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Cover Page Footnote
This research was funded by the Sydney Futures Exchange under Corporations Regulation 7.5.88(2). The authors thank the Securities Industry Research Centre of Asia-Pacific (SIRCA) for providing data

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Angelo Aspris*[1], Alex Frino[1] and Andrew Lepone[1]

Abstract

This paper examines the dynamic relationship between competition, liquidity provision, and market structure. By examining the entry and exit of market makers in the Australian Options market, this study empirically analyses the issue of market maker competition. Results indicate that market maker entry depends on a broad range of profit, risk and market concentration characteristics, but *free* market maker movement does not explicitly result in a competitive market structure. This study also finds that the degree of market concentration additionally affects the marginal impact of market maker entry (exit), but the effect is significantly more pronounced for the most liquid classes of options. The implication of this finding is pertinent to market regulators since market maker competition may not necessarily contribute to enhancing market quality for less liquid securities.

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Introduction

This paper examines the dynamic relationship between competition, liquidity provision, and market structure. A common perception, widely entrenched in the economics literature, is that the price setting structure of a dealer market approximately reflects the ideals engulfed in standard competitive economic analysis. In principle, the pervasive and (quasi) free movement of registered market makers, who underscore the liquidity provision and price discovery process, are necessary conditions that form the primary basis of this association.[2] The advent of recent high frequency data from dealer market equity structures, however, has provided market practitioners with a rare opportunity to further understand the dynamics of dealer market structures.

Recent literature on the dynamics of dealer market structures reveals that the attainment of a competitive outcome is both infeasible and potentially less than optimal in terms of its overall effect on market welfare (Schultz (2000), Ellis, Michaely and O'Hara (2002)). The inability to reconcile differences between the theoretical literature and these recent findings provides the motivation for this research. This study examines the mechanics of competition in a dealer market setting as a means of addressing whether competitive price formation is achievable in modern financial markets.

The widely publicised and cited findings of Christie, Harris and Schultz (1994) and Christie and Schultz (1994) provide formative evidence of an apparent deviation from the underlying principles of competitive economic theory. In an examination of the NASDAQ market structure, these studies introduce evidence of non-competitive pricing among market makers contrary to previous suggestions that the NASDAQ market operates as a competitive market. The authors conclude that the divergence from competitive pricing is most likely the result of tacit collusion among dealers. These findings are additionally attested to by Barclay (1997) and Bessembinder (1998), who suggest that the larger than average spreads observed on NASDAQ cannot be explained by stock-specific characteristics, but rather by the more plausible argument of collusive behaviour.

Despite evidence of a pronounced deviation from competitive dealer pricing, a number of authors have vehemently disputed these claims. Both Wahal (1997) and Klock and McCormick (1999), examine the contention that the NASDAQ market operates as a competitive structure and present resolute evidence to contradict previously asserted claims. The authors document a pervasive movement in market makers and show that the net incremental effect of market maker entry is positively associated with improvements in market quality. This evidence is therefore, consistent with the competitive model of dealer pricing.

While there is confusion in the literature as to whether the NASDAQ market represents a competitive dealership, previous literature is also at odds to explain the possible sources of deviation from competitive pricing. For example, Huang and Stoll (1996) conclude that structural impediments – such as internalisation, preferencing of orders, and the presence of inter-dealer trading systems (which reduce incentives for brokers and dealers to act as advocates for investors seeking price improvement) – are

[2] Stigler (1957) outlines a number of additional conditions relating to the pursuit of a competitive outcome, including: that participants must operate independently of each other (not collusively); that the economics units must posses tolerable knowledge of market opportunities; and that they must be free to act on this knowledge.

primary contributors.[3] Shultz (2000) further argues that since dealers are not equal in terms of size, industry and geographical specialisation, potential deviations from atomistic pricing are more than likely in dealership structures. This point is echoed by Ellis, Michaely and O'Hara (2002), who show that despite minimal restrictions to the entry and exit of market makers, certain market makers are able to yield greater market power which is likely to result in a divergence from competitive price setting.

The conflicting findings in the literature, narrowly based on the NASDAQ market structure, shape the direction of this study. We also address issues including whether or not free market maker entry is conducive to competitive price formation, and if dealership structures more closely reflect specialist-like structures than models of standard competitive economic analysis.

In particular, this study empirically analyses the issue of market maker competition, specifically addressing three main issues in order to promote a better understanding of the effect of market maker dynamics. The issues initially centre on determining which factors are associated with maker entry and exit. Following this initial examination, the impact of dealer competition and marginal market maker entry (exit) impact is analysed with respect to quoted bid-ask spreads. Lastly, the types of affirmative market obligations, which are nestled with market maker entry (exit), are examined with respect to their effect on trading costs. The ASX options market is the subject of this examination.

The remainder of this paper is organised as follows. The second section discusses the institutional framework of the ASX options market. The third section describes the dataset and provides summary statistics of the sampled data. The fourth section outlines the research design, the fifth section presents the empirical results and discusses the primary findings. The sixth section presents several additional robustness tests and the final section provides a concluding summary.

Institutional Detail

The Australian Options Market (AOM) is a contemporary mixed market dealer structure. Like many international option exchanges, the AOM has undergone a significant transformation over time evolving from a floor-traded dealer market structure to a dealer structure superimposed on an electronic limit order book. The market is characterised by a competitive dealer price structure that operates with an open electronic limit order book. ASX options are traded on a screen-based system over a range of leading shares that are viewable to all market participants. These options are characterised by a standardised set of strike prices and expiry dates that occur on the Thursday before the last Friday of the settlement month.[4] Trades are

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[3] Additionally, whether deviation from the competitive outcome adversely affects the social welfare of market participants is also a contestable issue. Hansch, Naik and Viswanathan (1998) investigate the effect of preferencing and internalisation on spreads and dealer profits. The authors show that preferenced trades pay higher spreads than unpreferenced order flow. While this finding is indicative of the costs that result from violations to competition the authors do however, suggest that preferencing overall does not impair market quality. Other opinions expressed on this issue are provided by: Kandel and Marx (1997), Chung, Chuwonganant, McCormick (2004).

[4] The effect of excessive product differentiation through a range of expiries and moneyness levels has the ability to foster market power. Requirements by the AOM for market makers to undertake obligations in identical combinations of moneyness and expiry are designed to prevent possible market failures.

executed on a price then time priority basis, and quotes represent firm orders. In the financial year ending 30 June 2007, nearly 23 million options contracts traded on the ASX market.[5]

Market makers play a pivotal role in the AOM. Market makers 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. The obligations for market makers as at 8 February 2006, are tabulated in Table 1. These obligations are ascertained from the liquidity category that a security is designated to.[6] This process demonstrably contributes to the price discovery process by ensuring that option quotes are informative, binding and continuous throughout the trading day.[7] Although the exchange compensates market makers for providing liquidity, market makers are not granted any special trading privileges over other market participants.[8]

Table 1

Security Categories and Maximum Spread Obligations for Market Makers

	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

This table documents the maximum spread (the difference between the best bid and offer prices) that a dealer can quote when making a market for an option security. The size of the maximum spread depends on whether a stock belongs to Category 1 or 2. Category 1 securities represent the most actively traded option securities. As at 8 February 2006, there were 25 Category 1 option securities and 60 Category 2 securities.

Market makers in the AOM can operate in one of three capacities: making a market on a continuous basis only; making a market in response to quote requests only; or making a market both on a continuous basis and in response to quote

[5] This represents the equivalent of AUD 27 billion in turnover.

[6] The two categories are referred to as Category 1 and Category 2 in order of the most liquid group.

[7] Demsetz (1968) argues that the lack of 'predictable immediacy of exchange in financial markets' is a trading problem that can be mitigated by the regular presence of market makers (pg.30).

[8] This is distributed as a discount in trading fees. There is no public record of the monetary amounts paid to market makers for maintaining obligations. Additionally, there is no public record specifying which market makers have maintained these affirmative obligations.

requests.[9] Table 2 reports that there are on average 3 market makers for each of the 134 securities for which options were written on between 18 September 2000 and 29 September 2006. A dissection of these results reveals a heavy skew of market makers towards the more liquid securities group. The average number of daily market makers in Category 1 stocks is 8.5 as compared to an average of 1.8 market makers for Category 2 stocks. Furthermore the results show that market makers most prominently select to provide liquidity on a continuous basis where there is an average of 1.957 daily 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 for each security[10].

Table 2
Market Maker Designated Obligations

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	1	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*

The following table presents descriptive characteristics of the average number of market makers over 134 securities between 18 September 2000 and 29 September 2006. Market makers in the Australian Equity Options market operate in one of three capacities: to make a market on a continuous basis only; to make a market in response to quote requests only; or to make a market both on a continuous basis and in response to quote requests. Summary statistics relating to the segmentation of their obligations are detailed below.

However the presence of market makers is not the sole source of competition on the ASX Options market. Market makers may face direct competition for order flow from limit order traders. Despite this direct competition, however, market makers are the

[9] A detailed outline of market maker obligations in the AOM is available from http://www.asx.com.au/investor/options/trading_information/market_makers.htm

[10] A difference in means test between obligations across the different categories of stocks reveals that these results are statistically significant.

primary providers of liquidity, representing approximately 80-85 per cent of executed volume and a much greater percentage of overall quoting behaviour.[11]

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).[12] The data extends from 18 September 2000 to 29 September 2006 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.[13] Option trades are matched with prevailing and average underlying trade and quote data.

The derivation of option volatilities and hedging parameters are solved numerically via the Black-Sholes model (1973) at each trade price.[14] Estimates of delta are given by $\Delta = N(d_1)$ for call options and $\Delta = N(d_1) - 1$ for put options. Gamma risk is measured in the following way:

$$\Gamma = \frac{\partial^2 p}{\partial S^2} = \frac{n(d_1)}{S\sigma\sqrt{T-t}}$$

where: p is the price of a call (put) option; Γ represents the net change in delta over the dollar change in the underlying price.

A series of market maker assignments from the Australian Clearing House (ACH) is used to determine individual market maker movements from specified classes of options.[15] Table 3 reports a total of 2,845 market maker obligation changes over the sample period. Between Category 1 and Category 2 securities, a similar number of obligation changes are observed. However, while there are 27 securities in Category 1, there are 107 securities in Category 2 over the defined sample period.

The event change category reported in Panel C of Table 3, reflects the number of independent market maker event changes. In this category, multiple market maker increases and decreases, pertaining to a particular security on a particular event date, are classified as a single event. Furthermore, where there is an opposing event – where the entry of a market maker corresponds with the exit of a market maker on the

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[11] The AOM is primarily made up of institutional investors and therefore direct competition from smaller limit order traders is limited.

[12] The ITS is a modified version of the CLICK system developed by OMX Technology. This data is cross-verified with data provided by ASX CORE in order to mitigate potential errors.

[13] Most recent studies that examine bid-ask spreads in the microstructure literature focus on the effective rather than the quoted spread (see Christie, Harris and Schultz (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 is carried out on an electronic platform where the effective spread is equal to the quoted spread since traders cannot trade inside the quotes.

[14] To mitigate potential errors in this approach, implied volatilities are also calculated as the average of option series at-the-money strike, one strike above, and one strike below. This is based on option series with more than 20 days to expiration, and is consistent with the methodology of De Fontnouvelle et al. (2003). This analysis also uses indicative volatility estimates provided by the Australian Clearing House (ACH) and finds quantitatively similar results across all three measures.

[15] The Exchange advises market participants of market maker movements in AOM securities. This treatment is in accordance with ASX Market Procedure 22.3. These reports are available at http://www.asx.com.au/investor/options/notices/

same event date – the event is categorised as a *no-change* event. Under these criteria, Table 3 reports 1,631 independent market maker changes and 514 'no change' events.[16]

Table 3
Frequency Distribution of Market Maker Changes

	Change = 1	Change = -1	Change > 1	Change < - 1	No Change
Panel A – Category 1 Stock Options (n = 27 securities)					
Continuous	390	357	41	16	-
Quote	154	151	20	4	-
Both	96	118	2	12	-
Panel B – Category 2 Stock Options (n = 107 securities)					
Continuous	378	304	48	36	-
Quote	266	255	25	20	-
Both	43	98	2	9	-
Panel C – Net Changes					
Net Change in Market Makers	748	697	102	84	514

This table documents the frequency distribution of market maker changes in relation to 134 equity option securities between 18 September 2000 and 29 September 2006. Panels A and B contain descriptive statistics regarding the type of market maker entry and exit. Panel C tabulates the aggregate total of market maker changes across Category 1 and Category 2 securities. The *Net Changes* calculation in Panel C examines the net movement in market makers in particular securities. For a particular security on a particular event date, if a departing market maker is replaced by a new market maker, then it is classified as no change.

A series of standard filters were applied to the data. All records with time stamps outside the range 10:00 to 16:20 (EST), and the opening and closing trades of the day, are excluded.[17] Low Exercise Price Options (LEPOs), which are deep-in-the-money options and more accurately depict futures style contracts, are also deleted from the sample. In accordance with Anand (2005), trades and quotes that are more than four standard deviations away from the average trade price, or bid or ask quotes, for the particular option series per trading day are also excluded. The selection criteria results in a sample size of 4,693,469 observations.

Table 4 reports cross-sectional summary statistics of 134 option classes over a seven year window. Consistent with the findings of Benston and Hagerman (1974) and Stoll (1978), among others, Table 4 documents that the number of market makers per security is positively related to trade volume, volatility and market capitalisation. It is additionally negatively related to the bid-ask spread.

[16] Instances where market makers simply change obligations (without leaving a security) are very rare. They are not factored into the main analysis which only considers actual market maker movements.

[17] Market makers are required to maintain their obligations between 10:20-13:00 and 14:00-16:00 per trading day.

Table 4
Cross Sectional Summary Statistics

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*

Summary statistics are reported for 134 securities between 18 September 2000 and 20 December 2006. The statistics are segmented in quintiles, where quintile 1 represents securities, on average, with the lowest number of market makers, and quintile 5, the highest. *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 to the 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 is 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* is 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 makers as per their obligations.

Research Design

The design of appropriately structured methodologies relies exclusively on hypotheses that predict that the pervasive movement of market makers to and from securities is related to a range of profit, risk and market concentration considerations. The selection of variables for this analysis is guided by a number of standard competitive economic tenets, theoretical models of microstructure and extant empirical findings. The former two categories are largely bounded by modelling restrictions, whilst to date empirical findings are largely confounded by a range of contravening market frictions symptomatic of anti-competitive behaviour.

The contravening market frictions documented in previous empirical studies are largely averted in this study since the ASX forbids payment for order flow activity and trade internalisation procedures. Furthermore, strict compliance guidelines regarding market makers quote provision are enforced by the ASX. This study additionally differs from previous empirical studies since it considers not only the characteristics of the main market on which the security is traded, but also associated markets for which hedging characteristics are relevant.

The selection of relevant variables is both guided by perceived and actual profit, risk and market concentration considerations. Specifically, this analysis considers stock-specific characteristics that are likely to have formed part of a dealer's information set at the time of entry (exit). As a consequence, lagged variables that measure the spread, volume, volatility and the number of market makers of individual securities are included. Furthermore, assuming that a market maker's profit and risk considerations largely depend on the liquidity of the underlying market, (consistent with the hypothesis of Cho and Engle (1999)), hedging variables are included in the analysis.

Both the dependent and independent variables are computed as fixed time-series means over two-week intervals.[18] This leads to the following general specification:

$$E_{i,t} = f(X_{i,t-1})$$

where:

$$X_{i,t} = (Spread_{i,t}, USpread_{i,t}, IVOL_{i,t}, Delta_{i,t}, Gamma_{i,t}, Volume_{i,t}, MMakers_{i,t}),$$

$$i = 1,2...,n.$$

$E_{i,t}$ denotes the probability of dealer entry (exit) in stock i in period t; $Spread_{i,t}$ is the percentage quoted bid-ask spread[19]; $USpread_{i,t}$ is the underlying bid-ask spread; $IVOL_{i,t}$ is the implied volatility of an asset; $Delta_{i,t}$ is the option delta; $Gamma_{i,t}$ is

[18] The two-week timeframe is selected to ensure that the necessary parameters influencing a market maker's decision to enter and exit are captured. For robustness purposes, monthly fixed intervals are considered and the results are qualitatively similar. These results are available upon request.

[19] Percentage quoted bid-ask spreads are used in this analysis rather than absolute quoted bid-ask spreads since percentage spreads are better able to deal with price discreteness. Additionally, percentage spreads provide a more equivalent method of comparing trading costs across different series.

the option gamma; $Volume_{i,t}$ is the log of the average daily trading volume; $MMakers_{i,t}$ is the number of market makers, and is used to measure market concentration.

The model is estimated using both Poisson and logistic regressions. For these specifications, the dependent variable is set to equal one when entry (exit) is positive and zero otherwise. In both specifications, independent variables are lagged by a single period. To examine the possibility that market makers respond to different trade characteristics for particular classes of securities, separate regressions are estimated for Category 1 and 2 securities.

To examine if a dealer market which allows pervasive market maker movement and price competition will approximately reflect a competitive equilibrium, the concentration ratio of the market is examined on a discrete yearly basis.[20] A Herfindahl Index proxy measure is employed which examines the proportion of volume executed by active market makers. This measure is calculated as the sum of squares of the market share of each market making participant as indicated below:

$$Herfindahl_{i,t} = \sum_{n=1}^{N} S_{n,i,t}^2$$

where $S_{n,i,t}^2$ is the percentage of daily traded volume in security i traded by market maker n. A Herfindahl index score will range from $\frac{1}{\text{number of market makers}}$ to 1. This is the range between a perfectly competitive market and a single monopolistic market.

To examine the association between market maker entry (exit) and the impact on quoted bid-ask spreads, both 30-day and 60-day event windows are constructed around the entry (exit) of single market maker event changes. All overlapping event windows which result from multiple dealer entry (exit), from the time of the originating event, are excluded so as not to confound empirical findings. Finally, to control for other determinants of the bid-ask spread, a pooled regression analysis is undertaken with the following specification:

$$\begin{aligned}Spread = {} & a_0 + a_1 OptionPrice + a_2 \sum_{i=1}^{i=7} Tick + a_3 Daily\ Series\ Volume + a_4 UnderlyingSpread + \\ & a_5 MarketConcentration + a_6 Moneyness + a_7 TimeTo\ Expiry + a_8 Volatility + a_9 Delta + a_{10} Event\ Dummy\end{aligned}$$

where:

Spread is the bid-ask spread prevailing at each trade; *Option Price* is the option price; *Tick* are a set of dummy variables that indicate the maximum spread per price step, as specified in Table 1. For example, where the option price is less than 9.5 cents, the maximum allowable bid-ask spread is 5 basis points which rises to 6 basis points, where the option price increases to 19.5 cents.

Daily Series Volume is the daily trade volume summed across option series; *Underlying Spread* is the mean daily quoted underlying spread; *Market Concentration*

[20] The inclusion of a concentration index as an independent variable was first purported in the market microstructure literature by Tinic and West (1972).

is an index of the sum of the squares of the percentage market share of each market maker; *Moneyness* describes the intrinsic value of the option; *Time To Expiry* is the time to maturity of each trade; *Volatility* is the average implied standard deviation of trades across daily option series; *Delta* is the average hedge ratio of trades across daily option series; *Event Dummy* is a dummy variable assigned the value of one if the observation occurs after the entry (exit) of a market maker and zero otherwise. If an observed change in the bid-ask spread of an option security is related to the entry (exit) of a market maker, it is expected that the coefficient of the event dummy will be negative (positive) and significant.[21]

The previous specification implicitly assumes that the type of market maker obligations associated with market maker entry (exit) is irrelevant. Recent literature on the examination of affirmation obligations, however, suggests that the nature of market maker obligations may in fact affect market welfare (see Bessembinder, Hao and Lemmon 2007). In their survey, Charitou and Panayides (2009) document a plethora of obligations that are adopted by international security exchanges for assigned market makers.

Thus, to examine the effect of differing affirmative obligations associated with market maker entry (exit), separate regressions based on the type of obligation associated with market maker entry (exit) are performed. The following specification is described below:

$$\begin{aligned} &\mathit{Obligation\ Type} = a_0 + a_1 \mathit{Option\ Price} + a_2 \sum_{i=1}^{i=7} \mathit{Tick} + a_3 \mathit{Daily\ Series\ Volume} + a_4 \mathit{Underlying\ Spread} + \\ &a_5 \mathit{Market\ Concentration} + a_6 \mathit{Moneyness} + a_7 \mathit{Time\ To\ Expiry} + a_8 \mathit{Volatility} + a_9 \mathit{Delta} + a_{10} \mathit{Event\ Dummy} \end{aligned}$$

where:
Obligation Type represents one of three types of affirmative obligations: continuous, quote or mixed quote-continuous. The regressions are performed across security categories to examine whether particular obligations associated with market maker entry (exit) are affected by different trade characteristics. Excluded from this sample are events where multiple market maker movements are associated with differing market maker obligations. Results of the following specifications are discussed in the following section.

Empirical Results

Table 5 presents the results of the analysis described in the previous section. The results are based on both logistic and Poisson regression frameworks for which there are 6,600 entry and 6,501 exit combinations over a seven year sample period. The findings in Table 5 indicate that stock characteristics, based on executed trades,

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[21] An issue with empirical analyses characterised by large samples is a tendency to reject the null hypothesis at conventional significance levels, even when posterior odds favour the null hypothesis. This propensity is commonly referred to as Lindley's paradox. In order to avoid Lindley's paradox, the critical *t* values are adjusted for the large sample size according to the following formula:

$$t^* = \sqrt{[c^{\frac{2}{T}} T^{\frac{1}{T}} - 1](T - k)}$$

where t^* is the new critical t value; T and k denote the sample size and the number of regressors, respectively, in the model. According to Bayesian inference, a parameter is significantly different from zero when $t > t^*$. See Johnstone (2005) for the derivation and further discussion of this method.

significantly influence the market maker entry and exit decision. However, the direction and significance of these variables seemingly deviates, not only from the expectations outlined in the previous section, but also from prior theoretical and empirical analyses.

Table 5
Determinants of Market Maker Entry and Exit

	Market Maker Entry		**Market Maker Exit**	
	Logistic Regression	**Poisson Regression**	**Logistic Regression**	**Poisson Regression**
Intercept	-6.167*	-5.916*	-3.811*	-3.789*
	(0.602)	(0.572)	(0.685)	(0.646)
Spread	3.468*	3.150*	5.174*	4.642*
	(1.273)	(1.200)	(1.435)	(1.336)
USpread	6.00	5.611	12.808	11.373
	(7.428)	(7.079)	(8.154)	(7.644)
IVOL	1.158**	1.021**	0.817	0.685
	(0.505)	(0.471)	(0.619)	(0.577)
Delta	2.387*	2.181*	-0.414	-0.353
	(0.931)	(0.885)	(1.103)	(1.044)
Gamma	0.242***	0.217***	-0.1745	-0.152
	(0.133)	(0.125)	(0.151)	(0.141)
Volume	0.400*	0.363*	-0.330*	-0.286*
	(0.056)	(0.053)	(0.063)	(0.058)
MMakers	-0.057*	-0.051*	0.340*	0.299*
	(0.021)	(0.020)	(0.025)	(0.023)

This table presents the results of the logistic and Poisson regressions used to model the determinants of market maker entry and exit. The logistic and Poisson regression models are based on fixed two-week time-series intervals. Independent variables are lagged by a single period. *Spread* is the percentage quoted bid-ask spread; *USpread* is the underlying bid-ask spread; *IVOL* is the implied volatility of the asset; *Delta* is the option delta; *Gamma* is the option gamma; *Volume* is the log of the average daily trading volume; *MMakers* is the number of market makers. Standard errors are reported in parentheses. A single (double, triple) asterisk implies a 99% (95%, 90%) level of significance based on adjusted critical t-values.

Firstly, the results show that higher quoted bid-ask spreads are positively associated with both market maker entry and exit. While this finding appears counter-intuitive (since wider spreads are traditionally connoted with greater market maker income, which should lead to increased (decreased) market maker entry (exit)), it cannot be simply discounted as statistically erroneous. While market makers are attracted to the possibility of higher spreads, if higher spreads reflect higher market maker costs, then market makers may leave the market if they are bounded by exchange-mandated maximum spread rules.[22] This is particularly pertinent for

[22] The continuous spread rules may lead to an overall social welfare loss (transfer to informed traders) if market makers are forced to maintain two-sided quotes in an environment characterised by large information asymmetries.

Category 2 securities, which are characterised, on average, by higher levels of information asymmetry (Easley, Kiefer and O'Hara (1996) and Weston (2000)).[23]

To examine the rigidity of the conjecture from the previous paragraph, a comparison of determinants between Category 1 and 2 securities is required. If the reason that higher quoted spreads are correlated with market maker exit is due to higher adverse selection costs, which are exacerbated by exchange-mandated quoting obligations, then it is expected that this association will be significantly greater for Category 2 securities. According to the results in Table 6, quoted bid-ask spreads, for Category 2 securities, are on average, strongly associated with market maker exit. This relationship, for Category 1 securities, is only statistically significant at the 10 percent level. The nature of these findings lends support to the conjecture that if market makers are forced to maintain two-sided markets in environments characterised by higher levels of information asymmetry, then this may lead to market maker exit which may affect overall competition.

In relation to market maker entry, the results in Table 5 emphasise that higher levels of volatility, option delta costs and levels of trading activity are positively associated with market maker entry. The positive coefficient pertaining to the level of trading activity is largely intuitive and consistent with competitive expectations. Similarly, with implied volatility and option delta variables, the positive and significant coefficients associated suggest that they are important determinants of market maker entry. This latter result, however, contradicts competitive expectations as well as extant empirical evidence (Wahal 1997).

This previous evidence argues that an increase in volatility will increase the risk of carrying inventory and as such deter market maker entry. While this finding is suited to equities-based research, the nature of this finding may be of limited applicability to the options market, since in a more volatile pricing environment, hedging and other risk management techniques become more relevant and profitable for market makers.[24] Thus the nature of this finding is likely to vary from previous microstructure results. Results in Table 6 suggest only limited support for this hypothesis. On average, the coefficient associated with volatility is positive and significant for Category 2 securities, yet insignificant for Category 1 securities. Finally, the results in Tables 5 and 6 also indicate that for both Category 1 and 2 securities, stocks with fewer dealers have a higher probability of market maker entry.

The decision of a market maker to leave a particular security is also analysed with respect to a range of stock and option characteristics. Table 5 indicates that the decision of a market maker to exit a security is significantly associated with the bid-ask spread, trading volume, and number of existing market makers. Table 6 provides corroborative evidence of this pattern across Category 1 and 2 securities.[25] Overall, the decision of a market maker to enter (exit) from the quote provision process is guided by rational and competitive, profit, risk and market concentration characteristics as predicted in the previous section.

[23] This argument supposes that market makers may not always be able to hedge the risk associated with increased levels of information asymmetry. This type of risk is inherently greater for smaller and less liquid securities that dominate the sample of securities examined.

[24] In an environment characterised by higher volatility, hedging and other risk management techniques become more relevant and importantly can be profitable if strategies have been designed with a long gamma and kappa or vega risk stance.

[25] Table 6 additionally finds weak evidence of a relationship between higher levels of implied volatility and market maker withdrawal from Category 2 securities.

Table 6
Determinants of Market Maker Entry and Exit for Category 1 and 2 Securities

	Market Maker Entry		Market Maker Exit	
	Category 1	**Category 2**	**Category 1**	**Category 2**
Intercept	-4.409*	-6.440*	-3.359*	-4.277*
	(1.003)	(0.779)	(1.109)	(0.896)
Spread	2.227	3.351*	5.444***	5.447*
	(2.465)	(1.556)	(2.979)	(1.786)
USpread	5.615	8.882	24.000***	6.342
	(12.16)	(9.266)	(13.452)	(10.600)
IVOL	-0.186	2.333*	-0171	1.703***
	(0.744)	(0.692)	(0.854)	(0.906)
Delta	1.597	2.630**	-1.511	0.022
	(1.547)	(1.191)	(1.764)	(1.442)
Gamma	0.231	0.059	0.017	-0.518**
	(0.206)	(0.181)	(0.221)	(0.220)
Volume	0.361*	0.335*	-0.289*	-0.347*
	(0.085)	(0.079)	(0.096)	(0.088)
MMakers	-0.114*	-0.077**	0.313*	0.415*
	(0.030)	(0.035)	(0.036)	(0.043)

This table presents results of a logistic regression analysis used to examine the determinants of market maker entry and exit for Category 1 and 2 securities. The logistic regression model is based on fixed two-week time-series intervals. Independent variables are lagged by a single period. *Spread* is the percentage quoted bid-ask spread; *USpread* is the underlying bid-ask spread; *IVOL* is the implied volatility of an asset; *Delta* is the option delta; *Gamma* is the option gamma; *Volume* is the log of the average daily trading volume; *MMakers* is the number of market makers. Standard errors are reported in parentheses. A single (double, triple) asterisk implies a 99% (95%, 90%) level of significance based on adjusted critical t-values.

Table 7 presents results of the analysis related to market concentration. According to the examination, which involves analysing the average Herfindahl concentration ratio of securities in Category 1 and 2 security groups, a wide disparity in the nature of competition exists between liquid and less liquid securities. The results show that Category 1 securities are less concentrated than Category 2 securities, with an average Herfindahl index score of 0.172 for Category 1 securities and 0.447 for Category 2 securities.

The average concentration ratio of a perfectly competitive market, in which (in theory), each market maker receives an equally distributed proportion of the order flow, is also reported. The reporting of this statistic provides a direct comparison of the degree of market concentration for ASX option securities. Relative to the average concentration ratio of a perfectly competitive market, the results documented enforce the view that low volume securities (Category 2) are more concentrated than high volume securities (Category 1). This result is consistent with Ellis, Michaely and O'Hara's (2002) analysis of the NASDAQ market.

Table 7
Herfindahl Index Ratios

	Category 1		Category 2	
Year	**Herfindahl Index**	**1 / number of market makers**	**Herfindahl Index**	**1 / number of market makers**
2000	0.16203	0.1275	0.36871	0.18574
2001	0.14208	0.11575	0.41902	0.17947
2002	0.15752	0.10692	0.42859	0.22663
2003	0.17334	0.09804	0.45854	0.22407
2004	0.17687	0.09615	0.49909	0.22341
2005	0.18255	0.10132	0.48586	0.22248
2006	0.21401	0.12018	0.47168	0.23811

This table documents Herfindahl index scores for Category 1 and Category 2 securities across discrete time intervals. The Herfindahl index measure is calculated as the sum of squares of the market share of each dealer as indicated below:

$$Herfindahl_{i,t} = \sum_{n=1}^{N} S_{n,i,t}^{2}$$

where $S_{n,i,t}^{2}$ is the percentage of daily traded volume in security *i* traded by market maker *n*.
1/ (number of market makers) is a comparative ratio of a situation where market makers equally share trade volume and thus is the benchmark for a competitive market.

The results in this study, however, show that low liquidity securities yield a greater degree of market power despite relatively free market maker entry and the emphasis of price competition between market makers. Therefore, while free market maker entry is viewed as a central requisite of competitive price formation, a positive association in this analysis also encompasses the level of overall liquidity.

Table 7 additionally highlights that the average Herfindahl index ratio is up-trending for both Category 1 and Category 2 securities. This result indicates that the proportion of business taken by leading market makers has increased over time. Although this may stem from a range of factors, the most likely reason for this up-trend is that incumbent market makers accrue a greater degree of market power and are therefore able to offer superior quotes. This market power may be the result of incumbent market marker experience which is exhibited in terms of superior market timing or greater industry specialisation.[26] As such, new competitors may be limited in their ability to attract a similar degree of order flow.[27] The veracity of this statement, however, warrants further research.

[26] Schultz (2000) argues that the fact that not all dealers are created equal in terms of capitalisation and industry specialisation may lead to divergences from a competitive outcome. The ASX strictly forbids order preferencing or trade internalisation so that this disparity in market power is most likely due to the factors outlined above.

[27] The average Herfindahl index ratio may also increase if there is a decrease in the number of market makers. This reasoning, however, is seemingly implausible given the steady increase in market makers over time.

The previous set of results indicates that the market structure of AOM securities diverges between a competitive (Category 1) and less than competitive (Category 2) state. To examine whether the nature of this state has implications for the entry (exit) of market makers, an event-study regression analysis focusing on the impact on quoted bid-ask spreads, is performed on Category 1 and 2 securities. Pooled 30-day and 60-day event estimates are presented in Table 8. The explanatory power of the regression models ranges between 25.95 percent and 36.76 percent. The F-statistics indicate that the hypothesis that the estimated coefficients are jointly equal to zero can be rejected at the 0.01 level.[28] The standard errors of the estimated coefficients are corrected for heteroskedasticity using White's (1980) method.

The results show that market maker entry (exit), pertaining specifically to Category 1 securities, is on average associated with a significant decline (increase) in quoted bid-ask spreads. This result is robust for 30-day and 60-day event windows. The marginal economic impact associated with market entry (exit), is an average decline (increase) in quoted spreads of 3.02 percent (4.42 percent). In relation to Category 2 securities, results show that market maker entry (exit) has a statistically insignificant impact on quoted bid-ask spreads. While these results contradict findings pertaining to Category 1 securities, they are nevertheless consistent with expectations that greater market power in less-liquid securities adversely affects the competitive price formation process.

The results in Table 7 regarding Category 2 securities suggests that if market makers enjoy disparate market power, then the ability of new market makers to compete for order flow may be significantly compromised. On no condition, however, does this finding suggest that by improving the degree of competitiveness then trading costs will decrease. The results of this conjecture are tested and additionally presented in Table 8. According to these results, a significant (insignificant) association between the degree of market concentration and quoted bid-ask spreads is documented for Category 1 (2) securities. The implication of this finding for Category 1 securities is that bid-ask spreads are wider (narrower) under more (less) concentrated market structures. However, for Category 2 securities, irrespective of the level of market concentration, the impact on bid-ask spreads is insignificant.

The findings in Table 8 *inter alia,* assume that obligations attached with market maker entry (exit) have a negligible impact on the price formation process. To examine this proposition further, three separate regressions are performed, based on a selection of obligations associated with market maker entry (exit). Table 9 presents the results of these regressions based on a 30-day event sample for Category 1 and 2 securities.

Focusing on affirmative market maker obligations that are dually associated with market maker entry and exit, the results in Table 9 indicate that in Category 1

[28] Conditional Index (CI) values furthermore indicate that multicollinearity is not a major issue in the regression model framework.

Table 8

Market Maker Entry (Exit) and the Bid-Ask Spread

	Market Maker Entry				Market Maker Exit			
	30 Day		60 Day		30 Day		60 Day	
	Category 1	Category 2	Category 1	Category 2	Category 1	Category 2	Category 1	Category 2
Intercept	0.138*	0.299*	0.142*	0.287*	0.092*	0.128*	0.097*	0.145*
Option Price	0.018*	0.005*	0.019*	0.006*	0.015*	0.020*	0.011*	0.023*
Tick Dummy (1)	-0.044*	-0.172*	-0.040*	-0.163*	-0.038*	-0.058*	-0.052*	-0.070*
Tick Dummy (2)	-0.040*	-0.163*	-0.035*	-0.152*	-0.034*	-0.051*	-0.047*	-0.061*
Tick Dummy (3)	-0.036*	-0.154*	-0.032*	-0.143*	-0.032*	-0.045*	-0.042*	-0.057*
Tick Dummy (4)	-0.032*	-0.139*	-0.027*	-0.128*	-0.028*	0.039*	-0.039*	-0.051*
Tick Dummy (5)	-0.024*	-0.114*	-0.018*	-0.106*	-0.021*	-0.026*	-0.030*	-0.039*
Tick Dummy (6)	-0.011*	-0.078*	-0.006*	-0.068*	-0.009*	-0.009*	-0.017*	-0.021*
Tick Dummy (7)	-0.003*	-0.046*	0.003*	-0.026*	-0.002*	-0.002*	-0.008*	-0.009
Daily Series Volume (‘000)	-0.003*	2.06*	-0.005*	0.003**	-0.003*	1.04*	-0.003*	0.001
Underlying Spread	0.268*	0.423*	0.283*	0.414*	0.311*	0.470*	0.294*	0.537*
Market Concentration	0.004*	0.001	0.008*	0.003	0.015*	0.001	0.007*	-0.002
Moneyness	-0.106*	-0.127*	-0.122*	-0.140*	-0.064*	-0.072*	-0.055*	-0.080*
Time to Expiry	0.022*	0.005*	0.024*	-0.002	0.019*	0.012*	0.021*	0.009*
Volatility	0.014*	0.042*	0.017*	0.050*	0.012*	0.018*	0.015*	0.12*
Delta	0.022*	-0.020*	0.037*	0.006	0.016*	9.35*	0.020*	0.007
Event Dummy	-0.001*	-0.001	-0.001*	3.27*	0.001*	3.72*	0.001*	0.001
F-Value	12292.6	2166.82	11245.5	2783.03	8471.44	1165.99	10229.9	1664.36
Adj. *R*-squared	0.3378	0.3676	0.3116	0.3289	0.2595	0.2855	0.2605	0.2832
Critical t-value								
-1%	4.695	4.492	4.699	4.539	4.696	4.465	4.715	4.506
-5%	4.330	4.108	4.334	4.160	4.331	4.078	4.351	4.123
-10%	4.179	3.949	4.183	4.002	4.180	3.918	4.201	3.965

This table presents estimates from regressing quoted bid-ask spreads, of Category 1 and 2 option securities, on independent market maker entry (exit) event changes between 18 September 2000 and 20 December 2006. The estimates are based on 30 and 60-day event windows and are corrected for heteroskedasticity using White’s (1980) method. Independent control variables include *Option Price*, *Daily Series Volume, Underlying Spread*, *Market Concentration*, *Moneyness*, *Time to Expiry*, *Volatility* and *Delta*. *Underlying Spread* is the mean daily quoted underlying spread; *Market Concentration* is the sum of squares of the percentage market share of each market maker; *Monyeness* describes the intrinsic value of the option; *Time to Expiry* is the time to maturity of each trade; *Volatility* is the average implied standard deviation of trades across daily option series; *Delta* is the average hedge ratio of trades across daily option series. Event Dummy is a dummy variable assigned the value of one if the observation occurs after the entry (exit) of a market maker and zero otherwise.A single (double, triple) asterisk implies a 99% (95%, 90%) level of significance based on adjusted critical t-values.

Table 9
Affirmative Obligations associated with Market Maker Entry (Exit) and the Bid-Ask Spread

	Market Maker Entry						Market Maker Exit					
	Category 1			Category 2			Category 1			Category 2		
	Both	Quote	Continuous	Both	Quote	Continuous	Both	Quote	Continuous	Both	Quote	Continuous
Intercept	0.091*	0.167*	0.142*	0.010	0.368*	0.248*	0.070*	0.095*	0.190*	-0.066*	0.203*	0.082*
Option Price	0.013*	0.021*	0.016*	0.016*	0.023*	0.012*	0.026*	0.014*	0.017*	0.023*	0.006*	0.034*
Tick Dummy (1)	-0.019*	-0.040*	-0.055*	-0.015	-0.195*	-0.147*	-0.006*	-0.038*	-0.072*	-0.069*	-0.116*	-0.025*
Tick Dummy (2)	-0.018*	-0.035*	-0.050*	-0.015	-0.182*	-0.137*	-0.004*	-0.034*	-0.066*	-0.074*	-0.104*	-0.021*
Tick Dummy (3)	-0.016*	-0.032*	-0.046*	-0.013	-0.170*	-0.130*	-0.003*	-0.031*	-0.060*	-0.077*	-0.096*	-0.017*
Tick Dummy (4)	-0.013*	-0.028*	-0.040*	-0.016	-0.151*	-0.119*	-0.003*	-0.028*	-0.053*	-0.084*	-0.085*	-0.014**
Tick Dummy (5)	-0.005*	-0.020*	-0.031*	-0.026	-0.124*	-0.100*	0.004	-0.022*	-0.039*	-0.096*	-0.061*	-0.009***
Tick Dummy (6)	0.009*	-0.003**	-0.021*	0.004	-0.090*	-0.067*	0.013	-0.011*	-0.022*	-0.085*	-0.041*	0.002
Tick Dummy (7)	0.019*	0.001	-0.009*	-0.004	-0.055*	-0.039*	0.017	-0.005*	-0.003*	-0.054*	-0.028*	0.010
Daily Series Volume ('000)	-0.002*	-0.006*	-0.002*	-0.005*	-0.005*	4.62*	-0.001*	-0.003*	0.003*	0.001	-0.002	0.000
Underlying Spread	0.233*	0.240*	0.237*	0.125*	0.397*	0.395*	0.198*	0.307*	0.229*	0.134	0.426*	0.473*
Market Concentration	0.007*	0.009*	0.003**	0.003	-0.009*	-0.002	0.008*	0.012*	0.006*	-0.002	0.002	-0.003**
Moneyness	-0.063*	-0.152*	-0.094*	-0.012	-0.163*	-0.106*	-0.064*	-0.063*	-0.132*	-0.015	-0.078*	-0.065*
Time to Expiry	0.030*	0.014*	0.023*	0.014*	0.012*	4.65*	0.033*	0.016*	0.014*	0.029*	0.007*	0.014*
Volatility	0.020*	0.028*	0.010*	0.012*	0.051*	0.038*	0.023*	0.013*	0.050*	0.024*	0.038*	0.020*
Delta	0.002	0.040*	0.017*	2.87*	0.045*	-0.002	0.022*	0.008*	0.003	0.027*	-0.038	0.014*
Event Dummy	-0.001*	-0.002*	1.49*	4.58*	4.45*	-0.001	8.05***	0.002*	3.20*	0.001	-7.34*	0.001

This table shows estimates from regressing quoted bid-ask spreads,of Category 1 and 2 option securities on independent market maker entry (exit) event changes associated with three types of affirmative obligations. These obligations include *Continuous*, *Quote* and *Both* (mixed continuous/quoted) based on rules between 18 September 2000 and 20 December 2006. The estimates are based on a 30-day event window and are corrected for heteroskedasticity using White's (1980) method. Independent control variables include *Option Price*, *Daily Series Volume, Underlying Spread*, *Market Concentration*, *Moneyness*, *Time to Expiry*, *Volatility* and *Delta*. Event Dummy is a dummy variable assigned the value of one if the observation occurs after the entry (exit) of a market maker and zero otherwise. A single (double, triple) asterisk implies a 99% (95%, 90%) level of significance based on adjusted critical t-values.

securities, both quote and mixed quote-continuous based obligations are significantly associated with narrower bid-ask spreads. This finding, however, does not extend to continuous-based obligations attached to market maker entry and exit. Regarding Category 2 securities, results indicate that the extent of obligations associated with market maker entry and exit are insignificant.

The implications of these findings are significant since they suggest that the type of obligation associated with market maker entry (exit) affects quoted spreads. While these findings do not necessarily suggest that quoted and mixed-based obligations dominate continuous-based obligations, they indicate that the marginal benefit of quote and mixed-based obligations is significant for quoted bid-ask spreads of Category 1 securities.[29]

The results documented in Tables 8 and 9 additionally provide pertinent evidence regarding the determinants of spreads in options markets. Consistent with previous empirical findings (including Neal (1987) and Mayhew (2002)), price, volatility and time-to-expiry are significant determinants of option bid-ask spreads. Interestingly however, while volume is expected to vary inversely with quoted spreads, the significance of this relationship is attributable to securities in Category 1. A similar finding is also reported in terms of market concentration. In relation to the underlying spread and the option delta variables, which are designed to capture the costs of hedging on quoted spreads, the reported results are additionally inconclusive. Specifically, the results related to Category 1 securities provide evidence that higher hedging costs increase option spreads concurring with the "derivative hedge theory" proposed by Cho and Engle (1999). There is however, only limited evidence to support this theory for Category 2 securities.

Robustness Tests

A number of additional robustness tests are performed in this section to validate findings documented in the previous section. For space considerations, these results are not reported but are available upon request from the authors. Firstly, to examine the robustness of trade characteristics, used to explain the market maker entry and exit decision, the sampling procedure is altered so that trade characteristics are defined over a monthly rather than fortnightly period. In addition to the sampling changes, a specification change is also imposed so that the decision between entry, exit and no change (neither entry nor exit) is analysed on an ordinal rather than binomial scale. This is consistent with the methodology of Wahal (1997). As such, an ordered regression analysis is used. This model encompasses a random utility framework

[29] It cannot be said that quote and mixed-based obligations dominate continuous obligations since the type of entry (exit) may be dependent on the overall mix of prevailing obligations. Since continuous market makers dominate the existing pool of dealers, as documented in Table 2, the addition of an extra market maker with continuous obligations may be less relevant than a market maker with quote-based obligations.

which assumes that the utility of an alternative decision is a function of a set of attributes plus a random variable. The structural model is described as follows:

$$y_i = x_i'\beta + u_i \quad \text{where } i = 1,......, n;$$

where a latent variable y^*, ranging from $-\infty$ to ∞, is defined by an observed y according to the following underlying latent model:

$$y_i = m \text{ if } \tau_{m-1} \leq y_i^* < \tau_m \text{ for } m = 1 \text{ to } J$$

where τ_m represents a range of cut-points. Accordingly, the ordered response model is categorised as follows: y_i = -1 for a decrease in market makers relative to the previous period, y_i = 0 for no change in market makers relative to the previous period, and y_i = 1 for an increase in market makers relative to the previous period. Estimation is performed via maximum-likelihood procedures. On average, the results reveal that, based on stock characteristics from the previous month, increases in delta hedging costs and volume are associated with an increase in market maker entry across all option securities. Furthermore, securities with a lower number of market makers also have a higher probability of market entry.

It is furthermore documented in the previous section that market maker entry (exit), for Category 1 securities leads to a significant marginal decline (increase) in quoted bid-ask spreads. To reduce the effects of intra-day patterns, an examination of this issue is undertaken by averaging all trades for a given security and trade series on a given day. Results indicate that consistent with findings in the previous section, market maker entry (exit) is on average negatively (positively) associated with quoted bid-ask spreads for Category 1 securities. The relationship is however, insignificant for Category 2 securities. This result is additionally robust in both 30-day and 60-day event samples.

To address a methodological issue related to the exiguously non-normal (rightly skewed) distribution of quoted bid-ask spreads, a non-parametric generalised linear regression model (GLM) with a Poisson distribution is used to affirm the quantitative trends presented in the fifth section. To additionally ensure that the results are not driven by any market anomalies (and so that only the most active option series are considered), the sampling procedure is also altered so that both longer term and near-expiration options are excluded. Options that expire within the next 90 days, but not within the next 7 calendar days are included which is consistent with the procedure of De Fontnouvelle, Fishe & Harris (2003) who argue that trades in the near term are likely to be motivated to avoid delivering stock on in-the-money options. The GLM regression uses a Poisson distributional assumption which more robustly approximates the marginally right skewed distribution of the quoted spreads dependent variable. The direction and significance of the coefficient estimates from this regression procedure are qualitatively consistent with the primary findings in the previous section.

Conclusion

Standard economic theory proposes a direct association between market maker competition and financial market quality. The extent of the association between competition for order-flow and market quality is additionally recognised by market regulators who seek to mitigate market frictions and impediments to competition as well as market participants who are concerned with the level of trading costs and price discovery. In light of scant empirical evidence regarding the dynamics of market making in financial dealer markets, this study is based on the ASX options dealer market and provides evidence of a positive link between endogenous market maker movement and the level of trading costs. Significant insight is also shed with respect to the vexed issue of what impact affirmative market maker obligations have on market welfare.

The results derived in this paper argue that market maker entry (exit) in financial dealer markets depends on a broad range of profit, risk and market concentration characteristics. Specifically, these factors relate to trading characteristics of the main and underlying market. However, while pervasive market maker movement is commonly observed in financial dealer markets, recent empirical evidence suggests that this factor alone does not necessarily lead to competitive price formation. This paper examines a trading structure absent of market frictions and provides evidence that *free* market maker movement does not explicitly result in a competitive market structure.

This study finds that the degree of market concentration additionally affects the marginal impact of market maker entry (exit). Results pertaining to the transaction cost analysis indicate that market maker entry (exit) leads to a significant reduction (increase) in quoted bid-ask spreads for Category 1 securities, but not Category 2 securities. In addition to this evidence, results in this study also highlight that the degree of market concentration is not significantly associated with the level of trading costs for illiquid securities. The implication of this finding is pertinent to market regulators since market maker competition may not necessarily contribute to enhancing market quality for less liquid securities.

References

Anand, A. 2005 'Specialist: The Firm or the Individual? Empirical Evidence from the Options Markets', *Journal of Economics and Business,* vol.57, pp.555-575.

Barclay, M. J. 1997 'Bid-ask spreads and the avoidance of odd-eighth quotes on Nasdaq: An examination of exchange listings', *Journal of Financial Economics,* vol.45, pp.35-60.

Benston, G. J. & Hagerman R. L. 1974 'Determinants of Bid-Ask Spreads in the Over-the-Counter Market', *Journal of Financial Economics,* vol.1, pp.353-364.

Bessembinder, H, Hao, J and Lemmon, M., Why Designate Market Makers? Affirmative Obligations and Market Quality (June 2011). Available at SSRN: http://ssrn.com/abstract=989061 or http://dx.doi.org/10.2139/ssrn.989061

Black, F and M. Scholes (1973). 'The Pricing of Options and Corporate Liabilities'. *Journal of Political Economy* 81 (3): 637–654

Charitou, A. & Panayides, M. 2009 'Market Making in International Capital Markets: Challenges and Benefits of Its Implementation in Emerging Markets', *International Journal of Managerial Finance,* vol. 5, no.1, pp.50-80.

Cho, Y.-H. & Engle, R. F. 1999 'Modeling the Impacts of Market Activity on Bid-Ask Spreads in the Option Market', *NBER Working Paper*, pp.1-46.

Christie, W. G., Harris, J. H. & Schultz, P. H. 1994 'Why did NASDAQ Market Makers Stop Avoiding Odd Eighth Quotes?', *The Journal of Finance,* vol.49, pp.1841-1860.

Christie, W. G. & Schultz, P.1994 'Why do NASDAQ Market Makers Avoid Odd-Eighth Quotes?', *The Journal of Finance,* vol.49, pp.1813-1840.

Chung, K. H., Chuwonganant, C. & McCormick, D. T. 2004 'Order preferencing and market quality on NASDAQ before and after decimalization', *Journal of Financial Economics,* vol.71, pp.581-612.

De Fontnouvelle, P., Fishe, R. P. H. & Harris, J. H. 2003 'The Behaviour of Bid-Ask Spreads and Volume in Options Market during the Competition for Listings in 1999', *Journal of Finance,* vol.58, pp.2437-2463.

Demsetz, H. 1968 'The Cost of Transacting', *Quarterly Journal of Economics*, vol. 82(1), pp.33-53.

Easley, D., Kiefer, N. & O'Hara, M. 1996 'Cream-Skimming or Profit Sharing? The Curious Role of Purchased Order Flow', *Journal of Finance*, vol.51, pp.811-833.

Ellis, K., Michaely, R. & O'Hara, M. 2002 'The Making of a Dealer Market: From Entry to Equilibrium in the Trading of NASDAQ Stocks', *The Journal of Finance,* vol.57, pp.2289-2316.

Hansch, O., Naik, N. Y. & Viswanathan, S. 1998 'Do Inventories Matter in Dealership Markets? Evidence from the London Stock Exchange', *The Journal of Finance,* vol.53, pp.1623-1656.

Huang, R. D. & Stoll, H. R. 1996 'Dealer versus auction markets: A paired comparison of execution costs on NASDAQ and the NYSE', *Journal of Financial Economics,* vol.41, pp.313-357.

Johnstone, D. 2005 'Significance levels and large samples in finance: Correction of Connolly (1989)', pp.1-46, *Working Paper*, University of Sydney.

Kandel, E. & Marx, L. 1997 'NASDAQ Market Structure and Spread Patterns', *Journal of Financial Economics*, vol.45, July, pp.61-89.

Klock, M & McCormick, D T, 1999. ’The Impact of Market Maker Competition on NASDAQ Spreads’, *The Financial Review*, Eastern Finance Association, vol. 34(4), pages 55-73, November.

Mayhew, S. 2002 ‘Competition, Market Structure, and Bid-Ask Spreads in Stock Option Markets’, *The Journal of Finance,* vol.57, pp.931-958.

Neal, R. 1987 ‘Potential Competition and Actual Competition In Equity Options’, *The Journal of Finance,* vol.42, pp.511-531.

Schultz, P. 2000 ‘Regulatory and Legal Pressure and the Costs of NASDAQ Trading, *Review of Financial Studies*, vol.13, pp.917-958.

Stigler, G. J. 1957 ‘Perfect Competition, Historically Contemplated’, *The Journal of Political Economy,* vol.65, pp.1-17.

Stoll, H. R. 1978 ‘The Pricing of Security Dealer Services: An Empirical Study of NASDAQ Stocks’, *The Journal of Finance,* vol.33, pp.1153-1172.

Tinic, S. M. & West, R. R. 1972 ‘Competition and the Pricing of Dealer Service in the Over-the-Counter Stock Market,’ *Journal of Financial and Quantitative Analysis*, vol.7, pp.1707-1727.

Viswanathan, S. & Wang, J. J. D. 2002 ‘Market Architecture: Limit-Order Books versus Dealership Markets’, *Journal of Financial Markets,* vol.5, pp.122-167.

Wahal, S. 1997 ‘Entry, Exit, Market Makers, and the Bid-Ask Spread’, *The Review of Financial Studies,* vol.10, pp.871-901.

Weston, J. 2000 ‘Competition on the NASDAQ and the impact of recent market reforms’, *Journal of Finance,* vol.55, pp.2565-2598.

White, H. 1980, ‘A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity’, *Econometrica* 48 (4): 817–838