The Effect of Market Maker Competition in an Electronic Limit Order Market: Evidence from the Australian Equities Options Market

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Abstract

This paper documents the significant decrease (increase) in bid-ask spreads following the entry (exit) of market makers from individual option classes. We examine the effect over multiple event-windows and find that our results are robust across window selection. These results suggest the Australian Equities Options market structure behaves consistently with competitive models of dealer pricing, furthermore stoking debate between academics and market practitioners in the area of optimal market design.

I. Introduction

The issue of competition and its vexed implications for liquidity, efficiency and competitiveness has evolved over the last decade following dynamic changes in the technological and regulatory frameworks of financial markets. To date, the literature on competition in financial markets and its effects on market quality has been framed in two ways; as an examination of the dynamics of dealer competition and its impact on market quality; secondly, as a question of the effect of competing market platforms[1]. Many of the regulatory developments in financial markets in the past have been motivated by the desire to enhance competition facing individual orders[2]. The adoption of maximum spread rule, the implementation by exchange officials of designated market maker obligations, or rules such as the trade-through rule by the SEC have purported to enhance competition at an atomistic level. This study contributes to the literature by further exploring the effects of market maker dynamics outside the traditional competitive dealer structure.

Competitive economic theory underlies the importance of competition between market makers in dealer markets. Dealer markets contribute

[1] The first strand of literature includes Wahal (1997), Klock and McCormick (1999), Weston (2000), Ellis, Michaely and O'Hara (2002), Schultz (2003). The second strand of literature includes Neal (1987), Mayhew (2002), De Fontnouvelle, Fishe and Harris (2003) and Battalio (2003) assess the competitive effect of multiple listing of stock options.

[2] Weston (2000) additionally documents the effect of recent market reforms on the competitive structure of the Nasdaq. Weston finds that the difference between NYSE and Nasdaq spreads have been greatly diminished with the new rules.

to the price discovery process through the provision of quotes by individual market makers that ensures that these markets are both informative and liquid throughout the trading day. Underpinning the competitive effect of dealer markets is a further tenet that there is fluid movement by market makers into and out of securities. To date, the there is only limited evidence of whether the dynamics of market maker competition and their implications for trading costs and market quality are actually realised. In this limited sample, most prior studies are confined to the analysis of the NASDAQ market. For example, Tinic and West (1972), Benston and Hagerman (1974), Stoll (1978) and McCormick (2004) focus on the relationship between the spread and the number of dealers on the NASDAQ market and show that the spread is lower for stocks with a larger number of dealers[3]. Additionally Wahal (1997) examines the impact of the movement of market makers across listed on the NASDAQ and shows that their entry (exit) is associated with significant declines (increases) in end of day quotes. Despite these findings, however, Christie and Schultz (1994) amongst others have documented that the tacit collusion of market makers in the NASDAQ has imposed imperfect market competition over the periods analysed.

The Australian Equities Options (AOM) market is a hybrid market structure with multiple market makers superimposed on an electronic

[3] Or Herfindahl index – spread is lower with a smaller herfindahl index.

limit order book. As with traditional dealer markets the AOM is characterised by the free movement of market makers across option classes[4]. Market makers are allotted with special requirements to maintain fair and orderly markets and consequently compete for order flow through their competing quotes[5].

This study examines the fluid entry (exit) of market makers in the AOM and its impact on bid-ask spreads. It is unique in that it is the first that deals with the competitive entry and exit of market makers outside the traditional NASDAQ market. Furthermore, this study is undertaken in an equity options market structure where market makers are required to create multiple markets based on different option series. With a unique data set of consisting of all trade, quote and market maker related data over an extended eight year period we also avoid the potential problems in the related work of Wahal (1997), who is limited to the use of end-of-day quotes[6]. This paper addresses a number of ancillary questions such as: What determines the probability of entry (exit) of market makers from particular option classes? Are spread changes different in magnitude for underlying securities with different market capitalisations or different levels of market makers? Are market makers

[4] The relatively minor rules characterizing the registration and movement of market makers between underlying securities is documented in the ASX Market Rules Section 23.
[5] Unlike traditional dealer markets, market makers on the AOM are remunerated by exchange officials for fulfilling their obligations. Market makers do not enjoy any privileges beyond limit order traders.
[6] Chan, Christie and Schultz (1995) and Simaan, Weaver and Whitcomb (2003) amongst others show that show that spreads may narrow at the end of the day as a result of dealers competing to go home flat. Whilst this represents a form of competition between dealers it poses potential problems in generalizing these results.

competitive and do the enforced designated obligations ensure that they are active in the price discovery process? Are spread changes related to the type of obligations imposed on market makers? These questions provide further insight into the dynamics of market maker competition in financial markets.

Our empirical results indicate a number of important findings. Firstly, we show that spreads are affected by the entry and exit of market makers. The entry and exit of market makers in the AOM is a frequent and event with over 3000 event changes over the eight year period. We show that after controlling for other determinants of spreads, an increase (decrease) in the pool of market makers for the underlying security results in a decrease (increase) in spreads. This result is robust across different event-windows and furthermore consistent with the competitive model of dealer pricing.

The remainder of the paper is organised as follows. Section II describes the institutional framework of the Australian Options market. Section III describes the data and Section 4 describes the methodology. Section V presents a discussion of the results. Section VI concludes.

II. The Australian Equity Options Market and the Role of Market Makers

The Australian Equity Options Market

The ASX Equity Options market is an open electronic limit order market. The ASX options market is the second oldest options market in the world with its first listing dating back to 1976. ASX options are traded on a screen based system over a range of leading shares and are viewable to all market participants. These options are characterized by a standardized set of strike prices and expiry dates which occur on the Thursday before the last Friday of the settlement month. Trades are executed on a price/time priority basis and quotes represent firm orders. In the financial year, ending June 30, 2007, nearly 23 million options contracts traded on the ASX market.[7]

Market Makers in the Australian Equity Options Market

Market makers play a pivotal and active role in the Australian equities options market. Market makers are designated by exchange officials in one or more stocks in which they are charged with maintaining a regular market presence by quoting maximum bid-ask-spreads and a minimum depth on a range of option series and maturities. They additionally form an integral role by demonstrably contributing to the

[7] This represents the equivalent of 27 billion dollars in turnover.

price discovery process by providing options quotes that are informative, binding and continuous throughout the trading day[8].

Market makers in the Australian options market can operate in one of three capacities: making a market on a continuous basis only; or making a market in response to quote requests only; or making a market both on a continuous basis and in response to quote requests.[9] Table 1 reports for the 144 securities for which options were written on between September 18, 2000 and December 20, 2007 the average number of market makers across the various designated obligations is 3.01. Dissecting this figure reveals that the most prominent capacity in which market makers chose to operate is on a continuous basis where there is an average of 1.957 market makers per security. Additionally, there are an average of 0.749 market makers with quote obligations and 0.304 with both continuous and quote obligations.

The presence of market makers with designated obligations is however, not the sole source of competition on the ASX Options market. Although the exchange compensates market makers for providing liquidity when other public traders are not, market makers are not granted any special trading privileges over other market participants.

[8] Demsetz (1968) identifies the lack of 'predictable immediacy of exchange in financial markets as a trading problem that can be mitigated by the regular presence of market makers. See also Garbade and Silber (1979) and Grossman and Miller (1988), Seppi (1997) and Viswanathan and Wang (2002) further treatment.

[9] A detailed outline of the obligations of markets makers in the Australian Options Market (AOM) is available from http://www.asx.com.au/investor/options/trading_information/market_makers.htm

Market makers face direct competition for order flow from limit order traders. This non-dealer competition has important linkages to financial market stability as documented in the now burgeoning literature in this area[10].

III. DATA

The Reuters intra-day data used in this study are provided by the Securities Institute Research Centre of Asia Pacific (SIRCA) and are captured in real time from the Australian Securities Exchange Integrated Trading System (ITS)[11]. The data extends from September 18, 2000 to December 20, 2007 for equity options contracts listed on corresponding ASX securities. Each record contains a date and time stamp, to the nearest second, as well as fields outlining the trade price, volume and prevailing quotes. Quoted spreads are calculated using the best bid and offer prices.[12] We match option trades with prevailing and average underlying trade and quote data. Using this information

[10] See Glosten (1994) Schwartz and Whitcomb (1988), Harris (1990), Laux (1995) and Bloomfield, O'Harar and Saar (2004).
[11] The ITS is a modified version of the CLICK system developed by OMX Technology. This data is furthermore, cross-verified with data provided by ASX CORE in order to mitigate potential errors in our dataset.
[12] Most recent studies of *spreads* in the microstructure literature have focused on the effective spread (See Christie, Harris and Schultz (1994), Huang and Stoll (1994)). Effective spreads capture the actual cost of executing trades by calculating the deviation of the trade price from the true price. Trading on the ASX's is carried out on an electronic where the effective spread is equal the quoted spread since traders cannot trade inside the quotes.

we compute option volatilities, deltas and gammas using the Black-Sholes formula at each trade price.[13]

Additionally, we obtain a series of market maker assignments from the Australian Clearing House (ACH) and use this information to assess the entry and exit of designated market makers with particular obligations from specified classes of options.[14] Table 2 reports that between September 18, 2000 and December 20, 2007 a total of 3,126 changed obligations were recorded on the ASX. Of the changes, nearly 90% of these represent an increase or decrease in the pool of market makers by a total of 1[15].

A series of standard filters are applied to the data. All records with time stamps outside of the range 10:00 to 16:20 (Sydney Time) and the opening and closing trades of the day are excluded.[16] We delete all prices and quotes with a zero quote and exclude longer-term options as they are thinly traded making inferences difficult. [17] Furthermore, Low

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[13] To mitigate the potential errors from this approach we also calculate implied volatilities as the average of the at-t-he-money strike, one strike above, and one strike below for series with more than 20 days to expiration as consistent with De Fontnouvelle (2003). We also use indicative volatility parameters provided by the ACH and find quantitatively similar results across all three measures.

[14] The Exchange advises of the following assignment of classes to Market Makers in accordance with ASX Market Procedure 22.3. These reports are available at http://www.asx.com.au/investor/options/notices/

[15] We also document 525 non-changes. This reflects a change of obligations by the market maker rather than exiting or entering a particular stock.

[16] Market makers need only to conform to their obligations between 10:20-13:00 and 14:00-16:00 per trading day.

[17] Additionally options with maturities longer than 9 months are deleted from the final sample since market maker obligations only extend to those options within that period. We additionally analyze these data across a range of periods with varying lengths and find that our results are robust to the removal of both shorter and longer term options.

Exercise Price Options (LEPOs), which are deep-in-the-money options that more accurately depict futures style contracts, are excluded from the final sample. In accordance with Anand (2005) we similarly delete trades and quotes that are more than four standard deviations away from the average price, bid or ask prices for the particular option series per trading day[18]. This process results in a sample of 4,693,469 observations. Table 3 reports cross sectional summary statistics for 144 option classes over an eight year window. Consistent with the findings of Benston and Hagerman (1974), Stoll (1978), amongst others, we show that the number of market makers per security is negatively related to the bid-ask spread and positively related to trade volume, volatility and market capitalisation.

To construct the sample, we average across all trades in a given series per given day. This approach reduces the effects of intraday patterns.
[19]

IV. Methodology

Spread Determinants in the Options Market

Since the seminal work of Demsetz (1968) on the determinants of the bid-ask spread, a rich (crescendoing) body of theoretical literature has

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[18] We also consider a longer window to allow for thin trading in particular option series.

[19] Reproducing this analysis using transaction level data provides evidence consistent with the finding reported.

emerged that has predominately modelled market making costs as a function of inventory holding or asymmetric information costs.

The information-based models, developed by Copeland and Galai (1983), Easley and O'Hara (1987) Glosten and Milgrom (1985) and Easley, O'Hara and Srinivas (1998) postulate that market makers, in the supply of liquidity, set the bid-ask spread to offset the losses incurred in trading with better informed counterparties[20]. These models investigate the informational role of transactional volume and thereby predict that the bid-ask spread increases for higher priced, more volatile and less frequently traded securities[21].

The inventory-based models of Stoll (1978), Amihud and Mendelson (1980) and Ho and Stoll (1981,1983) suggest that the spread is a reflection of the risk incurred by the market maker from the asynchronous arrival of market orders and the uncertainty associated with return on the inventory. Inventory-based models suggest that the bid-ask spread will be positively related to the price and volatility of the asset and negatively related to the level of trading activity.

[20] See Kyle (1985), Admati and Pfleiderer (1992), Madhavan (1992), and Foster and Viswanathan (1994), among others develop asymmetric information models of bid-ask spreads.
[21] Despite the theory underlying these models, there is limited consensus on the proxies of liquidity in the financial markets. See "Determinants of Liquidity in Open Limit Order Book" Kumar, S. (2003) Working Paper

Despite the developed plethora of literature on the relationship between bid-ask spreads and market activity, non-stock market spread analyses are far less developed. A small but growing number of market making models exist in the options market. For example, Berkman (1992) extends the Ho and Stoll (1983) model to an options trading framework and posits that an option's bid-ask spread is a function of the price and variance of returns of the underlying security as well as the hedge ratio of the option. In addition John, Koticha and Subrahmanyam (1991) and Biais and Hillion (1994) amongst others develop asymmetric information models that examine the impact of option listing on trading activity. John et al. contend that the level of informed traders (from a fixed pool) in the options market is related to the leverage provided by the options market and as such the size of the spread and the level of price volatility will vary with the degree of leverage[22].

In addition to the main underlying theories, Cho and Engle (1999) offer "derivative hedge" theories to relate option and underlying spreads. The authors hypothesise that if market makers in derivative markets dynamically hedge their option interest in the underlying securities market, then liquidity and spreads in derivative markets will be determined by spreads in the underlying market. Furthermore, as a

[22] Easley, O'Hara and Srvinivas (1998) suggest that informed agents may trade in both the option and stock market simultaneously. Furthermore, the empirical evidence surrounding the finding is mixed. See Vijh (1990) and Cho and Engle (1999).

result of first order price risks being eliminated, market makers are indifferent between trading with informed and uninformed traders so that the spread is a reflection of the cost of an offsetting position. In their analyses, Jameson and Wilhelm (1992) and De Fontnouvelle, Fishe and Harris (2003) provide empirical support for the derivative hedging theory.

In addition to the theoretical literature discussed above, the empirical literature suggests a number of factors that affect option bid-ask spreads. Neal (1987) models the spread as a function of volume, price, and volatility. Neal (1987), Mayhew (2002) and De Fontnouvelle et al (2003) find that competition, through the multiple listing of options reduces spreads[23]. Fleming, Ostdiek and Whaley (1996), George and Longstaff (1993) and Kail et al. (2004) also document that option bid-ask spread is related to option time-to-maturity and option moneyness.

Entry and Exit of Market Makers

We construct a number of event windows around the entry and exit of each of the market maker changes so to examine the effect on bid-ask spreads. To control for other determinants of the spread, as

[23] Demsetz (1969) and Tinic (1972) expresses competition in terms of the number of market makers and a Herfindahl index.

specified in the previous section, we run the following regression model, where;

$$BAS = a_0 + a_1\text{Price} + a_2\sum_{i=1}^{i=7}\text{Tick} + a_3\text{BAS\_Under} + a_4\text{Volatility} + a_5 Quote + a_6 Both + a_7 Volume + a_8 Entry / Exit$$

BAS is the bid ask spread per trade; *Price* is the option price; *Tick* are a set of dummy variables that reflect bounds that the exchange sets on quoted option spreads. These bounds vary with the option price. For example, where the option price is less than 9.5 cents the maximum allowable bid-ask spread is 5 basis points which increases to 6 basis points where the option price increases to 19.5 cents[24]. *BAS_Under* is the quoted prevailing spread of the underlying stock; *Volatility* is the implied standard deviation for the option class[25]; *Quote* and *Both* are dummy variables indicating that the change in market maker is with quote/both obligations; Volume is summed across all trades in the series and the Entry/Exit is a dummy variable assigned the value of 1 if the observation occurs following the introduction or exit of a market maker , zero otherwise. If observed changes in the bid-ask spread are related to the introduction/exit of a designated market maker, then we would expect the estimate to be statistically significant.

[24] For a list of the designated option bounds for Category 1 and 2 stocks see Table 4 in appendix
[25] We compute the implied standard deviation and option deltas using the Black-Scholes formula at each trade price

V. Results

Regression Based Evidence:

Table 5 presents regressions results to show that that changes in the bid-ask spread are significantly related to the entry or exit of market makers. The coefficient estimates on the *entry/exit* variable strongly support the competitive economic tenet of dealer pricing. Therefore, as expected the entry (exit) of a market maker is associated is associated with a significant negative (positive) increase in the bid-ask spread. This analysis is repeated on 10-day, 30-day and 60-day event windows with comparative results[26].

Among our control variables, option price is positively related to option bid-ask spreads. The inclusion of dummy price variables to capture the effects that spread limits may have on the size of the quoted spread shows a positive stepwise relation between option prices and spreads for option classes. The results for option volatility and underlying spread suggest they are additionally important spread determinants as they may impact on the costs of hedging for market makers. As expected total daily series volume varies inversely to the level of bid-ask spreads.

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[26] These results are not included for brevity purposes. They are available upon request from the authors.

Our *Quote* and *Both* coefficients provide an interesting insight into the dynamics of market maker competition. Our results suggest that market makers that engage in providing requests for quote in addition to creating markets on a continuous basis have a greater marginal impact on bid-ask spreads following both the entry or exit of markets. This result may be intuitive in that the larger market makers that can afford to adopt both sets of obligations have more of an impact than do the market makers with single sets of obligations.

Conclusion

This paper documents significant reduction (increase) in bid-ask spreads following the entry (exit) of market makers from individual option classes. We examine the effect over multiple event-windows and find that our results are robust across window selection. These results suggest the AOM structure behaves consistently with competitive models of dealer pricing. The topical issue of optimal market design has received considerable attention from market regulators and academics in the equities domain. Contrastingly, derivative markets have been far less analysed and as such the margin for further progress in these markets is substantive.

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Table 1:
Market Maker Designated Obligations per Option Class

The following table describes the average number of market makers over 144 securities between September 18, 2000 and December 20, 2007. Market makers in the Australian Equity Options market operate within one of three capacities: making a market on a continuous basis only; or making a market in response to quote requests only; or making a market both on a continuous basis and in response to quote requests. Summary statistics relating to the segmentation of their obligations has been detailed below.

Obligation Type	Average	Median	Std Dev.	Max	Min
Panel A - Category 1 Stocks (n= 8,075)					
Continuous	5.81709	6	2.87108	15	0
Quote	1.48173	1	0.9602	6	0
Both (Continuous + Quote)	1.25845	1	1.13404	7	0
Panel B - Category 2 Stocks (n= 38,437)					
Continuous	1.14658	0	1.89057	11	0
Quote	0.59542	0	0.97853	5	0
Both (Continuous + Quote)	0.10297	0	0.37205	7	0
Panel B - ALL (n= 46,512)					
Continuous	1.957	1	2.74	15	0
Quote	0.749	0	1.031	6	0
Both (Continuous + Quote)	0.304	0	0.727	7	0
Average	*3.01*	*1*	*3.834*	*17*	*0*

Table 2:

Frequency Distribution of Market Maker Changes

This table documents the frequency distribution of market maker changes of 144 equity option classes between September 18, 2000 and December X, 2007. Panel A contains changes pertaining to particular designated obligation types: Continuous, Quote and Both. Panel B presents the distribution of changes collated across individual event dates. As such the *No Change* column refers to offsetting changes in the number of market makers for particular option classes.

Frequency of Market Maker Changes					
Panel A - Independent Market Maker Changes					
	Change = 1	Change > 1	Change = -1	Change < - 1	
Continuous	846	103	699	66	
Quote	449	52	465	33	
Both	146	13	224	30	
Total	1441	168	1388	129	
Panel B - Full Sample					
	Change = 1	Change > 1	Change = -1	Change < - 1	No Change
Total	839	122	751	104	525

Table 3:

Cross Sectional Summary Statistics segmented across Market Maker Quintiles

Summary statistics are reported for 144 securities between September 18, 2000 and December 20, 2007. *Bid-Ask spread* is the average prevailing bid-ask spread measured in cents. *PBAS* is the average prevailing percentage bid-ask spread. *Depth* is the average cumulative volume posted on the buy and sell sides of the limit order book prior execution of a trade. *Daily series volume* is measured in contracts (one contract equals 100 shares of the underlying stock). *Volatility* is the implied volatility and computed using the Black Scholes formula at each trade price. *Market Capitalisation* is the average market capitalisation of the securities in the respective market maker quintiles. *No. Market Makers* are the average number of designated market makers per security. The former category is made up of *MM-Both*, *MM-Continuous*, *MM-Quote* which are categories denoting the number of market maker per their obligations.

Market Maker Quintile	N	Bid-Ask Spread	PBAS	Depth	Daily Series Volume	Volatility	Market Capitalisation	No. Market Makers	MM-Both	MM-Continuous	MM-Quote
1	938,694	0.046	15.98%	46.84	100.00	26.65%	$3,404,021,172	5.31	0.57	2.98	1.75
2	938,694	0.036	12.58%	39.00	196.81	27.22%	$8,873,482,919	8.99	1.21	6.33	1.45
3	938,693	0.033	12.04%	46.46	254.73	25.73%	$12,066,900,540	10.78	1.37	7.81	1.59
4	938,694	0.031	10.44%	51.32	296.64	23.70%	$14,214,111,733	12.34	1.87	8.78	1.68
5	938,694	0.026	10.35%	42.33	407.74	24.18%	$18,710,873,124	14.43	2.32	9.80	2.30
Full Sample	*4,693,469*	*0.034*	*12.28%*	*55.09*	*251.19*	*25.50%*	*$11,453,877,767*	*10.37*	*1.47*	*7.14*	*1.76*

Table 4:
Categories of Stocks and Bid/Ask Spreads for Obligated Market Makers (As at February 8, 2006)

This table documents the maximum spread (the difference between the bid and offer prices) the designated market maker(s) may quote when making a market for options series in either category 1 or category. Categories of stocks are determined on the basis of the liquidity and turnover of options classes, such that the most active are categorised in group 1 and less traded option classes and category 2. There are currently 25 category 1 option classes and 60 category 2 classes.

	Category – 1	**Category - 2**
Premium Range	**Maximum Spread**	**Maximum Spread**
0 to 9.5 cents/pts	5	6
10 to 19.5 cents/pts	6	7
20 to 34.5 cents/pts	8	9
35 to 60 cents/pts	10	12
61 to 120 cents/pts	12	14
121 to 180 cents/pts	14	16
181 to 266 cents/pts	16	18
> 266 cents/pts	18	20

Table 5:

Entry/Exit of Market Makers and the Bid-Ask Spread (-15/+15 Days)

This table shows regression estimates from all options over sample period. The quoted bid-Ask Spread is regressed on option price, underlying effective spread, option delta, option volatility, series volume and a market maker entry/exit variable. The estimates are corrected for heteroskedasticity using White's (1980) method. A double asterisk implies a 99% level of significance and single asterisk implies a 95% level of significance.

	Entry		Exit	
	Estimate	t-statistic	Estimate	t-statistic
Intercept	0.05667	68.37	0.04288	40.05
Price	0.01646	106.8	0.01413	54.48
Dummy	-0.04774	-59.01	-0.03831	-36.35
Dummy2	-0.04414	-55.65	-0.0348	-33.73
Dummy3	-0.04166	-53.73	-0.03241	-32.33
Dummy 4	-0.03788	-50.54	-0.02943	-30.74
Dummy 5	-0.02996	-42.56	-0.02229	-25.52
Dummy 6	-0.01747	-26.16	-0.00985	-12.88
Dummy 7	-0.00722	-11.16	-0.00364	-5.36
Underlying Spread	0.35438	71.2	0.36921	76.07
Implied Volatility	0.01062	16.49	0.01065	21.72
Quote Dummy	-0.00087	-5.67	0.00364	29.87
Both Dummy	-0.00718	-46.98	0.0085	47.44
Series Volume ('000)	-0.00496	-31.02	-0.00434	-46.29
Entry/Exit	-0.0013	-11.2	0.000959	9.87
R-squared	30.25		24.47	
F-Test	13,289.4		10,057.1	