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Jenwittayaroje, Nattawut; Charoenwong, Charlie; Ding, David K.; Yang, Yung Chiang

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*Title Page

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Nattawut Jenwittayaroje

Department of Banking and Finance
Faculty of Commerce and Accountancy
Chulalongkorn University
Bangkok 10330, Thailand
nattawut@cbs.chula.ac.th

Charlie Charoenwong

Nanyang Business School
Nanyang Technological University
Singapore 639798, Singapore
Tel: (65) 6790-4799; Fax: (65) 6791-3236
charlie@pmail.ntu.edu.sg

David K. Ding**

School of Economics and Finance
Massey University
Auckland, New Zealand
Tel: (64) 9414-0800 ext. 43159; Fax: (64) 9441-8177
d.ding@massey.ac.nz
and
Lee Kong Chian School of Business
Singapore Management University
Singapore 178899, Singapore
Tel: (65) 6828-0245; Fax: (65) 6828-0427
davidding@smu.edu.sg

Yung Chiang Yang

Queen's University Management School
Queen's University Belfast
Belfast BT9 5EE, United Kingdom
(44) 2890-973091
y.yang@qub.ac.uk

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**Corresponding author: David K. Ding, School of Economics and Finance, College of Business, Massey University, Auckland, New Zealand, Tel: (64) 9 414 0800 ext 43159, Fax: (64) 9 441 8177, e-mail: d.ding@massey.ac.nz.

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Trading Costs on the Stock Exchange of Thailand

Abstract

This study examines the components of trading costs incurred in trading large and liquid stocks listed on the Stock Exchange of Thailand. We find that aggressive orders pay an immediacy price measured by price impact, whereas executed passive orders gain the immediacy price. We also find a sizable opportunity cost from the unexecuted portion of a limit order that is more than to offset the benefit obtained from the partial fulfillment of the order. The total trading cost, which includes price impact and opportunity cost, is positively related to order size and stock price volatility, and is negatively associated with firm size, stock price, and stock liquidity. The total trading cost has a U-shaped relation with order aggressiveness. Collectively, our study suggests that, to minimize the total trading cost, the optimal strategy is simply to use a limit order submitted at the best quote.

JEL classification: G11; G15

Keywords: Trading Costs; Thailand; Order Aggressiveness; Order Submission Strategy; Implementation Shortfall

1. INTRODUCTION

In this study, we analyze trading costs incurred by market- and limit- order traders and compare the costs of different order submission strategies. We also examine the relationship between the associated trading costs and stock/order characteristics. Previous studies[1] that use transactional data such as NYSE TAQ focus on trading costs incurred by traders who initiate trades. These studies implicitly assume that trade initiators pay trading costs proxied by the effective half spread for demanding immediacy, and liquidity suppliers such as limit order traders gain the effective spread by supplying immediacy.[2] However, limit order traders incur implicit cost these studies do not take into account. Because the order execution is not guaranteed as in the case of market orders, limit orders face a non-execution risk (Cohen et al. 1981). The non-execution risk exposes limit order traders to opportunity cost. Opportunity cost is incurred when a portion of a limit order is unfilled and subsequently filled at an unfavorable price (Handa and Schwartz 1996; Liu 2009; Perold 1988; Wagner and Edwards 1993).[3] Therefore, it is important to take the opportunity cost into account when measuring the total trading cost of a limit order.

In order to quantify the opportunity cost faced by limit order traders, detailed data beyond the trade and quote (TAQ) are required. In this study, we obtain proprietary order-level data that contain information on all orders submitted to the Stock Exchange of Thailand in our sample period. The full detailed order-level data allow us to reconstruct the order book and to quantify the full trading costs incurred by traders using either limit or market orders. Because the data provide the exact time for submission of an order, a more accurate

[1] See, for example, Bennett and Wei (2006), Berkman et al. (2005), Bessembinder and Kaufman (1997a, 1997b), Boehmer (2005), Frino and Oetomo (2005), Huang and Stoll (2001), and Venkataraman (2001).

[2] Bodurtha and Quin (1990) show that institutional investors can reduce trading costs by trading patiently (e.g., by using more limit orders instead of predominantly using market orders).

[3] In addition, there is an adverse selection problem associated with the filled portions of limit orders, frequently called the winner's curse problem, picked-off risk, or bagging cost (Handa and Schwartz 1996, Liu 2009). This problem results from the option character embedded in limit orders (Copeland and Galai 1983). This risk is related to information-based trades initiated by informed market orders against limit orders (or against market makers in quote-driven markets).

characterization of the true cost of trading[4] is possible than it would otherwise be from using TAQ data, where only the best quotes and executed trades are available. According to Bessembinder (2003) and Peterson and Sirri (2003), the mid-point quote at the time of order submission is a more appropriate benchmark for measuring the trading cost than the mid-point price at the time of order execution. Therefore, information on the timing of an order submission mitigates such estimation biases resulted from an inappropriate benchmark. More importantly, the quantity of a stock sought in an order can be considered an *ex ante* quantity as opposed to the quantity of stock traded, which is an *ex post* quantity. Specifically, it is possible to evaluate and quantify the two types of cost of an order using information from the *ex ante* quantity, i.e., the cost of the filled portion as well as the (opportunity) cost of the unfilled portion of an order.

The result of this study confirms that the total trading cost measured by implementation shortfall has a U-shaped relation with order aggressiveness. The most aggressive and the least aggressive orders have the highest implementation shortfall; and the limit orders submitted at the best quotes have the lowest implementation shortfall. The U-shaped relationship between implementation shortfall and order aggressiveness is expected because the implementation shortfall is the sum of price impact and opportunity cost. The aggressive order such as market order incurs higher price impact, while the less aggressive order such as limit order suffer more opportunity cost of not transacting. Therefore, the implementation shortfall is not linear to the order aggressiveness because price impact and opportunity cost have opposite relation with order aggressiveness. In addition, we document the relationship between stock/order characteristics and cost of trading. The total trading cost proxied by implementation shortfall is positively correlated to order size and volatility; and it is negatively associated to firm size, stock price, and stock liquidity proxied by trading value.

[4]These costs are conceptually similar to costs computed by studies using order-level data about institutional equity trades (e.g., Chiyachantana et al. 2004, Keim and Madhavan 1997, and Chan and Lakonishok 1995; 1997).

The patterns on the price impact and the opportunity cost are conditional on the order types. The price impact of market orders is higher for large orders, small firm stocks, low priced stocks, stocks with high volatility, and stocks with low liquidity. As expected, the opposite is true for limit orders. The opportunity cost of limit orders is higher for small firm stocks, low priced stocks, stocks with high volatility, and stocks with low liquidity. Finally, we propose an optimal trading strategy for traders who wish to minimize their total trading cost. The optimal trading strategy is to use a limit order submitted at the best quote, i.e., use a buy limit order submitted at the best bid or a sell limit order submitted at the best ask. The average total cost of trading that includes the price impact and the opportunity cost using this strategy is merely 0.02% of the order value in our sample period.

This study provides a comprehensive examination of trading cost using large and liquid stocks on the Stock Exchange of Thailand. The finding contributes to the finance literature in the following ways. First, the study is the pioneer to utilize implementation shortfall proposed by Perold (1988) as a measure of total trading cost in a pure order-driven market. Most of the existing studies focus on hybrid or quote-driven market such as NYSE, NASDAQ, and Toronto Stock Exchange. We fill this gap by employing a proprietary data from the Stock Exchange of Thailand. Second, no previous studies have investigated total trading cost in a developing market. We find that the firm size cross-sectional variation of trading cost as well as the contribution of price impact and opportunity cost toward the total trading cost are similar to prior findings in developed markets. Third, our study provides further evidence on the cross-sectional variation of trading cost on order characteristics and stock characteristics than prior studies. We provide systematic and comprehensive evidence on not only the cross-sectional variation of total trading cost, but also the cross-sectional dynamics of price impact and opportunity cost. Specifically, ours is the first study in the literature to document the trading cost variation on stock return volatility and the cross-

sectional variation on trading costs conditional on order aggressiveness. Fourth, we show the importance of opportunity cost in order submission. Ignoring opportunity cost underestimates the total cost of trading especially for the less aggressive limit order with lower filled rate. More importantly, lacking this knowledge may lead to a wrong trading decision and favor less aggressive orders with low price impact but high opportunity cost. Finally, we propose a cost-effective trading strategy based on our finding. The optimal strategy for a trader, who wants to minimize the total trading cost, is to use a limit order submitted at the best quote. In summary, we provide a deeper understanding of the nature, determinants, and characteristics of total trading costs in a pure order-driven market. We believe that this study is of interest to regulators, policy makers, brokers, and individual as well as institutional traders.

The remainder of the paper is organized as follows. Section 2 provides a literature review and develops hypotheses. Section 3 describes the institutional background of the Stock Exchange of Thailand, the proprietary data employed, and trading cost measurement. Sections 4 and 5 discuss empirical results and provide additional robustness checks. Finally, Section 6 concludes.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Trading cost is one of the most heavily researched areas in market microstructure. However, the focus of the research varies. Harris and Hasbrouck (1996) and Peterson and Sirri (2002) compare the spreads for different order types (market vs. limit orders) placed through the NYSE SuperDOT system. Cooney and Sias (2004) and Werner (2003) investigate spreads for orders placed through different channels (electronics system, floor broker, and specialist) in the NYSE. Griffiths et al. (2000), and Harris and Hasbrouck (1996) examine trading costs of orders with different aggressiveness. A large number of studies including Bessembinder and Kaufman (1997a, 1997b), and Huang and Stoll (2001) compares trading

cost between NYSE and NASDAQ.[5] There is another strand of study investigates the institutional trading cost (Chan and Lakonishok 1997; Chiyachantana et al. 2004; Keim and Madhavan 1997, 1998; Wagner and Edwards 1993). Recently, Lee (2011) estimates trading cost for 50 countries in his liquidity-adjusted asset pricing study.

A trader needs to decide the type of order to place when he trades shares. A market order demands immediacy from the counterparty and, therefore, incurs an implicit price of immediacy. On the other hand, while a limit order does not pay for the price of the immediacy, the order faces a non-execution risk and may end up being unfilled. Conventional trading cost measures such as bid-ask spread and price impact underestimate the cost for limit order because they ignore the opportunity cost of not transacting. Perold (1988) develops implementation shortfall measure of transaction costs to capture the entire cost of trading that includes both price impact cost for the executed portion of an order and opportunity cost for unfilled portion of the same order. In this study, we utilize implementation shortfall as the key measure of total trading.

2.1 Determinants of Total Trading Cost

Prior research such as Chiyachantana et al. (2004), Keim and Madhavan (1998), and Wagner and Edwards (1993) document a number of factors that affect spreads and, by association, trading costs. In this study, we classify these factors into two main categories. The first category is made up from a trader's trading decision that comprises order size and order aggressiveness. The second category consists of stock characteristics that are unrelated to a trader's decision. These factors include firm-size measured by market capitalization, stock return volatility, and stock liquidity. In this section, we hypothesize the cross-sectional difference in trading cost on trader's decision and stock characteristics.

[5] Other studies, e.g., Bennett and Wei (2006) and Boehmer (2005), compare trading cost between NYSE and NASDAQ. Venkataraman (2001) compares trading cost across Paris Bourse and NYSE.

According to Griffiths et al. (2000), an aggressive order is expected to pay a higher price impact cost than a passive order because of the demand for immediacy. However, an aggressive order incurs very little or no opportunity cost since the order is almost fully executed immediately upon submission. On the other hand, a limit order incurs opportunity cost because, in whole or in part, the order may remain unfilled. Our first hypothesis is:

H1: Price impact is positively correlated to the aggressiveness level of an order.

The total cost of trading is affected by the size of order. In their theoretical work, Easley and O'Hara (1987) show that a large order incurs a higher trading cost. The prediction is empirically studied by Keim and Madhaven (1997, 1998) using institutional equity trades. They find that larger trades incur higher trading cost in terms of commission cost and price impact. For a limit order, as the size of the order increases, it becomes more difficult for the order to be filled. This leads to a higher opportunity cost (i.e., the cost of the need to eventually transact the unfilled portions, usually at unfavorable prices). For a limit order, opportunity cost forms the bulk of total cost; therefore, a larger order size of the limit order should incur a higher total trading cost. This leads us to the second hypothesis:

H2: Total trading cost is positively correlated to order size.

The trading cost is also affected by firm size and stock price. Bessembinder and Kaufman (1997a), and Keim and Madhavan (1997, 1998) find that the trading cost for large-cap stocks is less than those for small-cap stocks. Similarly, Griffiths et al. (2000) find that the total trading cost, measured by implementation shortfall, is less for large-cap stock than those for small-cap stock in the Toronto Stock Exchange. Griffiths et al. (2000) and Wagner and Edwards (1993) show that an order's filled rate is lower for small-cap stocks than for large-cap stocks, which leads to higher opportunity costs for trades in smaller stocks. Therefore, a limit order's overall trading cost is higher among small capitalization firms. In addition, Huang and Stoll (2001) reports negative relationship between bid-ask spread and

stock price. We expect negative association between trading cost and stock price. All these arguments lead to our third and fourth hypotheses.

H3: Total trading cost is negatively correlated to firm size.

H4: Total trading cost is negatively correlated to stock price.

Foucault's (1999) model predicts that the posted spread is positively related to stock return volatility in a limit order market. The reason given is that high return volatility increases the probability of a limit order being picked off, thus leading a limit order trader to post a less attractive offer. In other words, the bid-ask spread widens and the trading cost for market order increases. Limit orders consequently become more frequent than market orders. Note that while the proportion of limit orders in the order flow increases with stock volatility, the limit order filled rate decreases with stock volatility. In addition, the adverse price change of the unexecuted portion of a limit order is likely to be large when stock volatility increases. As a result, the price impact of a market order and the opportunity cost of a limit order become larger because of the wider bid-ask spread. Copeland and Galai (1983) also show that the bid-ask spread is a positive function of return volatility since the spread can be characterized as a combination of a put and a call option, i.e., a straddle, arising from limit orders. Ho and Stoll (1981) illustrate that spread increases in stock price volatility. These arguments lead to our fifth hypothesis.

H5: Total trading cost is positively correlated to stock price volatility.

The total trading cost is related to the stock liquidity because illiquid stock tends to have higher price impact and lower order filled rate. Wagner and Edwards (1993) show that illiquid stocks have higher unfilled rates and, therefore, higher opportunity costs. Bessembinder and Kaufman (1997a, 1997b), Chan and Lakonishok (1995), and Keim and Madhavan (1997, 1998) show that the price impact cost is high among the illiquid stocks. We

posit the relationship between total cost of trading and stock liquidity in the following hypothesis.

H6: Total trading cost is negatively correlated to stock liquidity.

2.2 Optimal Order Submission Strategy

Harris (1998) takes the opportunity cost of not transacting into account and develops a model that suggests placing limit order close to the market is the optimal trading strategy. Using a sample of the NYSE SuperDOT orders, Harris and Hasbrouck (1996) provide empirical evidence that limit orders submitted at the best quotes have the lowest total trading cost. They employ the implementation shortfall developed by Perold (1988) as the measure of total trading cost in the study. Griffiths et al. (2000) conclude to a similar optimal trading strategy for stocks traded on the Toronto Stock Exchange. However, NYSE and Toronto Stock Exchange have market makers in place to facilitate trading. The Stock Exchange of Thailand, on the other hand, uses a centralized electronic auto-matching system that does not require any designated market maker. This study examines whether the optimal order submission strategy reported for the NYSE and the Toronto Stock Exchange is applicable to a pure order-driven market adopted by the Stock Exchange of Thailand. Consistent with prior findings, we hypothesize the following:

H7: Total trading cost is minimized by submitting limit orders at the best bid (for buy) or best ask (for sell).

3. DATA AND VARIABLE CONSTRUCTION

3.1 Institutional Background

The Stock Exchange of Thailand (hereafter SET) is a pure order-driven market without any designated market makers. Both limit orders and market orders are allowed on

the SET but all orders expire at the end of the trading day. Trading on the SET occurs on five trading boards: main, foreign, big lot, odd lot, and special. Common stocks, preferred stocks, warrants, and unit trusts are traded on the main board, big lot board, and odd lot board. Each board lot size is 100 shares except for higher priced stocks[6] for which one board lot is 50 shares. Orders of incomplete board lots are traded on the odd lot board, while orders of either more than 3 million baht or 1 million shares are traded on the big lot board. Trading on the SET occurs primarily through an order queuing process that arranges orders according to a price-time priority. Call market matching is used to determine the opening price in the morning and afternoon sessions and the closing price of a day. The last transaction price, traded volume, and the best five bid and ask prices along with the corresponding depths of the order book are revealed continuously to the public. The identity of the trader remains anonymous to the public.

3.2 Data

The data used in this study are proprietary and provided by the SET.[7] The data contain an order file and a trade file from January 2011 to June 2011. The trade file contains information on transaction date, transaction time, traded price, traded volume in shares, unique trade identification (trade ID), and corresponding counterparty orders. The order file contains information on the order submission date, order time, price, volume, and unique order identification (order ID). The order file provided by the SET contains not only the best bid and ask orders, but all the submitted orders. Therefore, we are able not only to reconstruct the full limit order book from the order and trade files, but also to define aggressiveness of each order given the condition on the current order book. Most importantly, we can trace the

[6] Higher priced stocks are defined as stocks trading at 500 bath or above for six consecutive months.
[7] There are few studies that utilize order-level from pure order-driven developing markets. Using data from the Shanghai Stock Exchange, Jain and Jiang (2014) find that information contained in the limit order book may predict future price volatility. Wang et al. (2012) and Chiao et al. (2009) use order-level data from the Taiwan Stock Exchange to study order submission behaviors across different investor groups.

executed and unfilled portions of a specific order with the unique order ID. This feature enables us to compute the opportunity cost of the unfilled portion of an order along with the price impact of the executed portion of the same order.

Chordia et al. (2000) argue that displayed prices for thinly traded stocks are not informative. Therefore, we include only the constituent stocks of the SET100 index to ensure that the constructed limit order book is informative and updated frequently. The main criteria used in selecting the stocks into SET100 index are market capitalization and trading volume. These constituent stocks are shares of the largest firms with the most trading liquidity. Although the number of stocks covered is about 20% of the companies listed on the SET, they represent approximately 80% of the market capitalization and trading volume of the exchange.

Harris and Hasbrouck (1996) suggest that comparison of the performance of buy and sell orders during periods of sharply rising or falling trends are not meaningful. Therefore, we select a period that the days with positive returns are approximately equal to those with negative returns. In our sample period from January 2011 to June 2011, 56 of the 119 days in the sample period have negative market returns. We also use an alternative period from October to December 2009 as a robustness check.

3.3 Aggressiveness Level Classification

We compute order aggressiveness based on Biais et al.'s (1995) classification system. All orders are classified into one of the seven levels of aggressiveness. A Category 7 buy (sell) order is the most aggressive level because the order price is greater (lesser) than the best ask (bid) price, and the size of the order exceeds the depth at the best ask (bid). A Category 6 order is the second-most aggressive level because its price is equal to the best ask (bid), but the size of the order exceeds the depth at the best ask (bid). A Category 5 buy (sell) order is an order with a price that is equal to or even greater (less) than the best ask (bid), and the size of

the order is smaller than the best ask (bid) depth. Although Category 5-7 are market orders and are executed immediately, only orders under Category 5 are executed in full, while orders under Category 6 and 7 are executed in part.

Category 1 to 4 are essentially limit orders not executed immediately. Category 4 orders have prices that lie between the best bid and ask and form a new best quote. Category 3 buy (sell) orders have prices equal to the best bid (ask). Category 2 buy (sell) orders have prices less (greater) than the best bid (ask) but greater (less) than the fifth best bid (ask).[8] Category 1 buy (sell) orders have prices less (greater) than the fifth best bid (ask). Category 1 orders are not visible to traders because only the best five quotes are visible to the public. Nevertheless, we are able to identify Category 1 orders because the data provided by the SET contain all orders including those placed outside the best five quotes. A recent study by Garvey and Wu (2011) finds that informed traders strategically switch across different levels of aggressiveness to minimize their trading cost.

3.5 Price Impact Calculation

Following Griffiths et al. (2000), the price impact of an order is measured as the percentage change from the true or unperturbed value of a security to the volume-weighted average executed price of the shares filling the order. The pre-trade benchmark price is used as a proxy for the true value of a security and is the mid-point of the quotes prevailing at the time of order submission. Specifically, the price impact (PI) is defined as follows:

$PI = \log(avprice/midquote)$ for a buy order

$PI = \log(midquote/avprice)$ for a sell order

[8]The fifth best quote is used as the cutoff point because it is the last quote that is shown on the screen and visible to all participants on the SET.

where *PI* represents the price impact of an order, *avprice* refers to the volume-weighted average of the prices of the shares filling the order, and *midquote* stands for the mid-point quote immediately before an order is submitted.

3.6 Opportunity Cost Calculation

When a market order is submitted, execution is almost guaranteed. Unlike a market order, a limit order encounters non-execution risk. Unexecuted and partially executed limit orders cannot be neglected because they represent the opportunity cost of foregone trades. We follow the method employed by Harris and Hasbrouck (1996) to compute the opportunity cost of the unfilled portion of an order. Specifically, if an order is not filled completely, we assume that it is possibly executed at the closing ask price for buy orders and at the closing bid price for sell orders.[9] If the size of the unfilled portion exceeds the depth of the closing bid or ask price, the portion in excess of the available depth is assumed to be filled completely at the next minimum tick size step. Thus, this method implicitly assumes that an investor is pre-committed to trade in the stocks. A similar approach is used for cancelled orders. The cancelled portion of a buy (sell) order is assumed to be filled at the best ask (bid) price prevailing at the time of cancellation. As in the case of expired orders, the size of the cancelled portion of an order is also taken into account.[10]

The approach of assigning a filled price to the unexecuted portion of a limit order is equivalent to assuming that the unfilled portion is resubmitted by a market order at the time of order cancellation or expiration.[11] This approach is appropriate for pre-committed traders who use limit orders to lower their trading costs but they must trade before a certain deadline (e.g.,

[9] On the SET, orders that are not completely filled at the end of the trading day will expire automatically.
[10] If the size of the cancelled portion of a buy (sell) order exceeds the depth of the best ask (bid) price prevailing at the point of cancellation, the portion in excess of the available depth is assumed to be fully filled at the next step price.
[11] Some may argue that assuming a market order always executes against the opposite-side quote overstates the true economic loss because market orders often execute at inside-quote prices. This concern is not applicable on the SET because market orders always execute at the quoted prices.

within a day). Furthermore, it is not possible to measure the trading cost for a very large order that uses multiple split orders because the originally desired size is not known. Ainsworth and Lee (2014) find that traders become more aggressive before an ex-dividend deadline because of the higher opportunity cost of not transacting. However, we do not include this event-specific opportunity cost because we are more concerned with the cross-sectional rather than time-series differences.

3.7 Implementation Shortfall Calculation

We adopt the implementation shortfall measure proposed by Perold (1998) as the key measure of total trading cost. The implementation shortfall measure contains both the execution cost component and the opportunity cost component. Specifically, the implementation shortfall is calculated as the sum of the price impact of the filled portion of an order and the opportunity cost of the unfilled portion of an order.

4. EMPIRICAL RESULTS

4.1 Descriptive Statistics of Order Classification

Table 1 presents the descriptive statistics of the order classifications. The total number of orders is distributed evenly among buy and sell orders with a total of 9.47 million orders during the sample period of 119 trading days. The average number of orders submitted per day is just above 80,000. Close to 80% of orders are limit orders, i.e., orders under Category L1 – L4, and the rest are market orders, i.e., orders under Category M5 – M7. Category L2 orders are the most frequently used, constituting roughly 39% of all orders, and Category L3 orders comes in second, constituting approximately 31% of all orders. Category M5 and L1 orders are the third and fourth most frequent types of orders, constituting 19% and 10% of all orders, respectively. Category M7 and L4 orders are the two least frequent types of orders,

constituting only 0.03% and 0.14% of all orders, respectively. Note that the average size of a firm that attracts Category M7 and L4 orders is just slightly over 50,000 million baht, which is substantially smaller than the size of firms that are attracted to other categories. This suggests that Category M7 and L4 orders are more prevalent among small and less-liquid stocks.

Although the two most aggressive types of order (Category M7 and M6) represent only 0.03% and 1.35% of all orders submitted, they, having a much larger order size and higher order filled rate, constitute approximately 8.5% of the total traded volume (see Table 1, column 5). These two most aggressive orders are more prevalent among the smaller firms. The average size of firms that attract Category M7 and M6 orders are 53,008 and 77,330 million baht, respectively, while the average size of firms that attract other types of order, except Category L4, is more than 100,000 million baht.

The average percentage of filled rate for limit order categories declines as order aggressiveness decreases (i.e., from Category L4 to Category L1). Specifically, for limit orders placed at the best quotes (Category L3), approximately half of them are executed. The filled rate drops significantly when an order is priced away from the best quotes (i.e., Categories L2 and L1). The low execution rate of limit orders indicates that limit order traders face a substantial non-execution risk.

4.2 Univariate Analysis on Determinants of Trading Costs

Table 2 presents the trading cost of orders. Panel A reports the implementation shortfall for all aggressiveness levels across different order and firm characteristics while Panel B and C disclose the price impact of the executed portion of an order and the opportunity cost of the unexecuted portion of an order. The total trading cost proxied by implementation shortfall has a U-shaped relation with order aggressiveness. The

implementation shortfall is the highest among the most and the least aggressive order (M7=0.54%, L1=0.35%), and is the lowest for limit orders submitted at the best quotes (L3=0.02%). The results in Panel B and C reveal that the price impact is positively associated with order aggressiveness, while the opportunity cost is negatively correlated with order aggressiveness. The result is consistent with our prediction in H1 that the relation between price impact and order aggressiveness is positive. The U-shaped relationship between implementation shortfall and order aggressiveness is a natural result of combining price impact and opportunity cost. The overall pattern is intuitive: aggressive orders cause higher a price impact because they move prices; but they face a lower opportunity cost because of a higher order filled rate. On the other hand, less aggressiveness orders have a lower price impact but face substantial opportunity cost.

The univariate results in Table 2 confirm hypotheses H2-H6. The total trading cost proxied by implementation shortfall is positively correlated to order size (H2) and volatility (H5); and it is negatively associated to firm size (H3), stock price (H4), and stock liquidity proxied by trading value (H6). The differences in trading cost between large/high and small/low groups are not only statistically significant unconditionally for all stocks, but also significant conditional on most levels of order aggressiveness. While the different order aggressiveness levels exhibit a similar cross-sectional pattern in total trading cost stated in H2-H6, the patterns in price impact and opportunity cost vary with the order types. The price impact of market orders (M5-M7) is higher for large orders, small firm stocks, low priced stocks, stocks with high volatility, or stocks with low liquidity. The opposite is also true for limit orders (L1-L4). For the opportunity cost, the differences between large/high and small/low groups are not statistically significant for market orders (M5-M7) as most of these orders are executed in full. On the other hand, the opportunity cost of limit orders (L1-L4) is higher for stocks associated with a small firm, a low price, high volatility, and low liquidity.

Our finding on the relation between components of trading cost and firm size is consistent to Wagner and Edwards (1993).

We also study the relation between order filled rate and stock or order characteristics across all order aggressiveness levels. From Table 3, the filled rate decreases as order aggressiveness decreases. Even for a limit order that matches the best quote (Category L3), 39% of the order is not filled. When the limit order is priced away from the best quotes, more than 80% of the order remains unfilled (Categories L1 and L2). Limit order traders encounter a considerable non-execution risk which leads to a substantial opportunity cost. Large volume orders have a higher unfilled rate, reflecting the difficulty in locating sufficient shares to complete large orders. Orders for small firms or illiquid stocks have a higher unfilled rate. Finally, neither stock volatility nor stock price has a clear relationship with the order unfilled rate.

On top of the order filled rate, adverse price changes also affect the opportunity cost. Adverse price changes measure the cost of adverse selection arising from the nature of options embedded in limit orders. When a limit order to buy (sell) is placed, the market is given a free put (call) option. The adverse price change captures the adverse selection cost through the trades that the market chooses not to transact. The results suggest that the adverse selection problem associated with an unfilled portion of orders is more severe in stocks associated with a small firm, a low price, high volatility, and low liquidity. Finally, a large order faces a higher adverse selection problem.

As shown in Panel A of Table 2, a limit order has a higher total trading cost measured by the implementation shortfall for stocks associated with a large order size, small firms, low prices, high volatility, and illiquidity. However, the opposite relationship exists for the price impact cost in Panel B. Although an executed limit order attracts a higher immediacy price for a certain group of stocks, the opportunity cost is comparatively larger and outweighs the

favorable price impact of the executed portion. Thus, the total trading cost is mainly dominated by opportunity cost in the case of a limit order.

4.3 Multivariate Analyses on Determinants of Trading Costs

We conduct the following cross-sectional regression to test hypotheses H1 to H6 with a set of controlling factors.

$$Y_i = \sum_{j=1}^{7} [c_j I_{i,j} + c_{j+7} I_{i,j} \times Buy_{i,j} + c_{j+14} I_{i,j} \times FirmSize_{i,j} + c_{j+21} I_{i,j} \times Volatility_{i,j} + c_{j+28} I_{i,j} \times PriceInverse_{i,j} + c_{j+35} I_{i,j} \times OrderSize_{i,j} + c_{j+42} I_{i,j} \times AvTrdVal_{i,j}] + \varepsilon_i, \quad \textbf{(1)}$$

where Y_i denotes one of the three measures of trading cost (implementation shortfall, price impact, or opportunity cost); $I_{i,j}$ is a dummy variable that equals 1 if the aggressiveness (*Agg*) of order *i* is Category *j* and 0 otherwise, where *j* takes a value from {1, 2, 3, 4, 5, 6, 7}, *j*=1 is the most passive order, and *j*=7 is the most aggressive order; Buy_i is a dummy variable with a value of 1 if order *i* is a buy order and 0 otherwise; $Firmsize_i$ is the natural logarithm of the average market capitalization of a firm in year 2010 (before the sample period); $Volatility_i$ is the standard deviation of the daily return of a stock in year 2010; $PriceInverse_i$ is the inverse of a stock price defined as 100 times the inverse of the mid-point quote prevailing at the time of order submission; $Ordersize_i$ is the order size divided by the average daily trading volume over the recent 5 trading days; $AvTrdVal_i$ is the average daily trading value of a stock in year 2010; and c_j denotes the coefficient of each explanatory variable.

Our multivariate analyses employ three different cross-sectional regressions to test hypotheses H1-H6 while controlling for other factors.[12] We also use three different measures of trading cost. In Table 4, Panel A reports the results using implementation shortfall as the dependent variable; Panel B uses price impact as the dependent variable; and Panel C uses

[12] To avoid multicollinearity among control variables, we only include one of the three highly correlated variables in the multiple regression model: *FirmSize*, *Volatility*, and *AvTrdVal*.

opportunity cost as the dependent variable. The overall result is very similar to the univariate analysis. From coefficients c_1 to c_7, we find that the implementation shortfall has a U-shaped relation with order aggressiveness. The price impact is positively correlated with order aggressiveness and opportunity cost is negatively associated with order aggressiveness. The finding provides further confirmation of our prediction in H1 that price impact is positively correlated with order aggressiveness.

The multivariate results in Table 4 further confirm prediction of hypotheses H2-H6. In Panel A of Table 4, the total trading cost is positively correlated to order size (H2, coefficients c_{29}-c_{35}) and volatility (H5, coefficients c_{22}-c_{28}); and it is negatively associated to firm size (H3, coefficients c_{15}-c_{21}), stock price (H4, coefficients c_{36}-c_{42}), and stock liquidity proxied by trading value (H6, coefficients c_{43}-c_{49}). We control for the order type in the multivariate analysis and find that buy orders have a lower total trading cost than do sell orders (coefficients c_8-c_{14}).

While the different order aggressiveness levels exhibit a similar cross-sectional pattern in the total trading cost stated in H2-H6, the patterns of price impact and opportunity cost vary with the order type. From Panel B of Table 4, the price impact of a market order is positively correlated with stock volatility, and is negatively correlated with firm size and liquidity. The opposite correlation exists for a limit order. However, we find that the price impact for both market and limit orders are positively correlated with order size, and negatively correlated with stock price. In Panel C of Table 4, the opportunity cost for both types of order is positively correlated with order size and volatility and is negatively correlated with firm size, stock price, and stock liquidity.

In summary, the multivariate results resemble the univariate results shown in Table 2. Some of the price impact and the opportunity cost cross-sectional variations in order type disappear in the multivariate analysis. The behavior of total trading cost proxied by

implementation shortfall remains unchanged despite the presence of additional control variables. From the intercept coefficient c_3, we find that the limit order at the best quote (L3) has the lowest total trading cost among all order aggressiveness levels, confirming H7 in a multivariate setting.

4.4 Optimal Order Submission Strategy

Table 3 shows that there is a substantial opportunity cost for the unexecuted portion of a limit order. The cost of the unexecuted portion is a function of the unfilled rate of a limit order and adverse price change of the stocks. Table 3 demonstrates that, for a limit order (order with an aggressiveness level of L1 to L4), a favorable price impact is always offset by a larger opportunity cost. The total cost of trading measured by implementation shortfall is positive.

Table 3 shows that a limit order with aggressiveness level L3 has the lowest total trading cost. This result supports our hypothesis H7. The total cost of trading using Category L3 orders is 0.02%, whereas the total cost of trading ranges from 0.06% to 0.54% for the remaining types of order. In addition, Table 4 shows that, after controlling for various types of stock characteristics and order sizes, Category L3 orders still offer the lowest overall trading cost.[13] Traders who wish to minimize their trading cost would do well by submitting a buy (sell) limit order priced at the best bid (ask).

5. ROBUSTNESS

To ascertain the relationships found in the previous sections, we conduct robustness checks on an earlier dataset from October 20, 2009 to December 30, 2009 using a similar

[13]In the multivariate analyses, the total trading cost among various aggressiveness levels is compared by simultaneously controlling for differences in stock/order characteristics, and this comparison shows that Categories L3 and L4 orders incur the lowest total trading cost after these differences are controlled.

analysis. The number of days with a negative market return is 28 while the number of days with a positive market return is 21. The numbers of negative return days and positive return days are approximately balanced despite the time period being just after the 2008 global financial crisis. The full results of the robustness checks are qualitatively similar to the main results. We present an analysis on trading cost and compare the results based on these two periods. Table 5 replicates the results that are comparable to those reported in Table 3.

Across all aggressiveness levels, the percentages of orders filled in 2009 are similar to those in 2011. The magnitudes of price impact in 2009 are also similar to those in 2011. However, the adverse price changes in 2009 are much larger than those in 2011 which contribute to the much higher opportunity cost in 2009. Implementation shortfall has a U-shaped relation with order aggressiveness. The lowest total trading cost among all aggressiveness levels is from Category L3 with an implementation shortfall of 0.16%. This is substantially higher than its value of 0.02% in 2011. The implementation shortfall in 2009 is much higher across all order aggressiveness in 2009 than it was in 2011. Nonetheless, the results in Table 5 indicate that the best order submission strategy in terms of the minimal implementation shortfall is to submit a buy order at the best bid, and a sell order at the best ask. This is consistent to our 2011 conclusion in support of hypothesis H7. We also conduct both univariate and multivariate analyses on the relation between trading cost and order/firm characteristics. The resulting conclusions are in support of hypotheses H1-H6 and are qualitatively similar to those of the main results despite the presence of a higher opportunity cost for limit orders.

In summary, the 2009 results echo the 2011 results and confirm the relation between each component of the total trading cost and its determinants, as suggested in our seven hypotheses. In addition, the total trading cost is much higher in 2009 than in 2011 due to the higher opportunity cost. The sample in year 2009 is from a period with high uncertainty as it

was just after the global financial crisis. We thus observe a larger adverse price change, resulting in a higher opportunity cost for unfilled orders.

6. CONCLUSION

This study examines and quantifies various components of trading cost incurred when trading in the 100 largest and most liquid stocks listed on the Stock Exchange of Thailand. The results show that more aggressive orders incur a higher price impact cost because such orders pay an immediacy price, while less aggressive orders suffer from a much greater opportunity cost because of a lower filled rate. The total trading cost measured by implementation shortfall is high for both the most aggressive orders and the least aggressive orders. The total trading cost is observed to be the lowest for limit orders submitted at the best bid or at the best ask prices. Our empirical results highlight the importance of opportunity cost as it constitutes a large portion of the total trading cost. In addition, we identify five factors that have a significant impact on the total trading cost.

This study suggests that, because it takes into account the opportunity cost of the unfilled portion of an order, implementation shortfall should be used to measure the total trading cost for comparing the cost of orders across various order aggressiveness levels. We demonstrate that the optimal order submission strategy is to use a limit order submitted at the best quote.

REFERENCES

Ainsworth, A, and A. D. Lee. 2014. Waiting costs and limit order book liquidity: Evidence from the ex-dividend deadline in Australia. *Journal of Financial Markets* 20: 101–128.

Bennett, P., and L. Wei. 2006. Market structure, fragmentation, and market quality. *Journal of Financial Markets* 9: 49–78.

Berkman, H., T. Brailsford, and A. Frino. 2005. A note on execution costs for stock index futures: Information versus liquidity effects. *Journal of Banking and Finance* 29: 565–577.

Bessembinder, H. 2003. Issues in assessing trade execution costs. *Journal of Financial Markets* 6: 233–257.

Bessembinder, H., and H. M. Kaufman. 1997a. A comparison of trade execution costs for NYSE and NASDAQ-listed stocks. *Journal of Financial and Quantitative Analysis* 32: 287–310.

Bessembinder, H., and H. M. Kaufman. 1997b. A cross-exchange comparison of execution costs and information flow for NYSE-listed stocks. *Journal of Financial Economics* 46: 293–319.

Biais, B., P. Hillion, and C. Spatt. 1995. An empirical analysis of the limit-order book and the order flow in the Paris Bourse. *Journal of Finance* 50: 1655–1689.

Bodurtha, S., and T. Quin. 1990. Does patient program trading really pay? *Financial Analysts Journal* 46: 35–42.

Boehmer, E. 2005. Dimensions of execution quality: Recent evidence for US equity markets. *Journal of Financial Economics* 78: 553–582.

Chan, L., and J. Lakonishok. 1995. The behavior of stock prices around institutional trades. *Journal of Finance* 50: 1147–1174.

Chan, L., and J. Lakonishok. 1997. Institutional equity trading costs: NYSE versus NASDAQ. *Journal of Finance* 52: 713–735.

Chiao, C., Z. M. Wang, and H. L. Lai. 2009. Order submission behaviors and opening price behaviors: Evidence from an emerging market. *Review of Quantitative Finance and Accounting* 33: 253–278.

Chiyachantana, C. N., P. K. Jain, C. Jiang, and R. A. Wood. 2004. International evidence on institutional trading behavior and price impact. *Journal of Finance* 59: 869–898.

Chordia, T., R. Roll, and A. Subrahmanyam. 2000. Commonality in liquidity. *Journal of Financial Economics* 56: 3–28.

Cohen, K., S. Maier, R. Schwartz, and D. Whitcomb. 1981. Transaction costs, order placement strategy, and existence of the bid-ask spread. *Journal of Political Economy* 89: 287–305.

Cooney, J. W., and R. W. Sias. 2004. Informed trading and order type. *Journal of Banking and Finance* 28: 1711–1743.

Copeland, T., and D. Galai. 1983. Information effects on the bid-ask spread. *Journal of Finance* 38: 1457–1469.

Easley, D., and M. O'Hara. 1987. Price, trade size, and information in securities markets. *Journal of Financial Economics* 19: 69–90.

Foucault, T. 1999. Order flow composition and trading costs in a dynamic limit order market.

Journal of Financial Markets 2: 99–134.

Frino, A., and T. Oetomo. 2005. Slippage in futures markets: Evidence from the Sydney futures exchange. *Journal of Futures Markets* 25: 1129–1146.

Garvey, R., and F. Wu. 2011. Information, speed vs. cost trade-offs, and order routing decisions in U.S. equity markets. *Journal of Empirical Finance* 18: 408–422.

Griffiths, M. D., B. F. Smith, D. A. S. Turnbull, and R. W. White. 2000. The costs and determinants of order aggressiveness. *Journal of Financial Economics* 56: 65–88.

Handa, P., and R. A. Schwartz. 1996. Limit order trading. *Journal of Finance* 51: 1835–1861.

Harris, L. 1998. Optimal dynamic order submission strategies in some stylized trading problems. *Financial Markets, Institutions, and Instruments* 7: 1–76.

Harris, L., and J. Hasbrouck. 1996. The SuperDOT evidence on order submission strategy. *Journal of Financial and Quantitative Analysis* 31: 213–231.

Ho, T., and H. Stoll. 1981. Optimal dealer pricing under transactions and return uncertainty. *Journal of Financial Economics* 9: 47–73.

Huang, R. D., and H. R. Stoll. 2001. Tick size, bid-ask spreads, and market structures. *Journal of Financial and Quantitative Analysis* 36: 503–522.

Jain, P., and C. Jiang. 2014. Predicting future price volatility: Empirical evidence from an emerging limit order market. *Pacific-Basin Finance Journal* 27: 72–93.

Keim, D. B., and A. Madhavan. 1997. Transactions costs and investment style: An inter-exchange analysis of institutional equity trades. *Journal of Financial Economics* 46: 265–292.

Keim, D. B., and A. Madhavan. 1998. The cost of institutional equity trades. *Financial Analysts Journal* 54: 50–69.

Lee, K. H. 2011. The world price of liquidity risk. *Journal of Financial Economics* 99: 136–61.

Liu, W. M. 2009. Monitoring and limit order submission risks. *Journal of Financial Markets* 12: 107-141.

Perold, A. F. 1988. The implementation shortfall: Paper versus reality. *Journal of Portfolio Management* 14: 4–9.

Peterson, M., and E. Sirri. 2002. Order submission strategy and the curious case of marketable limit orders. *Journal of Financial and Quantitative Analysis* 37: 221–241.

Peterson, M., and E. Sirri. 2003. Evaluation of the biases in execution cost estimation using trade and quote data. *Journal of Financial Markets* 6: 259–280.

Venkataraman, K. 2001. Automated versus floor trading: An analysis of execution costs on the Paris and New York exchanges. *Journal of Finance* 56: 1445–1488.

Wagner, W., and M. Edwards. 1993. Best execution. *Financial Analysts Journal* 49: 65–71.

Wang, Z. M., C. Chiao, and Y. T. Chang. 2012. Technical analyses and order submission behaviors: Evidence from an emerging market. *International Review of Economics & Finance* 24: 109–128.

Werner, I. M. 2003. NYSE order flow, spreads, and information. *Journal of Financial Markets* 6: 309–335.

Table 1

Descriptive Statistics for Order Classifications

This table presents the descriptive statistics of all orders used in the study. The orders are from top 100 stocks listed on the Stock Exchange of Thailand (SET). All orders are classified into one of the seven order aggressiveness level. M7 orders are market buy (sell) orders with an order price higher (lower) than the best ask (bid) price and an order size larger than the shares available at the ask (bid). M6 orders are market buy (sell) orders with an order size larger than shares available at ask (bid) and an order price equal to the price at the ask (bid). M5 orders are market buy (sell) orders with order prices equal to the best ask (bid) and volumes smaller than the prevailing ask (bid) depth. L4 orders are limit buy (sell) orders with order prices higher (lower) than the best bid (ask) price but lower (higher) than the best ask (bid) prices. L3 orders are limit buy (sell) orders with order prices equal to the best bid (ask) prices. L2 orders are limit buy (sell) orders with order prices lower (higher) than the best bid (ask) price but higher (lower) than the fifth best bid (ask) prices. L1 orders are limit buy (sell) orders with order prices lower (higher) than the fifth best bid (ask) prices. The figures in columns 2 to 8 are calculated from all submitted orders that include the fully executed, partially executed, and unexecuted orders. The figures in columns 9 to 11 describe the disposition of executed orders only. Relative order size is calculated using the ratio of the number of shares demanded in an order to the 5-day moving average number of shares traded for a particular stock. The sample period is from January 2011 to June 2011.

Aggressiveness level	Number of orders	Number of orders as a percentage of total (%)	Average number of shares in order	Average number of shares per order as a percentage of total (%)	Relative order size (%)	(Volume-weighted) average percentage of filled rate (%)	Average size of firm to which orders belong (million baht)	Average number of filled trades of executed orders	Average time to first disposition of executed orders (minutes)	Average time to complete disposition of executed orders (minutes)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
M7	3,185	0.03%	209,558	0.19%	2.40%	99.41%	53,008	14.5	0.0	1.4
M6	128,241	1.35%	227,340	8.42%	1.36%	93.04%	77,330	10.9	0.0	10.9
M5	1,826,619	19.28%	36,862	19.45%	0.16%	100.00%	112,305	2.0	0.0	0.0
L4	13,078	0.14%	17,584	0.07%	0.70%	73.21%	50,692	2.4	9.3	17.1
L3	2,914,222	30.76%	39,584	33.31%	0.18%	50.02%	118,062	1.7	44.1	48.0
L2	3,647,902	38.50%	30,720	32.36%	0.16%	11.86%	121,158	1.3	143.7	147.3
L1	940,907	9.93%	22,809	6.20%	0.14%	1.96%	140,457	1.3	225.9	231.9
Total	9,474,154	100.00%	36,549	100.00%	0.18%	48.14%	119,702	2.0	42.6	45.1

Table 2

Trading Cost of Orders

This table compares the total trading cost and its components across different order and firm characteristics. Panel A presents the total trading cost measured by implementation shortfall. Panel B presents the price impact cost for executed orders. Panel C presents the opportunity cost for unfilled portion of orders. The orders are from top 100 stocks listed on the Stock Exchange of Thailand (SET). All orders are classified into one of the seven order aggressiveness level described in Table 1. M7 is the most aggressive order and L1 is the least aggressive order. Price impact for buy (sell) orders is defined as the (minus of) the logarithm of the ratio of the volume-weighted average of the executed prices to the mid-point quote prevailing at the time of order submission. The opportunity cost is calculated using the product of the percentage of unfilled rate and the adverse price change for each corresponding cell. Adverse price changes for buy (sell) orders are defined as the (minus of) the logarithm of the ratio of the best ask (bid) price at the expiration/cancellation time to the mid-point quote at the time of order submission. Implementation shortfall is sum of the price impact of the filled portion of an order and the opportunity cost of the unfilled portion part of an order. Orders are partitioned into three groups according to order size, firm size, stock price, volatility, or liquidity. Order size is the number of shares in the order divided by 5-day moving average trading volume of the stock. Firm size is the average market capitalization in year 2010 (before sample period). Stock price is the closing price at the end of year 2010. Volatility is the standard deviation of the daily stock return in year 2010. Liquidity is measured by average daily trading value in year 2010. The trading costs for the small/low and large/high are reported. The L-S and H-L are the differences between large and small groups or between high and low groups. * and ** denote the significance levels of 5% and 1%, respectively. All figures including the trading cost measures are in percentage. The sample period is from January 2011 to June 2011.

Panel A: Implementation Shortfall of All Orders

Aggressive-		Order Size			Firm Size			Stock Price			Volatility			Liquidity (Trading Value)		
ness	All	Small	Large	L-S	Small	Large	L-S	Low	High	H-L	Low	High	H-L	Low	High	H-L
M7	0.54	0.51	0.53	0.03	0.58	0.44	-0.14**	0.60	0.46	-0.15**	0.44	0.62	0.18**	0.57	0.51	-0.06**
M6	0.30	0.29	0.30	0.01*	0.33	0.25	-0.08**	0.35	0.23	-0.11**	0.24	0.34	0.11**	0.31	0.27	-0.04**
M5	0.31	0.30	0.32	0.03**	0.34	0.26	-0.08**	0.38	0.23	-0.15**	0.21	0.37	0.16**	0.31	0.29	-0.02**
L4	0.06	0.03	0.07	0.05**	0.08	0.04	-0.05**	0.08	0.05	-0.03**	0.05	0.07	0.02*	0.08	0.03	-0.05**
L3	0.02	0.02	0.02	0.00	0.02	0.01	-0.01**	0.05	0.00	-0.05**	0.02	0.03	0.01**	0.04	0.02	-0.02**
L2	0.22	0.19	0.27	0.08**	0.27	0.18	-0.10**	0.34	0.12	-0.22**	0.13	0.31	0.18**	0.25	0.21	-0.03**
L1	0.35	0.31	0.42	0.11**	0.47	0.26	-0.21**	0.51	0.23	-0.28**	0.21	0.51	0.30**	0.37	0.32	-0.05**
All	0.19	0.18	0.21	0.03**	0.23	0.15	-0.08**	0.27	0.12	-0.15**	0.12	0.25	0.13**	0.21	0.18	-0.03**
Panel B: Price Impact of Executed Orders																
M7	0.54	0.51	0.53	0.03	0.58	0.44	-0.14**	0.60	0.46	-0.15**	0.44	0.62	0.18**	0.57	0.51	-0.06**
M6	0.30	0.29	0.30	0.01*	0.32	0.25	-0.07**	0.34	0.23	-0.11**	0.23	0.34	0.10**	0.30	0.27	-0.03**
M5	0.31	0.30	0.32	0.03**	0.34	0.26	-0.08**	0.38	0.23	-0.15**	0.21	0.37	0.16**	0.31	0.29	-0.02**
L4	-0.01	-0.01	-0.01	-0.01*[14]	-0.02	-0.01	0.02**	-0.02	-0.02	0.00	-0.01	-0.01	0.00	-0.02	0.00	0.02**
L3	-0.31	-0.30	-0.33	-0.03**	-0.34	-0.27	0.08**	-0.39	-0.23	0.16**	-0.21	-0.38	-0.17**	-0.31	-0.30	0.02**
L2	-1.18	-1.14	-1.24	-0.11**	-1.42	-1.02	0.40**	-1.51	-0.91	0.60**	-0.85	-1.47	-0.62**	-1.22	-1.11	0.11**
L1	-2.82	-2.72	-3.10	-0.39**	-3.79	-2.24	1.55**	-3.89	-2.19	1.70**	-2.11	-3.92	-1.81**	-3.27	-2.59	0.68**
All	-0.20	-0.23	-0.14	0.09**	-0.22	-0.20	0.02**	-0.22	-0.19	0.04**	-0.17	-0.22	-0.05**	-0.14	-0.21	-0.07**
Panel C: Opportunity Cost of Unfilled Portion of Orders																
M7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M6	0.02	0.01	0.02	0.01	0.03	0.01	-0.01	0.02	0.02	-0.01	0.02	0.02	0.00	0.03	0.01	-0.01
M5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L4	0.07	0.03	0.08	0.05	0.10	0.05	-0.06**	0.09	0.06	-0.03**	0.06	0.08	0.02**	0.09	0.03	-0.06**
L3	0.21	0.21	0.21	0.00	0.24	0.18	-0.06**	0.28	0.14	-0.14**	0.15	0.26	0.11**	0.23	0.20	-0.03**
L2	0.47	0.47	0.46	-0.01	0.58	0.40	-0.18**	0.61	0.34	-0.27**	0.33	0.59	0.25**	0.46	0.45	-0.01**
L1	0.43	0.41	0.47	0.06**	0.60	0.33	-0.27**	0.61	0.30	-0.31**	0.29	0.60	0.31**	0.47	0.40	-0.06**
All	0.29	0.29	0.27	-0.02**	0.35	0.25	-0.10**	0.38	0.21	-0.17**	0.21	0.36	0.15**	0.28	0.28	0.00**

[14] Note that the difference of -0.01 is the rounded value of -0.008, which comes from -0.013 - (-0.005).

Table 3

Analysis on Total Trading Cost

This table presents breakdown of the implementation shortfall cost of all orders submitted on the Stock Exchange of Thailand (SET). All orders are classified into one of the seven order aggressiveness level. M7 orders are market buy (sell) orders with an order price higher (lower) than the best ask (bid) price and an order size larger than the shares available at the ask (bid). M6 orders are market buy (sell) orders with an order size larger than shares available at ask (bid) and an order price equal to the price at the ask (bid). M5 orders are market buy (sell) orders with order prices equal to the best ask (bid) and volumes smaller than the prevailing ask (bid) depth. L4 orders are limit buy (sell) orders with order prices higher (lower) than the best bid (ask) price but lower (higher) than the best ask (bid) prices. L3 orders are limit buy (sell) orders with order prices equal to the best bid (ask) prices. L2 orders are limit buy (sell) orders with order prices lower (higher) than the best bid (ask) price but higher (lower) than the fifth best bid (ask) prices. L1 orders are limit buy (sell) orders with order prices lower (higher) than the fifth best bid (ask) prices. Price impact for buy (sell) orders is defined as the (minus of) the logarithm of the ratio of the volume-weighted average of the executed prices to the mid-point quote prevailing at the time of order submission. The cost of the filled portion is the product of the percentage of orders filled and the price impact. Adverse price changes for buy (sell) orders are defined as the (minus of) the logarithm of the ratio of the best ask (bid) price at the expiration/cancellation time to the mid-point quote at the time of order submission. The cost of the unfilled portion (i.e., opportunity cost) is the product of the percentage of the unfilled rate and the percentage of adverse price changes. Implementation shortfall is defined as the sum of the cost of the filled portion and opportunity cost. All figures including the trading cost measures are in percentage. The sample period is from January 2011 to June 2011.

Aggressiveness Level	Percent of Orders Filled	Price Impact	Cost of Filled Portion	Percent of Orders Unfilled	Adverse Price Change	Cost of Unfilled Portion (Opportunity Cost)	Implementation Shortfall
M7	99.74	0.54	0.54	0.26	0.25	0.00	0.54
M6	95.27	0.30	0.28	4.73	0.41	0.02	0.30
M5	100.00	0.31	0.31	0.00	0.22	0.00	0.31
L4	82.40	-0.01	-0.01	17.60	0.40	0.07	0.06
L3	61.22	-0.31	-0.19	38.78	0.54	0.21	0.02
L2	20.63	-1.18	-0.24	79.37	0.59	0.47	0.22
L1	2.91	-2.82	-0.08	97.09	0.44	0.43	0.35
All	47.78	-0.20	-0.10	52.22	0.55	0.29	0.19

Table 4

Multivariate Analyses of Trading Cost of Orders

This table presents the coefficients (multiplied by 100) of three GMM regression analyses. Each regression model is a variation of the full model shown below. In panel A, the dependent variable is the implementation shortfall of all orders. In Panel B, the dependent variable is the price impact of executed orders. In Panel C, the dependent variable is the opportunity cost of unfilled orders. The full regression model is

$$Y_i = \sum_{j=1}^{7} [c_j I_{i,j} + c_{j+7} I_{i,j} \times Buy_{i,j} + c_{j+14} I_{i,j} \times FirmSize_{i,j} + c_{j+21} I_{i,j} \times Volatility_{i,j} + c_{j+28} I_{i,j} \times PriceInverse_{i,j} + c_{j+35} I_{i,j} \times OrderSize_{i,j} + c_{j+42} I_{i,j} \times AvTrdVal_{i,j}] + \varepsilon_i ,$$

where Y_i denotes one of the three measures of trading costs (Implementation Shortfall [IS_i], Price Impact [PI_i], or Opportunity Cost [OC_i]). IS_i is the implementation shortfall of order i; PI_i is price impact of order that equals to $ln(P_i / M_i)$ for buys orders and $ln(M_i / P_i)$ for sell orders where P_i is the volume-weighted average of the trade price for order i and M_i is the mid-point quote immediately before the submission of order i; OC_i is the opportunity cost of order i; $I_{i,j}$ is a dummy variable equal to 1 if the aggressiveness (Agg) of order i is Category j and 0 otherwise, where j takes a value from {1, 2, 3, 4, 5, 6, 7}, j=1 is the most passive order, and j=7 is the most aggressive order; Buy_i is a dummy variable equal to 1 if order i a buy order and 0 otherwise; $Firmsize_i$ is the natural logarithm of the average market capitalization of a firm in year 2010 (before the sample period); $Volatility_i$ is the standard deviation of the daily return of a stock in year 2010; $PriceInverse_i$ is the inverse of a stock price defined as 100 times the inverse of the mid-point quote prevailing at the time of order submission $(100/ M_i)$; $Ordersize_i$ is the order size divided by the average daily trading volume over the recent 5 trading days; $AvTrdVal_i$ is the average daily trading value of a stock in year 2010; and c_j denotes the coefficient of each explanatory variable. Adjusted R^2 and the number of observations (orders) used in the multivariate analysis are reported. * and ** denote the significance levels of 5% and 1%, respectively. The sample period is from January 2011 to June 2011.

		Panel A: Implementation Shortfall			**Panel B: Price Impact**			**Panel C: Opportunity Cost**		
		Model 1 Coeff.	Model 2 Coeff.	Model 3 Coeff.	Model 1 Coeff.	Model 2 Coeff.	Model 3 Coeff.	Model 1 Coeff.	Model 2 Coeff.	Model 3 Coeff.
c_1	Agg_1	1.654**	1.137**	0.135**	-0.466**	-0.223**	-0.020**	2.117**	1.357**	0.155**
c_2	Agg_2	0.935**	0.723**	0.168**	-0.848**	-0.486**	-0.093**	1.779**	1.205**	0.261**
c_3	Agg_3	-0.090**	0.018**	0.080**	-0.653**	-0.500**	-0.076**	0.567**	0.522**	0.156**
c_4	Agg_4	0.402**	0.303**	0.025*	-0.147**	-0.111**	-0.005	0.597**	0.443**	0.036**
c_5	Agg_5	0.851**	0.762**	0.160**	0.851**	0.762**	0.160**			
c_6	Agg_6	0.836**	0.712**	0.181**	0.769**	0.651**	0.177**	0.190**	0.160**	0.021**
c_7	Agg_7	1.735**	1.236**	0.399**	1.741**	1.246**	0.399**	0.004	0.014	0.000
c_8	Buy_1	-0.246**	-0.252**	-0.258**	-0.028**	-0.026**	-0.027**	-0.219**	-0.226**	-0.231**
c_9	Buy_2	-0.188**	-0.190**	-0.190**	-0.040**	-0.039**	-0.042**	-0.148**	-0.151**	-0.148**
c_{10}	Buy_3	-0.095**	-0.095**	-0.094**	-0.023**	-0.023**	-0.024**	-0.073**	-0.072**	-0.070**
c_{11}	Buy_4	-0.025**	-0.026**	-0.026**	-0.006**	-0.005**	-0.005**	-0.027**	-0.028**	-0.027**
c_{12}	Buy_5	-0.002**	-0.001**	0.001**	-0.002**	-0.001**	0.001**			
c_{13}	Buy_6	-0.005**	-0.005**	-0.005**	-0.002**	-0.002**	-0.001	-0.003*	-0.003*	-0.003*
c_{14}	Buy_7	-0.165**	-0.167**	-0.159**	-0.166**	-0.168**	-0.160**	-0.001	-0.001	-0.001
c_{15}	$FirmSize_1$	-0.051**			0.016**			-0.066**		
c_{16}	$FirmSize_2$	-0.027**			0.025**			-0.052**		
c_{17}	$FirmSize_3$	0.006**			0.020**			-0.014**		
c_{18}	$FirmSize_4$	-0.014**			0.006**			-0.022**		
c_{19}	$FirmSize_5$	-0.024**			-0.024**					
c_{20}	$FirmSize_6$	-0.023**			-0.021**			-0.006**		
c_{21}	$FirmSize_7$	-0.049**			-0.049**			0.000		
c_{22}	$Volatility_1$			0.813**			-0.141**			0.953**
c_{23}	$Volatility_2$			0.380**			-0.348**			0.728**
c_{24}	$Volatility_3$			-0.023**			-0.268**			0.244**
c_{25}	$Volatility_4$			0.116**			-0.007			0.138**
c_{26}	$Volatility_5$			0.376**			0.376**			
c_{27}	$Volatility_6$			0.295**			0.292**			0.034**
c_{28}	$Volatility_7$			0.510**			0.513**			0.004

Table 4 (Continued)

		Panel A: Implementation Shortfall			Panel B: Price Impact			Panel C: Opportunity Cost		
		Model 1 Coeff.	Model 2 Coeff.	Model 3 Coeff.	Model 1 Coeff.	Model 2 Coeff.	Model 3 Coeff.	Model 1 Coeff.	Model 2 Coeff.	Model 3 Coeff.
c_{29}	$OrderSize_1$	1.292**	1.280**	2.400**	0.805**	0.743**	0.588**	0.470**	0.522**	1.794**
c_{30}	$OrderSize_2$	1.054**	0.998**	1.845**	1.566**	1.513**	1.300**	-0.544**	-0.545**	0.513**
c_{31}	$OrderSize_3$	1.120**	1.086**	1.515**	0.765**	0.895**	-0.032	0.344**	0.179**	1.539**
c_{32}	$OrderSize_4$	0.742**	0.720**	0.896**	-0.126	-0.114	-0.173	1.028**	0.997**	1.247**
c_{33}	$OrderSize_5$	0.220**	-0.014	1.461**	0.220**	-0.014	1.461**			
c_{34}	$OrderSize_6$	0.449**	0.364**	0.785**	0.310**	0.237**	0.636**	0.874**	0.849**	0.902**
c_{35}	$OrderSize_7$	1.039**	0.986**	1.220**	1.052**	0.998**	1.234**	0.021*	0.019	0.022*
c_{36}	$PriceInv_1$	0.003**	0.005**		0.000**	0.000**		0.003**	0.005**	
c_{37}	$PriceInv_2$	0.003**	0.003**		0.000**	0.000**		0.003**	0.003**	
c_{38}	$PriceInv_3$	0.001**	0.001**		-0.001**	-0.001**		0.003**	0.003**	
c_{39}	$PriceInv_4$	0.000	0.001**		0.000	0.000		0.000	0.001**	
c_{40}	$PriceInv_5$	0.003**	0.003**		0.003**	0.003**				
c_{41}	$PriceInv_6$	0.002**	0.003**		0.002**	0.003**		0.000**	0.000	
c_{42}	$PriceInv_7$	0.002**	0.004**		0.002**	0.004**		0.000	0.000	
c_{43}	$AvTrdVal_1$		-0.038**			0.008**			-0.046**	
c_{44}	$AvTrdVal_2$		-0.023**			0.013**			-0.036**	
c_{45}	$AvTrdVal_3$		0.002**			0.017**			-0.016**	
c_{46}	$AvTrdVal_4$		-0.013**			0.006**			-0.020**	
c_{47}	$AvTrdVal_5$		-0.026**			-0.026**				
c_{48}	$AvTrdVal_6$		-0.023**			-0.021**			-0.007**	
c_{49}	$AvTrdVal_7$		-0.037**			-0.037**			-0.001	
	Adj R-Sq	0.032	0.032	0.027	0.227	0.225	0.222	0.077	0.074	0.071
	No. of Obs.	9,474,154	9,474,154	9,474,154	9,474,154	9,474,154	9,474,154	9,474,154	9,474,154	9,474,154

Table 5

Analysis on Total Trading Cost (Year 2009)

This table presents implementation shortfall breakdown similar to Table 3 using a different sample period as a robustness check. All orders are classified into one of the seven order aggressiveness level. M7 orders are market buy (sell) orders with an order price higher (lower) than the best ask (bid) price and an order size larger than the shares available at the ask (bid). M6 orders are market buy (sell) orders with an order size larger than shares available at ask (bid) and an order price equal to the price at the ask (bid). M5 orders are market buy (sell) orders with order prices equal to the best ask (bid) and volumes smaller than the prevailing ask (bid) depth. L4 orders are limit buy (sell) orders with order prices higher (lower) than the best bid (ask) price but lower (higher) than the best ask (bid) prices. L3 orders are limit buy (sell) orders with order prices equal to the best bid (ask) prices. L2 orders are limit buy (sell) orders with order prices lower (higher) than the best bid (ask) price but higher (lower) than the fifth best bid (ask) prices. L1 orders are limit buy (sell) orders with order prices lower (higher) than the fifth best bid (ask) prices. Price impact for buy (sell) orders is defined as the (minus of) the logarithm of the ratio of the volume-weighted average of the executed prices to the mid-point quote prevailing at the time of order submission. The cost of the filled portion is the product of the percentage of orders filled and the price impact. Adverse price changes for buy (sell) orders are defined as the (minus of) the logarithm of the ratio of the best ask (bid) price at the expiration/cancellation time to the mid-point quote at the time of order submission. The cost of the unfilled portion (i.e., opportunity cost) is the product of the percentage of the unfilled rate and the percentage of adverse price changes. Implementation shortfall is defined as the sum of the cost of the filled portion and opportunity cost. All figures including the trading cost measures are in percentage. The sample period is from October 2009 to June 2009.

Aggressiveness Level	Percent of Orders Filled	Price Impact	Cost of Filled Portion	Percent of Orders Unfilled	Adverse Price Change	Cost of Unfilled Portion (Opportunity Cost)	Implementation Shortfall
M7	99.60	0.53	0.53	0.40	2.35	0.01	0.54
M6	94.60	0.32	0.30	5.40	1.38	0.07	0.37
M5	100.00	0.32	0.32	0.00	2.21	0.00	0.32
L4	83.30	-0.02	-0.02	16.70	1.07	0.18	0.16
L3	62.60	-0.32	-0.20	37.40	0.97	0.36	0.16
L2	19.30	-1.20	-0.23	80.70	0.71	0.58	0.34
L1	2.90	-2.86	-0.08	97.10	0.46	0.44	0.36