The Trading Behaviour of Australian Treasury Bond Futures Overnight Options and the Impact of Their Introduction

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ABSTRACT

The introduction of overnight options at the Sydney Futures Exchange (SFE) offers a unique opportunity to study trading behavior with a different market microstructure, namely the SFE overnight market. This study first examines trading patterns on 3-Year & 10-Year TBond Futures overnight options. Unlike a normal U-Shaped pattern, it is found that the bid-ask spreads for overnight options are relatively flat during the first half of the trading night, before fluctuating through the second half of the night. One explanation would be the special nature of the overnight options: it was designed to hedge against USA market risk. Quoted bid-ask spreads appear to be explained by the transaction price, trading volume and return volatility. Over time, the quoted bid-ask spread narrowed for most observations, while trading volume and trading frequency became larger. Next the impacts on the 3-Year TBond Futures and its day options when overnight options are introduced are examined. Results indicate that the quality of the underlying 3&10-Year TBond futures has been improved by the introduction of short dated options as the bid-ask spread and the variance of the pricing error both decrease, while there was an increase in trading volume and trading frequency. Results for the day options were mixed, indicating that trading in these instruments was not unambiguously improved.

INTRODUCTION

Research into the trading and pricing behavior of options has been a popular topic for researchers. Previous work has focused on standard options primarily traded on large markets with available data in the USA and UK. Conclusions indicated that time, volatility and maturity effects make it difficult for market participants to conduct price discovery in the face of new information. In particular, studies about the impact of stock options listings on their underlying securities risk and return patterns suggest that options listings have a beneficial impact on the quality of the market for the underlying securities in terms of higher liquidity, lower information asymmetry, and greater pricing efficiency. A relatively new strand of research considers these results in light of differing microstructure aspects.

In line with the emerging research area, the introduction of overnight options at the Sydney Futures Exchange (SFE) offers a unique opportunity to study trading behavior with a different market microstructure, namely the SFE overnight market. Trading in the major contracts (i.e. 3-Year & 10-Year TBond Futures Overnight Options) at the SFE has been among the most liquid in the world in contrast to the relatively newer and illiquid overnight trading in Europe and the USA, and the Australian 3-Year TBond Futures contract is ranked amongst the 10 most traded interest rate futures products in the world (www.sfe.com.au). SFE's Australian 3-Year & 10-Year TBond Futures and Options are the benchmark derivative products for the trading and hedging of medium Australian fixed interest securities and interest rate swaps. Overnight options listed on the 3-Year & 10-Year TBond futures provides market users with a flexible and cost effective means of managing short term exposure. Overnight options also give traders and professional option market makers an additional tool with which to gain leveraged market exposure. Overnight options listed on 10-Year TBond Futures contracts have been actively traded for several years because they have greater tick value than the 3-Year contracts, thus investors may use fewer 10-Year contracts to hedge the same number of underlying positions. However, recently investors have shifted trading from 10-Year contracts to 3-Year contracts mainly because the options on underlying 3-Year TBond Futures contracts are more liquid, the advent of day trading for 3-Year's Futures options and the increase in interest in the physical 3-Year TBond. It appears that derivative traders favor trading products with high liquidity in underlying markets.

Overnight options on 3-Year & 10-Year TBond Futures started to trade at the SFE on November 15, 1993. The trading hours are from 5:10pm to 7:00am Australian winter time and 5:10pm to 7:30am Australian summer time. The contract unit has one Australian $100,000 face value, 6% coupon, 3-Year & 10-Year TBond Futures contract for a specified contract month on the SFE. The overnight puts and calls are available on futures contracts for the nearest quarter month ahead. They are quoted in yield percent per annum in multiples of 0.005 per cent (See Appendices 1 & 2 for the contract specifications). The exercise prices are set at intervals of 0.01 percent per annum yield. Nine option exercise prices are available for trading with additional strike prices listed at the discretion of the SYCOM[2] manager or the chief executive of the SFE. The overnight options expire at the cessation of each SYCOM session. All options, which are in-the-money are automatically exercised on the business day immediately following the SYCOM session. Exercise of an option results in the holder receiving a futures position at the option strike price. The settlement price is the weighted average of trade prices executed in the underlying contract between 8:30am and 8:40am on the business day immediately following the SYCOM session.

Overnight options (One-session options) are European style options that are only valid for the duration of the SYCOM session in which they are traded. There are no margin requirements for trading overnight options, but if the overnight options are exercised the holder of the options will have a position in their underlying futures contracts, and normal margin requirements will apply. Since these options low cost products, they provide investors and traders with additional flexibility in the bond market. They also can be used to manage short term exposure (i.e. overnight exposure), hedge positions from event risk (i.e. investors often take their position before the USA markets open particularly for those days with Economic Announcements), profit by anticipating short term price movements in the bond market, take a position on events and place the equivalent of a stop loss order in place. Thus, a comprehensive analysis of the overnight options will give investors a good understanding of how to best execute trading in this market.

[2] SYCOM (Sydney Computerized Market) is the world first after-hours electronic trading system. It was introduced in November 1989. Its aim was to provide an opportunity to trade SFE products during the key time zones of European and North American Markets (www.sfe.com.au).

This study first examines trading patterns on 3&10-Year TBond Futures overnight options by analyzing the relative bid-ask spreads. Also the determinants of the quoted bid-ask spreads are examined from its introduction. Overnight options data were segmented by year between November 15, 1993 and August 31, 2000 to test for significant changes regarding the quoted bid-ask spreads, the trading volume, and trading frequency.

Next the research turns to the impacts of the 3-Year & 10-Year TBond Futures and its day options when overnight options are introduced. Changes in the bid-ask spread, the trading volume, trading frequency and the pricing error before and after the introduction of the overnight options are examined to see if the introduction improves the market quality of the day options on futures and the underlying 3-Year & 10-Year TBond Futures.

LITERATURE REVIEW

The intra-day behavior of the bid-ask spread has a significant impact on how and when trades are executed within a marketplace. The concept has been studied within most financial markets over a range of differing financial instruments (McInish & Wood (1992) for stocks on the NYSE; Wang et al. (1994) for S&P500 index futures; Chan, Christie & Schultz (1995) for NASDAQ; Duffy (1999) for Australian futures markets; Chan, Chung & Johnson (1995) for CBOE options and their underlying NYSE stocks; Gwilym, Buckle & Thomas (1997) for LIFFE stock index options; Tse (1999) for the FTSE index futures, Pinder (2000) for Australian options. Most of the results report intra-day U-shape or reverse J-shape patterns for bid-ask spreads and returns from the market open to close.

Kumar, Sarin and Shastri (1998) claim that options listings may have a beneficial impact on the quality of the underlying asset market for several reasons. First, as suggested by Ross (1976) and Hakansson (1982), options improve the efficiency of incomplete asset markets by expanding the opportunity set facing investors. This in turn suggests that option listings reduce underlying stock volatility. Sahlstrom (2001) investigates the impact of stock option introduction on the return and risk characteristics of underlying stocks in Finland. Results suggest that volatility and bid-ask spread levels are lower after the option listing. Kumar, Sarin and Shastri (1998) found that option listings are associated with a decrease in the variance of the pricing error, a decrease in the adverse selection component of the spread, and an increase in the relative weight placed by the specialist on public information in revising prices for the underlying stocks. They also found a decrease in the spread and increase in quoted depth, trading volume, trading frequency, and transaction size after option listings.

Second, options listings may cause informed traders to migrate to the options market. In a model developed by John, Koticha, and Subrahmanyam (1993) informed traders migrate to options markets on the options listings because they view options as superior speculative vehicles. This superiority stems from an option's inherent leverage and the fact that investors may use options to avoid short sale restrictions on stocks. The reduction in the proportion of informed traders in the underlying market lowers the market maker's adverse selection costs, thereby lowering the spread and improving market liquidity.

Third, options may improve the efficiency of the underlying market by increasing the level of public information in the market. Specifically, the marginal benefit of becoming informed after the introduction of options is greater given the option's superiority as a speculative vehicle. This increase in marginal benefit results in a greater information symmetry, lowers the spread, improves liquidity, and reduces pricing error variance, thereby making the underlying market more efficient.

Demsetz (1968) was one of the first to theoretically address bid-ask spreads. He placed the bid and the ask price in a demand and supply framework so modelled the spread as a transaction cost paid by a trader for the opportunity to trade immediately. Since the bid-ask spread represents the difference between the price of buying and the price of selling for a particular trade, it is an important element in any financial market. Market microstructure theory (O'Hara (1995)), puts forward several explanations regarding the behaviour and determinants of the bid-ask spread: the inventory model, the asymmetric information model and different market structure theory.

Inventory models of bid-ask spread consider the costs faced by dealers who are forced to either take long or short position in the security. Market makers are rewarded by bid-ask spreads for bearing the risk of holding inventory that deviate from an equilibrium position. Under this framework, in order to maximizing the expected average profit per unit of time, a dealer would set the bid-ask spread as a mechanism to keep inventory at the desired level. Alternatively, the dealer can be viewed as an investor who would like to diversify holdings and has preferences regarding the risk-return profile of a portfolio (Coughenour & Shastri, 1999).

Amihud and Mendlson (1980) developed a model for specialists whereby spreads are widened as inventory imbalances accumulate. The bid-ask spread could be characterised as a means of assessing the liquidity in market that is being supplied by the dealer. Market microstructure theory suggests that one of the main elements of supplying liquidity to the market is the cost of holding inventory and processing orders. Coughenour & Shastri (1999) pointed out that a wider spread represents a lower liquidity level. The requirements of providing liquidity in the market force the market maker to hold portfolios that are sub-optimal. Therefore, the dealer sets the bid-ask spread such that the utility gained from the dollar compensation paid offsets the loss in utility from extra risk borne by holding the sub-optimal portfolio. The inventory models suggest that bid-ask spreads increase with price and the risk of the security, and decrease with trading volume and the number of market makers.

The asymmetry information model is based on the theory that the bid-ask spread is a pure informational phenomenon. This model (Kyle (1985), Easley and O'Hara (1987), Madhavan (1992)) focuses on the adverse selection in information between market makers, informed traders and the liquidity traders. Under this framework, informed traders have the informational advantages while liquidity traders who must trade at a given time during the day regardless of costs, will not be trading on the basis of information. Thus, the market makers must set the bid-ask spread wide enough so that the losses from trading with informed traders will be offset by the gains from trading with the liquidity traders. The model suggests that in periods of high price volatility informed traders win by picking off those traders wishing immediacy (liquidity traders). Thus the asymmetry information model suggests that the bid-ask spreads will increase with the increase of security price volatility.

The intraday pattern of the bid-ask spread has significant influence on when and how trades are executed in the market. There are theoretical and empirical distinctions which exist between the intraday behaviour of bid-ask spread in markets with a monopolistic specialist (e.g., NYSE) versus those with competing market makers [e.g. National Association of Securities Dealers Automated Quotation (NASDAQ)]. Brock and Kleidon (1992) developed a model where a single specialist has monopolistic power and is faced with inelastic demand at the open and close of trading due to information accumulation over the night prior to opening and the immediacy of the non-trading period after the close. Brock and Kleidon (1992), Chan et al. (1995) show the bid-ask spread at the NYSE followed a U-shape pattern throughout the day. However, Chan et al. (1995) found that the bid-ask spread on the CBOE narrows near the close. The same results are reported by Kleidon and Werner (1993) for the London Stock Exchange, and by Chan, Christie, and Schultz (1995) for NASDAQ. Also Tse (1999) found that spreads are stable over the day, but decline sharply at the close of FTSE-100 index futures trading on LIFFE (London International Financial Futures and Options Exchange).

DATA AND METHODOLOGY

Data Sample

The Security Industry Research Centre of Asia-Pacific (SIRCA) provided data for this research. The data of 3-Year & 10-Year TBond futures and its day options and overnight options consisted of daily and intra-day data between November 1991 to August 2000. Intra-day data included the time-stamped raw data for each quoted bid and ask in seconds. The completed trade data contained the time of the trade, the trading price and the trading volume. For daily data, the data set contained the day opening price, day closing price, day highest price, day lowest price, strike price, last trading price, the daily average bid-ask spread and the trading volume.

The 3-Year & 10-Year TBond Futures overnight options intra-night data starting from November 15, 1993 to August 31, 2000 is used to study the trading behaviour of the overnight option since introduction. This study uses the 3-Year & 10-Year TBond Futures and its day options intra-day data starting from November 15, 1992 to November 15, 1994. This is one year before and after the overnight option introduction on November 15, 1993.

Methodology

There are different methods being used in this study in order to examine the overnight option trading behaviour and to test the impact of the overnight option introduction.

Calculation of Time-Weighted Average Relative Bid-Ask Spreads

McInish and Wood (1992) is one of the classic articles which describes time weighted bid-ask spreads and volatility. In this study, a similar method is used to calculate the time-weighted bid-ask spreads. A relative bid-ask spread (BAS) is calculated for every quotation as: BAS = $\left[(ask - bid)/(ask + bid)/2\right]$. Thus the time-weighted average bid-ask spread will be calculated as follows:

$$\sum_{i=0}^{N} \frac{BAS_i(t_{i+1} - t_i)}{(t_{i+1} - t_i)}$$

Where $(t_{i+1} - t_i)$ is the interval for the quotation.

Calculation of Trading Volume and Trading Frequency

Daily trading volume is calculated as the sum of trading volume in a day. Trading frequency is defined as the average number of trades per day.

Regression Analysis

Market microstructure theory suggested that the quoted bid-ask spreads for options should be positively related to transaction price and return volatility, and negatively related to the trading volume. Glosten and Milgrom (1985), Stoll (1978) indicated that as spreads decrease, the trading volume will increase, volatility and the price will decrease. In order to find out whether the bid-ask spreads for the overnight options could be explained by the change in prices, volumes and volatility, a regression analysis will be used to analyse as the bid-ask spread as the dependent variable, and the price, trading volumes and volatility as the independent variables as shown below:

$$\text{Spread}_t = \alpha_0 + \alpha_1 \text{Price}_t + \alpha_2\ \text{Volume}_t + \alpha_3\ \text{Volatility}_t + \nu_t$$

Where Spread is the daily median time-weighted average relative bid-ask spreads, Price, Volume are the daily average price and daily total trading volume. Volatility is the return variance estimated by using the midpoint of bid and ask quotes instead of transaction prices as suggested by Mcinish and Wood (1992). The variance of returns using the quote midpoint avoids any bid-ask bounce problem.

Variance of Pricing Error

Hasbrouck (1993) suggests a method for measuring the deviations between actual transaction prices and implicit efficient prices, where security transaction prices are decomposed into random-walk and stationary components. The random-walk component may be identified with the efficient price and the stationary component is defined as the pricing error measured by using the difference between the efficient price and actual transaction price. Thus, the quality of a security market is tested by the use of pricing error variance. A lower variance of the pricing error would be an evidence of greater pricing efficiency. In this study, the pricing error variance for the underlying 3&10-Year TBond Futures contracts before and after the overnight option introduction are compared. A decrease in pricing error variance after the overnight options introduction would suggest an improvement of market quality.

Hasbrouck (1991) use a Vector Autoregression (VAR) representation of the price revision and trade process to analyse the market quality. In his model, the quoted mid-point of bid and ask prices are used. Instead of using the quoted midpoint prices, we use the actual transaction price, denoted as p_t in our model. As in Hasbrouck (1991), transaction price p_t is defined as the sum of the efficient price m_t and a term that embodies microstructure imperfections which could be seen as an error term s_t, so we have:

$$p_t = m_t + s_t \qquad (1)$$

Since the efficient price is a random-walk, m_t could be defined as

$$m_t = m_{t-1} + \omega_t \qquad (2)$$

Where $E\nu_t = 0$, $E\nu_t^2 = \sigma_\nu^2$, $E\,\nu_t \nu_T = 0$, for $t \neq T$. The variance of the pricing error σ_s^2 is used to measure the market quality.

Hasbrouck (1993) uses a VAR model by involving trades and price changes to measure the variance of the pricing error. Thus, we define our VAR model as follows:

$$r_t = a_1 r_{t-1} + a_2 r_{t-2} + \ldots\ldots + b_0 x_t + b_1 x_{t-1} + \ldots\ldots + \nu_{1,t} \qquad (3)$$

$$x_t = c_1 r_{t-1} + c_2 r_{t-2} + \ldots\ldots + d_1 x_{t-1} + d_2 x_{t-2} + \ldots. + \nu_{2,t} \qquad (4)$$

Where $r_t = p_t - p_{t-1}$, the term x_t is the signed trade variable, more generally, is a column vector of trade attributes. As in Hasbrouck (1991), the inclusion of the contemporaneous trade x_t in the transaction-revision r_t specification imposes a recursive structure that reflects the ordering at time t of the trade. In order to get the trade attributes x_t, we use the technique which defined x_t as +SquareRoot(TradeVolume) if the transaction price is above the quoted midpoint of the bid and ask prices, or – SquareRoot(TradeVolume) if the transaction price is below the quoted midpoint of the bid and ask prices. The error terms in equation 3 and 4 are mean zero and serially uncorrelated with $Var(\nu_{1,t}) = \sigma_1^2$, $Var(\nu_{2,t}) = \Omega$, and $E(\nu_{1,t}\ \nu_{2,t}) = 0$.

The corresponding Vector Moving Average (VAM) representation from our VAR model will be as follows:

$$r_t = a_0^*\nu_{1,t} + a_2^*\nu_{1,t-1} + \ldots\ldots + b_0^*\nu_{2,t} + b_1^*\nu_{2,t-1} + \ldots\ldots \qquad (5)$$

$$x_t = c_1^*\nu_{1,t} + c_2^*\nu_{1,t-1} + \ldots\ldots + d_0^*\nu_{2,t} + d_1^*\nu_{2,t-1} + \ldots\ldots \qquad (6)$$

Thus, the variance of the pricing error will be:

$$\sigma_s^2 = \sum_{j=0}^{\infty} (a_j^2\sigma_1^2 + b_j\Omega b_j')$$

Where $a_j = -\sum_{k=j+1}^{\infty} a_k^*$ and $b_j = -\sum_{k=j+1}^{\infty} b_j^*$

We are going to use 3 lags in the VAR model and 5 lags[3] in the VAM representation. The variance of pricing error will be calculated for the 3&10-Year TBond Futures data one-month before and one-month after the introduction of the overnight option. We hypothesize that the introduction of the overnight options improve the pricing efficiency in the underlying 3-Year TBond Futures market, so we expect to see a decrease in the variance of the pricing error in the post-introduction period.

ANALYSIS

Trading Behaviour of the 3-Year & 10-Year TBond Futures Overnight Options

Description of Number of Quotations and Trading Activities

Table 1 below shows the number of quotes and trades for 3-Year & 10-Year TBond Futures overnight calls and puts over the period November 15, 1993 to August 31, 2000.[4] The first time interval is the half hour starting from 16:30:00. A one-hour interval was used from 17:00:00[5].

Table 1 Number of Quotes and Trades for 3&10-Year TBond Futures Overnight Options

Time Interval [6]	3-Year TBond Futures						10-Year TBond Futures					
	Calls			Puts			Calls			Puts		
	Bid	Ask	Trade	Bid	Ask	Trade	Bid	Ask	Trade	Bid	Ask	Trade
16:30:00-17:00:00	2236	2360	339	2149	2275	502	11078	11640	1708	10971	11591	1780
17:00:00-18:00:00	4636	4778	1342	3989	4186	1332	11860	12484	2277	11209	11956	2425
18:00:00-19:00:00	1084	1130	298	910	959	322	3637	3830	668	3626	3833	617
19:00:00-20:00:00	495	510	143	471	491	172	1884	1987	321	1648	1742	350
20:00:00-21:00:00	269	270	95	280	303	89	1065	1130	197	919	1000	194
21:00:00-22:00:00	228	243	48	187	198	73	593	636	110	562	601	125
22:00:00-23:00:00	102	119	15	99	102	30	277	288	66	264	292	63
23:00:00-24:00:00	32	38	4	37	37	6	130	140	36	89	93	22
24:00:00-01:00:00	14	13	9	8	8	3	41	50	14	32	39	11
01:00:00-02:00:00	3	3	1	1	1	1	12	13	6	15	16	6
02:00:00-03:00:00	-	-	2	2	3	1	15	21	8	14	15	4
03:00:00-04:00:00	1	1	-	2	5	-	9	13	5	9	9	3
04:00:00-05:00:00	1	1	-	4	5	2	12	12	1	15	15	5
05:00:00-06:00:00	9	9	7	1	1	-	9	9	6	6	6	7
06:00:00-07:00:00	1	1	-	-	-	-	-	1	3	-	2	1
07:00:00-07:30:00-	-	-	-	1	1	-	-	-	-	-	-	-

From table 1, we observed that most of the quotes and trades occur during the first half of the night, particularly in the first two hours. This may be explained by the special nature of overnight options. Overnight options appear to be used for hedging or speculating against the USA market. Market participants take positions before the USA market opens or before USA economic announcements occur and then hold these positions to see what occurs. Because overnight options only last for one night, if they are in-the-money, exercise will be automatic at the end of the night session, while all other options will expire worthless. So we

[3] We use different lag values in order to avoid error term autocorrelation. The lags are selected by using the maximum-likelihood and AIC tests.
[4] More recent data will be added in later when ready.
[5] One-hour intervals were used in order to obtain enough observations in each time segment.
[6] The overnight options started to trade from 4:30:00pm and ceases at 7:30:00am the next day.

would expect to see more quotes and trades at the beginning of the night session, where enough liquidity exists to enable participants to hedge or speculate.

Another interesting characteristic of the data concerns the quotes and trades for the 10-Year TBond Futures overnight options over time. Initially the 10-Year TBond futures overnight options contracts were popular because they were cost effective, as the tick size for the 10-Year TBond futures overnight options contracts was greater than the tick size for the 3-Year options. So investors would need fewer contracts for 10-Year's relative to the contracts for 3-Year's when taking positions (See Appendix 3 for the tick value calculation). However this relationship changed after 1999[7] and investors shifted back to the 3-Year TBond futures overnight options to speculate or hedge medium to long interest rate risk. This is a consequence of the underlying 3-Year TBond futures market and the physical 3-Year TBond market being more liquid than the underlying 10-Year TBond futures market and the 10-year TBond market. This indicates investors choose to trade the derivative securities with the most liquid underlying market despite higher transaction costs.

From table 1 we also observed that the trading of overnight puts for both the 3&10-Year TBond futures contracts are greater than overnight calls. That indicates investors are more pessimistic about the market, and expect the market to fall more often than to rise, leading to more puts than calls being traded.

Changes in Quoted Bid-Ask Spreads, Trading Volume and Trading Frequency

To test if there are changes regarding the quoted bid-ask spread, trading volume and trading frequency, overnight options data was segmented by year starting from their introduction on November 15 1993 to August 31 2000. Table 2 reports the daily mean and median time-weighted average relative bid-ask spread, trading volume and trading frequency. The quoted time-weighted average relative bid-ask spreads narrowed over time for most of the overnight calls and puts for both 3-Year & 10-Year TBond futures contracts. Over the period of the study, trading volume of the overnight calls and puts continually increases for the 3-year overnight options, however for 10-Year overnight options the trading volume fell over time. As discussed earlier, though the 10-Year options were cost effective, the

[7] The following section would have a detailed analysis of the data year by year.

underlying market did not provide as much liquidity relative to the 3-Year options. Thus investors adjusted their trading strategies and moved to the most liquid market. The trading frequency pattern reflects an increase for the 3-Year contracts over time. We could conclude that the quoted bid-ask spreads shrunk, while trading volume and trading frequency became larger for 3-Year TBond futures overnight options. It appears that the 3-Year TBond futures overnight options market is becoming more efficient overtime as its use by market participants increased. On the other hand, the 10-Year TBond futures overnight options market became less efficient with decreasing trading volume and trading frequency, although the bid-ask spread did shrink.

Table 2 Mean and Median Relative Bid-Ask Spreads, Trading Volume, Trading Frequency Overtime

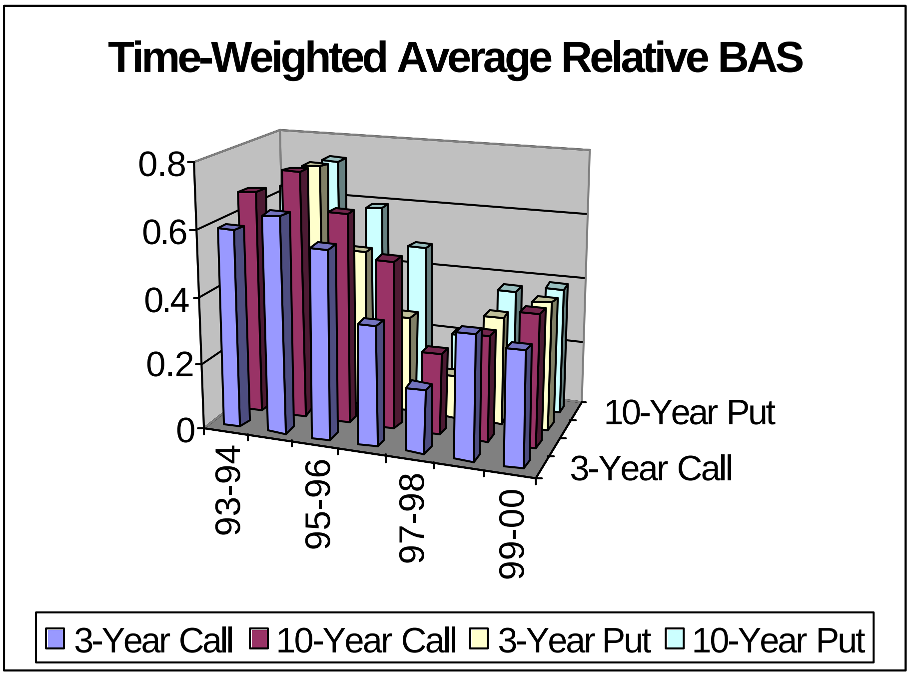
RBAS is the daily mean and median relative time-weighted average bid-ask spreads. Volume is daily mean and median total trading volume during one night. Frequency is the daily mean and median average number of transactions one night.

Year	3-Year TBond Futures						10-Year TBond Futures					
		Calls			Puts			Calls			Puts	
	BAS	Vol	Freq	BAS	Vol	Freq	BAS	Vol	Freq	BAS	Vol	Freq
93-94	0.60[8]	63	1.30	0.49	97	1.40	0.68	99	2.60	0.64	88	2.30
	0.61[9]	50	1.00	0.39	100	1.00	0.68	60	2.00	0.64	73	2.00
94-95	0.65	106	1.70	0.74	154	1.90	0.75	132	2.90	0.73	130	2.20
	0.60	63	1.00	0.60	100	1.00	0.73	100	2.00	0.67	100	2.00
95-96	0.57	218	2.80	0.49	260	3.40	0.64	311	6.10	0.59	281	5.90
	0.60	150	2.00	0.48	150	2.00	0.65	250	5.00	0.59	200	4.00
96-97	0.36	176	2.10	0.30	282	3.50	0.51	353	6.20	0.48	369	6.60
	0.18	150	2.00	0.17	170	3.00	0.55	258	5.00	0.51	250	5.00
97-98	0.19	302	2.90	0.13	339	3.20	0.25	235	4.50	0.21	211	4.20
	0.00	275	2.00	0.00	231	2.00	0.08	157	4.00	0.05	150	3.00
98-99	0.37	658	4.00	0.33	650	4.30	0.32	336	5.90	0.37	416	7.00
	0.29	400	3.00	0.24	500	3.00	0.37	230	5.00	0.31	311	6.00
99-00[10]	0.34	1076	6.20	0.39	1931	10.10	0.40	166	2.80	0.39	173	2.90
	0.28	940	5.00	0.33	1600	9.50	0.34	110	2.00	0.34	150	2.00

[8] Mean value.
[9] Median value.
[10] Till August 31 2000.

Figure 1 below illustrates the time-weighted average relative bid-ask spreads over time by using the mean value from table 2. We found that the time-weighted average relative bid-ask spreads for 10-Year TBond futures overnight options (both calls and puts) are greater than that for the 3-Year options.

Figure 1 Time-Weighted Average Relative BAS for 3-Year &10-Year Overnight Options Over Time

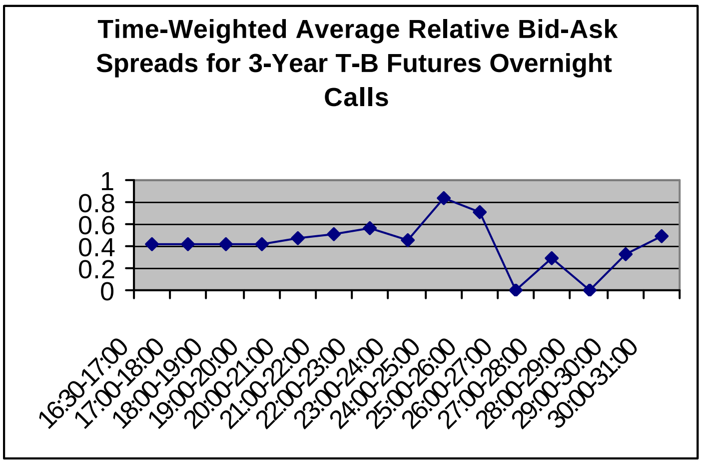


Patterns of the Bid-Ask Spreads

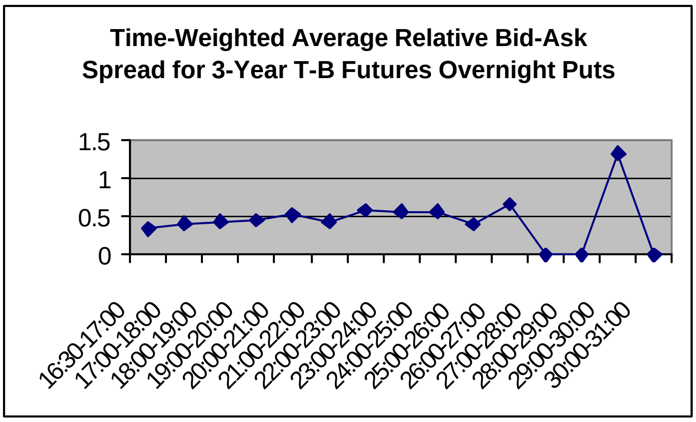
Figure 2 Panels A and B illustrates the quoted bid-ask spreads for the 3-Year TBond overnight options. Figure 3 Panels A and B illustrates the quoted bid-ask spreads for the 10-Year TBond overnight options. The time-weighted average relative bid-ask spreads for one-hour intervals are calculated following Mcinish and Wood (1992). The first time interval is the half hour starting from 16:30:00. A one-hour interval was used from 17:00:00[11].

Figure 2 Quoted Time-Weighted Average Relative Bid-Ask Spreads

Panel A



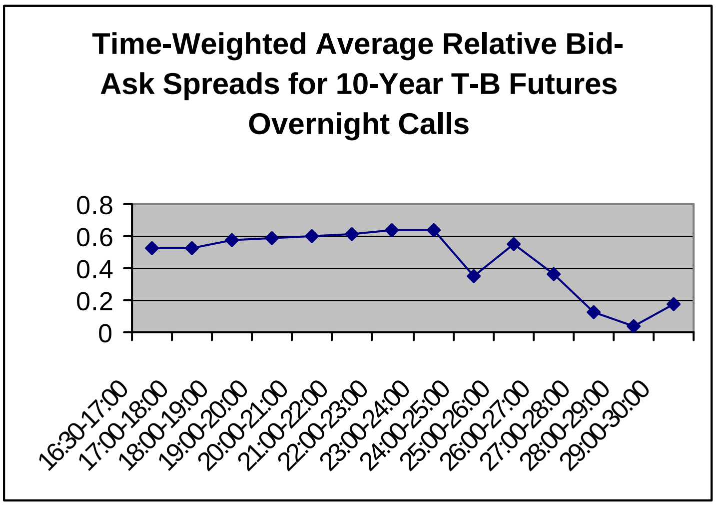
Panel B



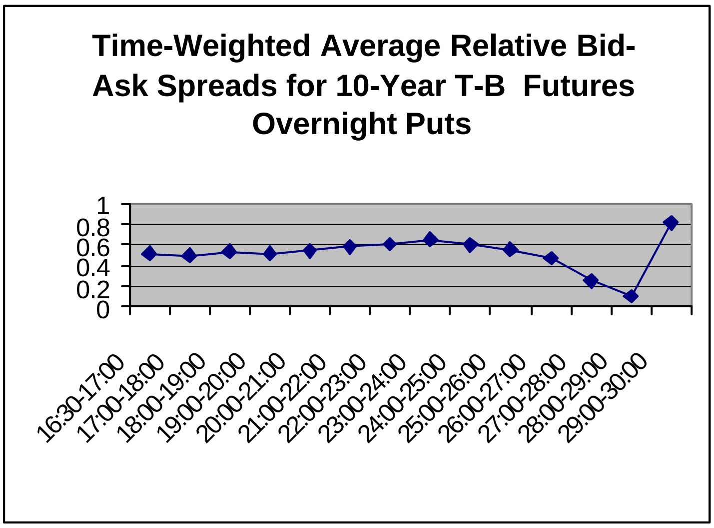
[11] One-hour intervals were used in order to obtain enough observations in each time segment.

Figure3 Quoted Relative Time-Weighted Average Bid-Ask Spreads

Panel A



Panel B



Most of the previous studies observed U-Shaped or reversed J-Shaped quoted bid-ask spread patterns. In contrast, this study found that the bid-ask spreads patterns for the overnight options are relative flat during the first half of the trading night, for both calls and puts. However, after 22:00 and particularly after 24:00, the bid-ask spread patterns fluctuate, and the numbers of quotes are thin during the second half of the night[12]. One explanation of the patterns found in this study may be differing market microstructure. As

[12] From table 1 we observe the quotes and trades after 22:00 decreased substantially, although the patterns in figure 1 & 2 are relative flat up till 24:00 for the 3-Year contracts and 26:00 for the 10-Year contracts.

the overnight option only lives for one night, it was designed for the investors to hedge or speculate when the USA market opens. Thus investors who want to hedge or speculate against risk, while USA markets are open or USA economic announcements are scheduled, would take their position before the USA market opened.

Determinants of the Quoted Bid-Ask Spreads

Market microstructure theory suggested that the quoted bid-ask spreads for options should be positively related to transaction price and return volatility, and negatively related to the trading volume. We perform a regression analysis to test the determinants of the quoted bid-ask spreads of the 3-Year & 10-Year TBond Futures overnight option. Results of this analysis are reported in table 3.

The coefficients for all overnight calls and puts have their expected signs, as the coefficients on the Price variables and the Return Variance variables are positive. This indicates that bid-ask spreads will be larger if the transaction price increases and the return volatility increases. However, the results for the 3-Year TBond futures overnight calls are statistically significant at the 10% level for the price variables, but for the return variance the results are statistically significant at the 5% level. In contrast, the results for the 10-Year TBond futures overnight calls and puts are statistically significant at the 1% level for both the price and return variance variables.

The coefficient on the Volume variable has a negative sign that means with an increase in trading volume, bid-ask spreads fall. The results for the overnight calls for both 3-Year & 10-Year TBond futures are statistically significant at the 5% level. The results for the overnight puts are not statistically significant although the coefficients are negative as expected.

Overall, we might conclude that for both 3- Year & 10-Year TBond futures overnight options, the bid-ask spreads will be larger if the price and return variance increase and it will be smaller if the trading volume increases. Thus the regression analysis shows a consistent result with most of the previous results in terms of the determinants of the bid-ask spreads for the overnight options, despite the overnight options having a differing market microstructure.

Table 3 Determinants of Relative Bid-Ask Spreads

$\mathbf{RBAS}_t = a_0 + a_1\mathbf{Price}_t + a_2\mathbf{Volume}_t + a_3\mathbf{Volatility}_t + e_t$

RBAS, Price, Volume and Volatility are the of daily time-weighted relative bid-ask spreads, average transaction price, total trading volume and time-weighted bid-ask midpoint return variance, respectively. Using the midpoint of bid and ask quotes instead of transaction prices as suggested by Mcinish and Wood (1992) avoids a bid-ask bounce problem.

Variable	3-Year TBond Futures				10-Year TBond Futures			
	Overnight Calls		Overnight Puts		Overnight Calls		Overnight Puts	
	Coefficient	P Values	Coefficient	P Values	Coefficient	P Values	Coefficient	P Values
Intercept	0.4520	0.0000**	0.3820	0.0000**	0.2040	0.0690	0.0774	0.2260
Price	0.0221	0.0810	-0.0053	0.6960	0.0687	0.0000**	0.0616	0.0000**
Volume	-0.0368	0.0010**	-0.0176	0.1650	-0.0316	0.0410*	-0.0071	0.4190
Volatility	0.1610	0.0490*	0.6170	0.0000**	0.4430	0.0070**	0.5240	0.0000**
R^2	0.1860		0.2870		0.1720		0.2940	
F Test	5.8460	0.0010**	15.1670	0.0000**	10.6200	0.0000**	32.6820	0.0000**

** Significant at 1% level.

* Significant at 5% level.

Impacts of the Overnight Options Introduction on the Underlying Markets

Liquidity

An improvement in the liquidity of the underlying 3-Year & 10-Year TBond Futures and its day options should be seen if the overnight options introduction has a beneficial impact. Market microstructure theory suggests the quoted bid-ask spreads may be used to measure market liquidity. The method adopted by Mcinish and Wood (1992), Skinner (1989) and Kumar, Sarin and Shastri (1998) is used in this work to measure the bid-ask spreads. More specifically, the quoted bid and ask one year before and one year after the introduction is constructed.

Table 4 reports the daily median relative bid-ask spread ratios for the underlying 3-Year & 10-Year TBond Futures and their day options. For both the 3-Year & 10-Year TBond Futures and their day options. There are four contracts being traded at any point in time. These are denoted as YBH, YBM, YBU and YBZ for 3-Year contracts, or XBH, XBM, XBU and XBZ for 10-Year contracts. The last letters, H, B, U and Z indicate the contracts which mature in March, June, September and December.

The relative bid-ask spread ratios are defined as the ratio of the median daily time-weighted relative bid-ask spread in the post-introduction period divided by the median daily time-weighted relative bid-ask spread in the pre-introduction period. A ratio less than one implies a decrease in the bid-ask spread in the post-introduction period, suggesting the possibility of liquidity improvement.

In table 4, almost all (except for 10-Year XBH contract) 3-Year &10-Year TBond Futures contracts have relative bid-ask spread ratios less than one, indicating that the liquidity of the underlying 3-Year & 10-Year TBond Futures has been improved after the overnight options introduction. An intuitive explanation would be, because the overnight options are derivatives of the underlying futures contracts, we would observe an improvement of the liquidity of the underlying market once derivatives are introduced. Interviews with traders of overnight options from 3 different financial institutions in Sydney suggested that a large majority of overnight options traders are speculators. If the overnight options are in-the-money during the one night session or tend to be exercised after the session, it will result in a position on the underlying futures position. Thus the trading of the underlying futures contract would be expected to be larger.

Table 4 also reports the relative Bid-Ask Spread ratios for the 3-Year & 10-Year TBond Futures day options. Here, the bid-ask spreads improved for all 3-Year & 10-Year TBond Futures put options as they have ratios less than one. But the calls have ratios greater than one. Because the overnight options were designed for investors who want to hedge their positions against USA market risk, investors wishing to hedge overnight risk might shift trading from day options to overnight options. This could explain why we observe decreased liquidity for the day options in both markets. However, we did observe a liquidity improvement for all day put options, it might have some other reasons causing the improvement. One possible explanation of this result may be related to pessimistic traders. As traders expect markets to fall, they would turn to the use of puts, thus increasing their liquidity.

Table 4 Relative Bid-Ask Spread Ratios
Bid-ask spread for futures and day options are calculated as the daily median time-weighted relative bid-ask spreads. Bid-ask spread ratios will be the median relative bid-ask spreads after the introduction divided by the median relative bid-ask spreads before the introduction of the overnight options.

Contract[13]	BAS Ratios (Futures)		BAS Ratios (Day Options)			
	3-Year TBond	10-Year TBond	3-Year TBond		10-Year TBond	
			Calls	Puts	Calls	Puts
Y/XBH	0.9548	1.0372	1.1048	0.8012	1.1281	0.8711
Y/XBM	0.9281	0.9124	1.0906	0.6265	1.0502	0.7893
Y/XBU	0.9675	0.9673	1.3353	0.7578	1.1897	0.5944
Y/XBZ	0.9484	0.9999	1.2773	0.7937	1.3079	0.8308

Order Flow

Market microstructure theory suggests that lower spreads would be a proxy for lower transaction costs and should be accompanied by higher trading activity. Thus, one may expect an increased trading volume of the underlying 3&10-Year TBond Futures and their day put options. With an increase of the trading volume, one may also expect a trading frequency increase as a result of the overnight options introduction. Thus, the median trading volume and trading frequency is used to measure the order flow changes.

Table 5 below summarizes the results for the trading volume ratios and trading frequency ratios. The trading volume ratios and trading frequency ratios are defined as the post-introduction period daily median trading volume and trading frequency divided by the pre-introduction period trading volume and trading frequency. A ratio greater than one indicates an improvement in the order flow. Results show that the trading volume and trading frequency became larger in association with the overnight options introduction for both of the underlying 3-Year & 10-Year TBond Futures. Again, the results for the 3-Year & 10-Year TBond futures day options are mixed. The results from previous section suggested that the bid-ask spreads for both 3-Year & 10-Year TBond Futures day call options became larger after the overnight options introduction, indicating a relative lower trading activity consistent with market microstructure theory. However, the results from the order flow suggest that the trading volume and trading frequency increase after the introduction, in

[13] For 3-Year TBond Futures and its day options, there are four types of contracts traded. These are coded by their maturity month, i.e. B, H, U, Z stands for the March, June, September and December maturity.

contrast with liquidity analysis results. The results from the liquidity analysis of day put options indicated that the bid-ask spreads became lower after the overnight options introduction. But we expected an increase of trading activities for the day puts. These results suggest that the trading volume and trading frequency fell after the introduction of overnight options. So the option results are not consistently good or bad.

Overnight options traders in Sydney suggested that some overnight option traders are hedgers, and are using overnight options to hedge underlying futures positions. But some are using overnight options to hedge their day option's positions. So the trading activity of overnight options will have a direct impact on the day options market, although the results from liquidity and order analysis conflict. This apparent anomaly warrants further attention.

Table 5 Trading volume and trading frequency ratios

The trading volume ratios and trading frequency ratios are defined as the post-introduction period trading volume and trading frequency divided by the pre-introduction period trading volume and trading frequency. Daily trading volume is calculated as the sum of trading volume in a day. Trading frequency is defined as the average number of trades per day.

	Futures		Day Options			
	3-Year TBond	10-Year TBond	3-Year TBond		10-Year TBond	
			Calls	Puts	Calls	Puts
Trading Volume Ratio	1.4297	1.2710	1.0892	0.7329	1.1197	1.0068
Trading Frequency Ratio	1.2808	1.3869	1.0833	0.7692	1.2273	0.9773

The analysis of the bid-ask spreads, trading volume and trading frequency suggests that the liquidity and order flow of the underlying 3-Year & 10-Year TBond Futures market has been improved. But the results for the 3-Year & 10-Year TBond Futures day options are mixed, indicating that the information effects associated with the overnight options introduction may only transfer unambiguously to the underlying 3-Year & 10-Year TBond Futures markets and not their day options. So in the following sections, the Vector Autoregressive Regression and Vector Moving Average framework will only consider the underlying 3-Year & 10-Year TBond Futures when testing the change in pricing error for the underlying 3-Year & 10-Year Futures contracts.

Variance of the Pricing Error

Hasbrouck (1993) suggests a method for measuring the deviations between actual transaction prices and implicit efficient prices, where security transaction prices are decomposed into random-walk and stationary components. The random-walk component may be identified with the efficient price and the stationary component is defined as the pricing error measured by using the difference between the efficient price and actual transaction price. Thus, the quality of a security market is tested by the use of the variance of the pricing error. In this study, the pricing error variance for the underlying 3&10-Year TBond Futures before and after the overnight options introduction are compared. A decrease in pricing error variance after the overnight options introduction would suggest an improvement of market quality.

Vector Autoregressive Regression and Vector Moving Average analysis as suggested in the methodology section is used to test the pricing error variance for the underlying 3&10-Year TBond Futures one-month[14] before and after the overnight options introduction. Results are reported in table 6 and table 7.

Table 6: Coefficients of VAR for Pre and Post Introduction Period

$$r_t = a_1 r_{t-1} + a_2 r_{t-2} + \ldots\ldots + b_0 x_t + b_1 x_{t-1} + \ldots\ldots + n_{1,t}$$

$$x_t = c_1 r_{t-1} + c_2 r_{t-2} + \ldots\ldots + d_1 x_{t-1} + d_2 x_{t-2} + \ldots. + n_{2,t}$$

Where $r_t = p_t - p_{t-1}$, the term x_t is defined as +SquareRoot(TradeVolume) if the transaction price is above the quoted midpoint of the bid and ask prices, or – SquareRoot(TradeVolume) if the transaction price is below the quoted midpoint of the bid and ask prices. The error terms in equations 3 and 4 are mean zero and serially uncorrelated with $Var(\nu_{1,t}) = \sigma_1^2$, $Var(\nu_{2,t}) = \Omega$, and $E(\nu_{1,t}\, \nu_{2,t}) = 0$.

Panel A VAR for 3-Year TBond Futures Contracts

	VAR- Equation (3)		VAR- Equation (4)	
Variables	Pre-Period Coefficients (P)	Post-Period Coefficients (P)	Pre-Period Coefficients (P)	Post-Period Coefficients (P)
r_{t-1}	-0.6353(0.00)[15]	-0.1632(0.00)	-296.46(0.21)	-8532.07(0.00)
r_{t-2}	-0.4238(0.00)	-0.0732(0.00)	-332.66(0.21)	-1257.97(0.33)
r_{t-3}	-0.3093(0.00)	-0.0118(0.17)	-166.84(0.48)	2306.71(0.05)
x_t	-	-	-	-
x_{t-1}	-	-	0.3980(0.00)	0.3600(0.00)
x_{t-2}	-	-	0.2530(0.00)	0.1300(0.00)
x_{t-3}	-	-	0.2260)0.00)	0.0600(0.00)
$Var(\nu_{1,t}) = \sigma_1^2$	2.3005E-08	1.3069E-09	-	-
$Var(\nu_{2,t}) = \Omega$			11.4216	24.2936

[14] One-month intra-day data in seconds will be used to obtain sufficient observations for the VAR and VAM analysis. This resulted in 10,575 observations before introduction and 10,837 after for the 3-Year contracts, and 14,404 observations before introduction and 17,206 after for the 10-Year contracts.
[15] The number in the bracket following each coefficient is the P value.

Panel B VAR for 10-Year TBond Futures Contracts

	VAR- Equation (3)		VAR- Equation (4)	
	Pre-Period	Post-Period	Pre-Period	Post-Period
Variables	Coefficients (P)	Coefficients (P)	Coefficients (P)	Coefficients (P)
r_{t-1}	-0.8979(0.00)	-0.0944(0.00)	-4538.56(0.00)	-5394.21(0.00)
r_{t-2}	-0.0296(0.00)	0.0003(0.01)	17.25(0.98)	-2.95(0.01)
r_{t-3}	-0.0042(0.53)	-0.0001(0.45)	929.12(0.15)	-5.16(0.00)
x_t	-	-	-	-
x_{t-1}	-	-	0.39(0.00)	0.38(0.00)
x_{t-2}	-	-	0.19(0.00)	0.18(0.00)
x_{t-3}	-	-	0.09(0.00)	0.09(0.00)
$Var(\nu_{1,t}) = \sigma_1^2$	9.55E-10	1.01E-09	-	-
$Var(\nu_{2,t}) = \Omega$			6.2571	6.8816

Table 7: Coefficients of VAM for Pre and Post Introduction Period

The corresponding Vector Moving Average (VAM) representation from our VAR model will be as follows:

$$\mathbf{r_t = a_0^* \nu_{1,t} + a_2^* \nu_{1,t-1} + \ldots\ldots + b_0^* \nu_{2,t} + b_1^* \nu_{2,t-1} + \ldots\ldots}$$

$$\mathbf{x_t = c_1^* \nu_{1,t} + c_2^* \nu_{1,t-1} + \ldots\ldots + d_0^* \nu_{2,t} + d_1^* \nu_{2,t-1} + \ldots\ldots}$$

$\nu_{1,t}$ and $\nu_{2,t}$ are the residuals from the VAR.

For pre-introduction and post-introduction periods, the corresponding VAM (with 5 lags) are shown.

Panel A VAM for 3-Year TBond Futures Contracts

	VAM- Equation (5)		VAM- Equation (6)	
	Pre-Period	Post-Period	Pre-Period	Post-Period
Variables	Coefficients(P)	Coefficients(P)	Coefficients(P)	Coefficients(P)
$\nu_{1,t}$	0.9980(0.00)	1.0007(0.00)	228.08(0.33)	199.22(0.06)
$\nu_{1,t-1}$	-0.6348(0.00)	-0.1362(0.00)	-194.93(0.41)	-8291.28(0.00)
$\nu_{1,t-2}$	-0.0200(0.00)	-0.0611(0.00)	-145.854(0.53)	-2847.59(0.00)
$\nu_{1,t-3}$	-0.0257(0.00)	-0.0104(0.00)	-57.99(0.80)	824.98(0.00)
$\nu_{1,t-4}$	0.2171(0.00)	0.0032(0.00)	61.40(0.79)	-824.12(0.00)
$\nu_{1,t-5}$	-0.1237(0.00)	-0.0008(0.04)	-140.09(0.55)	-566.45(0.00)
$\nu_{2,t}$	-	-	1.19(0.00)	1.00(0.00)
$\nu_{2,t-1}$	-	-	0.57(0.00)	0.39(0.00)
$\nu_{2,t-2}$	-	-	0.58(0.00)	0.27(0.00)
$\nu_{2,t-3}$	-	-	0.61(0.00)	0.19(0.00)
$\nu_{2,t-4}$	-	-	0.46(0.00)	0.12(0.00)
$\nu_{2,t-5}$	-	-	0.42(0.00)	0.09(0.00)

Panel B VAM for 10-Year TBond Futures Contracts

	VAM- Equation (5)		VAM- Equation (6)	
	Pre-Period	Post-Period	Pre-Period	Post-Period
Variables	Coefficients(P)	Coefficients(P)	Coefficients(P)	Coefficients(P)
$v_{1,t}$	-0.9997(0.00)	0.9998(0.00)	-142.71(0.33)	-103.39(0.37)
$v_{1,t-1}$	-0.0745(0.00)	-0.0776(0.00)	-4642.59(0.00)	-5408.34(0.00)
$v_{1,t-2}$	-0.0307(0.00)	-0.0025(0.00)	-1408.97(0.00)	-1694.17(0.00)
$v_{1,t-3}$	0.0019(0.00)	-0.0044(0.00)	-305.87(0.04)	-1510.41(0.00)
$v_{1,t-4}$	-0.0003(0.00)	-0.0023(0.32)	-848.93(0.00)	-1326.27(0.00)
$v_{1,t-5}$	-0.0014(0.00)	-0.0025(0.00)	-514.53(0.00)	-938.14(0.05)
$v_{2,t}$	-	-	1.02(0.00)	1.01(0.00)
$v_{2,t-1}$	-	-	0.42(0.00)	0.41(0.00)
$v_{2,t-2}$	-	-	0.36(0.00)	0.33(0.00)
$v_{2,t-3}$	-	-	0.30(0.00)	0.29(0.00)
$v_{2,t-4}$	-	-	0.22(0.00)	0.20(0.00)
$v_{2,t-5}$	-	-	0.17(0.00)	0.15(0.00)

Since we have the variance of the pricing error defined as $\sigma_s^2 = \sum_{j=0}^{\infty} (a_j^2\sigma_1^2 + b_j\Omega b_j')$

Where $a_j = -\sum_{k=j+1}^{\infty} a_k^*$ and $b_j = -\sum_{k=j+1}^{\infty} b_j^*$, the variance of the pricing error for 3-Year TBond Futures are $\sigma_s^2 = 0.0010$ and $\sigma_s^2 = 0.1730$ for the pre and post introduction periods respectively. And the variance of the pricing error for 10-Year TBond futures are $\sigma_s^2 = 0.2353$ and $\sigma_s^2 = 0.1218$ for the pre and post introduction periods respectively.

Since the pricing error for 10-Year TBond futures contracts decreases after the introduction of the overnight options, the underlying 10-Year TBond futures market was becoming more efficient. However, the pricing error for the 3-Year TBond futures contract increases after the introduction of the overnight options. This result was consistent with the findings from previous sections, as we observed that trading of the 10-Year TBond futures overnight options were higher than for the 3-Year options.

Conclusions

The introduction of overnight options at the Sydney Futures Exchange (SFE) offers a unique opportunity to study trading behavior with a different market microstructure. One-session options (i.e. overnight options) can be used to manage short term exposure, hedge positions form event risk, profit by anticipating short term price movements in the bond market, take a position on events and put the equivalent of a stop loss order in place. Thus, a comprehensive analysis of the overnight options will give investors a good understanding of how to execute trading in this market.

Bid-ask spreads normally show a U-shaped pattern during a day, but we found that the bid-ask spreads for overnight options are relatively flat during the first half of the trading night, before fluctuating throughout the second half of the night for both 3-Year & 10-Year TBond futures overnight calls and puts. Also the number of quotes and trades are thin during the second half of the night. One explanation of the patterns found in this study may be related to the special nature of overnight options. As the overnight option only lasts for one night, it was designed to match the time zone for the investors who want to hedge the USA market risk. Anyone wishing to use the overnight option as a hedging tool might trade the overnight option at the beginning of the night. But as the overnight market gets closer to its close, liquidity necessary for hedging or speculating falls.

Results also indicated that over time the quoted bid-ask spread narrowed for both 3&10-Year TBond futures overnight calls and puts, while trading volume and trading frequency increased for the 3-Year contracts. Trading volume and trading frequency fell for the 10-Year contracts. One reason for this result may be that the underlying 3-Year TBond futures market provides more liquidity than does the 10-Year market, although initially investors were using 10-Year contracts because of its larger tick size. This suggests that 3-Year TBond Futures overnight options are becoming more efficient as the underlying futures market provides more liquidity. Similarly to most of the options traded on world exchanges, quoted bid-ask spreads of the overnight options appear to be explained by the transaction price, the trading volume and the volatility of the return. Specifically, the quoted bid-ask spreads increase with higher transaction prices and increased return volatility, while quoted bid-ask spreads fall as trading volume increases.

Typically new product introduction, particularly in derivative markets, will impact underlying markets and this was found to hold for the introduction of the overnight options on 3&10-Year TBond Futures traded at the Sydney Futures Exchange. The impacts of the 3&10-Year TBond Futures and its day options when overnight options were introduced was also tested in this study. Changes in quoted bid-ask spread, trading volume, trading frequency and the pricing error before and after the introduction of the overnight options are also examined to see if the introduction improves the market quality of the 3-Year & 10-Year TBond futures day options and the underlying 3-Year & 10-Year TBond Futures.

The analysis of the bid-ask spreads, trading volume and trading frequency suggests that the liquidity and order flow of the underlying 3-Year & 10-Year TBond Futures market has been improved, as the quoted bid-ask spreads became smaller and trading volume and frequency became larger after the introduction. But the results for the 3-Year & 10-Year TBond Futures day options are mixed. The bid-ask spreads for 3-Year & 10-Year TBond futures day call options increased, while trading volume and trading frequency became larger. For the 3-Year & 10-Year TBond futures day put options, results indicated that the bid-ask spreads shrunk while trading volume and trading frequency became smaller. This indicated that the information effects associated with the overnight options introduction may only transfer unambiguously to the underlying 3-Year & 10-Year TBond Futures markets and not their day options.

As 3-Year & 10-Year TBond futures are derived from the 3-Year & 10-Year physical TBond, it might be useful to analyse the physical TBond markets to see if there are any improvements of quality. Also, a comprehensive analysis between the 3-Year & 10-Year TBond, their futures markets and their day and overnight options markets will be useful when fully explaining the interrelationship and information transmission across the markets.

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Appendix1

Overnight Options on 3 Year Commonwealth Treasury Bond Futures

Contract Unit:	One A$100,000 face value, 6% coupon, 3-Year Treasury Bond futures contract for a specified contract month on the Sydney Futures Exchange.
Contract Months:	Put and call options available on futures contracts for the nearest quarter month ahead.
Commodity Code:	YO
Listing Date:	15/11/1993
Minimum Price Movement:	Quoted in yield per cent per annum in multiple of 0.005 per cent.
Exercise Prices:	Set at intervals of 0.01 per cent per annum yield. Nine option exercise prices are available for trading with additional strike prices listed at the discretion of the Trading Manager or the Chief Executive of SFE.
Contract Expiry:	At the cessation of each SYCOM session.
Trading Hours:	5.10pm – 7.00am[16] (during US daylight saving time)[17] 5.10pm – 7.30am[8] (during US non daylight saving time)[9]
Settlement Method:	All options, which are in-the-money, are automatically exercised on the business day immediately following the SYCOM session. Exercise of an option results in the holder receiving a futures position at the options strike price. The settlement price is the weighted average of trade prices executed in the underlying contract between 8.30am and 8.40am on the business day immediately following the SYCOM session. Calculation of the settlement price is to 3 decimal places and rounded to 2 decimal places. When the third decimal place is five or above, the arithmetic mean is rounded up to the next highest decimal place.[8]

Source: WWW.SFE.COM.AU

[16] Unless otherwise indicated, all times are Sydney times.
[17] US daylight saving begins first Sunday in April and ends last Sunday in October.

Appendix2

Overnight Options on 10 Year Commonwealth Treasury Bond Futures

Contract Unit:	One A$100,000 face value, 6% coupon, 3-Year Treasury Bond futures contract for a specified contract month on the Sydney Futures Exchange.
Contract Months:	Put and call options available on futures contracts for the nearest quarter month ahead.
Commodity Code:	XO
Listing Date:	15/11/1993
Minimum Price Movement:	Quoted in yield per cent per annum in multiple of 0.005 per cent.
Exercise Prices:	Set at intervals of 0.01 per cent per annum yield. Nine option exercise prices are available for trading with additional strike prices listed at the discretion of the Trading Manager or the Chief Executive of SFE.
Contract Expiry:	At the cessation of each SYCOM session.
Trading Hours:	5.10pm – 7.00am[18] (during US daylight saving time)[19] 5.10pm – 7.30am[8] (during US non daylight saving time)[9]
Settlement Method:	All options, which are in-the-money, are automatically exercised on the business day immediately following the SYCOM session. Exercise of an option results in the holder receiving a futures position at the options strike price. The settlement price is the weighted average of trade prices executed in the underlying contract between 8.30am and 8.40am on the business day immediately following the SYCOM session. Calculation of the settlement price is to 3 decimal places and rounded to 2 decimal places. When the third decimal place is five or above, the arithmetic mean is rounded up to the next highest decimal place.[8]

Source: WWW.SFE.COM.AU

[18] Unless otherwise indicated, all times are Sydney times.
[19] US daylight saving begins first Sunday in April and ends last Sunday in October.

Appendix 3[20]

The dollar value of a 0.01% change in yield does not remain constant but rather varies in accordance with changes in the underlying interest rate. Accordingly, to establish what the dollar value of a futures tick will be at a given price, the following calculations are made:

1. Use the contract valuation formula to calculate the underlying value of the contract at the nominated futures price.
2. Apply the same formula to that same futures price minus 0.01(i.e. increase the yield by 0.01%).
3. The difference between the two contract values represents the dollar value of the tick at the nominated futures price.

For example, to determine the dollar value of a 0.01% change in yield on a 10-Year Bond contract trading at a price of 94.360 (i.e. A yield of 5.64%), the following calculations are performed.

1. Futures contract value at 94.360 (5.64%) = $102,723.06023
2. Futures contract value at 94.350 (5.65%) = $102,646.18658
3. Difference (Value of 0.01% of premium) = **$76.87365**

To determine the dollar value of a 0.01% change in yield on a 3-Year Bond contract trading at a price of 94.76 (i.e. a yield of 5.24%), the following calculations are performed.

1. Futures contract value at 94.76 (4.25%) = $102,084.713790
2. Futures contract value at 94.75 (5.25%) = $102,056.939570
3. Difference (Value 0.01% of premium) = **$27.77422**

[20] Source: www.sfe.com.au