EXECUTION COSTS AND TRADER IDENTITY IN THE OTC MARKET

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Abstract

This study is the first to explicitly examine the role of trader identity in an opaque OTC market. Utilising two unique data sets, we measure market impact costs for institutional trade packages of Bank Accepted Bills and Negotiable Certificates of Deposit. We find that market impact costs vary greatly across individual traders, and that trader identity explains almost 20% of the variation in market impact costs. Importantly, results suggest that trader identity explains the negative relation between market impact costs and trade size reported in Schultz (2001) and Harris and Piwowar (2006). After controlling for the identity of individual traders, market impact costs increase with trade package size. We conclude that information asymmetries in OTC markets are driving our results, as unobservable true values prevent infrequent traders from executing trade packages with minimal market impact costs.

JEL Classification: G15, G21

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1. INTRODUCTION

The Australian over-the-counter (OTC) short-term money market is particularly opaque, offering effectively no pre-or post-trade transparency to investors. Turnover in the short-term money market in Australia totalled approximately AUD 4 trillion in 2005-2006, almost four times greater than the turnover in Australian equity markets. The liquidity of the Australian short-term money market and the unique data employed in this study provide a rare opportunity to examine execution costs and the role of trader identity in OTC markets.

In contrast with equity and futures market literature, studies of execution costs in OTC markets find execution costs *decline* with trade size.[1] Schultz (2001), Harris and Piwowar (2006), and Green, Hollifield, and Schühoff (2007) all report a reduction in execution costs as trade size increases. One possible explanation for this occurrence is that transaction prices reflect the order processing cost component of the bid-ask spread. Huang and Stoll (1997) decompose the bid-ask spread and find that the order processing component of the spread decreases with trade size. Order processing costs are large in an OTC market, as minimal transparency makes searching for price information expensive. Harris and Piwowar (2006) examine the role of order processing costs in an OTC market by explicitly modelling the fixed cost component of their total cost function. They find high fixed costs do not explain the decline in execution costs across their range of trade sizes.

[1] Studies in both equity and futures markets find execution costs increase with trade size. Equity market studies that find this include Kraus and Stoll (1972), Holthausen, Leftwich, and Mayers (1987, 1990), Chan and Lakonishok (1995), and futures market studies that find this include Frino and Oetomo (2005), Berkman, Brailsford, and Frino (2005), and Frino, Kruk, and Lepone (2007).

Literature thus far suggests the reduction in execution costs with trade size is attributable to the lack of price transparency in OTC markets; the reduced price transparency creates information asymmetries among investors. Harris and Piwowar (2006) suggest institutional investors trading large volumes on a regular basis invariably know more about the true value of an OTC product than smaller traders. Schultz (2001) and Green et al. (2007) provide empirical evidence to support this information asymmetry hypothesis. Schultz (2001) finds that less active institutions always pay more to trade corporate bonds than active institutions, and Green et al. (2007) find investors incur lower dealer mark-ups on larger trades. Both Schultz (2001) and Green et al. (2007) identify information asymmetries between different classes of OTC investors. This suggests trader identity could be the primary determinant of execution costs in OTC markets.

Almost all studies of OTC execution costs focus on the U.S. municipal and corporate bond markets.[2] Empirical studies utilising U.S. municipal and corporate bond data face several limitations. First, the secondary market for U.S. municipal and corporate bonds is relatively illiquid. Harris and Piwowar (2006) note that whilst many trades occur in the municipal bond market, trades in a particular municipal bond occur infrequently, often less than once per week (p. 1368). Second, the data do not capture contemporaneous bid and ask quotes, implying any estimation of the bid-ask spread is potentially noisy. Numerous studies estimate bid-ask spreads from corporate and municipal bond data, including Hong and Wagra (2000, 2004), Schultz (2001), Chakravarty and Sarkar (2003), and Harris and Piwowar (2006). Third, the intraday data used in Harris and Piwowar

[2] Chakravarty and Sarkar (2003) also examine U.S. Treasury bonds, and Green (2004) examines U.S. Treasury notes.

(2006) and Green et al. (2007) do not contain the identity of transaction counterparties. Whilst the data used in Schultz (2001), Chakravarty and Sarkar (2003), and Hong and Wagra (2004) do contain institution and dealer identifiers, the data sets employed contain only a portion of all institutional trades.

This study is the first to focus solely on the role of trader identity in an opaque OTC market. Utilising two unique data sets, we aim to (i) implement new methodology to measure execution costs in an OTC market, (ii) establish the role of trader identity in determining OTC execution costs, and (iii) formally examine all determinants of execution costs in an OTC market.

Our study of the OTC short-term money market in Australia has several natural advantages over prior bond market studies. In comparison with the municipal and corporate bond markets, the short-term money market is relatively liquid. Further, the products we examine (Bank Accepted Bills and Negotiable Certificates of Deposit) are homogenous and substitutable, given they are of similar maturity. This study also improves on prior literature through the use of two unique data sets. The clearing-level short-term money market data provide a comprehensive account of the wholesale market in Australia. The data contain an identifier for the buyer and seller in each transaction, allowing us to measure the market impact costs of institutional orders and further examine the role of trader identity in the OTC market. The second unique data set contains clearing-level data for exchange traded 90 Day Bank Accepted Bill (BAB) futures. The futures data provide a natural control for the methodology employed in the

OTC market, as both Bank Accepted Bills (BABs) and Negotiable Certificates of Deposit (NCDs) are acceptable upon settlement of the 90 Day BAB futures contract.

The remainder of this article is organised as follows. Section 2 contains a description of the short-term money market in Australia, including details of the Austraclear System. Section 3 contains the data and the method employed to measure execution costs, and Section 4 presents empirical results from nonparametric testing. Section 5 examines the determinants of market impact costs in the short-term money market and conclusions are reported in Section 6.

2. THE SHORT-TERM MONEY MARKET IN AUSTRALIA

The short-term money market in Australia is self-regulated by the Australian Financial Markets Association (AFMA). AFMA is an industry body developed to coordinate and promote the operation and self-regulation of the OTC financial markets in Australia. AFMA currently has over 120 members from all aspects of the wholesale banking industry.[3] One role of AFMA is to determine which banks have bank bills and certificates of deposit acceptable for inter bank trades. These banks are referred to as prime banks. The criteria for inclusion as a prime bank is largely qualitative; however, prime banks must have a short term Standard & Poor's rating of A1+ and a minimum long term rating

[3] Only financial institutions are full members of AFMA; however, government agencies and regulatory bodies can be affiliate members. In contrast, the Australian Securities and Investments Commission (ASIC), a government agency, regulates the bond market in Australia.

of AA-. There are six prime banks in the short-term money market during our sample period.[4]

Prime banks sell their commercial paper to other banks (both prime and non-prime) in the wholesale primary market.[5] Once purchased, commercial paper is either held by an institution until maturity or re-traded in the secondary market. Since March 15, 2004 the Reserve Bank of Australia (RBA) has participated in the secondary market, conducting repurchase agreements with eligible banks.

Transactions in the short-term money market are conducted over the counter. There are two ways to negotiate a transaction in this market. First, institutions can transact through an OTC broker.[6] There are two major OTC brokers in this market, and each have a live Reuters feed on which they post bid and ask prices for set quantities of commercial paper across a selection of maturities. An institution may choose to contact an OTC broker and begin negotiations based on these prices. Second, institutions can transact directly with each other. This is common when an institution is looking for commercial paper issued by a specific prime bank.

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[4] The six banks classified as prime banks during the sample period are ANZ Banking Group, BNP Paribas, Citibank, Commonwealth Bank of Australia, National Australia Bank, and Westpac Banking Corporation. Both BNP Paribas and Citibank were added as prime banks in March 2005. To date there are now eight prime banks, with two new banks added in February 2007.

[5] Wholesale transactions represent between 80% and 85% of the total short-term money market in Australia and are the focus of this study. Retail trades represent only a small fraction of the market and are not captured in the Austraclear data.

[6] There are no dealers in the short-term money market. OTC brokers will facilitate trades but will not act as principal in those trades. As compensation for their services, brokers will charge a flat fee per million depending on the maturity of the security.

The Austraclear System is the only clearing house for debt instruments in Australia. Austraclear provides registry and depository services to its members, as well as electronic trade confirmation and settlement.[7] Upon completion of a transaction in commercial paper, the seller enters transaction details into the Austraclear System, and only a confirmation is required from the buyer. All wholesale transactions in the short-term money market are entered into the Austraclear System.

There is effectively no pre-or post-trade transparency in this OTC market. Prior to trading, only the bid and ask quotes of the two OTC brokers are available to institutions. These quotes are indicative at best, as they relate to the commercial paper of any prime bank, and are for fixed quantities across different maturities. The final transaction price is determined by negotiation between counterparties and can differ substantially from the quotes on offer depending on the quantity and maturity of the commercial paper. There is also no post-trade trade transparency in this market. Completed transactions are reported to Austraclear, but this information is never released to the market. AFMA report end of day reference rates for BABs and NCDs; however, these rates are not market-determined.[8]

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[7] Austraclear does not act as counterparty to transactions between institutions. For further details regarding the Austraclear System, see Hall, Hamilton, Payne, and Veale (2000). During the sample period examined in this study, Austraclear was a wholly owned subsidiary of the Sydney Futures Exchange. Austraclear is regulated by the Reserve Bank of Australia.

[8] At the end of each business day, contributing members submit their BAB/NCD mid-rates for a selection of maturities. To compute the reference rates, AFMA eliminate the highest and lowest rates from each tenor until eight rates remain. The average of the eight remaining rates is reported to the market. These reference rates are provided so as to allow institutions to price their Australian Dollar short-term securities and evaluate their exposure to interest rate risk. As the rates are reported independently, it is possible the AFMA end of day reference rates may not reflect the day's trading, as contributing members can submit reference rates in line with their own agenda.

3. DATA AND EXECUTION COST MEASUREMENT

3.1. Data

This paper employs two unique data sets containing clearing-level information for the period 1 August, 2005 to 31 October, 2005. The short-term money market data is provided by Austraclear and for each transaction reports the trade date, trade function, face value, maturity date, deal value, security code, and the identity of both the buyer and seller in the transaction. For the purposes of this analysis we only include transactions in BABs and NCDs. The timestamps the Austraclear data are inaccurate and are not used in this study. The 90 Day BAB futures data is provided by the Sydney Futures Exchange (SFE) and for each transaction reports the trade date, transaction price, trade time, volume traded, trade direction, contract code, and the identity of both the buyer and seller in the transaction.

We infer the yield for BAB and NCD transactions, and convert yields into prices by subtracting the yield from 100. This is the pricing convention adopted in futures markets. Applying this convention to OTC transactions creates consistency in the measurement of execution costs across the OTC and futures markets.

Several filters are applied to the Austraclear and SFE data. We delete transactions in the Austraclear data identifying the RBA as a buyer or seller, as the RBA conduct repurchase agreements with eligible banks in the short-term money market. RBA transactions represent 1.9% of the total sample. We also delete Austraclear transactions executed at a yield higher than 6.5%. The cash rate during the entire sample period was 5.5%, and we assume any trades executed at a yield greater than 6.5% are erroneous. This filter removes less than 1% of the total transactions in the data set, and results are robust to altering this benchmark. [9] The SFE data is restricted to trades in the near and deferred contracts, and transactions executed by locals are removed from the sample. Further, we delete trades occurring within ten days of expiration of the near contract. These restrictions are consistent with futures market literature.[10]

3.2. Measuring market impact costs

Data limitations have thus far prevented researchers from applying equity and futures market methodology to measure execution costs in OTC markets. Instead, past studies have either used simplistic and noisy execution cost estimators (Hong and Wagra, 2000; Chakravarty and Sarkar, 2003; Hong and Wagra, 2004) or developed econometric methodology to estimate execution costs (Schultz, 2001; Harris and Piwowar, 2006). The liquidity of the short-term money market, richness of the Austraclear data, and homogeneity of BABs and NCDs permit the application of equity and futures market methodology to the OTC market in this study. Specifically, we apply the trade package methodology developed in Chan and Lakonishok (1995) to the OTC data, and estimate market impact costs for packages of trades in BABs and NCDs.

[9] The cut-off yield of 6.5% was determined in conjunction with OTC brokers and the General Manager of Interest Rate Markets at the SFE. Results produced using different cut-off yields are similar to results reported in this study and are not presented for space considerations.

[10] See Frino and Oetomo (2005). Transactions by locals are deleted in order to proxy for institutional trades. Trades within ten days of expiration of the near contract are deleted to remove potential rollover effects as traders roll their positions from the near to the deferred contract. As an additional test, we remove this sample restriction and repeat the analysis for 90 Day BAB futures with no trading days deleted. The results of this analysis are similar to results presented in this study and are not reported for space considerations.

To form trade packages in BABs and NCDs, we isolate each institution and aggregate their trades on a particular day if (i) the trades are in the same direction, (ii) the trades are in commercial paper with the same maturity year and month, and (ii) the commercial paper matures early month or late month. These criteria were developed through discussions with OTC brokers and institutions trading in the short-term money market.[11]

The futures market provides a natural control for the trade package methodology employed in the OTC market, as BABs and NCDs are acceptable upon settlement of the 90 Day BAB futures contract. Frino and Oetomo (2005) and Frino et al. (2007) create trade packages from individual trades in futures markets, and find that market impact costs increase with the size of the trade package. To test the robustness of our trade package methodology and execution cost measures we apply similar trade package criteria to the sample of 90 Day BAB futures. To form trade packages in 90 Day BAB futures, we again isolate each institution and aggregate their trades on a particular day if (i) the trades are in the same direction, and (ii) the trades are in the same contract.

Market impact costs are calculated in the same manner for the OTC and futures trade packages, and the methodology employed is analogous to that of Berkowitz, Logue, and Noser (1988). Berkowitz et al. (1988) use the volume-weighted average price (VWAP) across the trading day as their benchmark to measure market impact costs.
There are several criticisms of the VWAP benchmark in the literature. Berkowitz et al. (1988) recognise that abnormally large trades in less liquid products will obtain a heavy

[11] When of a similar maturity, BABs and NCDs are perfect substitutes. Institutions trading in the short-term money market will execute trade packages across both BABs and NCDs.

weighting in the VWAP, creating a downward bias in the measurement of market impact costs. In addition, traders may game the VWAP benchmark if they believe it is used to measure their performance. If many traders aim to transact at the VWAP on a particular day, the measurement of market impact costs will again be biased downwards. Chan and Lakonishok (1995) also recognise the downward bias in measuring market impact costs based on the VWAP across the trading day, and suggest using a benchmark price independent of the trade package.

The primary benchmark implemented in this study to measure market impact costs is the notional value-weighted average price (again, VWAP) from the previous day's trading.[12] The disadvantages of the VWAP benchmark identified in Berkowitz et al. (1988) and Chan and Lakonishok (1995) do not necessarily apply to this study. The liquidity of the short-term money market and the futures market mitigates the undue influence of abnormally large transactions on the VWAP. Over the sample period, there are an average of 324 trades per day in BABs and NCDs, and an average of 1,530 trades per day in 90 Day BAB futures. The effects of abnormal trades are further reduced by implementing the VWAP on the previous day as the benchmark, as it represents a benchmark price independent of the trade package. In addition, it is not possible to game the VWAP in an opaque OTC market as there is no post-trade transparency. Institutions are unable to determine the VWAP throughout the trading day, and are also unaware of the VWAP on the previous trading day. This does not apply to the electronically traded 90 Day BAB futures. Estimates of market impact costs in the futures sample will contain

[12] There are no volumes reported for OTC trades so instead we weight all transactions according to their notional value. In standardised interest rate futures contracts, such as 90 Day BAB futures, weights according to notional value are synonymous with volume-based weights.

a downward bias if traders game the VWAP on the day. Using the VWAP on the previous day will reduce but not entirely remove this bias.

To measure the market impact cost (*Market Impact*) associated with trade package i, we estimate the following equation

$$Market\ \ Impact_{it} = D_i * (VWAP\ \ Package_{it} - VWAP_{j,t-1}) * 100, \qquad (1)$$

Where D_i is a binary variable that equals 1 if trade package i is a buy and -1 if trade package i is a sell and $VWAP\ Package_{it}$ is the notional value-weighted price of trade package i on day t. For OTC packages, $VWAP_{j,t-1}$ is the notional value-weighted price across the previous day's trading for one of four maturity groups j; less than or equal to 30 days, greater than 30 days and less than or equal to 90 days, greater than 90 days and less than or equal to 180 days, and greater than 180 days. Each OTC package is matched with an appropriate benchmark for its maturity.[13] For futures packages, $VWAP_{i,t-1}$ is the notional value-weighted average price across the previous day's trading in contract j. All market impact costs in this study are reported in basis points. To provide a check of the methodology, we also report results using the VWAP on the day as the benchmark price.

[13] The first three groups represent approximately 30% of the sample each, and the final group represents approximately 10% of the sample. Sample size restrictions prevent us forming more than four maturity groups.

3.3. Descriptive statistics for OTC and futures trade packages

Table I reports summary statistics for trade packages. The sample consists of 2,766 buy packages and 2,499 sell packages of BABs and NCDs, and 2,981 buy packages and 2,777 sell packages of 90 Day BAB futures. Buy packages of BABs and NCDs have an average notional value of AUD 94.16 million and are executed in approximately 4.85 trades, while sell packages have an average notional value of AUD 112.13 million and are executed in approximately 5.79 trades. Trade packages of 90 Day BAB futures are much larger in notional value than trade packages of BABs and NCDs. Buy packages of 90 Day BAB futures have an average notional value of AUD 378.97 million and are executed in approximately 6.66 trades, while sell packages have an average notional value of AUD 386.53 million and are executed in approximately 6.80 trades. The average size of a trade package in 90 Day BAB futures is over three times larger than the average size of a trade package executed in BABs and NCDs. This difference in trade package size reflects the leveraged position of a futures contract. Margin payments allow institutions to trade larger volumes with minimal capital outlay, while a transaction in the OTC market requires full payment of the deal value.

< INSERT TABLE I ABOUT HERE >

Both the futures market and the short-term money market are extremely liquid. Table I reports that an average of 42.02 buy packages and 37.63 sell packages are executed per day in BABs and NCDs, and an average of 52.29 buy packages and 46.73 sell packages are executed per day in 90 Day BAB futures.[14] The average trade package yield is similar in the OTC and futures markets, with trade packages of BABs and NCDs incurring an average yield of 5.62% and trade packages of 90 Day BAB futures incurring an average yield of 5.64%. The slightly higher yield incurred by the futures trade packages is attributable to the additional interest rate risk inherent in the forward price of the 90 Day BAB futures contract when compared with the cash price of the BABs and NCDs.

4. MARKET IMPACT COSTS

To examine the variation in market impact costs with trade package size, we separate trade packages into mutually exclusive quintiles based on notional value. We also examine whether buy packages and sell packages incur similar market impact costs. The primary benchmark employed in this study to measure market impact costs is the VWAP from the previous day's trading ($VWAP_{t-1}$). As an additional test of our methodology, we also measure market impact costs using the VWAP from the day's trading ($VWAP_t$). This analysis is conducted for the OTC and futures market samples, and results are reported in Table II.

< INSERT TABLE II ABOUT HERE >

Panel A of Table II reports market impact costs for trade packages of BABs and NCDs, along with estimated *t*-statistics. For both buy and sell trade packages, market impact

[14] These figures are not representative of the total daily market turnover in either the futures market or short-term money market as trade packages exclude individual trades not belonging to institutional orders. Note that the VWAP calculations include all trades, not just the trades from trade packages. The criteria for institutional trade packages are defined in Section 3.

costs estimated using the $VWAP_{t-1}$ benchmark decline monotonically as the notional value of the trade package increases.[15] The observed negative relation between market impact costs and trade package size is consistent with Schultz (2001) and Harris and Piwowar (2006). Interestingly, the average market impact cost for the group containing the largest trade packages is negative for buy and sell packages. This implies that institutions buying or selling extremely large trade packages of BABs and NCDs on average transact at a better price than the VWAP on the previous day. This is also consistent with prior literature, as the total cost function reported in Harris and Piwowar (2006) is negative for the largest trades, and Green et al. (2007) find that dealers more often lose money on large trades than small trades. Section 5 of this paper examines this issue in detail.

The futures market provides a natural test of the methodology employed to measure market impact costs in the OTC market. Panel B of Table II reports market impact costs for trade packages of different sizes executed in 90 Day BAB futures. For the $VWAP_{t-1}$ benchmark, market impact costs increase with the notional value of the trade package and are always statistically significant in the largest size group.[16] Berkman et al. (2005), Frino and Oetomo (2005), and Frino et al. (2007) also find that market impact costs increase with trade size in futures markets. The replication of futures market results in Table II

[15] Using the $VWAP_t$ benchmark to measure market impact costs produces the same negative relation observed with the $VWAP_{t-1}$ benchmark; however, the magnitudes of the market impact costs are slightly lower when using the VWAP on the day as the benchmark price.
[16] As with BABs and NCDs, the use of the $VWAP_t$ benchmark produces results similar to the $VWAP_{t-1}$ benchmark; however, the market impact costs are lower in magnitude when using the VWAP on the day. This downward bias is more noticeable in the futures sample as institutions can observe the VWAP throughout the trading day.

implies that the methodology employed to form trade packages and measure market impact costs in this study is robust.

Table II also reports the mean difference in market impact costs of buy and sell trade packages. Berkman et al. (2005) find no significant difference between the market impact costs of buy and sell trades in futures markets, and we expect OTC transactions to behave similarly. In both Panels A and B, there is no statistically significant difference in mean market impact costs for buy and sell trade packages. This holds for both markets (OTC and futures) and both benchmarks ($VWAP_{t-1}$ and $VWAP_t$), suggesting that buy and sell trade packages incur market impact costs of a similar magnitude. The similar magnitude and direction of market impact costs for buy and sell trade packages alleviates the need to examine them separately. From this point forward, we examine OTC buy and sell trade packages simultaneously.

As a preliminary analysis of the role of trader identity in an OTC market, we examine the distribution of market impact costs across all traders in the sample.[17] Skilful traders with informational advantages and relative bargaining power should incur lower market impact costs in an opaque OTC market. This analysis will provide an initial indication of the dispersion of market impact costs across traders in the short-term money market, and is similar to the analysis in Chan and Lakonishok (1995). Results for the preliminary analysis of trader identity are reported in Table III below.

[17] These are individual traders, not institutions. Some institutions have more than one person executing transactions on their behalf in the short-term money market.

< INSERT TABLE III HERE >

There is substantial dispersion of market impact costs across the 133 traders examined in this study. Table III reports that market impact costs measured using the $VWAP_{t-1}$ benchmark have a standard deviation of approximately 2.75 basis points, and a 6.23 basis point difference between the top and bottom 10% of traders. Similar results are produced using the $VWAP_t$ benchmark. In a short-term money market setting, these figures represent a large variation in market impact costs across traders. This variation across traders suggests that trader identity may influence the market impact costs incurred when trading in an OTC market.

Table III shows that market impact costs differ considerably across traders in the OTC market. To further investigate of the role of trader identity in an OTC market, we classify traders according to four categories based on their trading activity. Schultz (2001) finds that institutions actively participating in the opaque corporate bond market incur lower execution costs than inactive institutions. These differences in execution costs are attributable to information asymmetries, and we expect similar findings in the short-term money market. The analysis of institutional trading activity is reported in Table IV.

< INSERT TABLE IV ABOUT HERE >

Consistent with Schultz (2001), Table IV shows that traders who transact frequently in the OTC market incur lower market impact costs than less frequent traders. Market impact costs in Table IV decline monotonically with trading activity, and there is a large variation in market impact costs across each category. When measured against the $VWAP_{t-1}$ benchmark, traders in the least active category (Group 1) incur average market impact costs of 1.82 basis points and traders in the most active category (Group 4) incur average market impact costs of 0.26 basis points. Standard deviations for Group1 and Group 4 are 4.90 and 3.59 basis points respectively. The substantial differences in mean market impact costs across trade frequency categories and the high variation in all categories suggests that trader identity in the OTC market could be a primary determinant of market impact costs.

Table IV also provides an additional insight into the distribution of trading activity among traders. The majority of traders (59 of 133) trade in the OTC market less than once per fortnight and the dollar value of their transactions represent only 1.25% of the total notional value traded. In contrast, the 25 traders that trade on average at least once per day account for 84.54% of the notional value traded. Schultz (2001) reports that in his sample of 601 dealers, the largest 12 dealers represented 72% of the total amount traded (p.680).

5. THE DETERMINANTS OF MARKET IMPACT COSTS

Table II, Table III and Table IV provide evidence that market impact costs differ substantially across traders in the OTC market. The remainder of this study examines the determinants of market impact costs. In particular, we focus on the specific role of trader identity in determining market impact costs in an opaque OTC market.

Several determinants of execution costs examined in prior bond market literature are relevant to this study. These variables include trade size (Schultz, 2001; Harris and Piwowar (2006), time to maturity (Hong and Wagra, 2001, 2004; Chakravarty and Sarkar, 2003; Harris and Piwowar, 2006), and macroeconomic announcement days (Chakravarty and Sarkar, 2003). In addition to these variables, we also propose a series of dummy variables to capture the role of trader identity in the OTC market. These dummy variables improve upon the analysis in Schultz (2001) as they encapsulate informational advantages and bargaining power of *individual* traders.[18] To examine the determinants of market impact costs in the OTC market, we estimate the following regression model:

$$\begin{aligned} Market\,Impact\,Cost_{it} &= \alpha + \beta \ln(DTM)_{it} + \delta D_{t-1}^{Macro} + \sum_{j=2}^{5} \phi_j S_{ij} \\ &\quad + \sum_{j=2}^{108} \gamma_j TrID_{ij} + \varepsilon_i . \end{aligned} \tag{2}$$

The dependent variable, *Market Impact Costs*$_{it}$, is measured for each trade package *i* executed on day *t*. To control for interest rate volatility and macroeconomic announcements, we include the natural log of days to maturity, $\ln(DTM)$, and a dummy variable for macroeconomic announcement days, D_{t-1}, respectively. The macroeconomic announcement dummy variable equals one if there was a macroeconomic announcement made on the previous trading day and zero otherwise. The variable is lagged by one day as almost all trading in the short-term money market on a particular day occurs prior to major Australian macroeconomic announcements. Consequently, any reaction in the

[18] Schultz (2001) employs a single dummy variable to classify institutions as either active or inactive in the corporate bond market.

short-term money market will not occur until the day after the announcement.[19] The set of dummy variables, S_{ij}, establish the effect of package size on market impact costs. They relate to the trade package size quintiles created in Section 4, where trade package *i* takes on a value of one if it is drawn from size quintile *j*, and is zero otherwise. Similar to the money manager variable in Chan and Lakonishok (1995), the set of $TrID_{ij}$ dummy variables capture the effect of trader identity on market impact costs. $TrID_{ij}$ is one if trade package *i* is executed by trader *j* and is zero otherwise. Both sets of dummy variables (S_{ij} and $TrID_{ij}$) are standardised by their respective first category; however, the trader identity variables are standardised by the first prime bank trader as opposed to just the first trader.[20]

Regression estimates and *t*-statistics for various forms of equation 2 are reported in Table V. The first column of Table V documents coefficient estimates for the regression of market impact costs on the set of trade size dummy variables. Consistent with Table II and prior literature, the coefficients on the trade size dummy variables decrease monotonically as trade package size increases. The smallest trade packages (Group 1) incur average market impact costs 0.903 basis points greater than the largest trade packages (Group 5). The very low adjusted R-square of this model (< 1%) suggests trade size contains little explanatory power.

[19] The lagged version of this variable was suggested by the General Manager of Interest Rate Markets at the SFE and OTC brokers. As a robustness test, we also examine the effect on market impact costs of a macroeconomic announcement on day *t*, and find that the macroeconomic dummy variable is insignificant.
[20] The market impact costs of all traders are measured in comparison with a prime bank as we assume that the superior market knowledge and negotiating skills of prime bank traders enable them to execute trades at significantly better prices than traders with less information.

The second and third columns of Table V report coefficient estimates for regression models containing two additional variables; the log of days to maturity and the macroeconomic announcement dummy variable. The positive coefficient of the log of days to maturity in column two suggests that market impact costs are higher for trade packages further away from maturity. The sign of this coefficient is consistent with bond market literature; however, the short-term nature of BABs and NCDs renders this coefficient statistically insignificant in the short-term money market. Column three of Table V documents a positive and statistically significant coefficient for the macroeconomic announcement dummy variable. This implies that market impact costs are higher on day *t* if there is a macroeconomic on trading day *t-1*. Both the log of days to maturity and the macroeconomic announcement dummy variable contain little explanatory power, as determined by the minimal change in adjusted R-square values once they are added to the model.

The full regression model is reported in the fourth column of Table V.[21] The set of trader identity dummy variables contain substantial explanatory power; the adjusted R-square increases from less than 1% to 20% when these variables are added to the model. This suggests that of the variables examined, trader identity is overwhelmingly the primary determinant of market impact costs in an opaque OTC market. In addition, there is a change in the relation between trade size and market impact costs when trader identity is included in the model. The coefficients on the trade size dummy variables now *increase* monotonically as trade package size increases, suggesting that once controlling for trader

[21] Similar to Chan and Lakonishok (1995), we focus on the direction and economic significance of coefficients as our observations are not independent. Statistical significance should be cautiously interpreted.

identity larger trade packages incur relatively greater market impact costs. The largest trade packages (Group 5) incur average market impact costs 0.347 basis points greater than the smallest trade packages (Group 1). This positive relation between market impact costs and trade size is consistent with equity and futures market literature. Regression results for all model variations are similar across the two benchmarks employed in this study.

The results presented in Table V suggest that strong information asymmetries exist between traders in OTC markets. Minimal pre-and post-trade price transparency in OTC markets provides regular traders with a natural advantage in the negotiation process, and consequently trader identity plays a pivotal role in determining market impact costs. After controlling for information asymmetries and relative bargaining power through the introduction of trader identity dummy variables, the observed negative relation between trade size and market impact costs disappears. This implies that trader identity is driving this negative relation. Consistent with the conjecture in Harris and Piwowar (2006), our results suggest that institutions regularly transacting large volumes in an opaque OTC market undoubtedly have superior knowledge of true market prices. In turn, they will incur lower market impact costs.

6. CONCLUSIONS

This paper utilises two unique data sets to examine the role of trader identity in an opaque OTC market; the Australian short-term money market. Trader identity in a market with minimal price transparency primarily encompasses an individual trader's knowledge of true market values, but also incorporates their negotiating skills and bargaining power. This study provides evidence that market impact costs in the short-term money market vary substantially with trade size, trader identity, and trading activity; however, we find that trader identity is the primary determinant of OTC market impact costs. The results presented in this paper also suggest trader identity explains the negative relation between market impact costs and trade size reported in prior literature. If we control for differences in market impact costs across individual traders, market impact costs no longer decrease as trade package size increases. In contrast, market impact costs now increase with the size of the trade package, consistent with findings in equity and futures markets.

The pivotal role of trader identity in OTC markets has important implications for future OTC market research and OTC market regulators. Future studies of OTC markets must consider the role of trader identity in determining execution costs. An interesting avenue for future research is examining the role of trader identity in OTC markets with active dealers. Our results suggest that there is a need to improve price transparency in OTC markets. This is the responsibility of OTC market regulators, as any reduction in information asymmetries will help minimise the significant market impact costs incurred by small traders.

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Table I
Descriptive statistics: Trade packages in OTC and futures markets

This table reports descriptive statistics for OTC trade packages executed in BABs and NCDs and futures trade packages executed in 90 Day BAB futures. To form a trade package of BABs and NCDs, we aggregate trades by the same institution on a particular day if the trades are in the same direction, the trades are in commercial paper with the same maturity year and month, and the commercial paper matures early month or late month. To form trade packages of 90 Day BAB futures, we aggregate trades by the same institution on a particular day if the trades are in the same direction and in the same contract. *Notional value* is the average notional value of a trade package, *No. of trades per package* is the average number of trades it takes to execute a trade package, *No. of packages per day* is the average number of trade packages executed per trading day, and *Yield* is the average yield of a trade package. *N* is the total number of trade packages. Statistics are reported separately for buy and sell trade packages.

		BABs and NCDs		90 Day BAB futures	
Average		Buy	Sell	Buy	Sell
Notional Value (AUD '000,000)	Mean	94.16	112.13	378.97	386.53
	Median	55.00	70.00	196.00	200.00
	Std Dev	112.03	132.77	615.18	600.73
No. of trades per package	Mean	4.85	5.79	6.66	6.80
	Median	3.00	3.00	4.00	4.00
	Std Dev	5.68	7.14	8.61	9.08
No. packages per day	Mean	42.02	37.63	52.29	46.93
	Median	42.00	37.00	49.00	46.00
	Std Dev	7.71	6.11	20.01	13.75
Yield (%)	Mean	5.62	5.62	5.64	5.64
	Median	5.61	5.61	5.64	5.64
	Std Dev	0.05	0.05	0.07	0.07
N		2,766	2,499	2,981	2,777

Table II
Market impact costs for trade packages as determined by trade size

This table presents market impact costs for trade packages of BABs and NCDs (Panel A) and trade packages of 90 Day BAB futures (Panel B). Trade packages are ranked by notional value and sorted into five mutually exclusive size quintiles. Group 1 contains the smallest trade packages, and Group 5 contains the largest trade packages. Market impact costs are measured (1) as the difference between the value-weighted average price (VWAP) of the trade package and the matched VWAP on the previous trading day ($VWAP_{t-1}$) and (2) as the difference between the VWAP of the trade package and the matched VWAP on the day ($VWAP_t$). Market impact costs are multiplied by a binary variable that equals 1 for buy packages and -1 for sell packages. Abs(buys) – Abs(sells) is the absolute difference in market impact costs for buy and sell packages. All market impact costs are reported in basis points and *t*-statistics are reported in parentheses.

		Market impact costs (basis points)					
		$VWAP_{t-1}$		$VWAP_t$		Abs (Buys)–Abs(Sells)	
	Notional Value (‘000,000)	*Buys*	*Sells*	*Buys*	*Sells*	*$VWAP_{t-1}$*	*$VWAP_t$*
Panel A: BABs and NCDs							
1	0 – 18.99	0.7756	0.8137	0.6856	1.0395	-0.0381	-0.3539
		(6.12)	(3.34)	(6.32)	(4.91)	(-0.14)	(-1.49)
2	19 – 39.99	0.5578	0.6711	0.6046	0.5718	-0.1133	0.0328
		(4.17)	(3.22)	(5.14)	(3.02)	(-0.46)	(0.15)
3	40 – 69.99	0.5094	0.3424	0.4635	0.2540	0.1670	0.2094
		(3.30)	(2.22)	(3.87)	(1.74)	(0.77)	(1.11)
4	70 – 139.99	0.1347	0.2620	0.0992	0.1931	-0.1273	-0.0938
		(0.69)	(1.88)	(0.59)	(1.54)	(-0.54)	(-0.45)
5	> 140	-0.2516	-0.0480	-0.2244	-0.0601	0.2036	0.1643
		(-1.63)	(-0.38)	(-2.01)	(-0.66)	(1.03)	(1.14)
Panel B: 90 Day BAB futures							
1	2 – 29.99	-0.0477	0.0878	-0.0107	0.0817	-0.0401	-0.0709
		(-0.58)	(-0.75)	(-0.24)	(2.26)	(-0.28)	(-1.21)
2	30 – 114.99	0.0440	0.1194	0.0366	0.0909	-0.0754	-0.0543
		(0.42)	(1.32)	(0.85)	(2.15)	(-0.54)	(-0.89)
3	115 – 284.99	0.1433	0.1622	0.0526	0.0961	-0.0189	-0.0434
		(1.32)	(1.69)	(1.22)	(2.63)	(-0.13)	(-0.75)
4	285 – 574.99	0.3048	0.2267	0.0751	0.1108	0.0782	-0.0356
		(3.00)	(2.01)	(1.85)	(2.75)	(0.51)	(-0.61)
5	> 575	0.4224	0.4682	0.0976	0.1455	-0.0458	-0.0479
		(3.60)	(3.99)	(2.48)	(3.96)	(-0.23)	(-0.88)

Table III
The distribution of market impact costs across all traders in the short-term money market

This table describes the distribution of market impact costs across the 133 traders in the OTC market sample. Market impact costs are calculated for each trade package, and then average market impact costs are calculated across all packages executed by each of the 133 traders in the sample. Buy and sell trade packages are included in this analysis.

	Market Impact Costs	
	$VWAP_{t-1}$	$VWAP_t$
Mean	0.968	1.021
Median	0.574	0.454
Std Deviation	2.754	2.523
10-percentile	-1.949	-1.151
25-percentile	-0.435	-0.421
75-percentile	2.323	2.119
90-percentile	4.277	4.030
Difference between 90- and 10-percentile	6.226	5.181

Table IV
Market impact costs for traders as determined by trading activity

This table presents statistics describing market impact costs for OTC market traders based on their level of trading activity. Trading activity is defined as the average number of trade packages executed per week by a particular trader over the sample period. Traders are ranked based on their trading activity and sorted into four groups. Group 1 contains the least active traders, and Group 4 contains the most active traders. The table reports the mean, median, and standard deviation of market impact costs incurred by the traders in each trading frequency group. Market impact costs are measured for trade packages as the difference between the value-weighted average price (VWAP) of the package and one of two benchmarks; the VWAP on the previous day ($VWAP_{t-1}$) and the VWAP on the day ($VWAP_t$). Buy and sell trade packages are included in this analysis, and market impact costs are converted to basis points. The table also reports the number of traders in each category (No. Traders) and the percentage of total notional value traded in each category (% Notional Value Traded).

			Market Impact Costs			
	Av. Trading Frequency (Packages)		*$VWAP_{t-1}$*	*$VWAP_t$*	*No. Traders*	*% Total Notional Value Traded*
1	*Less than* once per fortnight	Mean	1.820	2.007	59	1.25%
		Median	1.365	1.698		
		Std Dev	4.900	3.962		
2	*Greater than/Equal to* once per fortnight and *less than* once per week	Mean	0.752	0.680	12	0.64%
		Median	0.482	0.514		
		Std Dev	4.578	3.572		
3	*Greater than/Equal to* once per week and *less than* once per day	Mean	0.390	0.346	37	13.57%
		Median	0.176	0.201		
		Std Dev	4.289	3.733		
4	*Greater than/Equal to* once per day	Mean	0.263	0.246	25	84.54%
		Median	0.056	0.039		
		Std Dev	3.509	2.963		

Table V

The determinants of market impact costs in the short-term money market

This table presents regression results from the following model

$$Market\ Impact\ Cost_{it} = \alpha + \beta \ln(DTM)_{it} + \delta D_{t-1}^{Macro} + \sum_{j=2}^{5} \phi_j S_{ij} + \sum_{j=2}^{108} \gamma_j TrID_{ij} + \varepsilon_i,$$

where *Market Impact Costs*$_{it}$, are measured for each trade package *i* executed on day *t*. Market impact costs are measured as the difference between the value-weighted average price (VWAP) of the trade package and one of two benchmarks; the VWAP on the previous day ($VWAP_{t-1}$) and the VWAP on the day ($VWAP_t$). ln*(DTM)* is the natural log of days to maturity, and D_{t-1} is a dummy variable that equals one if there was a macroeconomic announcement made on the previous trading day and zero otherwise. The set of trade size dummy variables, S_{ij}, take on a value of one if trade package *i* is drawn from size quintile *j*, and is zero otherwise. The set of $TrID_{ij}$ dummy variables capture the effect of trader identity on market impact costs. $TrID_{ij}$ is one if trade package *i* is executed by trader *j* and is zero otherwise. There are 107 traders used in this analysis. Both sets of dummy variables (S_{ij} and $TrID_{ij}$) are standardised by their respective first category; however, the trader identity variables are standardised by the first prime bank trader as opposed to just the first trader. Buys and sells are reported together. *T*-statistics are reported in parentheses, and the F-statistic and the adjusted R-square is reported for each model.

	Dependent Variable: Market Impact Costs (basis points)							
	$VWAP_{t-1}$				$VWAP_t$			
Intercept	0.767	0.378	0.278	-0.968	0.815	0.594	0.566	-0.652
	(5.92)	(1.60)	(1.15)	(-2.98)	(7.39)	(2.96)	(2.76)	(-2.46)
Package Size								
2	-0.153	-0.158	-0.172	0.254	-0.198	-0.201	-0.205	0.246
	(-0.84)	(-0.87)	(-0.95)	(1.47)	(-1.28)	(-1.30)	(-1.32)	(1.74)
3	-0.371	-0.388	-0.389	0.307	-0.462	-0.471	-0.472	0.246
	(-2.10)	(-2.20)	(-2.20)	(1.76)	(-3.08)	(-3.13)	(-3.14)	(1.71)
4	-0.621	-0.635	-0.644	0.310	-0.695	-0.702	-0.705	0.248
	(-3.66)	(-3.74)	(-3.79)	(1.82)	(-4.81)	(-4.86)	(-4.88)	(1.79)
5 (Largest)	-0.903	-0.922	-0.930	0.347	-0.946	-0.957	-0.959	0.311
	(-5.31)	(-5.41)	(-5.47)	(1.98)	(-6.54)	(-6.60)	(-6.62)	(2.17)
Log Days to Maturity		0.106	0.106	0.066		0.060	0.061	0.022
		(1.96)	(1.95)	(1.29)		(1.33)	(1.33)	(0.53)
Macro Dummy (t-1)			0.220	0.190			0.059	0.024
			(2.07)	(1.96)			(0.66)	(0.31)
Trader ID								
Difference between 90- and 10- percentiles								
Number of Trader ID coefficients significant at 5% level				35				42
F-statistic	9.31	8.23	7.57	11.86	13.88	11.46	9.62	16.89
Adjusted R-square	0.0067	0.0073	0.0080	0.2000	0.0103	0.0105	0.0103	0.2662