processing component is relatively steady throughout the day and ranges from a low of 52.43% to a high of 55.51%. These observations are consistent with the finding in Madhaven *et al*. (1997) that dealer costs rise towards the end of the day. Since inventory holding and order processing costs are not separated but lumped together as dealer costs in Madhaven *et al*.. These results further support their suggestion that the rise in dealer costs towards the end of the day reflects the increase in risks associated with carrying inventory overnight.

7.2 OPTION LEVERAGE AND ADVERSE INFORMATION

Easley *et al.* (1998) support Black's (1975) conjecture that informed traders prefer using options with the greatest leverage by showing that increasing the relative leverage in the options market should theoretically result in more informed traders using options.[18] To empirically investigate if there exists an option leverage effect on the adverse information component of the stock bid-ask spread, three alternative aggregate option trade indicators, $Q_{t-1}^{o,sl}$, $Q_{t-1}^{o,ml}$ and $Q_{t-1}^{o,ll}$, are defined to distinguish the information content inferred from the trade flows of options with small, medium and large degrees of leverage, respectively. In any period between two consecutive stock trades at *t-1* and *t*,

[18] However, Easley *et al.* (1998) do not categorize the trading volume of options according to their leverage ratios and empirically test for the presence of a leverage effect on the extent of information asymmetry between the stock and options markets. In their study, positive and negative option volume used in the regression analysis is aggregated from all the option series included in the data sample.

$Q_{t-1}^{o,sl}$ is assigned a value of +1, 0, or –1 if during the period the total value of positive option trades in the next-in and further-in-the-money calls, and next-out and further-out-of-the-money puts is larger than, equal to, or less than the total value of negative option trades in the same group of options,

$Q_{t-1}^{o,ml}$ is assigned a value of +1, 0, or –1 if during the period the total value of positive option trades in the at-the-money calls and at-the-money puts is larger than, equal to, or less than the total value of negative option trades in the same group of options, and

$Q_{t-1}^{o,ll}$ is assigned a value of +1, 0, or –1 if during the period the total value of positive option trades in the next-out and further-out-of-the-money calls, and next-in and further-in-the-money puts is larger than, equal to, or less than the total value of negative option trades in the same group of options. [19]

With the introduction of three leverage-based option trade indicators, Equation (9) of the revised cross-market model is modified to become:

$$\Delta M_t^s = \left(\alpha^s + \beta^s\right)\frac{S_{t-1}^s}{2}Q_{t-1}^s - \alpha^s\,\frac{S_{t-2}^s}{2}\left(1-2\pi^s\right)Q_{t-2}^s + \alpha^{o,\,lev}\,\frac{S_{t-1}^s}{2}Q_{t-1}^{o,\,lev} + e_t^s. \qquad (10)$$

where $Q_t^{o,lev}$ = $Q_t^{o,sl}$, $Q_t^{o,ml}$ or $Q_t^{o,ll}$ when the aggregate option trade indicator is based on the trade flows of options with small, medium or large leverage ratios, respectively. In other words, three separate sets of equations consisting of Equations (2) and (10) are estimated.

Insert Table 10 Here

A strong leverage effect is evident from the empirical results reported in Table 10.[20] The average estimated value of $\alpha^{o,lev}$, the proportion of common stock half-spread due to adverse information inferred from the trade flows in the options market, ranges from a low of 11.95% when low leverage options are used to compute the aggregate option trade indicator, to a high of 14.51% for high leverage options. Furthermore, when high leverage options are used to compute the aggregate option trade indicator, the estimated values of $\alpha^{o,lev}$ are significantly different from zero at the 5% level for all stocks. These results indicate that limit order traders in the stock market place more emphasis on information-based trading volume in high leverage options to infer adverse information. Thus the findings are consistent with Black (1975) and support the theoretical model of Easley *et al.* (1998).

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[19] Defining M as the difference between the stock price (strike price) and the strike price (stock price) for calls (puts) and I as the strike price interval of the stock option, an option is classified as further-out-of-the-money if –2.5I < M ≤ –1.5I, next-out-of-the-money if –1.5I < M ≤ –0.5I, at-the-money if –0.5I < M ≤ +0.5I, next-in-the-money if 0.5I < M ≤ 1.5I, and further-in-the-money if 1.5I < M ≤ 2.5I.

[20] To ensure that option liquidity does not confound the results, if on any day there are less than 20 trades in either leverage group of options, the data collected on that day is removed from the sample. This filtering procedure explains the drop in the number of observations in Table 10 compared with other reported results.

7.3 THE EFFECT OF STOCK TRADE SIZE AND OPTION TRADE IMBALANCE ON STOCK BID-ASK SPREAD COMPONENTS

The cross-market model is developed on the assumption that all stock trades are of the same size of one unit and that the strength of information signal from the options market is the same irrespective of the extent of imbalance between positive and negative option trades.

Following Huang and Stoll (1994) and Lin (1992), Lin, Sanger, and Booth (1995) regress the midpoint change on the effective bid-ask spread to extract the adverse information component of the bid-ask spread and find that the adverse information component increases significantly and monotonically as trade size increases. To study the potential stock trade size impact on the distribution of stock spread components, two trade sizes are defined and the revised cross-market model consisting of Equations (2) and (9) are extended to become:[21]

$$Q_{t-1}^{s,j} = \left(1 - 2\pi^{s,ij}\right)Q_{t-2}^{s,i} + \zeta_{t-1}^{s,ij}, \tag{11}$$

$$\Delta M_t^{s,ij} = \left(\alpha^{s,ij} + \beta^{s,ij}\right)\frac{S_{t-1}^{s,j}}{2}Q_{t-1}^{s,j} - \alpha^{s,ij}\frac{S_{t-2}^{s,i}}{2}\left(1 - 2\pi^{s,ij}\right)Q_{t-2}^{s,i} + \alpha^{o}\frac{S_{t-1}^{s,j}}{2}Q_{t-1}^{o} + e_t^{s,ij}. \tag{12}$$

where *i* is the trade size category at time *t-2* and *j* is the trade size category at time *t-1*. Since the stock trade indicator is required for two past periods, the above model is estimated for four subsets of data associated with the four stock trade size sequences observed at *t-2* and *t-1*, namely small to small, small to large, large to small and large to large.

Similarly, to study the potential impact of information-based option trade imbalance on the distribution of stock spread components, two option trade imbalance categories are defined and Equation (9) of the revised cross-market model is extended to become:[22]

$$\Delta M_t^{s} = \left(\alpha^{s} + \beta^{s}\right)\frac{S_{t-1}^{s}}{2}Q_{t-1}^{s} - \alpha^{s}\frac{S_{t-2}^{s}}{2}\left(1 - 2\pi^{s}\right)Q_{t-2}^{s} + \alpha^{o,y}\frac{S_{t-1}^{s}}{2}Q_{t-1}^{o,y} + e_t^{s}. \tag{13}$$

where *y* is the option trade imbalance category at time *t-1*. Since the aggregate option trade indicator is required for the last period only, the above model is estimated for two subsets of data associated with the two option trade imbalance categories observed at *t-1*.

(i) STOCK TRADE SIZE EFFECT

Insert Table 11 Here

[21] Based on the distribution of stock trades reported in Table 1, \$100,000 is used as the cutoff to distinguish small and large stock trades.

[22] \$20,000 is used as the cutoff to categorise small and large information-based option trade imbalance.

The results of the cross-market model used to examine the stock trade size effect are reported in Table 11. There are obvious differences in the distribution of common stock bid-ask spread components across the four stock trade size sequences. The average total adverse information component inferred from the trade flows in both the stock and options markets ranges from a low of 10.82% for sequences of a large stock trade followed by a small stock trade to a high of 31.19% for sequences of two large stock trades. The average inventory component varies from a low of 24.25% for sequences of two small stock trades to a high of 41.89% for sequences of a large stock trade followed by a small stock trade. In contrast to the results reported in previous tables, order processing costs fall below inventory holding costs when the sequence of trades finishes with a large stock trade. The order processing component ranges from a low of 32.88% for sequences of two large stock trades to a high of 57.96% for sequences of two small stock trades.

The results indicate that large stock trades are associated with larger adverse information and inventory holding costs, but smaller order processing costs. As illustrated by the average estimated values of α^s and α^o, a larger total adverse information component is inferred when the sequence of stock trades ends with a large trade (27.77% and 31.19% for sequences of a small trade to a large one and two large trades, respectively) than when the sequence finishes with a small trade (10.82% and 17.79% for sequences of a large trade to a small one and two small trades, respectively). The direct relationship observed between stock trade size and the adverse information component is in contrast to the inverse relationship observed in Huang and Stoll (1997). Huang and Stoll (1997) explain that a large stock trade in the NYSE is usually pre-negotiated upstairs and preceded by transactions that convey information about the block. Consequently, a large stock trade may not contain much information to influence subsequent quotes. The upstairs trade in the NYSE is similar to the special crossing in the ASX which involves a minimum consideration that ranges between $1,000,000 and $5,000,000. Details of a special cross trade are entered into SEATS only after the trade has taken place and the price may be at any agreed value regardless of the current market price. However, all cross trades are removed in this study to ensure consistency of market structure. This filtering procedure may explain the difference in results between these two studies.

The stock size effect on the inventory component appears to last longer than the adverse information component. The average inventory component measures 24.25% for sequences of two small stock trades and is at least 10% below the other three trade sequences. This result reflects the persistent impact of a large stock trade on the inventory component of the bid-ask spread in subsequent trades. Finally, since both the adverse information and inventory components are higher for large stock trades, the order processing component is inversely related to trade size. This inverse relationship is expected because the cost of executing an order is relatively fixed irrespective of its size.

(ii) OPTION TRADE SIZE EFFECT

Insert Table 12 Here

Table 12 reveals that the option trade size also influences the distribution of common stock bid-ask spread components. When a small imbalance in information-based option trades is observed in the last period, the average stock bid-ask spread components are of similar magnitude to those in Table 8. When a large imbalance in information-based option trades is observed, the total adverse information component drops unexpectedly to 10.38% from 21.49%, the inventory component rises to 50.36% from 25.02%, and the remaining order processing component is reduced to 39.26% from 53.49%. Similar results are obtained when different option trade size cutoffs (at $5,000, $10,000, and $15,000) are used to partition the data.

A large imbalance in information-based option trades in any period between two consecutive stock trades means that either the total value of positive option trades in that period far exceeds that of negative option trades, otherwise the reverse is true. Hence, a larger adverse information component is expected. However, the empirical results suggest otherwise as a substantial portion of the option trade imbalance effect is due to inventory effects. Perhaps the occurrence of a large option trade imbalance is related to an increase in the demand or supply of stocks in subsequent periods. Those who provide liquidity to the stock market may demand a larger inventory component to prepare for the resulting swings in inventory levels. Further research on the relationship between stock volume and imbalance in information-based option trades is needed to validate this postulation.

8. SUMMARY AND CONCLUSIONS

In this paper, I extend the theoretical model of Huang and Stoll (1997) which decomposes the common stock bid-ask spread into components by constructing a new trade-indicator model, denoted as the ‘cross-market model’, to estimate all the components of the bid-ask spread of a common stock.

This research contributes to the theoretical literature in a number of important ways. The cross-market model takes into account the findings of the options-related literature, and improves the measurement of the adverse information component of a common stock by incorporating the trade flows observed in the options market. Such an approach is particularly useful in less frequently traded markets allowing the extent of order flows and quotes set in both markets to be considered in the model.

Besides, the cross-market model provides an alternative method (to the causality approach) of testing the presence of informed trading in the options market. Furthermore, in a similar vein to other trade-indicator models, not only does the cross-market model have a simple structure for easy empirical implementation, this model also provides a flexible framework for examining a variety of microstructure issues such as the intra-day distribution of bid-ask spread components, the impact of stock trade size and information-based option trade imbalance on the distribution of bid-ask spread components, and the relationship between option leverage and adverse information content.

The cross-market model is empirically estimated using the underlying stocks of ten of the most active exchange-traded options listed on the Australian Stock Exchange in the year 2000. The presence of the aggregate option trade indicator is shown to significantly contribute to the measurement of the adverse information component of the stock bid-ask spread. Based on the cross-market model, the estimated adverse information component averages 16.41% of the stock bid-ask spread. When the Huang and Stoll (1997) model based on serial correlation in trade flows is applied to the same set of data, the adverse information component averages only 7.96% of the stock bid-ask spread. These results suggest that informed traders transact in both the stock and options markets. Therefore, by ignoring the trade flows in the options market, previous studies relying solely on the trade flows in the stock market to decompose the stock bid-ask spread into components have understated the adverse information component of the stock bid-ask spread.

Furthermore, the stock bid-ask spread components display intra-day patterns that explain the intra-day variation of bid-ask spreads observed in this and other studies. While the estimated adverse information component declines throughout the day from a high of 22.21% in the first hour to a low of 16.33% in the last hour, the estimated inventory component remains relatively stable throughout the day in the vicinity of 25% until the last hour when it rises to 29.19%. Finally, the order processing component is relatively steady throughout the day and ranges from a low of 52.43% to a high of 55.51%. Thus, the relatively larger adverse information component observed in the first trading hour and its gradual decline for the remaining trading hours result in the intra-day high of the stock bid-ask spread in the opening hour of trading and its gradual decline throughout the day observed in this and other studies. Furthermore, the continual decline in the adverse information component and the rise in the inventory component in the last trading hour offset one another so that there is little change in the stock bid-ask spread in the last hour of trading.

The results of the cross-market model also suggest that informed traders prefer to transact in high leverage options. When high leverage options are used to compute the aggregate option trade indicator, the trade flows in the options market account for 14.51% of the adverse information component of the stock bid-ask spread. This compares to 11.95% when low leverage options are used. Thus, for studies that consider the information asymmetry between the stock and options markets, it is important to exclude the low leverage option series because there is little information trading in these series.

Finally, the trade size of a stock and the size of information-based option trade imbalance influence the distribution of stock bid-ask spread components. When the sequence of two stock trades finishes with a large trade, a larger estimated adverse information component of the stock bid-ask spread is obtained. When the sequence of two stock trades contains at least one large trade or when a large imbalance in information-based option trades occurs in the last period, a larger estimated inventory component of the stock bid-ask spread is recorded.

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TABLE 1
Cumulative Distribution of Stock Trades

This table reports the cumulative percentage of stock trades in each trade size category.

Value per trade	TLS	NAB	CWO	NCP	BHP	CBA	WMC	QAN	MIM	NDY	Average
< $1000	4.38	3.99	4.30	4.47	4.62	4.35	4.72	6.79	7.25	8.37	5.32
< 5000	26.83	18.70	25.90	14.57	16.27	20.93	20.67	41.12	41.19	43.52	26.97
< 10000	46.85	32.85	45.38	25.15	30.01	35.09	39.01	62.81	64.07	67.34	44.86
< 15000	56.28	45.45	56.41	33.19	36.79	45.34	49.26	72.74	76.29	77.49	54.92
< 20000	62.49	50.46	63.31	39.52	46.39	50.57	57.22	80.41	81.01	82.59	61.40
< 25000	66.27	57.67	69.87	46.16	50.79	54.98	63.09	83.77	85.42	86.35	66.44
< 50000	78.27	72.01	84.35	61.03	67.30	68.96	80.45	93.11	92.87	93.86	79.22
< 75000	85.14	80.25	90.91	70.32	76.47	77.50	88.61	96.39	95.96	96.19	85.77
< 100000	88.67	85.02	94.41	77.43	87.77	82.96	92.92	98.19	97.29	97.84	90.25
< 125000	91.21	90.05	96.70	84.79	90.70	87.22	95.24	98.84	98.53	98.63	93.19
< 150000	93.36	93.70	97.88	87.75	92.61	92.42	96.81	99.20	98.84	98.94	95.15
< 175000	95.21	94.83	98.54	90.12	94.64	93.99	97.98	99.52	99.13	99.20	96.32
< 200000	96.49	95.78	98.98	92.23	97.37	94.91	98.74	99.77	99.31	99.41	97.30
< 250000	97.58	97.74	99.51	96.19	98.29	96.58	99.30	99.85	99.63	99.66	98.43
< 500000	99.68	99.74	99.94	99.45	99.87	99.54	99.93	99.98	99.93	99.95	99.80
Total no. of trades	334922	252194	213631	210038	207963	182197	137086	130133	107923	68527	184461

TABLE 2

Summary Statistics on Stock Midpoint and Bid-Ask Spread

This table reports the average midpoint (MP) and bid-ask spread (BAS) of each stock for the entire sample, two size categories and five intra-day periods during normal trading. The stocks are listed in a descending order by the average midpoint.

Stock	Average	All	Trade Size		Time Periods				
			Small	Large	10:00 – 11:00 am	11:00 – 12:30 pm	12:30 – 2:00 pm	2:00 – 3:00 pm	3:00 – 4:00 pm
CBA	MP	27.47	27.47	27.43	27.46	27.42	27.54	27.45	27.49
	BAS	0.0231	0.0231	0.0232	0.0302	0.0228	0.0210	0.0206	0.0209
NAB	MP	24.61	24.48	25.33	24.63	24.60	24.49	24.61	24.67
	BAS	0.0199	0.0199	0.0199	0.0266	0.0194	0.0175	0.0174	0.0175
NCP	MP	20.68	20.41	21.60	20.45	20.74	20.55	20.86	20.74
	BAS	0.0278	0.0255	0.0290	0.0375	0.0268	0.0255	0.0260	0.0233
BHP	MP	18.76	18.74	18.89	18.81	18.73	18.82	18.74	18.72
	BAS	0.0186	0.0189	0.0183	0.0249	0.0176	0.0172	0.0168	0.0164
WMC	MP	7.48	7.48	7.53	7.51	7.48	7.52	7.49	7.45
	BAS	0.0129	0.0130	0.0128	0.0153	0.0126	0.0122	0.0120	0.0124
TLS	MP	6.89	6.88	6.96	6.86	6.90	6.87	6.92	6.89
	BAS	0.0105	0.0105	0.0105	0.0113	0.0103	0.0104	0.0102	0.0102
CWO	MP	4.95	4.94	5.13	4.94	4.96	4.97	4.97	4.95
	BAS	0.0114	0.0114	0.0116	0.0130	0.0111	0.0109	0.0110	0.0109
QAN	MP	3.63	3.63	3.66	3.64	3.63	3.63	3.63	3.64
	BAS	0.0105	0.0105	0.0105	0.0110	0.0104	0.0103	0.0104	0.0103
MIM	MP	1.09	1.09	1.12	1.09	1.08	1.08	1.09	1.09
	BAS	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
NDY	MP	0.96	0.96	0.99	0.96	0.96	0.96	0.95	0.96
	BAS	0.0100	0.0100	0.0100	0.0101	0.0100	0.0100	0.0100	0.0100
Average	MP	11.65	11.61	11.86	11.64	11.65	11.64	11.67	11.66
	BAS	0.0155	0.0153	0.0156	0.0190	0.0151	0.0145	0.0144	0.0142

TABLE 3

Distribution of Consecutive Stock Trades in Each Time Category

This table reports the number of consecutive trades in each time category. Time (x) is defined as the duration between two consecutive trades measured in seconds (s) or minutes (m). The maximum time between consecutive trades is reported in minutes. The stocks are listed in a descending order by the percentage of trades with x ≤ 1 minute.

	x = 0 s	0<x≤30 s	30<x≤60 s	1<x≤5 m	5<x≤15 m	15<x≤30 m	x>30 m	Max time (min)	Percentage of trades with x ≤ 1 minute
TLS	113626	169589	30221	20954	264	12	4	201	93.7%
NAB	72978	128327	27107	22867	649	10	4	202	90.7%
NCP	60227	105145	20749	22205	1397	57	7	202	88.7%
CWO	74692	90325	22316	24825	1196	21	4	201	87.8%
BHP	59330	101034	21837	24226	1232	48	4	203	87.7%
CBA	47835	84568	23062	25454	1010	14	4	201	85.4%
WMC	40124	56167	15408	22836	2198	92	9	204	81.6%
QAN	47441	39767	15502	25030	2092	46	3	204	79.1%
MIM	47994	24765	10394	20966	3397	147	8	204	77.2%
NDY	27941	13340	6333	16014	4249	369	29	203	69.7%
Average	59219	81303	19293	22538	1768	82	8	202	84.2%

TABLE 4

Average Time Between Consecutive Stock Trades

This table reports the number of observations (nobs) and average time in minutes between consecutive stock trades (t) for the entire sample and five intra-day periods.[23] The nobs for the entire sample does not equate to the sum of the nobs reported for each intra-day period because the latter only counts trades as consecutive if and only if both trades occur in the same time period. The stocks are listed in a descending order by t for the entire sample.

		All	10:00 – 11:00 am	11:00 – 12:30 pm	12:30 – 2:00 pm	2:00 – 3:00 pm	3:00 – 4:00 pm
TLS	nobs	334670	78998	81161	41954	55491	76069
	t	0.26	0.16	0.27	0.52	0.26	0.19
NAB	nobs	251942	56705	62252	27301	44855	59829
	t	0.35	0.23	0.35	0.80	0.32	0.25
CWO	nobs	213379	54697	50434	23117	33960	50171
	t	0.42	0.26	0.44	0.94	0.42	0.29
NCP	nobs	209787	47091	50333	19031	37946	54390
	t	0.42	0.27	0.43	1.13	0.38	0.27
BHP	nobs	207711	49429	50606	18679	37574	50422
	t	0.43	0.29	0.43	1.16	0.38	0.29
CBA	nobs	181947	41184	45235	19816	31738	42982
	t	0.49	0.34	0.48	1.10	0.45	0.34
WMC	nobs	136834	31441	34478	12847	24121	32947
	t	0.64	0.39	0.63	1.66	0.59	0.44
QAN	nobs	129881	31823	32852	16292	20385	27530
	t	0.68	0.40	0.66	1.32	0.69	0.53
MIM	nobs	107671	28858	25592	12834	16188	23199
	t	0.82	0.46	0.83	1.64	0.85	0.62
NDY	nobs	68275	15505	17671	8700	10111	15289
	t	1.28	0.78	1.18	2.34	1.31	0.91
Average	nobs	184210	43573	45061	20057	31237	43283
	t	0.58	0.36	0.57	1.26	0.57	0.41

[23] Since the last trade on any day and the first trade on the next day are not considered as consecutive, the total number of consecutive trades shown in Table 4 is less than the total number of trades shown in Table 1.

TABLE 5

Average Summary Statistics on Stock Trading Volume

This table reports for each stock, the average number of trades, average number of shares and value traded per day (in thousands of dollars), and the average number of shares and value transacted per trade. The stocks are listed in a descending order by the number of trades per day.

	No. of trades per day	No. of shares traded per day	Value per day (000s)	No. of shares transacted per trade	Value per trade
TLS	1329	7622656	52414	5735	39437
NAB	1001	1857492	46249	1856	46214
CWO	848	4776334	23229	5634	27401
NCP	837	2641143	55057	3156	65794
BHP	825	2166290	40584	2625	49177
CBA	729	1374788	37585	1886	51572
WMC	544	2379931	17785	4375	32694
QAN	516	2238783	8134	4335	15751
MIM	428	6400581	6961	14945	16254
NDY	272	4281841	4130	15746	15186
Average	733	3573984	29213	6029	35948

TABLE 6

Results of the Huang and Stoll (1997) Model based on Serial Correlation in Trade Flows

This table reports the results of the Huang and Stoll (1997) model represented by Equations (2) and (8). Panel A provides the parameter estimates and corresponding standard errors with no bunching for the stocks listed in column 1. Panels B and C provide the same information, but with bunching. In Panel B, simultaneous stock trades with the same trade indicator, transaction price, and bid and ask prices are considered as one single trade. In Panel C, sequential stock trades with the same trade indicator, transaction price, and bid and ask prices are combined to form one trade. The stocks are listed in a descending order by the number of observations (nobs).

α^s and β^s are the estimated adverse information and inventory components of the stock bid-ask spread, respectively. π^s is the estimated probability of a stock trade reversal. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

Panel A: No Bunching of Trades.

		α^s		β^s		π^s		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (8)
TLS	238263	0.0251*	0.0032	0.2105*	0.0026	0.2174*	0.0010	0.1824	0.1249
NAB	200775	0.0622*	0.0068	0.3936*	0.0056	0.2903*	0.0012	0.1111	0.1954
BHP	179698	0.1029*	0.0085	0.4151*	0.0068	0.3073*	0.0013	0.1001	0.2306
NCP	141231	0.1570*	0.0116	0.3176*	0.0075	0.2920*	0.0014	0.1111	0.2238
CWO	131345	0.0712*	0.0058	0.2824*	0.0045	0.2332*	0.0014	0.1594	0.1768
CBA	100800	0.2253*	0.0106	0.2737*	0.0087	0.3029*	0.0017	0.0956	0.2161
WMC	87341	0.0890*	0.0094	0.3909*	0.0076	0.2735*	0.0017	0.1148	0.2277
MIM	20749	0.0118*	0.0044	0.0485*	0.0031	0.0714*	0.0025	0.3187	0.0352
NDY	20555	0.0086	0.0048	0.0506*	0.0032	0.0810*	0.0026	0.3337	0.0350
QAN	14989	0.0434*	0.0104	0.1548*	0.0081	0.1458*	0.0035	0.2098	0.1024

Panel B: Simultaneous Trades with the Same Trade Indicator, Trade and Quote Prices are Bunched.

		α^s		β^s		π^s		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (8)
TLS	155765	0.0506*	0.0115	0.3471*	0.0111	0.4019*	0.0014	0.0204	0.1950
NAB	146394	0.0581*	0.0276	0.5841*	0.0268	0.4420*	0.0014	0.0079	0.2629
BHP	131316	0.1776*	0.0461	0.5550*	0.0453	0.4612*	0.0015	0.0034	0.3176
NCP	103769	0.5514*	0.0372	0.1586*	0.0358	0.4363*	0.0017	-0.0042	0.3064
CWO	84985	0.1065*	0.0282	0.4665*	0.0276	0.4368*	0.0019	0.0085	0.2701
CBA	75364	0.7951*	0.0541	-0.1272*	0.0528	0.4484*	0.0020	-0.0079	0.2875
WMC	61961	0.1455*	0.0407	0.5698*	0.0399	0.4418*	0.0022	-0.0013	0.3122
NDY	11317	0.0023	0.0111	0.1199*	0.0093	0.2567*	0.0049	0.0248	0.0680
MIM	10235	0.0099	0.0126	0.1369*	0.0118	0.2883*	0.0053	0.0282	0.0792
QAN	8779	0.0419	0.0381	0.3312*	0.0372	0.3749*	0.0058	0.0127	0.1756

TABLE 6 continued
Results of the Huang and Stoll (1997) Model based on Serial Correlation in Trade Flows

Panel C: Sequential Trades with the Same Trade Indicator, Trade and Quote Prices are Bunched.

		α^s		β^s		π^s		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (8)
NAB	97630	-0.2648*	0.0102	1.1643*	0.0101	0.7252*	0.0016	0.1101	0.3821
BHP	86978	-0.3169*	0.0103	1.3589*	0.0095	0.7590*	0.0017	0.1401	0.4566
TLS	77161	-0.1108*	0.0078	0.8067*	0.0059	0.9298*	0.0011	0.4818	0.3686
NCP	69178	-0.3381*	0.0160	1.3898*	0.0138	0.7126*	0.0020	0.0963	0.4302
CBA	49925	-0.3047*	0.0150	1.2548*	0.0136	0.7405*	0.0022	0.1217	0.4121
CWO	47675	-0.1571*	0.0096	1.0617*	0.0085	0.8847*	0.0018	0.3296	0.4436
WMC	36733	-0.1964*	0.0128	1.2692*	0.0109	0.8435*	0.0022	0.2417	0.4746
QAN	4266	-0.1137*	0.0271	0.7648*	0.0241	0.9481*	0.0041	0.4529	0.3442
NDY	3857	-0.0434	0.0319	0.3588*	0.0175	0.9970*	0.0011	0.8619	0.1936
MIM	3786	-0.0550	0.0324	0.3685*	0.0182	0.9963*	0.0012	0.8531	0.2063

Average Results for Each Panel.

		α^s		β^s		π^s		$\bar{R}^2$	
	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (8)
Panel A	113575	0.0796	0.0075	0.2538	0.0058	0.2215	0.0018	0.1737	0.1568
Panel B	78989	0.1939	0.0307	0.3142	0.0298	0.3988	0.0028	0.0093	0.2275
Panel C	47719	-0.1901	0.0173	0.9798	0.0132	0.8537	0.0019	0.3689	0.3712

TABLE 7

Results of the Cross-Market Model

This table provides the parameter estimates and corresponding standard errors of the cross-market model designed to decompose the common stock bid-ask spread into components. The model is represented by Equations (2), (4) and (7). The stocks are listed in a descending order by the number of observations.

The sum of α^s and α^o measures the total estimated adverse information component of the stock bid-ask spread inferred from the trade flows in the stock and options markets, respectively. β^s is the estimated inventory component of the stock bid-ask spread. π^s is the estimated probability of a stock trade reversal. π^o is the estimated probability that the aggregate option trade indicator reverses in sign between two consecutive periods. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

		α^s		β^s		π^s		α^o		π^o		$\bar{R}^2$		
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (4)	Eq. (7)
TLS	238263	0.0255*	0.0032	0.2121*	0.0027	0.2203*	0.0010	0.0534*	0.0087	0.4912*	0.0013	0.1838	0.0005	0.1255
NAB	200775	0.0627*	0.0068	0.3924*	0.0057	0.2917*	0.0012	0.0690*	0.0125	0.4870*	0.0014	0.1115	0.0009	0.1966
BHP	179698	0.1066*	0.0086	0.4123*	0.0069	0.3085*	0.0012	0.0700*	0.0147	0.4894*	0.0014	0.1004	0.0006	0.2315
NCP	141231	0.1662*	0.0116	0.3120*	0.0076	0.2930*	0.0014	0.1802*	0.0193	0.4825*	0.0016	0.1113	0.0014	0.2242
CWO	131345	0.0704*	0.0058	0.2828*	0.0045	0.2362*	0.0014	0.0613*	0.0139	0.4940*	0.0017	0.1608	0.0003	0.1777
CBA	100800	0.2310*	0.0107	0.2694*	0.0088	0.3046*	0.0017	0.1413*	0.0152	0.4914*	0.0019	0.0961	0.0005	0.2175
WMC	87341	0.0887*	0.0094	0.3893*	0.0076	0.2758*	0.0017	0.1059*	0.0164	0.4888*	0.0019	0.1157	0.0006	0.2293
MIM	20749	0.0123*	0.0045	0.0481*	0.0031	0.0743*	0.0025	0.0619*	0.0158	0.4886*	0.0054	0.3213	0.0007	0.0380
NDY	20555	0.0108*	0.0048	0.0516*	0.0032	0.0934*	0.0025	0.0277*	0.0128	0.5365*	0.0018	0.3438	-0.0132	0.0369
QAN	14989	0.0466*	0.0106	0.1566*	0.0080	0.1538*	0.0034	0.0495*	0.0252	0.5012*	0.0049	0.2160	-0.0006	0.1042
Average	113575	0.0821	0.0076	0.2527	0.0058	0.2252	0.0018	0.0820	0.0154	0.4951	0.0023	0.1761	-0.0008	0.1581

TABLE 8

Results of the Revised Cross-Market Model – Without the Estimation of π^o

This table reports the results of the revised cross-market model designed to decompose the common stock bid-ask spread into components. The revised model, consisting of Equations (2) and (9) does not include the estimation of π^o, the probability that the aggregate option trade indicator reverses in sign between consecutive periods. The stocks are listed in a descending order by the number of observations.

The sum of α^s and α^o measures the total estimated adverse information component of the stock bid-ask spread inferred from the trade flows observed in the stock and options markets, respectively. β^s is the estimated inventory component of the stock bid-ask spread and π^s is the estimated probability of a stock trade reversal. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

		α^s		β^s		π^s		α^o		$\bar{R}^2$ Eq.	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (9)
TLS	238263	0.0253*	0.0032	0.2100*	0.0026	0.2174*	0.0010	0.0754*	0.0094	0.1824	0.1251
NAB	200775	0.0633*	0.0068	0.3921*	0.0056	0.2904*	0.0012	0.1354*	0.0133	0.1112	0.1970
BHP	179698	0.1047*	0.0085	0.4126*	0.0068	0.3074*	0.0013	0.1348*	0.0159	0.1001	0.2316
NCP	141231	0.1605*	0.0116	0.3135*	0.0076	0.2920*	0.0014	0.1818*	0.0242	0.1111	0.2239
CWO	131345	0.0718*	0.0058	0.2816*	0.0045	0.2333*	0.0014	0.1290*	0.0149	0.1595	0.1781
CBA	100800	0.2275*	0.0106	0.2707*	0.0087	0.3030*	0.0017	0.1273*	0.0164	0.0956	0.2175
WMC	87341	0.0900*	0.0094	0.3883*	0.0076	0.2736*	0.0017	0.1740*	0.0186	0.1149	0.2295
MIM	20749	0.0116*	0.0044	0.0482*	0.0031	0.0715*	0.0025	0.1109*	0.0171	0.3188	0.0382
NDY	20555	0.0087	0.0048	0.0501*	0.0032	0.0811*	0.0026	0.0628*	0.0147	0.3338	0.0369
QAN	14989	0.0440*	0.0104	0.1545*	0.0081	0.1458*	0.0035	0.0917*	0.0270	0.2099	0.1036
Average	113575	0.0807	0.0076	0.2522	0.0058	0.2215	0.0018	0.1223	0.0172	0.1737	0.1581

TABLE 9

Results of the Revised Cross-Market Model – Intra-day Pattern of Bid-Ask Spread Components

This table reports the intra-day distribution of stock bid-ask spread components. The revised cross-market model, consisting of Equations (2) and (9), is applied to stock data with no bunching observed during four intra-day periods. Panel A presents the results of the first hour of stock trading from 10:00 am to 11:00 am. In panel B, stock data during 11:00 am - 12:30 pm is used. Panel C is based on stock trades observed from 2:00 pm - 3:00 pm. Panel D reports the results for the last hour of stock trading from 3:00pm - 4:00 pm. The stocks are listed in a descending order by the number of observations.

The sum of α^s and α^o measures the total estimated adverse information component of the common stock bid-ask spread inferred from the trade flows observed in the stock and options markets, respectively. β^s is the estimated inventory component of the common stock bid-ask spread and π^s is the estimated probability of a stock trade reversal. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

Panel A: 1st Period of Stock Trading from 10:00 am – 11:00 am.

		α^s		β^s		π^s		α^o		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (9)
TLS	65423	0.0343*	0.0066	0.2304*	0.0053	0.2049*	0.0019	0.1134*	0.0269	0.1821	0.1330
NAB	51141	0.0432*	0.0116	0.3823*	0.0095	0.2588*	0.0023	0.1237*	0.0243	0.1284	0.1891
BHP	47092	0.1985*	0.0145	0.2946*	0.0111	0.2700*	0.0024	0.1326*	0.0293	0.1238	0.2223
CWO	38967	0.0692*	0.0109	0.2977*	0.0082	0.2165*	0.0025	0.1270*	0.0354	0.1643	0.1771
NCP	35732	0.1315*	0.0176	0.3341*	0.0139	0.2753*	0.0027	0.2401*	0.0501	0.1176	0.2100
CBA	25705	0.1882*	0.0166	0.2748*	0.0130	0.2521*	0.0032	0.1303*	0.0326	0.1298	0.1960
WMC	22869	0.0860*	0.0186	0.4167*	0.0146	0.2584*	0.0033	0.1879*	0.0328	0.1172	0.2227
MIM	7198	0.0189*	0.0073	0.0449*	0.0050	0.0478*	0.0035	0.0585	0.0336	0.3734	0.0359
NDY	5455	0.0075	0.0105	0.0627*	0.0069	0.0675*	0.0046	0.0820*	0.0382	0.3456	0.0443
QAN	3732	0.0451*	0.0223	0.1975*	0.0169	0.1312*	0.0065	0.2031*	0.0677	0.1947	0.1299

Panel B: 2nd Period of Stock Trading from 11:00 am – 12:30 pm.

		α^s		β^s		π^s		α^o		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (9)
TLS	66214	0.0234*	0.0055	0.1933*	0.0045	0.2101*	0.0019	0.0534*	0.0141	0.1676	0.1184
NAB	56100	0.0543*	0.0117	0.3944*	0.0101	0.2861*	0.0022	0.1514*	0.0252	0.1007	0.1991
BHP	48470	0.0828*	0.0151	0.4183*	0.0127	0.3071*	0.0024	0.1314*	0.0240	0.0851	0.2301
NCP	37417	0.0579*	0.0151	0.4214*	0.0129	0.2699*	0.0026	0.1915*	0.0439	0.1124	0.2167
CWO	34824	0.0679*	0.0105	0.2780*	0.0084	0.2352*	0.0026	0.1201*	0.0259	0.1387	0.1759
CBA	28730	0.2284*	0.0188	0.2435*	0.0157	0.2970*	0.0031	0.1115*	0.0271	0.0885	0.2159
WMC	24599	0.0882*	0.0160	0.3685*	0.0134	0.2656*	0.0032	0.2306*	0.0384	0.0995	0.2260
NDY	6369	0.0030	0.0080	0.0488*	0.0055	0.0759*	0.0045	0.0770*	0.0245	0.3068	0.0374
MIM	5051	0.0032	0.0087	0.0551*	0.0068	0.0929*	0.0056	0.1501*	0.0324	0.2181	0.0424
QAN	4190	0.0342	0.0179	0.1470*	0.0141	0.1399*	0.0065	0.0198	0.0430	0.1714	0.0828

TABLE 9 continued

Results of the Revised Cross-Market Model –
Intra-day Pattern of Bid-Ask Spread Components

Panel C: 3rd Period of Stock Trading from 2:00 pm – 3:00 pm.

		α^s		β^s		π^s		α^o		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (9)
TLS	44660	0.0295*	0.0062	0.1898*	0.0051	0.1902*	0.0022	0.0752*	0.0178	0.1845	0.1217
NAB	40083	0.0673*	0.0135	0.3926*	0.0112	0.2678*	0.0026	0.1156*	0.0282	0.1140	0.2051
BHP	35710	0.1092*	0.0162	0.4279*	0.0135	0.2913*	0.0028	0.1247*	0.0344	0.0973	0.2398
NCP	27402	0.2411*	0.0344	0.2375*	0.0173	0.2798*	0.0031	0.1517*	0.0366	0.1162	0.2542
CWO	23023	0.0735*	0.0116	0.2582*	0.0091	0.2075*	0.0031	0.1765*	0.0282	0.1540	0.1828
CBA	19521	0.0634*	0.0221	0.4430*	0.0195	0.2989*	0.0037	0.1716*	0.0415	0.0823	0.2385
WMC	16899	0.0804*	0.0175	0.3602*	0.0144	0.2473*	0.0037	0.1706*	0.0348	0.1182	0.2277
MIM	3543	0.0090	0.0117	0.0405*	0.0069	0.0397*	0.0046	0.1181*	0.0417	0.4238	0.0331
QAN	3368	0.0529*	0.0182	0.1160*	0.0128	0.1044*	0.0067	0.0946	0.0488	0.2258	0.0989
NDY	3270	0.0107	0.0097	0.0394*	0.0070	0.0584*	0.0057	0.0081	0.0317	0.3480	0.0280

Panel D: 4th Period of Stock Trading from 3:00 pm – 4:00 pm.

		α^s		β^s		π^s		α^o		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (9)
TLS	61966	0.0245*	0.0055	0.1992*	0.0047	0.2099*	0.0019	0.0691*	0.0133	0.1709	0.1230
NAB	53451	0.0516*	0.0133	0.4263*	0.0117	0.3007*	0.0022	0.1818*	0.0256	0.0906	0.2058
BHP	48426	0.0719*	0.0158	0.4467*	0.0137	0.3152*	0.0023	0.1741*	0.0365	0.0817	0.2500
NCP	40680	0.0580*	0.0163	0.4702*	0.0139	0.2992*	0.0025	0.0986*	0.0258	0.0899	0.2349
CWO	34531	0.0592*	0.0097	0.2697*	0.0080	0.2187*	0.0026	0.1405*	0.0274	0.1533	0.1760
CBA	26844	0.0487*	0.0217	0.4773*	0.0198	0.3201*	0.0032	0.1619*	0.0323	0.0678	0.2437
WMC	22974	0.0591*	0.0162	0.3913*	0.0143	0.2690*	0.0032	0.1059*	0.0350	0.1030	0.2379
NDY	5461	0.0145	0.0080	0.0410*	0.0054	0.0727*	0.0046	0.0587*	0.0271	0.2908	0.0324
MIM	4957	0.0104	0.0085	0.0466*	0.0061	0.0770*	0.0050	0.1067*	0.0307	0.2453	0.0379
QAN	3699	0.0363	0.0193	0.1507*	0.0154	0.1420*	0.0067	0.1017	0.0546	0.1950	0.1015

Average for Each Period.

		α^s		β^s		π^s		α^o		$\bar{R}^2$	
Period	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (9)
1st	30331	0.0822	0.0136	0.2536	0.0104	0.1982	0.0033	0.1399	0.0371	0.1877	0.1560
2nd	31196	0.0644	0.0127	0.2568	0.0104	0.2180	0.0034	0.1237	0.0299	0.1489	0.1545
3rd	21748	0.0737	0.0161	0.2505	0.0117	0.1985	0.0038	0.1207	0.0344	0.1864	0.1630
4th	30299	0.0434	0.0134	0.2919	0.0113	0.2225	0.0034	0.1199	0.0308	0.1488	0.1643

TABLE 10

Results of the Revised Cross-Market Model – Leverage and Adverse Information

This table shows the impact of option leverage on the distribution of common stock bid-ask spread components. The results are based on Equations (2) and (10). Panels A, B and C present the results of the model when the value of the aggregate option trade indicator variable, $Q_t^{o,lev}$, is based on low, medium and high leverage options, respectively. The stocks are listed in a descending order by the number of observations.

The sum of α^s and $\alpha^{o,lev}$ is the total estimated adverse information component of the stock bid-ask spread due to the trade flows in both the stock and options markets. β^s is the estimated inventory component and π^s is the estimated probability of a stock trade reversal. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

Panel A: Low Leverage Options are Used to Determine the Values Assigned to $Q_t^{o\ lev}$.

		α^s		β^s		π^s		$\alpha^{o,\ lev}$		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (10)
TLS	166781	0.0234*	0.0037	0.2027*	0.0030	0.2075*	0.0012	0.0841*	0.0182	0.1893	0.1222
NAB	157394	0.0610*	0.0074	0.3904*	0.0062	0.2858*	0.0014	0.1338*	0.0229	0.1123	0.1970
BHP	155094	0.1079*	0.0091	0.4138*	0.0072	0.3041*	0.0014	0.1341*	0.0295	0.1022	0.2298
NCP	107476	0.0766*	0.0103	0.4201*	0.0082	0.2860*	0.0016	0.2155*	0.0323	0.1118	0.2218
CWO	58056	0.0692*	0.0081	0.2719*	0.0062	0.2181*	0.0020	0.0545	0.0382	0.1674	0.1671
WMC	51209	0.0819*	0.0113	0.3802*	0.0093	0.2624*	0.0022	0.0922*	0.0353	0.1172	0.2263
CBA	48690	0.2285*	0.0153	0.2752*	0.0126	0.3052*	0.0024	0.1223*	0.0297	0.0916	0.2100
QAN	5931	0.0539*	0.0156	0.1389*	0.0121	0.1181*	0.0052	0.0520	0.0628	0.2242	0.0945
MIM	4003	0.0137	0.0110	0.0537*	0.0073	0.0576*	0.0052	0.1774*	0.0749	0.3002	0.0415
NDY	3704	0.0031	0.0096	0.0432*	0.0067	0.0580*	0.0051	0.1290	0.0689	0.3025	0.0322

Panel B: Medium Leverage Options are Used to Determine the Values Assigned to $Q_t^{o\ lev}$.

		α^s		β^s		π^s		$\alpha^{o,\ lev}$		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (10)
TLS	166781	0.0235*	0.0037	0.2026*	0.0030	0.2075*	0.0012	0.0844*	0.0141	0.1893	0.1223
NAB	157394	0.0614*	0.0074	0.3902*	0.0062	0.2858*	0.0014	0.1571*	0.0255	0.1123	0.1969
BHP	155094	0.1076*	0.0091	0.4141*	0.0072	0.3041*	0.0014	0.0872*	0.0262	0.1022	0.2299
NCP	107476	0.0763*	0.0103	0.4205*	0.0082	0.2860*	0.0016	0.1369*	0.0332	0.1118	0.2214
CWO	58056	0.0697*	0.0081	0.2715*	0.0062	0.2181*	0.0020	0.1480*	0.0306	0.1674	0.1674
WMC	51209	0.0825*	0.0113	0.3791*	0.0093	0.2625*	0.0022	0.2146*	0.0427	0.1172	0.2269
CBA	48690	0.2286*	0.0153	0.2753*	0.0126	0.3051*	0.0024	0.0999*	0.0396	0.0916	0.2096
QAN	5931	0.0534*	0.0156	0.1392*	0.0120	0.1181*	0.0052	0.0825	0.0750	0.2242	0.0951
MIM	4003	0.0127	0.0110	0.0541*	0.0073	0.0575*	0.0052	0.1342	0.0728	0.3002	0.0417
NDY	3704	0.0036	0.0095	0.0429*	0.0065	0.0581*	0.0051	0.1174*	0.0559	0.3025	0.0351

TABLE 10 continued

Results of the Revised Cross-Market Model – Leverage and Adverse Information

Panel C: High Leverage Options are Used to Determine the Values Assigned to $Q_t^{o\,lev}$.

		α^s		β^s		π^s		$\alpha^{o,\,lev}$		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (10)
TLS	166781	0.0235*	0.0037	0.2027*	0.0030	0.2074*	0.0012	0.0728*	0.0141	0.1893	0.1224
NAB	157394	0.0607*	0.0074	0.3906*	0.0062	0.2858*	0.0014	0.1017*	0.0228	0.1123	0.1969
BHP	155094	0.1082*	0.0091	0.4131*	0.0072	0.3041*	0.0014	0.1502*	0.0257	0.1022	0.2299
NCP	107476	0.0765*	0.0104	0.4206*	0.0082	0.2860*	0.0016	0.0935*	0.0261	0.1118	0.2211
CWO	58056	0.0695*	0.0081	0.2712*	0.0062	0.2182*	0.0020	0.0965*	0.0367	0.1674	0.1672
WMC	51209	0.0821*	0.0114	0.3789*	0.0093	0.2624*	0.0022	0.1932*	0.0406	0.1172	0.2252
CBA	48690	0.2281*	0.0153	0.2768*	0.0126	0.3051*	0.0024	0.1598*	0.0349	0.0916	0.2103
QAN	5931	0.0514*	0.0156	0.1385*	0.0121	0.1182*	0.0052	0.2254*	0.0816	0.2243	0.0944
MIM	4003	0.0120	0.0109	0.0540*	0.0073	0.0575*	0.0052	0.1661*	0.0701	0.3002	0.0419
NDY	3704	0.0038	0.0095	0.0438*	0.0066	0.0580*	0.0051	0.1918*	0.0680	0.3024	0.0376

Average for Each Level of Leverage.

		α^s		β^s		π^s		$\alpha^{o,\,lev}$		$\bar{R}^2$	
	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (10)
Low	75834	0.0719	0.0101	0.2590	0.0079	0.2103	0.0028	0.1195	0.0413	0.1719	0.1542
Med.	75834	0.0719	0.0101	0.2589	0.0079	0.2103	0.0028	0.1262	0.0416	0.1719	0.1546
High	75834	0.0716	0.0101	0.2590	0.0079	0.2103	0.0028	0.1451	0.0421	0.1719	0.1547

TABLE 11

Results of the Revised Cross-Market Model – Stock Trade Size and Bid-Ask Spread Components

This table reports the impact of stock trade size on the distribution of bid-ask spread components of common stocks. With two stock trade sizes, the stock data is sorted into four subsets based on the four possible sequences of stock trade size observed in the last two periods. Equations (11) and (12) are applied to the four subsets of data. Panels A, B, C and D present the results of the model for subsets of data consisting of small to small (ss), small to large (sl), large to small (ls), and large to large (ll) stock trades, respectively. The stocks are listed in a descending order by the number of observations.

The sum of $\alpha^{s,ij}$ and α^{o} measures the total estimated adverse information component of the stock bid-ask spread due to the trade flows observed in the stock and options markets, respectively. $\beta^{s,ij}$ is the estimated inventory component and $\pi^{s,ij}$ is the estimated probability of a stock trade reversal. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

Panel A: Small to Small Stock Trades.

		$\alpha^{s,ij}$		$\beta^{s,ij}$		$\pi^{s,ij}$		α^{o}		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (11)	Eq. (12)
TLS	187325	0.0258*	0.0033	0.1801*	0.0027	0.2097*	0.0012	0.0518*	0.0098	0.1879	0.1063
NAB	145578	0.0691*	0.0071	0.3416*	0.0059	0.2764*	0.0014	0.1317*	0.0151	0.1237	0.1734
BHP	138222	0.0940*	0.0093	0.3956*	0.0074	0.3006*	0.0014	0.1248*	0.0181	0.1056	0.2162
CWO	117583	0.0648*	0.0059	0.2720*	0.0046	0.2288*	0.0014	0.1217*	0.0153	0.1648	0.1700
NCP	89348	0.0923*	0.0130	0.3823*	0.0087	0.2756*	0.0017	0.1531*	0.0292	0.1245	0.1819
WMC	75113	0.0813*	0.0100	0.3783*	0.0079	0.2692*	0.0018	0.1458*	0.0188	0.1185	0.2212
CBA	67231	0.1862*	0.0115	0.2248*	0.0088	0.2746*	0.0020	0.1101*	0.0193	0.1206	0.1757
NDY	19561	0.0084	0.0048	0.0497*	0.0032	0.0834*	0.0027	0.0624*	0.0147	0.3248	0.0363
MIM	19265	0.0104*	0.0046	0.0474*	0.0032	0.0743*	0.0027	0.1172*	0.0171	0.3084	0.0377
QAN	14231	0.0389*	0.0104	0.1531*	0.0081	0.1457*	0.0036	0.0894*	0.0267	0.2100	0.0989

Panel B: Small to Large Stock Trades.

		$\alpha^{s,ij}$		$\beta^{s,ij}$		$\pi^{s,ij}$		α^{o}		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (11)	Eq. (12)
NAB	24076	0.0382	0.0221	0.5948*	0.0206	0.3094*	0.0030	0.1835*	0.0349	0.0818	0.2800
TLS	22739	0.0443*	0.0138	0.3934*	0.0117	0.2521*	0.0030	0.0371	0.0332	0.1199	0.2109
NCP	21560	0.1468*	0.0285	0.4969*	0.0233	0.3113*	0.0033	0.1530*	0.0408	0.0805	0.2895
BHP	18665	0.3627*	0.0300	0.2926*	0.0268	0.3262*	0.0036	0.1732*	0.0403	0.0664	0.2932
CBA	14179	0.2464*	0.0375	0.4809*	0.0352	0.3446*	0.0041	0.1617*	0.0479	0.0548	0.3189
CWO	6398	0.0918*	0.0300	0.4717*	0.0273	0.2650*	0.0058	0.2141*	0.0651	0.0914	0.2476
WMC	5626	0.1497*	0.0406	0.5297*	0.0374	0.2902*	0.0063	0.1919*	0.0617	0.0728	0.2891
MIM	691	0.0186	0.0251	0.0922*	0.0195	0.0423*	0.0092	0.3828*	0.1464	0.4090	0.0627
NDY	475	-0.0031	0.0310	0.1098*	0.0248	0.0362*	0.0106	0.3475	0.2085	0.4406	0.0708
QAN	365	0.0853	0.0668	0.3016*	0.0497	0.1111*	0.0182	-0.2487	0.1812	0.1864	0.2098

TABLE 11 continued
Results of the Revised Cross-Market Model – Stock Trade Size and Bid-Ask Spread Components

Panel C: Large to Small Stock Trades.

		$\alpha^{s,ij}$		$\beta^{s,ij}$		$\pi^{s,ij}$		α^{o}		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (11)	Eq. (12)
NAB	24052	-0.0248	0.0219	0.5675*	0.0211	0.3128*	0.0031	0.0873*	0.0415	0.0781	0.2239
TLS	22715	-0.0238*	0.0115	0.3845*	0.0099	0.2072*	0.0028	0.1222*	0.0333	0.1769	0.1779
NCP	21541	0.1178*	0.0262	0.4211*	0.0222	0.3010*	0.0032	0.1604*	0.0754	0.0896	0.2530
BHP	18645	0.0271	0.0272	0.5993*	0.0239	0.3075*	0.0035	0.1464*	0.0523	0.0836	0.2699
CBA	14164	-0.0320	0.0349	0.6043*	0.0333	0.3424*	0.0040	0.1423*	0.0422	0.0524	0.2556
CWO	6392	0.0383	0.0298	0.4728*	0.0234	0.2267*	0.0056	0.1853*	0.0832	0.1293	0.2341
WMC	5610	0.0238	0.0378	0.5978*	0.0347	0.2648*	0.0061	0.1484*	0.0579	0.0974	0.2686
MIM	693	0.0082	0.0293	0.1169*	0.0205	0.0298*	0.0080	-0.3919*	0.1499	0.4717	0.0681
NDY	474	0.0389	0.0395	0.1007*	0.0209	0.0220*	0.0088	-0.1070	0.1772	0.5300	0.0533
QAN	365	0.1032	0.0723	0.3240*	0.0588	0.1216*	0.0194	0.3120	0.1962	0.1470	0.2140

Panel D: Large to Large Stock Trades.

		$\alpha^{s,ij}$		$\beta^{s,ij}$		$\pi^{s,ij}$		α^{o}		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (11)	Eq. (12)
NCP	8782	0.2778*	0.0510	0.4646*	0.0382	0.2992*	0.0052	0.3002*	0.0668	0.0886	0.2961
NAB	7069	0.3003*	0.0472	0.4039*	0.0429	0.3206*	0.0060	0.1482*	0.0622	0.0564	0.3169
TLS	5484	0.0785*	0.0238	0.4373*	0.0199	0.1697*	0.0055	0.0934	0.0602	0.1911	0.2606
CBA	5226	0.3112*	0.0768	0.4778*	0.0707	0.3698*	0.0070	0.2679*	0.0787	0.0317	0.3306
BHP	4166	0.2623*	0.0477	0.4484*	0.0431	0.2685*	0.0075	0.2262*	0.0839	0.0936	0.3130
WMC	992	0.0280	0.0803	0.6273*	0.0795	0.2608*	0.0151	-0.0579	0.1859	0.0666	0.2602
CWO	972	0.1189	0.0780	0.4448*	0.0676	0.2587*	0.0157	0.3013*	0.1459	0.0484	0.2567
MIM	100	0.0826	0.1088	0.0156	0.0197	0.0095	0.0108	0.0006	0.0564	0.6646	-0.0260
NDY	45	-0.0714	1.6532	0.1264	0.1300	0.0003	0.0042	-0.0919	1.1367	0.9066	0.0064
QAN	28	0.5429	0.2793	0.1466	0.1282	0.0273	0.0340	0.0001	0.0000	0.4640	0.3167

Average for Each Stock Trade Size Sequence.

		$\alpha^{s,ij}$		$\beta^{s,ij}$		$\pi^{s,ij}$		α^{o}		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (11)	Eq. (12)
ss	87346	0.0671	0.0080	0.2425	0.0060	0.2138	0.0020	0.1108	0.0184	0.1789	0.1418
sl	11477	0.1181	0.0325	0.3764	0.0276	0.2288	0.0067	0.1596	0.0860	0.1604	0.2273
ls	11465	0.0277	0.0330	0.4189	0.0269	0.2136	0.0065	0.0805	0.0909	0.1856	0.2018
ll	3286	0.1931	0.2446	0.3593	0.0640	0.1984	0.0111	0.1188	0.1877	0.2612	0.2331

TABLE 12

Results of the Revised Cross-Market Model – Option Trade Size and Bid-Ask Spread Components

This table reports the impact of information-based option trade imbalance on the distribution of stock bid-ask spread components. The results of estimating Equations (2) and (13) for two sets of data, one with small, and the other with large, option trade imbalance, are reported in Panels A and B, respectively. The stocks are listed in a descending order by the number of observations.

The sum of α^s and $\alpha^{o,y}$ measures the estimated adverse information component of the stock bid-ask spread due to the trade flows observed in the stock and options markets, respectively. β^s is the estimated inventory component of the stock bid-ask spread and π^s is the estimated probability of a stock trade reversal. Estimated coefficients that are different from zero at the 5% significant level are indicated by an asterisk.

Panel A: Small Option Trades in the Last Period.

		α^s		β^s		π^s		$\alpha^{o,y}$		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (13)
TLS	236459	0.0253*	0.0032	0.2090*	0.0026	0.2168*	0.0010	0.0831*	0.0102	0.1831	0.1248
NAB	197815	0.0651*	0.0068	0.3890*	0.0057	0.2897*	0.0012	0.1473*	0.0151	0.1117	0.1959
BHP	176672	0.1041*	0.0086	0.4096*	0.0069	0.3067*	0.0013	0.1431*	0.0172	0.1008	0.2309
NCP	139175	0.1635*	0.0117	0.3115*	0.0076	0.2914*	0.0014	0.2297*	0.0266	0.1117	0.2219
CWO	130040	0.0721*	0.0058	0.2796*	0.0045	0.2329*	0.0014	0.1355*	0.0162	0.1598	0.1774
CBA	99581	0.2301*	0.0106	0.2674*	0.0087	0.3022*	0.0017	0.1441*	0.0177	0.0963	0.2172
WMC	86263	0.0913*	0.0094	0.3861*	0.0076	0.2732*	0.0017	0.1743*	0.0202	0.1150	0.2281
MIM	20684	0.0118*	0.0044	0.0476*	0.0031	0.0715*	0.0025	0.1035*	0.0172	0.3188	0.0376
NDY	20340	0.0091	0.0048	0.0493*	0.0031	0.0801*	0.0026	0.0560*	0.0158	0.3374	0.0360
QAN	14874	0.0445*	0.0103	0.1531*	0.0080	0.1448*	0.0035	0.1152*	0.0281	0.2119	0.1039

Panel B: Large Option Trades in the Last Period.

		α^s		β^s		π^s		$\alpha^{o,y}$		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (13)
BHP	3026	0.0002	0.0732	0.7436*	0.0716	0.3216*	0.0087	0.1701*	0.0359	0.0538	0.2698
NAB	2960	-0.0342	0.0618	0.6651*	0.0640	0.3026*	0.0086	0.0845*	0.0251	0.0673	0.2526
NCP	2056	0.2329*	0.0920	0.5409*	0.0831	0.2977*	0.0101	0.1528*	0.0373	0.0586	0.3109
TLS	1804	-0.0630	0.0436	0.4721*	0.0423	0.2447*	0.0108	0.0074	0.0212	0.0753	0.1815
CWO	1305	-0.0728	0.0589	0.6256*	0.0558	0.2327*	0.0115	0.0722*	0.0359	0.1048	0.2680
CBA	1219	-0.0426	0.1089	0.6336*	0.1079	0.3425*	0.0131	0.1212*	0.0427	0.0271	0.2375
WMC	1078	-0.1284	0.0872	0.7390*	0.0751	0.2527*	0.0135	0.1767*	0.0467	0.0838	0.3177
NDY	215	-0.0548	0.0518	0.2211*	0.0672	0.1755*	0.0262	0.1023*	0.0365	0.0203	0.0893
QAN	115	0.1384	0.2215	0.2369	0.1902	0.2890*	0.0407	-0.0332	0.0679	0.0243	0.0867
MIM	65	0.0959	0.0996	0.1581*	0.0732	0.0675*	0.0307	0.1124	0.0584	0.2911	0.0965

Average for each Option Trade Size.

		α^s		β^s		π^s		$\alpha^{o,y}$		$\bar{R}^2$	
Stock	nobs	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Eq. (2)	Eq. (13)
Small	112190	0.0817	0.0076	0.2502	0.0058	0.2209	0.0018	0.1332	0.0184	0.1747	0.1574
Large	1384	0.0072	0.0899	0.5036	0.0830	0.2527	0.0174	0.0966	0.0408	0.0806	0.2111