Modeling the Determinants of Swap Spreads

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The objective of this article is to investigate empirically the determinants of swap spreads in the Australian interest rate market. We introduce two innovations.

First, the regressions of determinants of the swap spread are run *jointly* for swap spreads of different terms to maturity. Second, as the curvature factor of the term structure of interest rates is a poor proxy to explain changes in the swap spread, we adopt a more rigorous approach to model volatility.

For example, we accommodate the time-varying volatility structure of swap spreads, enabling us to estimate the dynamic interdependence and volatility spillovers across different swap maturities. Specifically, we use a multivariate exponential generalized autoregressive conditional heteroscedasticity (EGARCH) model.[1]

An interest rate swap is an agreement between two parties to exchange a series of cash flows in the future without exchanging the underlying debts. In a simple fixed/floating-rate swap, one party promises to pay a fixed rate of interest (known as the *swap rate*), and the other party promises to pay a floating rate of interest, at each periodic interval over the life of the swap.

The interest payments are based on a predetermined notional principal. The fixed rate is agreed upon at the outset of the swap.[2] The floating rate is for a period of either three months or six months and is paid and reset at each settlement (or reset) date.[3]

The cash flow at each settlement date is the net amount. That is, the two parties do not exchange the full amounts of the interest rate payments; rather, a single payment is made to cover the net difference in the promised interest payments.

The market generally sets the swap rate above the par yield on a Treasury bond of the same maturity. This premium is called the *swap spread*. As noted by Brown, Harlow, and Smith [1994, endnote 2], in practice, the swap spread is the main pricing variable of an interest rate swap.

Swap spreads vary over time; that is, they are volatile. Changes in the swap spread and movements in Treasury bond yields can significantly affect the value of an ongoing swap position for both the market maker and the corporate end-users of the agreement (Brown, Harlow, and Smith [1994, p. 62]). Thus, it is important to understand the factors that determine swap spreads.

I. DETERMINANTS OF THE SWAP SPREAD

One of the main characteristics that distinguishes a swap contract from a bond contract is that, in a swap, the default risk between the counterparties is asymmetric. Participants in a swap periodically exchange interest payments based on notional amounts, but there is no exchange of principal either at the beginning or at the end of the term of the swap, as there is with a bond. Moreover, in a swap, both parties face some probability of default. In a default, the solvent party will recover only part (if any) of the replacement cost due from the defaulting party. If the solvent party has a payment due, it must pay the full replacement cost.

Sorensen and Bollier [1994] argue that since the credit risk faced by the two counterparties is asymmetric, it can be explained using an option pricing model. They argue that the pricing of default risk will depend on the current shape and the estimated volatility of the yield curve, because the shape and volatility of the curve will determine the option value embedded in the replacement cost of the swap. This option value can be determined by using a term structure model as a proxy for future interest paths.

Applying this model, the value of the option will depend on the expected forward interest rates, the volatility of forward interest rates, and the probability that the counterparty may default. For instance, if the current yield curve is upward-sloping, the future path of interest rates is likely to be rising; as a result, the option to pay fixed (i.e., receive floating) is more attractive than the option to receive fixed (i.e., pay floating).

The presence of default risk, however, implies that the fixed-rate payer may not receive the later (increasing) floating payments. To reflect this risk, a lower fixed rate is set, thus causing the swap spread to narrow. Conversely, if the current yield curve is downward-sloping, the value of the option to receive fixed will be higher than the value of the option to pay fixed. To compensate for the default risk of the fixed-rate payer, the fixed-rate receiver will require a higher fixed rate, hence causing the swap spread to widen.

To sum it up, a higher (lower) option value of paying fixed is reflected in a narrow (wider) fixed rate, causing the swap spread to narrow (widen). Therefore, in the Sorensen-Bollier model, it is hypothesized that the swap spread will be negatively related to the slope of the term structure.

The opposite hypothesis is developed by Brown, Harlow, and Smith [1994] in a pure expectations equilibrium model. Such a model has two important implications. First, the swap rate will equal the expected average future value of the floating rate. Second, the expected yield on a sequence of one-period discount securities (such as Treasury bills) will equal the yield on the zero-coupon security with a term equal to that of the sequence.

Combining these two implications, together with definitions of various spreads, Brown, Harlow, and Smith show that the swap spread will depend, in part, on the difference between the yield on the zero-coupon bond and the yield on the coupon-paying bond of the same term. It is well known that this difference is positive (negative) when the yield curve slopes upward (downward). Therefore, the swap spread will be positively related to the slope of the term structure.

This prediction is the opposite of the Sorensen-Bollier model. Choosing between the two models is therefore in part an empirical issue.

Sorensen and Bollier [1994] further point out that interest rate volatility causes the value of both options to increase by equal amounts if their credit ratings are equal. In reality, however, swaps are likely to be used to lower the fixed-rate cost by the firm with the lower credit quality (Bicksler and Chen [1986]). Hence, if the volatility increases, the value of the option for the higher-credit quality firm (as a fixed-rate receiver) will increase. To compensate for this increase, the higher-credit quality firm will demand a higher fixed rate, causing the swap spread to widen.

Another possible explanation is that as interest rates become more volatile, the demand to hedge interest rate exposure using derivatives will increase as well, thus increasing the demand for swaps. The rising demand for "fixing" the interest rate using swaps will in turn push swap rates higher, causing the spread to increase.

Eom, Subrahmanyam, and Uno [2002] use term structure curvature as a proxy for interest rate volatility. To measure curvature, they first calculate the simple average of the long-term (ten-year) interest rate and the short-term (three-month) interest rate. They then calculate the difference between this average and the one-year interest rate. They find that yen swap spreads are positively related to the curvature factor.

Term structure curvature is a fairly crude approach to measuring interest rate volatility. Even if interest rate volatility is constant, the details of the relationship between curvature and volatility are unclear. To take a special but instructive case, a flat term structure has zero curvature, but this does not imply that market participants expect zero interest rate volatility. Moreover, interest rate volatility is unlikely to be constant. In this event, it is also unlikely that the volatility of the swap spread would be constant. We therefore hypothesize that curvature may not be a significant determinant of the swap spread and that the volatility of the swap spread may change over time.

In addition to the slope and curvature factors, some studies have found that the level of interest rates also has some impact on swap rates. Dai and Singleton [2000] find that the level, slope, and curvature are significant explanatory factors for dollar swap rates. Eom, Subrahmanyam, and Uno [2002] find that yen swap spreads are negatively related to a proxy for the level of interest rates. Similarly, Duffee [1998] finds that changes in corporate bond yield spreads are negatively related to changes in the yield on three-month Treasury bills.

Brown, Harlow, and Smith's [1994] model also predicts that the swap spread should depend (in part) on the anticipated average value of the future spread between LIBOR and the Treasury bill rate. This spread is referred to as the TED spread, as it is a measure of the gap between Treasury and Eurodollar interest rates. Eom, Subrahmanyam, and Uno [2002] regard the TED spread as a measure of the short-term default risk.

In addition, the swap spread may be influenced by the long-term credit spread, as measured by the difference between yields on corporate bonds and yields on Treasury bonds. Brown, Harlow, and Smith [1994, pp. 65-66] illustrate this argument using an example in which firms A and B can each issue short-term debt or long-term debt.

If short-term (one-period) debt is issued, the interest rate is equal to *LIBOR* (a proxy for the floating-rate indicator) plus *CQS*, where *CQS* is the credit quality spread for short-term debt. If long-term (*N*-period) debt is issued, the interest rate is equal to T_N (the Treasury bond rate) plus BS_N, where BS_N is the credit quality spread for long-term debt (the bond spread).

Assuming that firms A and B face the same costs of funds, then, in a pure expectations market, the expected cost of floating-rate funds over N periods will equal the known fixed-rate cost of funds:

$$E_N(LIBOR) + E_N(CQS) = T_N + BS_N$$

Under the pure expectations hypothesis, $E_N(LIBOR)$ will equal T_N plus the swap spread SS_N. Therefore, the equation can be rearranged to give:

$$SS_N = BS_N - E_N(CQS)$$

where $E_N(CQS)$ denotes the expectation of future credit quality spreads over *N* periods.

In equilibrium, this means that in the absence of an arbitrage opportunity, the swap spread should be significantly influenced by the default risk premiums for short-term debt (the TED spread) and for long-term debt (the bond spread). In their empirical study, however, Brown, Harlow, and Smith [1994] find that, although significant, the expected TED spread does not offer a powerful explanation of how swap spreads change.

They also try to test the default risk model by regressing swap spreads against the comparable bond spreads over the par Treasury yields. Their regression results show that there is a significant positive correlation between swap spreads and bond spreads. Eom, Subrahmanyam, and Uno [2002] find a significant positive relationship between the swap spread and the TED spread.

Minton [1997] finds that swap rates are related to proxies for the shape of the yield curve and par corporate bond yields. Her study, however, shows that the latter relationship is not quite one-to-one. She attributes this lack of perfect correspondence to the difference in contractual features of swaps and corporate bonds. Unlike counterparties in bonds, counterparties in swaps exchange only the net amount of the interest rate obligation, and not the full interest rate and principal amounts. Therefore, the default risk in a swap transaction should be lower than that in the corporate bond market. Finally, she finds that swap rates are positively related to short-term interest rate volatility, suggesting that swap rates include an option-like premium to default.

Lang, Litzenberger, and Liu [1998] analyze the relationship between default risk premiums and swap spreads. Their findings show that both lower and higher rating bond spreads have a positive impact on swap spreads. Furthermore, they find that the movement in swap spreads is less volatile than the movement in the single A-rated bond spread.[4]

Finally, liquidity may also play a part in determining the swap spread. While most financial markets in Australia are well developed, they are generally not as liquid as, say, the U.S. and U.K. markets. For example, as suggested by Brailsford and Heaney [1998, p. 93], it is well known that many stocks in the Australian market are subject to thin trading.

While it is generally believed that the Australian swap market is liquid, this feature has not been the subject of academic research. Moreover, it has been suggested by Montague [1997, p. 387] that liquidity in the Australian swap market declines significantly for maturities beyond three years. Therefore, it is possible that liquidity may play a role in the pricing of swaps, particularly where the swap is long-term. If liquidity in the swap market is inadequate, swap rates will be higher.

A standard measure of liquidity is the extent of the bid-ask spread. Therefore, if liquidity in the swap market increases, both the bid-ask spread and the swap spread should narrow.

Our empirical hypotheses are as follows:

1. Changes in the interest rate swap spread and changes in the slope of the term structure of interest rates may be positively or negatively related.
2. The curvature factor of the term structure of interest rates is a poor proxy in explaining the volatility of interest rates in modeling the swap spread.
3. A multivariate EGARCH approach to modeling will capture the time-varying nature of swap spread volatility.
4. Changes in the interest rate swap spread and changes in the level of the term structure of interest rates are negatively related.
5. Changes in the interest rate swap spread and changes in short-term and long-term credit spreads are positively related.
6. Changes in the interest rate swap spread and changes in the swap bid-ask spread are positively related.

II. EMPIRICAL MODEL

A regression equation for the spread on an *i*-year swap could be:

$$\begin{aligned}\Delta Swapspread_t = \beta_0 + \beta_1\, \Delta Slope_t + \beta_2 \Delta Curv_t + \\ \beta_3 \Delta TN_t + \beta_4 \Delta TEDS_t + \\ \beta_5 \Delta AASP_t \;+\; \beta_6 \Delta BidAsk_t + \varepsilon_t\end{aligned} \tag{1}$$

where:

$\Delta Swapspread_t$ is the change in the *i*-year swap spread between day $t-1$ and day t;

$\Delta Slope_t$ is the proxy variable for the change of slope of the Treasury spot curve measured by the difference between the yield on an *i*-year Treasury bond and the yield on a 13-week Treasury note;

$\Delta Curve_t$ is the curvature variable as measured by Eom, Subrahmanyam, and Uno [2002], included because of its connection to interest rate volatility;

ΔTN_t is the change in the three-month Treasury note rate between $t-1$ and t; this is a proxy for the change in the level of the short-term default-free interest rate;

$\Delta TEDS_t$ is the proxy variable for the short-term default premium, defined as the change in spread between the 90-day bank bill rate and the 13-week Treasury note rate;

$\Delta AASP_t$ is the proxy variable for the bond credit spread (i.e., the long-term default premium), defined as the change in the spread between the yield on a long-term AA-rated corporate bond and the comparable Treasury yield; and

$\Delta BidAsk_t$ is the proxy variable for the liquidity factor, defined as the change in bid-ask spread in the *i*-year swap market.

To investigate the determinants of interest rate swap spreads and to provide further insights into the movement of swap spreads, we extend Equation (1) by incorporating a multivariate EGARCH specification—see Deb [1996], Lee and Brorsen [1997], and St. Pierre [1998]. The multivariate EGARCH methodology is adopted for several reasons.

First, multivariate EGARCH modeling will capture the time-varying nature of swap spread volatility and provide evidence on the volatility transmission mechanism. Unlike univariate GARCH models, EGARCH models permit volatility interactions to be *fully* investigated and analyzed in a one-step estimation procedure.

Second, the hypothesis that innovation within and across different swap spreads influences volatility *asymmetrically* can be explicitly tested.

Third, the EGARCH approach offers particular advantages in testing some important empirical hypotheses. For example, the model allows us to test *simultaneously* possible swap spread determinants such as the term structure of interest rates, credit risk, and liquidity factors. It also allows us to test our conjecture that curvature may be an inadequate way of capturing interest rate volatility by estimating the full multivariate EGARCH model *with* and *without* this variable.

The multivariate EGARCH model can be written as follows:

$$\begin{aligned}\Delta Swapspread_{i,t} = \beta_{i,0} + \beta_{i,1}\Delta Slope_{i,t} + \beta_{i,2}\Delta TN_t + \\ \beta_{i,3}\Delta TEDS_t + \beta_{i,4}\Delta AASP_t + \\ \beta_{i,5}\Delta BidAsk_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{2}$$

$$\sigma_{i,t}^2 = \exp\left\{\alpha_{i,0} + \sum_{j=1}^{3} \alpha_{i,j} f(Z_{j,t-1}) + \gamma_i \ln(\sigma_{i,t-1}^2)\right\} \quad \text{for } i,\ j\ = 1,\ 2,\ 3 \tag{3}$$

$$f(Z_{j,t-1}) = \left(|\,Z_{j,t-1}\,| - E(|\,Z_{j,t-1}\,|) + \delta_j Z_{j,t-1}\right) \quad \text{for } j\ = 1,\ 2,\ 3 \tag{4}$$

$$\sigma_{i,j,t} = \rho_{i,j}\sigma_{i,t}\sigma_{j,t} \quad \text{for } i,\ j\ = 1,\ 2,\ 3, \text{ and } i \neq j \tag{5}$$

where $\Delta Swapspread_{it}$ is the swap spread on day t for swap maturities $i = 1, 2, 3$. For example, in this study, 1, 2, and 3 refer, respectively, to swaps with maturities of three, five, and ten years. The terms $\sigma_{i,t}^2$ and $\sigma_{i,j,t}$ are, respectively, the conditional variance and the conditional covariance between a spread i and a spread j; $\varepsilon_{i,t}$ is the innovation at time t; and $Z_{i,t}$ is the standardized innovation (i.e., $Z_{i,t} = \varepsilon_{i,t}/\sigma_{i,t}$).

Similar to Equation (1), Equation (2) describes the daily change in swap spreads as a function of daily changes in: the slope of the term structure ($\Delta Slope_{i,t}$), the level of interest rates (ΔTN_t), the short-term default premium ($\Delta TEDS_t$), the long-term default premium ($\Delta AASP_t$) and a liquidity factor ($\Delta BidAsk_{i,t}$). We have omitted from Equation (2) the change in term structure curvature ($\Delta Curve_t$) that is included in Equation (1) as a proxy for volatility. This is motivated by a desire to test the hypothesis that the curvature factor of the term structure of interest rates is a poor proxy in explaining the volatility of interest rates in modeling the swap spread.

Equation (3) explains the EGARCH representation of the variance of $\varepsilon_{i,t}$. According to the EGARCH representation, the conditional variance of the swap spread for a given maturity is an exponential function of past own cross-swap maturity standardized innovations and past own conditional variance. The persistence of volatility is measured by γ_i in Equation (3). The unconditional variance is finite if $\gamma_i < 1$. If $\gamma_i = 1$, then the unconditional variance does not exist, and the conditional variance follows an integrated process of order one.

Equation (4), which captures the ARCH effect, is an asymmetric function of past standardized innovations, and measures both the magnitude effect and the sign effect. For example, the term $|\,Z_{j,t-1}| - E(|\,Z_{j,t-1}|)$ measures the magnitude effect. If $Z_{j,t-1}$ is greater than its expected value, $E(|\,Z_{j,t-1}|)$, then the impact of $Z_{j,t-1}$ on $\sigma_{i,t}^2$ will be positive, provided that $\alpha_{i,j}$ is positive.

The term $\delta_j Z_{j,t-1}$ in Equation (4) measures the sign effect. For example, if δ_j is negative, then reductions in the swap spread ($Z_{j,t-1} < 0$) will be followed by higher volatility than increases in the swap spread ($Z_{j,t-1} > 0$). Thus the parameter δ_j measures the asymmetric volatility transmission mechanism. For example, if $\delta_j = 0$, a positive shock has the same effect as a negative shock of the same magnitude, but if $-1 < \delta_j < 0$, a negative shock (i.e., an unexpected drop in the swap spread) increases volatility more than a positive shock. If $\delta_j < -1$, then a negative shock actually increases volatility, while a positive shock actually reduces volatility.

Equation (5) provides the conditional covariance specification, which captures the contemporaneous relationship between the swap spreads of the three different maturities investigated. This specification implies that the covariance is proportional to the product of the standard deviations. The coefficient $\rho_{i,j}$ is the cross-correlation coefficient of the standardized residuals between two maturities. Statistically significant estimates of $\rho_{i,j}$ indicate that time-varying volatilities across maturities i and j are correlated over time. This assumption greatly simplifies estimation of the model and is plausible for many applications (see Bollerslev, Chou, and Kroner [1992]). Even with this simplification, there are 39 parameters to be estimated.

Under the conditional normality assumption and with a sample of T observations, the log-likelihood function for the multivariate EGARCH model is:

$$L(\theta) = -0.5(NT)\ln(2\pi) - 0.5\Sigma\left(\ln\left|S_t\right| + \varepsilon_t' S_t^{-1}\varepsilon_t\right)$$

where θ is the 39×1 parameter vector to be estimated; N is the number of equations (three in this case); T is the number of observations; S_t is the 3×3 time-varying conditional variance-covariance matrix with diagonal elements given by Equation (3) for $i = 1, 2, 3$ and cross-diagonal elements given by Equation (5) for $i, j = 1, 2, 3$, and $i \neq j$; and $\varepsilon_t' = [\varepsilon_{1,t}, \varepsilon_{2,t}, \varepsilon_{3,t}]$ is the 1×3 vector of innovations at time t. The log-likelihood function is highly non-linear in θ, so numerical maximization techniques have to be used. The BHHH algorithm is used to maximize $L(\theta)$ (see Berndt, Hall, Hall, and Hausman [1974]).

III. DATA AND EMPIRICAL RESULTS

We use Australian daily closing data for the period October 12, 1994, through December 31, 1999, giving a sample size of 1,323 observations for each swap maturity. Some of the data series were collected from Datastream (DS), and others were kindly provided by the Reserve Bank of Australia (RBA). Swap spreads are calculated using swap rates (from DS) and Treasury bond yields (from RBA) for maturities of three, five, and ten years.[5]

The swap spread is calculated by subtracting from the swap rate the Treasury bond yield rate for the same maturity. Data on the daily closing bid-ask swap spread for each maturity (from DS) are used to proxy for the liquidity factor.

Default risk at the long end of the term structure is measured by the difference between the yield on AA-rated bonds issued by the Commonwealth Bank of Australia (from DS) and the corresponding Treasury bond yield. Default risk at the short end of the term structure is measured by the difference between the 90-day bank bill rate (from DS) and the 13-week Treasury note rate (from RBA).

We detected 15 outliers in the spread series. These outliers are handled using the four-day moving average method.[6]

To establish the time series properties of each series, we calculate the augmented Dickey-Fuller (ADF) unit root test statistic and the Park-Choi (PC) unit root test for each of the 20 series: three maturities for each of the Treasury bond rate, the swap rate, the swap spread, the term structure slope, and the bid-ask spread; plus the bank bill rate, Treasury note rate, curvature, TED spread, and AA-spread. These statistics are presented in Exhibit 1.

Exhibit 2 provides the results for the ordinary least squares estimation of Equation (1), run separately for each swap maturity. The results are generally significant for all variables, with the exception of the coefficient (β_2) of the curvature variable. This tends to confirm our conjecture that the curvature variable may not adequately capture interest rate volatility.

The results of the EGARCH modeling are set out in Exhibit 3 (for the model including the curvature variable) and Exhibit 4 (for the model without the curvature variable).

Term Structure

Focusing first on the slope of the term structure, the estimated coefficients $\beta_{i,1}$ are statistically significant and negatively related to swap spreads across all maturities. This result is found whether the curvature variable is included (Exhibit 3) or excluded (Exhibit 4).

Therefore, our results support the hypothesis that the interest rate swap spread and the slope of the term structure of interest rates are negatively related. That is, we conclude that the swap spread narrows when the slope of the spot curve becomes steeper and widens when the slope flattens.

Volatility

The second and third hypotheses concern volatility. Consistent with our conjecture, Exhibit 3 shows that coefficient ($\beta_{i,2}$) of the curvature variable is not statistically significant for swap maturities of three, five, or ten years. As can be seen in Exhibit 4, however, the EGARCH modeling has clearly captured the characteristics of swap spread volatility. The relevant coefficients of the volatility effect and volatility persistence are all statistically significant.

The second-moment interdependence (volatility interaction) coefficients, $\alpha_{i,j}$, capture the degree of the volatility interactions as well as measure the influence of own-volatility. In general, the conditional variance in each swap spread is largely affected by its own past innovations (for example, in Exhibit 3 $\alpha_{1,1} = 0.277$, $\alpha_{2,2} = 0.147$, and $\alpha_{3,3} = 0.238$). Seven of nine $\alpha_{i,j}$ coefficients are statistically significant in the model *with* curvature (Exhibit 3) while nine of nine coefficients are statistically significant in the model *without* curvature (Exhibit 4), and the coefficients are relatively large in own past innovations for both models.

The asymmetric effects, measured by δ_i, are statistically significant in both Exhibits 3 and 4 for three- and five-year swaps but not for ten-year swaps.

As shown in Panel A of Exhibit 4, the degree of volatility persistence (measured by γ_i) is fairly strong, and all estimated coefficients are statistically significant. They range from 0.239 to 0.765. In both models (Exhibits 3 and 4), the persistence of volatility is highest for five-year swaps, followed by three-year swaps. The estimates of correlation in the volatility of the three swap spreads, $\rho_{i,j}$, are highest between five- and ten-year swaps, followed by three- and five-year swaps.

Overall, the results of diagnostic tests reported in Panel B of Exhibit 4 are better than those of Exhibit 3, especially in the LB(10) test. Panel C of each Exhibit provides the correlation coefficients of the standardized residuals. In both models, the strongest correlation is observed between the five-year spread and the ten-year spread, followed by the correlation between the three-year spread and the five-year spread. Moreover, for any given spread, the correlation lessens as the maturity gap between the two spreads increases.

EXHIBIT 1
Unit Root Tests: Augmented Dickey-Fuller (ADF) and Park-Choi (PC) Statistics

Panel A: Treasury Bond

		3-Year Bond	5-Year Bond	10-Year Bond
ADF	Level	−0.761	−0.585	−0.588
	Difference	−17.426	−17.520	−17.505
PC	Level	2.522	3.032	3.566
	Difference	0.003	0.004	0.003

Panel B: Swap Rate

		3-Year Swap	5-Year Swap	10-Year Swap
ADF	Level	−0.611	−0.561	−1.110
	Difference	−17.368	−17.370	−17.545
PC	Level	2.720	3.360	3.490
	Difference	0.003	0.002	0.002

Panel C: Swap Spread

		3-Year Spread	5-Year Spread	10-Year Spread
ADF	Level	−8.754	−11.142	−9.615
	Difference	−18.698	−23.583	−23.051
PC	Level	0.048	0.128	0.206
	Difference	0.001	0.001	0.000

Panel D: Slope

		3-Year Slope	5-Year Slope	10-Year Slope
ADF	Level	0.558	−3.512	−3.602
	Difference	−6.013	−21.479	−19.408
PC	Level	0.176	0.906	1.026
	Difference	0.001	0.001	0.001

Panel E: Bid-Ask Spread

		3-Year Bid-Ask	5-Year Bid-Ask	10-Year Bid-Ask
ADF	Level	−4.714	−6.555	−5.760
	Difference	−25.923	−23.934	−24.292
PC	Level	1.122	0.357	0.818
	Difference	0.000	0.000	0.000

Panel F: Bank Bill, Treasury Note, Curvature, TED Spread and AA Spread

		Bank Bill	Treasury Note	Curvature	TEDS	AA Spread
ADF	Level	−1.952	−2.239	−2.007	−4.874	−3.167
	Difference	−16.657	−15.978	−14.213	−20.842	−23.468
PC	Level	2.512	2.650	0.266	0.204	0.890
	Difference	0.015	0.017	0.004	0.001	0.002

Notes: The critical values of the ADF test are −3.41 (−3.96) at the 5% (1%) significance level. The critical values of the PC test are 0.295 (0.12) at the 5% (1%) significance level.

Exhibit 2
Ordinary Least Square Estimates for Swap Spread Model with Curvature

	3-Year Spread	5-Year Spread	10-Year Spread
β_0	–0.001	–0.002	–0.002
	(0.002)	(0.002)	(0.002)
β_1	–0.953*	–1.012*	–0.988*
	(0.024)	(0.025)	(0.027)
β_2	0.061	0.059	-0.036
	(0.042)	(0.042)	(0.046)
β_3	–0.207*	–0.330*	–0.472*
	(0.052)	(0.053)	(0.058)
β_4	0.620*	0.716*	0.517*
	(0.064)	(0.065)	(0.071)
β_5	–0.342*	–0.527*	–0.557*
	(0.042)	(0.043)	(0.047)
β_6	0.109	0.158	0.052
	(0.149)	(0.173)	(0.148)

$$\Delta Swapspread_t = \beta_0 + \beta_1 \Delta Slope_t + \beta_2 \Delta Curv_t + \beta_3 \Delta TN_t + \beta_4 \Delta TEDS_t + \beta_5 \Delta AASP_t + \beta_6 \Delta BidAsk_t + \varepsilon_t$$

*The standard errors are in parentheses. *Indicates significance at 5% level.*
Note that all coefficients of the curvature variable, (β_2), are insignificant at the 5% level.

Level of Interest Rates

The fourth hypothesis is that the swap spread is negatively related to the level of interest rates. The evidence on this hypothesis is clear. The estimates of the coefficients $\beta_{i,3}$ (in Exhibit 3) and $\beta_{i,2}$ (in Exhibit 4) are negative and statistically significant for all maturities. This result indicates that changes in the 13-week Treasury note rate (a proxy for the level of interest rates) have a significant negative impact on changes in swap spreads.

We conclude that the evidence supports the hypothesis.

Credit Spread Changes

For the fifth hypothesis, we find that credit spreads are an important source of variation in Australian swap spreads. In Exhibits 3 and 4, the coefficients of credit risk factors are significant in all swap spreads across the different maturities.

All six of the coefficients on the short-term (*TEDS*) and long-term (*AASP*) credit spread variables are statistically significant. While the coefficient on *TEDS* has the expected (positive) sign, the coefficient on *AASP* is negative.

Market Liquidity

The sixth hypothesis concerns the possible influence of swap market liquidity, as proxied by the bid-ask spread. It is found that all coefficients on the bid-ask spread are insignificant in both models.

One interpretation of this result is that a change in the bid-ask spread is a poor proxy for a change in liquidity. Another interpretation is that the Australian swap market is sufficiently liquid in all maturities to preclude liquidity as an issue in pricing swaps.

IV. CONCLUDING REMARKS

We use a multivariate EGARCH model to investigate the determinants of swap spreads in the Australian interest rate market. The swap spread is found to be influenced negatively by the slope of the default-free interest rate term structure and by the level of default-free interest rates. Term structure curvature does not contribute to the explanation of the swap spread.

One of the main empirical findings is that the full multivariate EGARCH model *without* the curvature variable comprehensively captures the volatility of the swap

EXHIBIT 3

Multivariate EGARCH Model for Swap Spread with Curvature

Panel A: Maximum-Likelihood Estimates

	3-Year Spread		5-Year Spread		10-Year Spread
$\beta_{1,0}$	−0.005*	$\beta_{2,0}$	0.001	$\beta_{3,0}$	0.000
	(0.002)		(0.002)		(0.002)
$\beta_{1,1}$	−1.016*	$\beta_{2,1}$	−1.064*	$\beta_{3,1}$	−1.032*
	(0.022)		(0.019)		(0.018)
$\beta_{1,2}$	0.010	$\beta_{2,2}$	−0.002	$\beta_{3,2}$	−0.016
	(0.034)		(0.022)		(0.018)
$\beta_{1,3}$	−0.256*	$\beta_{2,3}$	−0.226*	$\beta_{3,3}$	−0.490*
	(0.036)		(0.033)		(0.035)
$\beta_{1,4}$	1.013*	$\beta_{2,4}$	0.821*	$\beta_{3,4}$	0.469*
	(0.041)		(0.040)		(0.047)
$\beta_{1,5}$	−0.481*	$\beta_{2,5}$	−0.631*	$\beta_{3,5}$	−0.717*
	(0.038)		(0.030)		(0.024)
$\beta_{1,6}$	−0.208	$\beta_{2,6}$	−0.117	$\beta_{3,6}$	−0.155
	(0.141)		(0.161)		(0.092)
$\alpha_{1,0}$	−2.361*	$\alpha_{2,0}$	−1.277*	$\alpha_{3,0}$	−4.674*
	(0.236)		(0.131)		(0.078)
$\alpha_{1,1}$	0.277*	$\alpha_{2,1}$	0.134*	$\alpha_{3,1}$	0.028*
	(0.037)		(0.022)		(0.013)
$\alpha_{1,2}$	0.193*	$\alpha_{2,2}$	0.147*	$\alpha_{3,2}$	−0.029
	(0.035)		(0.015)		(0.019)
$\alpha_{1,3}$	0.157*	$\alpha_{2,3}$	-0.039	$\alpha_{3,3}$	0.238*
	(0.038)		(0.022)		(0.033)
δ_1	−0.595*	δ_2	0.720*	δ_3	0.112
	(0.136)		(0.109)		(0.078)
γ_1	0.571*	γ_2	0.782*	γ_3	0.189*
	(0.044)		(0.023)		(0.012)
$\rho_{1,2}$	0.469*	$\rho_{1,3}$	0.272*	$\rho_{2,3}$	0.459*
	(0.100)		(0.074)		(0.116)

*Standard errors are in parentheses. * indicates significance at the 5% level.*

Panel B: Diagnostic Tests for Standardized Innovations

	3-Year Spread	5-Year Spread	10-Year Spread
Mean	0.023	−0.039	−0.040
Variance	1.079	1.660	1.889
Skewness	−0.294	0.441	−0.928
Kurtosis	2.698	4.502	16.555
LB(10) for $Z_{i,t}$	44.832	15.209	9.986
	(0.000)	(0.033)	(0.189)
LB(10) for $Z^2_{i,t}$	32.267	13.428	2.083
	(0.000)	(0.062)	(0.955)

Significance levels in parentheses.

Panel C: Correlation Matrix for Standardized Innovations

	3-Year Spread	5-Year Spread	10-Year Spread
3-Year Spread	1.000	0.650	0.498
5-Year Spread		1.000	0.767
10-Year Spread			1.000

EXHIBIT 4
Multivariate EGARCH Model for Swap Spread without Curvature

Panel A: Maximum-Likelihood Estimates

3-Year Spread		5-Year Spread		10-Year Spread	
$\beta_{1,0}$	−0.002	$\beta_{2,0}$	0.003	$\beta_{3,0}$	0.001
	(0.002)		(0.001)		(0.001)
$\beta_{1,1}$	−0.997*	$\beta_{2,1}$	−1.038*	$\beta_{3,1}$	−1.004*
	(0.019)		(0.018)		(0.018)
$\beta_{1,2}$	−0.202*	$\beta_{2,2}$	−0.177*	$\beta_{3,2}$	−0.436*
	(0.029)		(0.032)		(0.032)
$\beta_{1,3}$	0.861*	$\beta_{2,3}$	0.834*	$\beta_{3,3}$	0.576*
	(0.040)		(0.039)		(0.030)
$\beta_{1,4}$	−0.347*	$\beta_{2,4}$	−0.462*	$\beta_{3,4}$	−0.572*
	(0.033)		(0.028)		(0.022)
$\beta_{1,5}$	−0.196	$\beta_{2,5}$	−0.164	$\beta_{3,5}$	−0.112
	(0.118)		(0.137)		(0.078)
$\alpha_{1,0}$	−2.647*	$\alpha_{2,0}$	−1.348*	$\alpha_{3,0}$	−4.269*
	(0.214)		(0.118)		(0.065)
$\alpha_{1,1}$	0.151*	$\alpha_{2,1}$	0.218*	$\alpha_{3,1}$	0.027*
	(0.011)		(0.026)		(0.011)
$\alpha_{1,2}$	0.266*	$\alpha_{2,2}$	0.274*	$\alpha_{3,2}$	−0.070*
	(0.037)		(0.026)		(0.018)
$\alpha_{1,3}$	0.148*	$\alpha_{2,3}$	−0.166*	$\alpha_{3,3}$	0.224*
	(0.032)		(0.034)		(0.031)
δ_1	−0.366*	δ_2	0.586*	δ_3	0.096
	(0.091)		(0.072)		(0.059)
γ_1	0.534*	γ_2	0.765*	γ_3	0.239*
	(0.039)		(0.021)		(0.011)
$\rho_{1,2}$	0.384*	$\rho_{1,3}$	0.368*	$\rho_{2,3}$	0.614*
	(0.110)		(0.078)		(0.126)

*Standard errors are in parentheses. * Indicates significance at 5% level.*

Panel B: Diagnostic Tests for Standardized Innovations

	3-Year Spread	5-Year Spread	10-Year Spread
Mean	−0.008	−0.054	−0.055
Variance	1.279	1.497	1.642
Skewness	−0.290	0.512	−0.837
Kurtosis	3.314	4.111	16.122
LB(10) for $Z_{i,t}$	51.376	10.445	9.030
	(0.000)	(0.165)	(0.251)
LB(10) for $Z^2_{i,t}$	62.522	9.198	2.301
	(0.000)	(0.239)	(0.941)

Significance levels in parentheses.

Panel C: Correlation Matrix for Standardized Innovations

	3-Year Spread	5-Year Spread	10-Year Spread
3-Year Spread	1.000	0.644	0.494
5-Year Spread		1.000	0.755
10-Year Spread			1.000

spread for all the maturities studied. In addition, we find significant volatility interactions among the three different swap spread maturities examined. The volatility transmission mechanism is highly persistent across all maturities.

Our empirical findings also suggest that both the short-term default premium and the long-term default premium have a significant impact on swap spreads, but we find no evidence that swap liquidity affects swap spreads.

Overall, these findings suggest that the Australian swap markets are integrated in the sense that instruments react not only to market conditions in their own maturity category but also to conditions in the other maturity categories. These results also support the importance of developing a better understanding of the nature of cross-swap market linkages and interactions.

ENDNOTES

[1]See Lee and Brorsen [1997]. This technique has been used before in the finance literature. See, for example, De Santis's [1991] study of stock returns and Brunner and Simon's [1996] study of U.S. interest rates.

[2]In Australia, the convention is to quote an all-in-cost for the fixed side of the swap. The floating side is usually the Bank Bill Swap Rate (BBSW). For further institutional details on the Australian market, see Hunt and Terry [1997, Ch. 18] or Montague [1997]. The international standard for the floating rate side is the London Inter Bank Offered Rate (LIBOR).

[3]In Australia, the settlement period is every three months for interest rate swaps with maturities of less than three years.

[4]Again, they attribute this finding to the higher credit risk of corporate bonds as compared to swaps.

[5]We considered including one-year swap spreads in the study but did not do so because of concerns about data comparability. The U.S. evidence of Amihud and Mendelson [1991], Warga [1992], and Daves and Ehrhardt [1993] suggests that liquidity differences can affect relative yields. Warga [1992] suggests that liquidity differences probably explain the marked differences between yields on recently issued (on-the-run) bonds and other bonds. During our sample period, under 5% of new bonds issued in Australia were for terms of shorter than three years, according to *Reserve Bank of Australia Bulletins*. Therefore, while many bonds with terms of three years or more would be on-the-run, virtually none of the observed one-year yields would be for on-the-run bonds.

[6]Outliers include one in the Treasury note/bank bill spread, two in the ten-year swap spread, and twelve in the five-year swap spread.

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