ESQUANT
Statistical Consulting

Estimating the Market Risk Premium

A REPORT FOR DBP

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ESQUANT STATISTICAL CONSULTING

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1 Executive Summary

The ERA (WA) have proposed that an estimate of the Market Risk Premium for the next five years should be 5.5%. They do so on the basis of the current and expected future levels of four forward indicators: The ASX 200 Volatility Index, the ASX 200 Dividend Yields, the 5 Year Interest Rate Swap Spread, and the Corporate Default Spread. They also form a composite index based on these variables, analysis of which leads them to this estimate of 5.5%.

The purpose of this report is to determine whether the driver variables the ERA has asserted are forward looking indicators for the MRP do in fact have this characteristic, and whether the composite index of these variables is indeed a good forward indicator of the market risk premium. If the index is not a good forward indicator, we examine whether other weighted versions of the same driver variables are preferable.

The time series available in the variables used by the ERA (WA) is very short, with the composite index only available from January 2007. Although the data are available on a daily basis, there is little advantage is analysing the daily series and instead the data is aggregated to a monthly series.

It is shown that the ERA composite variable is not co-integrated with the logarithm of the Market Index, and hence it is not possible to estimate a useful regression relationship. The only thing that can be done is to regress the log returns on the the changes in the composite variable. Such a relationship is not really useful for establishing long term predictions of the market risk premium because any prediction would not depend on the level of the composite variable. Additionally, fitting a vector auto regression model it can be shown that although the log returns are correlated with changes in the composite variable, the correlation is negative, that is increases in the composite variable are associated with decreases in the log returns. It can also be shown that while log market returns are predictive of future changes in the composite variable, changes in the composite variable are not predictive of future log returns. This means that the hypothesised forward-looking indicator is in fact, at best, a trailing indicator of market returns.

Similar results apply to an analysis of excess returns (that is, the return to the market minus the risk-free rate; what is often referred to as the market risk premium). Both sets of results, indicate, at least on the basis of the data at hand, that there is no established empirical relationship between the Market Risk Premium and the ERA composite variable. Accordingly, an estimate of the Market Risk Premium should not be based on the current or future levels of the ERA composite variable.

There is a single co-integrating relationship between the returns and excess returns and a linear combination of the four driver variables used by the ERA, which suggests it might be possible to form an index based on the ERA's hypothesised driver variables. However, despite both the returns and excess returns being correlated with this linear combination, the linear combination is not predictive of future values of the returns and excess returns and similarly the returns and excess returns are not predictive of future values of the linear combination.

2 Terms of Reference

The following terms of reference for the project were supplied by DBP.

> In its recent ATCO Draft Decision, the ERA has presented a novel methodology for the estimation of the market risk premium (pp 166-8). The approach involves the following:
>
> - Choosing four drivers which the ERA believes may describe the movement of the market risk premium.
> - "Normalising" these drivers so their movement is constrained to lie within the range of five to 7.5 percent.
> - Taking a weighted average of the movements of each driver within this range, with the weights chosen by regulatory judgement alone.

- Taking the mode of the weighted average as an indication of the most likely market risk premium.

DBP believes the approach of looking for drivers for the market risk premium and then using these to forecast it is a sound method, and that these four drivers may indeed be important in understanding movements in the MRP, but would like you to provide an empirical analysis of potential drivers of a variable, which addresses the following issues:

- The normalisation process constrains the variables to move within a fixed range, and thus they cannot discover any market risk premia outside this range by construction, even though, empirically, we understand the market risk premium has deviated outside these bounds on many occasions.
- There is no testing, either of whether the hypothesised drivers are actually associated with the movement of the variable, or whether the weights chosen by the ERA reflect the actual strength of any co-movement.
- The graph of the movement of the variables suggests a structural break around 2008, after which time the variables are much more volatile than previously, but the presence of such a break has not been tested for, nor its influence on inferences from the model considered.

We would like you to undertake an econometric estimation to understand whether these concerns above might change the value of the MRP the ERA has calculated. Thus, we would like you to:

- Regress the four driver variables on the market risk premium (market returns minus the five and ten year CGS; two separate regressions), taking all due care in respect of statistical issues such as stationarity, serial correlation, multicolinearity and heteroscedasticity, and provide a report on the robustness of these statistical estimates.
- Examine the regression for any structural breaks, and also examine Granger Causality between the dependent and independent variables (we are interested in understanding what drives what; if the MRP drives these variables rather than the other way around, then clearly they cannot be leading indicators of it).
- Use the coefficients to re-weight the weighted average the ERA has constructed; with the understanding that some (or indeed all) of the weights may be zero.

3 Acknowledgement

I have read, understood, and complied with the Federal Court of Australia Practice Note CM7, entitled ”Expert Witnesses in Proceedings in the Federal Court of Australia,” issued 3 June 2013, a copy of which is provided in Appendix A.

4 Introduction

In its recent ATCO Draft Decision, the ERA has presented a novel methodology for the estimation of the market risk premium (pp 166-8). The approach involves the following:

- Choosing four drivers which the ERA believes may describe the movement of the market risk premium.
- "Normalising" these drivers so their movement is constrained to lie within the range of five to 7.5 percent.
- Taking a weighted average of the movements of each driver within this range, with the weights chosen by regulatory judgement alone.
- Taking the mode of the weighted average as an indication of the most likely market risk premium.

In this report, I have used the same data that the ERA (WA) have used in the ATCO decision and evaluate whether the weighted average that the ERA (WA) has developed is predictive of the MRP. It should be noted that in attempting to estimate the MRP, the data is very limited in its extent. As indicated below, we only have daily data for the four driver variables since January 2007, which have been converted to monthly figures. The length of the data series used by the ERA (WA) is a severe limitation.

Other studies have used much longer series. For example, Hathaway (2005) has analysed data from 1875 to 2005. The longer time series allowed him to find trends in the data that could not be determined from shorter series. Similarly, NERA (2013) estimated the long-run historical average for the MRP, based upon earlier work by Brailsford, Handley Maheswaran (2012). This results in an MRP of 6.5 per cent,

The length of the series will also have an effect on the power of the statistical tests but also on what can be found. For example, as explained by Gibbard (2013), Fama and French (1988, p. 4), report that regressions of returns on yields explain less than 5% of monthly return variability, but the figure rises to more than 25% when two to four year returns are analysed, and later work on excess returns gives similar results (Fama and French, 1988, p.14).

The ERA (WA) has included four "forward-looking" indicators of market conditions over the next five years. These are.

VIX The ASX 200 Volatility Index (VIX). The VIX is available from January 2007[1].

DivYields ASX Dividend Yields. There are a number of possible (but related) dividend yield measures on the All Ordinaries. In this report I have used the ASA30 index, "EQY_DVD_YLD_12M". This index is available from June 1993.

IntRateSwap Interest Rate Swap Spread at 5 years. There were two possible versions considered, one based on the GACGB5 index over the 5 year CGS, and one using the C1275Y index over the 5 year CGS. It appears that the RBA is using the GACGB5 index and that is the one analysed in this report. This index is available from October 1998.

CorpDefaultSpread Corporate Default Spread. As indicated by the ERA (WA)

> "The default spread was calculated as the difference between the 5 year AA Australian corporate Bloomberg fair value curve and 5 year Commonwealth Government Bond index. These series are the most liquid, complete and up to date default spread measures available to the Authority and so are considered the most efficient reflection of market price movements." (ERA draft decision for ATCO Gas)

[1]The data for this and other indexes used in this report has been assembled with the kind assistance of Dr. Jeremy Rothfield of United Energy and Multinet Gas.

The 5 year AA fair value curve has not been published with a start data of June 1999, which what the chart from the ERA suggest. The start date for the BFVC series is 16th June 2000. The series is no longer available at a 5-year tenor after 24th May 2011. The BVAL curve for AA is available, at a 5-year tenor, from 18th June 2009 until the present.

Over the overlapping period, the BVAL index was higher than the BFVC series so some method of "splicing" the two series was needed. The difference between the two series was not constant. To determine when changes in the differences between the two series had occurred, the `breakpoints` (Zeileis, Kleiber, Kraemer, and Hornik, 2003) function in the **strucchange** package (Zeileis, Leisch, Hornik, and Kleiber, 2002) was used, implementing the procedure of Bai and Perron (2003). In this procedure, m breakpoints are chosen that minimises a penalised residual sum of squares of a model with $m+1$ segments, subject to the segments consisting of at least $h \times n$ observations, where n is the sample size, and the proportion h is a tuning parameter to be chosen by the user. According to Kleiber and Zeileis (2008, p.175), typical values of h are 10% or 15%. Using a value of 10%, the difference in the two series was estimated to be 0.79 over the earliest segment of the overlapping period. Accordingly, the spliced series consisted of the BFVC series plus 0.79 up to 17th June 2009, and the BVAL series from 18th June 2009. From this integrated series the yields on 5-year CGS were subtracted to form a Corporate Default Spread index. This index is then available from June 2000.

In addition, all variables were scaled. The ERA scaled the variables from 5 to 7.5; while I have scaled the variables from -0.5 to 0.5, i.e having a mean of 0 and a possible range of 1. This will have no effect on the results.

The composite variable, used by the ERA (WA) was calculated as

$$co1 = 0.1 * \text{VIXsc} + 0.3 * \text{DivYieldssc} + 0.3 * \text{IntRateSwap5yrsc} + 0.3 * \text{CorpDefaultSpreadsc}$$

Importantly, since the Volatility Index is only available from January 2007, the same applies to the Composite Index.

The dependent variable was the natural logarithm of the ASX Market Index, ASA30. Logarithms were used because log returns have more desirable properties than returns. A data set was formed by aggregating the results to monthly values. The log(MarketIndex) at the end of the month was taken, while for the other variables, the average over the month was used. The log returns were the difference in the logarithm of the Market Index. Analysis of weekly data was also initially performed, giving similar results to the monthly data analysis. On that basis, analysis of the daily data was judged not to be worthwhile.

5 Analysis of Monthly Returns vs ERA Composite Variable

5.1 Plots

Plots of the monthly data are given in Figures 1 to 7.

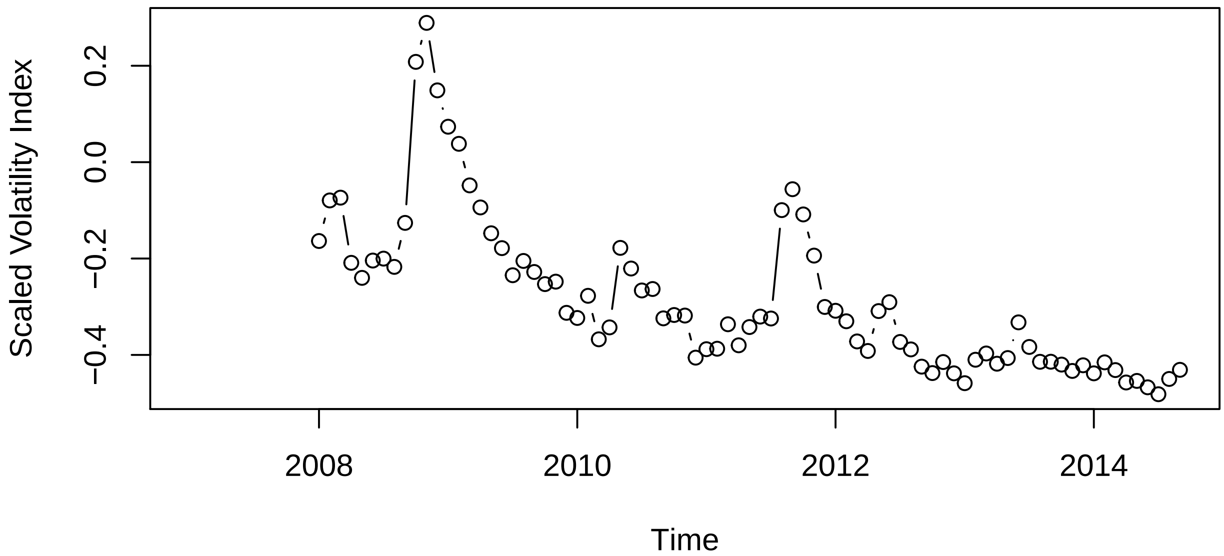

Figure 1: Time Series plot of Scaled (monthly) Volatility Index.

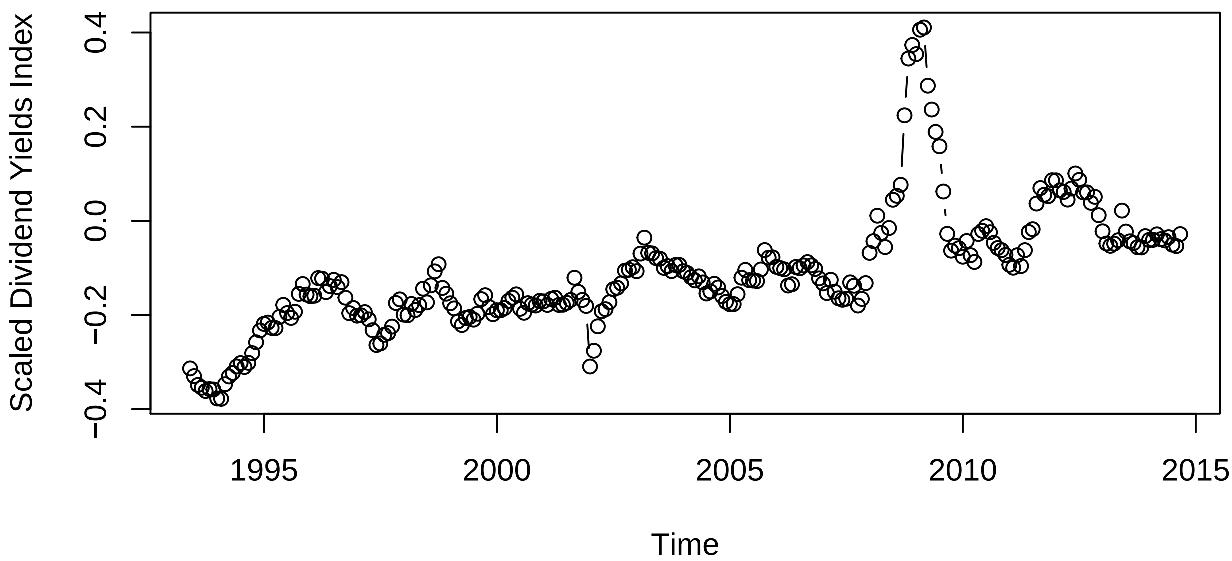

Figure 2: Time Series plot of Scaled (monthly) Dividend Yields Index.

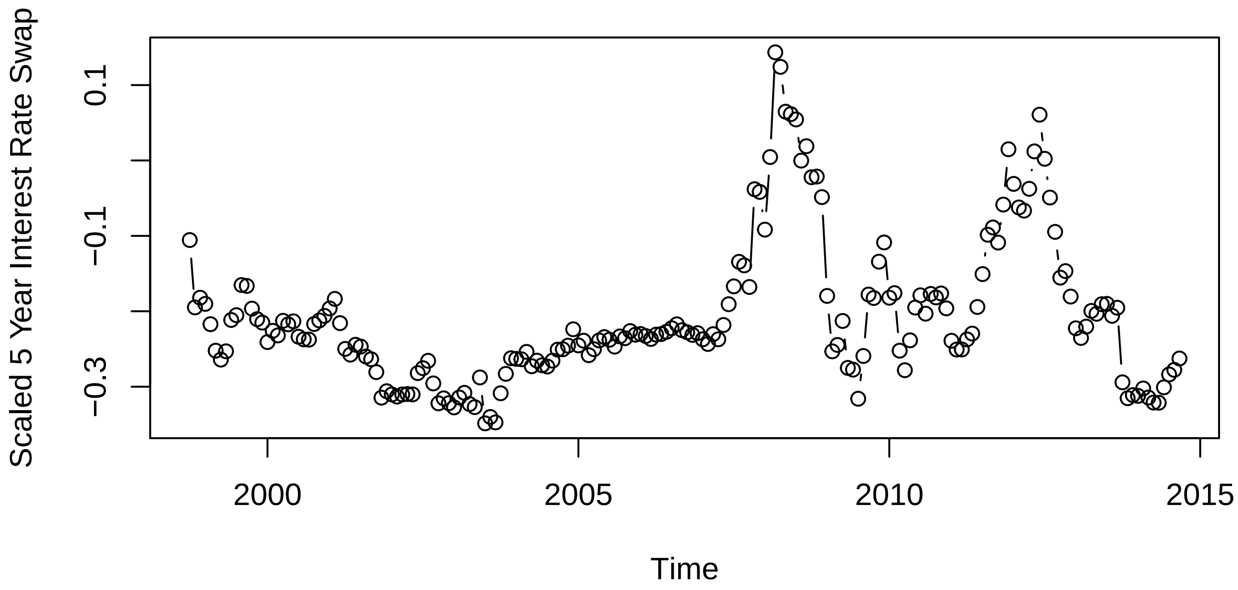

Figure 3: Time Series plot of Scaled (monthly) 5 Year Interest Rate Swap.

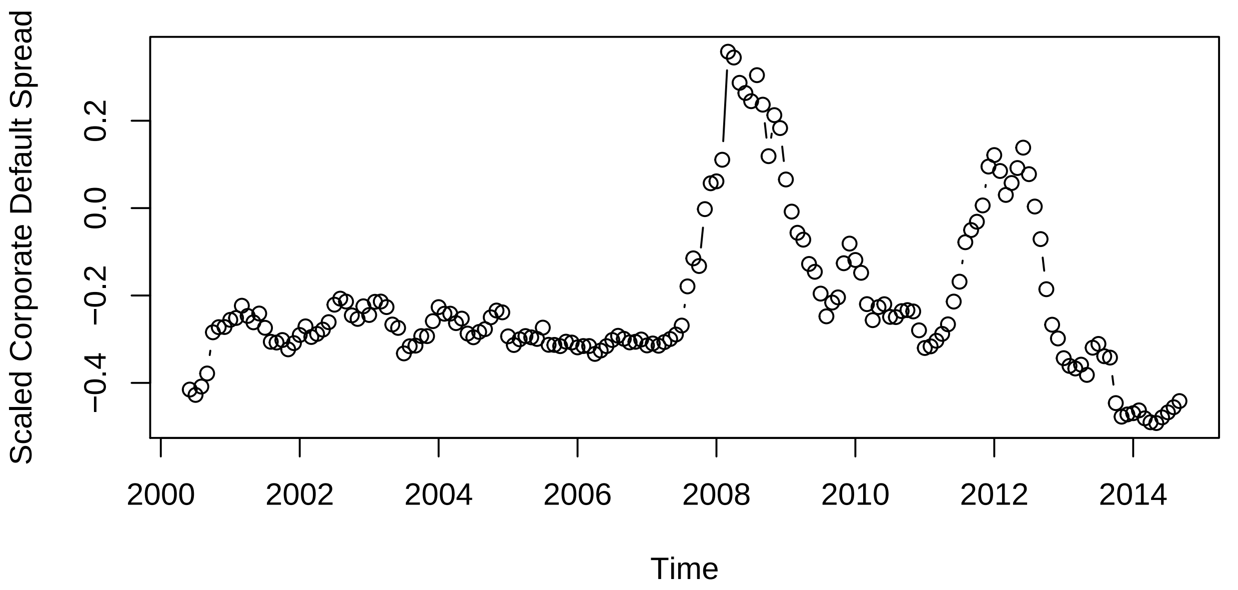

Figure 4: Time Series plot of Scaled (monthly) Corporate Default Spread.

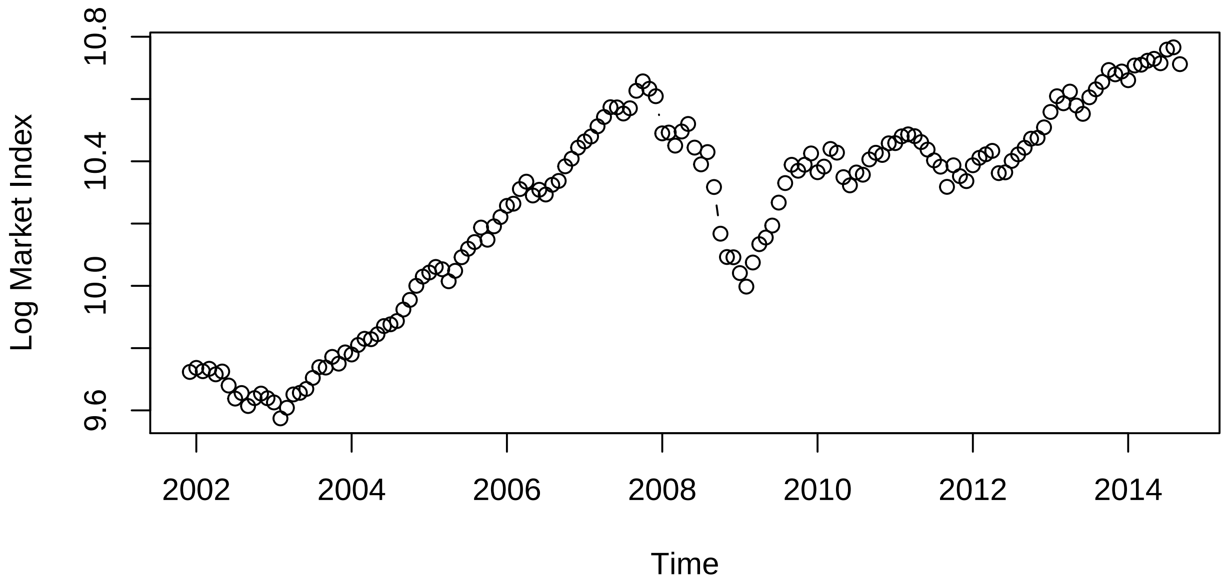

Figure 5: Time Series plot of Log Market Index.

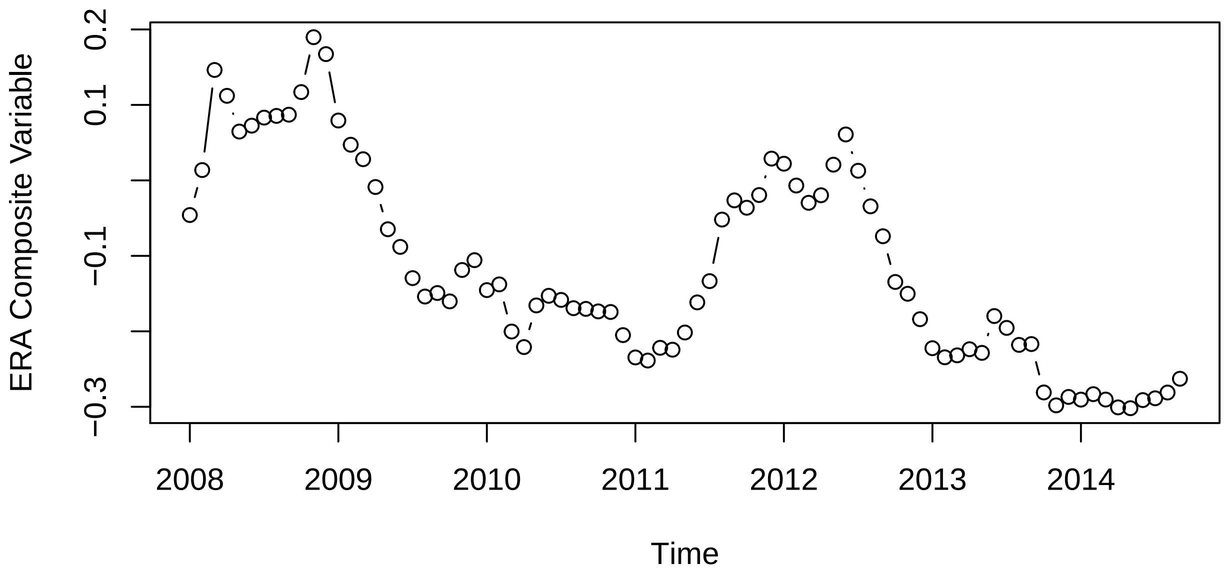

Figure 6: Time Series plot of ERA Composite Variable.

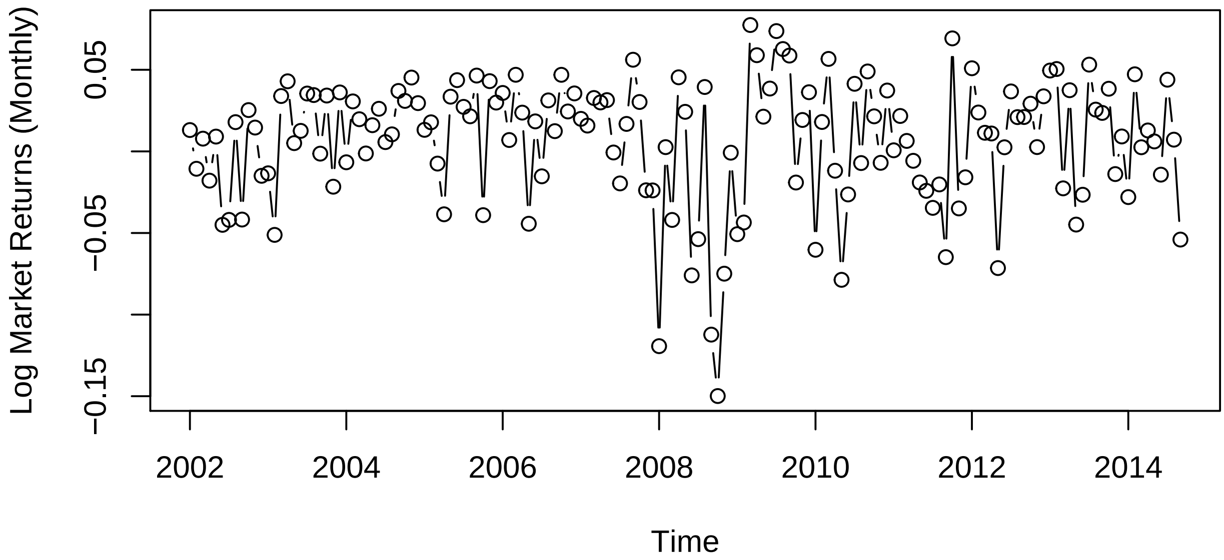

Figure 7: Time Series plot of Log Market Returns (Monthly).

5.2 Checking for Unit Roots

Before doing the regression analysis, it is important to check for unit roots, to prevent spurious regressions. Three tests for unit roots were used:

1. The KPSS test (Kwitkowski *et al.*, 1992) is based on testing for the presence of a random walk component r_t in the regression
$$y_t = d_t + r_t + \varepsilon_t$$
where d_t is a deterministic component, taken here to be a linear trend, and ε_t is stationary I(0) error process. The test was undertaken using the `kpss.test()` function in the R (R core team, 2014) package **tseries** (Trapletti 2008). The null hypothesis is that the random walk component is absent and hence the time series is stationary, while the alternative hypothesis is that the random walk component exists and hence the time series is non-stationary.

2. The Augmented Dickey-Fuller (ADF) test implements a $t-$test of $H_0 : \rho = 0$ in the regression
$$\Delta y_t = \alpha + \delta t + \rho y_{t-1} + \sum_{j=1}^{k} \phi_j \Delta y_{t-j} + \varepsilon_t.$$
The test was performed using the `adf.test()` function in the **tseries** package. The default number of lags,
$$k = \lfloor (n-1)^{1/3} \rfloor,$$
was used. Note that, in contrast to the KPSS test, the null hypothesis for the ADF test is that the time series is non-stationary, while the alternative hypothesis is that the series is stationary.

3. The Phillips-Perron test (with a time trend) (PP) is a variation of the Dickey-Fuller test employing a nonparameteric correction for autocorrelation. The test was undertaken using the `pp.test()` function in the **tseries** package. Similar to the ADF test, the null hypothesis for the PP test is that the time series is non-stationary, while the alternative hypothesis is that the series is stationary.

The results are given in Table 1. The differing null and alternative hypotheses for the kpss test compared to the ADF and PP tests can cause confusion in interpreting the p-values, so that the results of the hypothesis tests when testing at the 5% level are provided, with (NS) indicating non-stationarity and (S) indicating stationarity. Both kpss tests are statistically significant at the 1% level, and both sets of ADF and PP tests are not statistically significant.

	Log(MarketIndex)		ERA Composite	
kpss Trend	0.6437		0.2213	
Truncation lag parameter	2		2	
p-value	$p < 0.01$	(NS)	$p < 0.01$	(NS)
ADF test	-2.1527		-2.1488	
lag.order	5		4	
p-value	$p = 0.5127$	(NS)	$p = 0.5148$	(NS)
Phillips-Perron $Z(t\_alpha)$	-1.7895		-2.1817	
Truncation lag parameter	4		3	
p-value	$p = 0.6641$	(NS)	$p = 0.5013$	(NS)

Table 1: Tests for Stationarity/Unit Roots for the Monthly Data

Table 2 shows the stationarity tests for the differenced series. The `kpss.test()` values are now not statistically significant, while the ADF and PP tests are now statistically significant. Combined with the results of the non-differenced series, there is evidence that both the log(Market Index) and the ERA composite variable are I(1)[2].

[2] A time series is said to be I(1) when it has a unit root, but the difference is I(0), i.e. stationary.

	Δ(log(MarketIndex))		Δ(ERA Composite)	
kpss Level	0.1009		0.0805	
Truncation lag parameter	2		2	
p-value	$p > 0.1$	(S)	$p > 0.1$	(S)
ADF test	-4.3894		-3.0976	
lag.order	5		4	
p-value	$p < 0.01$	(S)	$p = 0.1263$	(S)
Phillips-Perron Z(alpha)	-130.8885		-48.2056	
Truncation lag parameter	4		3	
p-value	$p < 0.01$	(S)	$p < 0.01$	(S)

Table 2: Tests for Stationarity/Unit Roots for the differenced Monthly Data

5.3 Checking for Co-integration

Two series are co-integrated if they share a common time trend. This can be testing using the two-step procedure of Engle and Granger (1987). The test is performed by regressing one series on the other and then undertaking a unit root test of the residuals.

The hypothesis test is given by Phillips and Oularias (1990) and implemented using the `po.test()` function in the **tseries** package. As explained by Kleiber and Zeileis (2008, p.167), `po.test()` "performs a Phillips-Perron test using an auxiliary regression without a constant and linear trend and Newey-West estimator for the required long-run variance".

The `po.test` was applied to the log of the Market Index and the ERA composite variable. The de-meaned Phillips-Ouliaris test-statistic was -4.807 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the log of the Market Index on the ERA composite variable will be spurious[3] Figure 8 below reveals why the series are not cointegrated. For co-integration the residuals should be stationary over time. Clearly they are not with a visible trend over time.

5.4 Fitting a Vector Autoregression Model

Given that the two series are not co-integrated the next step is to difference both series, and as seen above both the differenced series are stationary. Unfortunately, that means that we cannot find a long run run relationship between the level of the Market Risk premium and the level of the composite variable, although it may be possible to find a relationship between changes in the Market Risk premium and changes in the level of the composite variable. If any such relationship exists, however, it will be a short term effect, not a long term effect and hence much less useful.

In this section we set

$$\begin{aligned} y_1 &= \Delta(\log(\text{Market Index})) \\ &= \log(\text{Market Returns}) \\ y_2 &= \Delta(\text{ERA Composite Index}) \end{aligned}$$

and fit a Vector autoregression model,

$$\mathbf{y}_t = A_1\mathbf{y}_{t-1} + \ldots + A_p\mathbf{y}_{t-p} + \mathbf{u}_t$$

with

$$\mathbf{y}_t = \begin{pmatrix} y_{1t} \\ y_{2t} \end{pmatrix}$$

using the `VAR()` function in the **vars** package (Pfaff, 2008).

[3] A regression is spurious if the error term is non-stationary (see, for example, Enders (2010) pp. 195-199. A spurious regression can have a high R^2 and t-statistics that appear to be significant, but the results are illusory because the least-squares estimates are not consistent and the usual tests of statistical significance do not hold.

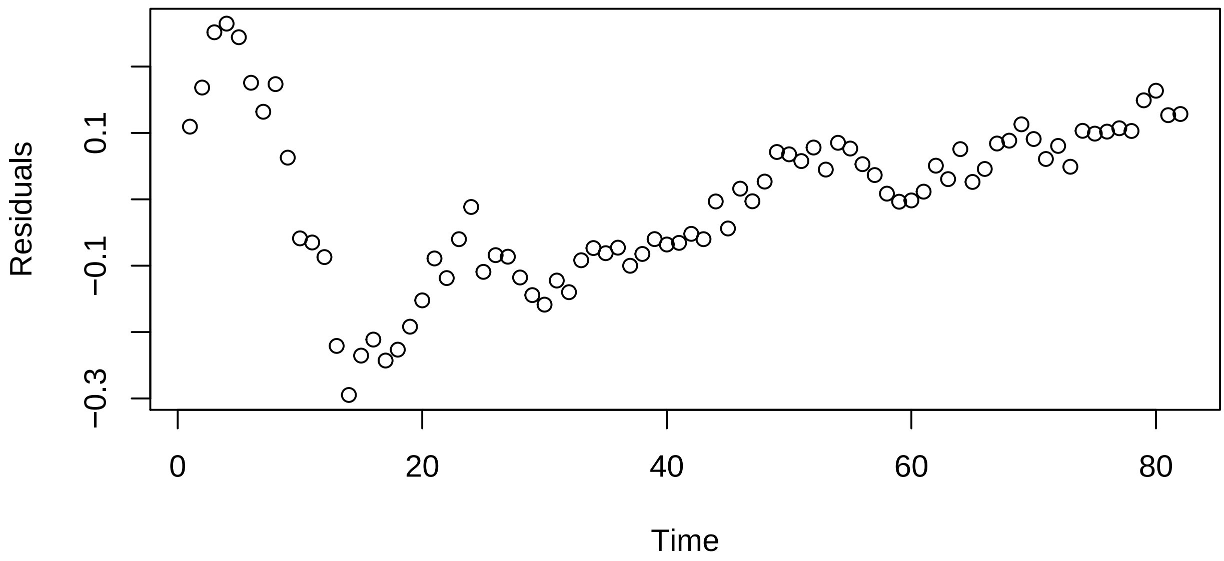

Figure 8: Residuals from regression of log of the Market Index on the ERA composite variable.

The lag order p needs to be selected. The function `VARselect()` suggests $p = 2$ with four different information criteria. However, based on the residual analysis, it appears that $p = 3$ is better.

The results are given in Tables 3 and 4.

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{1,t-1}$	0.20	0.12	1.65	0.10
$y_{2,t-1}$	-0.27	0.19	-1.42	0.16
$y_{1,t-2}$	-0.18	0.13	-1.37	0.17
$y_{2,t-2}$	0.11	0.17	0.62	0.53
$y_{1,t-3}$	0.30	0.13	2.32	0.02
$y_{2,t-3}$	-0.23	0.15	-1.55	0.13
const	-0.00	0.00	-0.01	0.99

Table 3: Results for Vector Autoregression for log Returns vs the differenced ERA Composite Index: Response log Market Returns

A number of tests were made to determine whether the assumptions were satisfied. First, the `serial.test()` showed that the residuals from the model did not have significant serial correlation. Second, the `arch.test()` tested for conditional heteroscedasticity. The results were not significant. Third, the `normality.test` applied the multivariate Jarque-Bera test to the residuals. Again the results were not statistically significant. Finally a stability test was applied using the `stability()` function in the **strucchange** package (Zeileis et al. 2002). The results of the test, shown in Figure 9, indicate that there is no evidence of instability, that is, there is no statistical evidence of a structural break over the extent of the data.

Given the vector auto-regression diagnostics are satisfactory, the model can be interpreted. Granger causality tests[4] show that the null hypothesis of no instantaneous causality between y_1 and y_2 can be rejected ($\chi^2_1 = 10.3084, \; p = 0.001324$); that the null hypothesis that y_1 does not Granger-cause y_2 can

[4] The Granger causality tests address the question of whether the variables are leading indicators of each other. The variable y_1 does not Granger-cause another variable y_2, if y_2 does not depend on past values of y_1, or, equivalently, predictions of future values of y_2 do not depend on the current level of y_1. Similarly, y_2 does not Granger-cause y_1, if y_1 does not depend on past values of y_2, or, equivalently, predictions of future values of y_1 do not depend on the current level of y_2.

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{1,t-1}$	-0.26	0.07	-3.47	0.00
$y_{2,t-1}$	0.39	0.12	3.20	0.00
$y_{1,t-2}$	0.23	0.08	2.87	0.01
$y_{2,t-2}$	-0.06	0.11	-0.56	0.58
$y_{1,t-3}$	0.05	0.08	0.68	0.50
$y_{2,t-3}$	0.14	0.09	1.51	0.13
const	-0.00	0.00	-0.91	0.37

Table 4: Results for Vector Autoregression for log Market Returns vs the differenced ERA Composite Index: Response ERA Composite Index

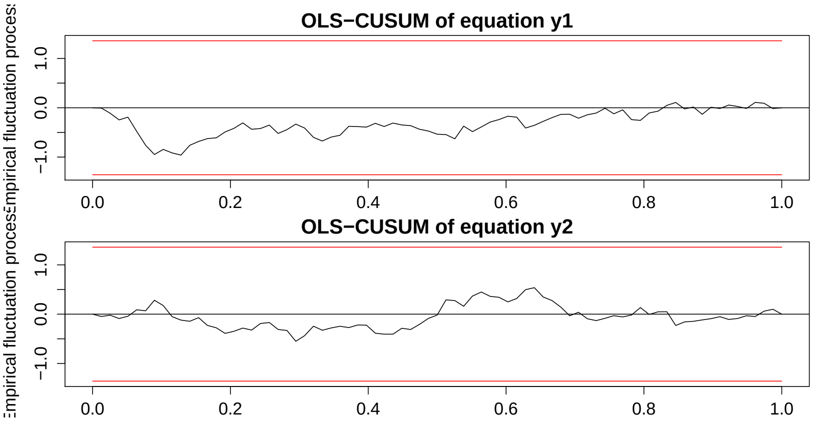

Figure 9: Results of Stability test on estimated VAR model

be rejected ($F_{3,142} = 6.7049$, $p = 0.0002899$); but that the null hypothesis that y_2 does not Granger-cause y_1 cannot be rejected ($F_{3,142} = 1.3191, p = 0.2706$). The results are summarised in Table 5

	y_1	y_2
R^2	0.2033	0.3783
adjusted R^2	0.136	0.3258
$F_{6,72}$	3.0203	7.2003
p	0.0109	0
Correlation	-0.3902	
Instantaneous Causality Test: χ^2_1	10.3084	
p	0.0013	
Granger Causality: y_1 does not $\implies y_2$		
$F_{3,144}$	6.7049	
p	2.8989×10^{-4}	
Granger Causality: y_2 does not $\implies y_1$		
$F_{3,144}$		1.3191
p		0.2706

Table 5: Results for Vector Autoregression for log Returns vs ERA Composite Index

The instantaneous causality test shows that log Returns and changes in the ERA Composite Index in the same month are correlated, but it is important to note that the correlation is negative: Positive changes in the ERA Composite Index are associated with decreases in the log Returns. The Granger causality tests show that although the log Returns is a leading indicator of the ERA Composite Index, the reverse does not apply.

6 Analysis of Excess Returns vs ERA Composite Index

6.1 Calculation of Excess Returns

The method used in the previous sections was repeated for excess returns (that is, returns to the market in excess of the risk-free rate; what is commonly called the market risk-premium by regulators). The logarithmic excess return was defined as

$$\log(\text{return}) - r_f$$

where r_f, the continuously compounded risk free rate, is defined as

$$r_f = \frac{1}{12} \log \left(\text{lag} \left(1 + \frac{y}{100} \right) \right).$$

with y the annual yield on the 5 year CGS. In addition, the cumulative sum of the log excess returns, was calculated. This is analogous to the (log) Market Index. The analysis for log excess returns, summarised in the following sections, proceeds as for log returns, with the cumulative sum of the log excess returns taking the place of the log Market Index.

6.2 Plots

Figures 10 and 11 give time series plots of the log excess returns and the cumulative sum of the log excess returns, respectively. Note that the time series plot of the cumulative sum of the log excess returns is similar in appearance to the time series plot of the log Market Index, shown in Figure 5.

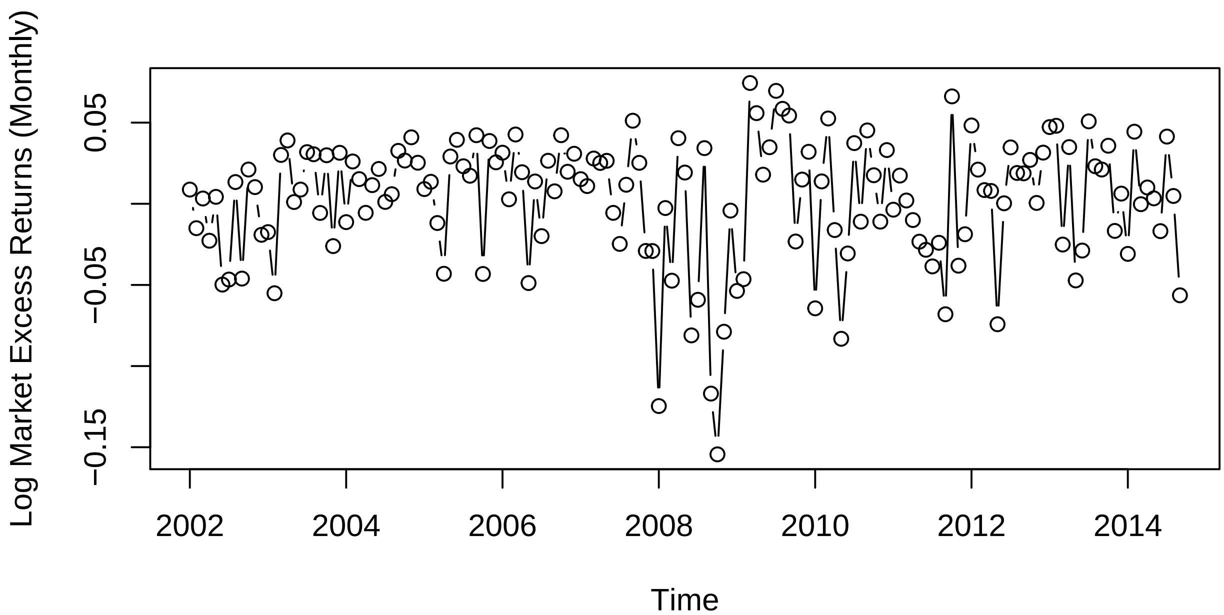

Figure 10: Time Series plot of Log Market Excess Returns (Monthly).

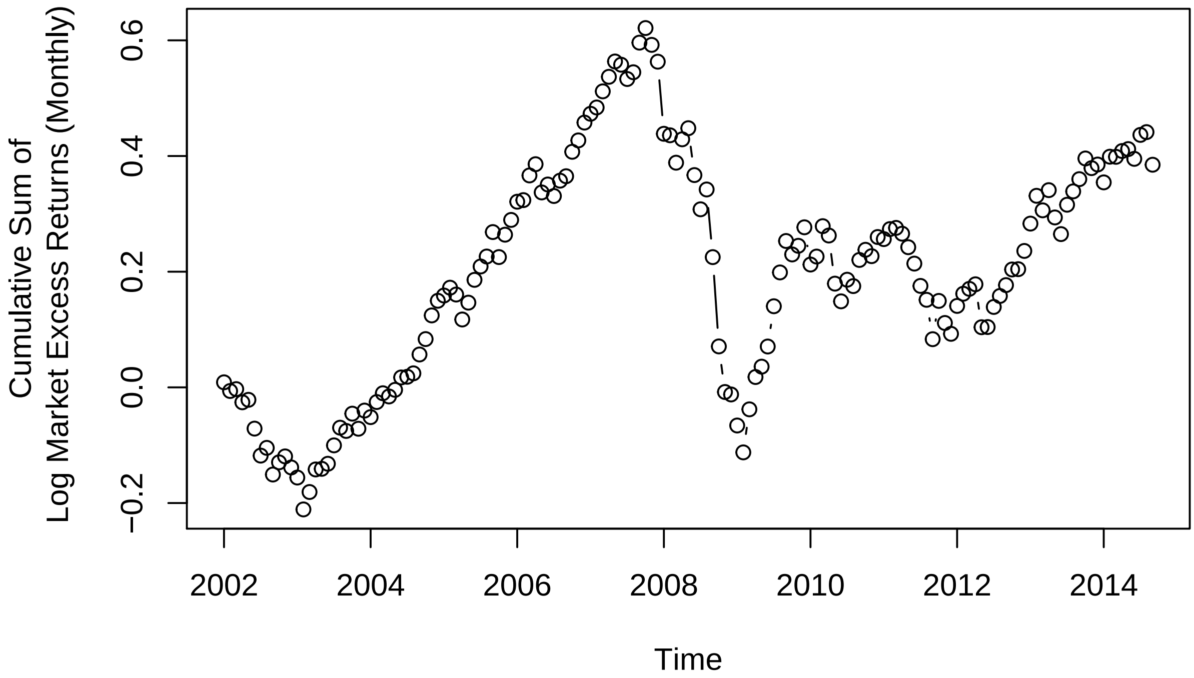

Figure 11: Time Series plot of Cumulative Sum of Log Market Excess Returns (Monthly).

	Cumulative Log Excess Return		Log Excess Return	
kpss Trend	0.5893			
kpss Level			0.0949	
Truncation lag parameter	2		2	
p-value	$p < 0.01$	(NS)	$p > 0.1$	(S)
ADF test	-2.2471		-4.3631	
lag.order	5		5	
p-value	$p = 0.4734$	(NS)	$p < 0.01$	(S)
Phillips-Perron $Z(t\_\text{alpha})$	-1.807			
Phillips-Perron $Z(\text{alpha})$			-130.3403	
Truncation lag parameter	4		4	
p-value	$p = 0.6568$	(NS)	$p < 0.01$	(S)

Table 6: Tests for Stationarity/Unit Roots for the Monthly Excess Data

6.3 Checking for stationarity/unit roots

Table 6 gives the stationary tests for the cumulative of the log excess returns and for the log excess returns themselves. For the cumulative sum of the log excess returns the `kpss.test()` results, using a trend, are significant; while both the results of the `adf.test()` and `pp.test()` are not significant. For the log excess returns the `kpss.test()`, using a level, is not significant; while both the results of the `adf.test()` and `pp.test()` are statistically significant. Combined, these results indicate that the cumulative of the log excess returns is I(1).

6.4 Checking for Co-integration

The `po.test` was applied to the cumulative of the log excess returns and the ERA composite variable. The de-meaned Phillips-Ouliaris test-statistic was -7.3892 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variable are not co-integrated. A regression of the log of the Market Index on the ERA composite variable will be spurious. Figure 12 below reveals why the series are not cointegrated. For co-integration, the residuals should be stationary over time. Clearly they are not with visible trends over time.

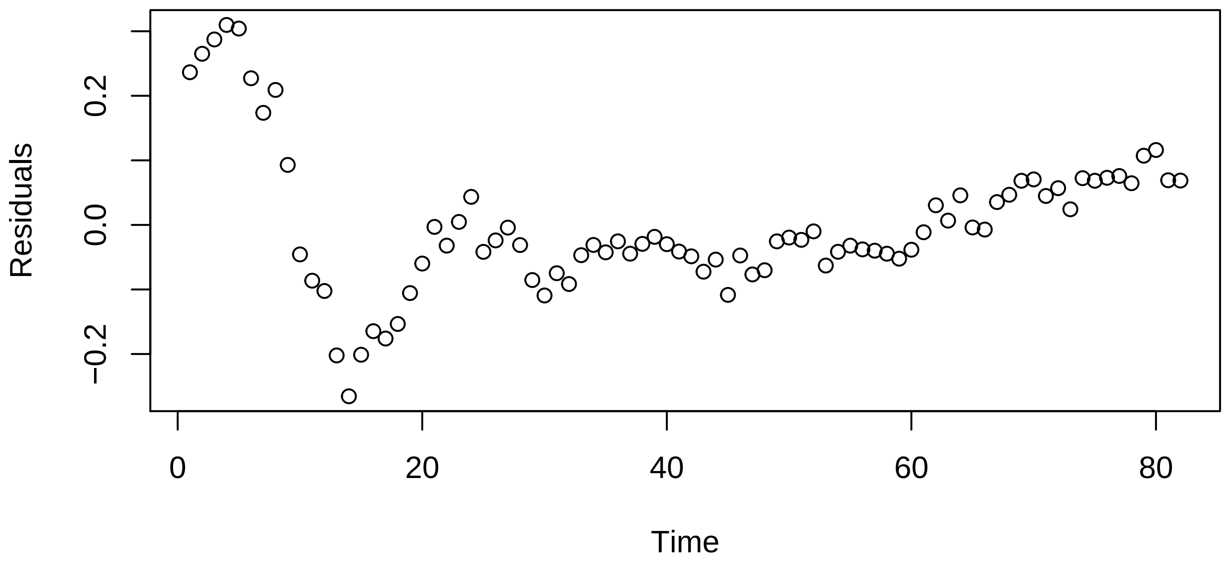

Figure 12: Residuals from regression of cumulative of the log excess returns on the ERA composite variable.

6.5 Vector Auto-regression

A vector auto-regression model with fitted to the log excess returns, denoted by y_3, and the differenced ERA composite variable, denoted by y_2 as before. Again a lag of order 3 was chosen. This was the preferred lag with two of the four information criteria, while the other information criteria indicated a lag of 1.

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{3,t-1}$	0.20	0.12	1.71	0.09
$y_{2,t-1}$	-0.27	0.19	-1.38	0.17
$y_{3,t-2}$	-0.17	0.13	-1.33	0.19
$y_{2,t-2}$	0.11	0.17	0.64	0.52
$y_{3,t-3}$	0.30	0.13	2.34	0.02
$y_{2,t-3}$	-0.23	0.15	-1.52	0.13
const	-0.00	0.00	-0.47	0.64

Table 7: Results for Vector Autoregression for log excess Returns vs the differenced ERA Composite Index

The results, shown in Figures 7, 8, and 9, show instantaneous causality between the two variables, that is in the same month both variables are correlated. Perhaps importantly, the correlation between the two variables is negative. Increases in the composite variable are associated with decreases in the log excess return, and decreases in the composite index are associated with increases in the log excess return. The Granger-causality tests show that the log excess return is a leading indicator of the composite index but the composite index is not a leading indicator of the log excess return. This means the ERA's index cannot be used to predict the MRP, which is the prime purpose of the index.

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{3,t-1}$	-0.26	0.07	-3.52	0.00
$y_{2,t-1}$	0.38	0.12	3.18	0.00
$y_{3,t-2}$	0.23	0.08	2.84	0.01
$y_{2,t-2}$	-0.06	0.11	-0.57	0.57
$y_{3,t-3}$	0.05	0.08	0.65	0.52
$y_{2,t-3}$	0.14	0.09	1.50	0.14
const	-0.00	0.00	-0.87	0.39

Table 8: Results for Vector Autoregression for log excess Returns vs the differenced ERA Composite Index

	y_3	y_2
R^2	0.2054	0.3783
adjusted R^2	0.1383	0.3258
$F_{6,72}$	3.0596	7.2018
p	0.0101	0
Correlation	-0.3917	
Instantaneous Causality Test: χ^2_1	10.3775	
p	0.0013	
Granger Causality: y_3 does not $\implies y_2$		
$F_{3,144}$	6.7073	
p	2.8902×10^{-4}	
Granger Causality: y_2 does not $\implies y_3$		
$F_{3,144}$		1.257
p		0.2916

Table 9: Results for Vector Autoregression for log excess Returns vs the differenced ERA Composite Index

7 Analysis of Individual Driver Variables

Having examined the ERAs index, I now turn to an examination of each of the individual elements which comprise this index, to understand how each element is related to market and excess returns.

7.1 Volatility Index

The tests of stationarity and unit roots were applied to the Scaled Volatility Index. The results given in Table 10 are not consistent. While the kpss tests and ADF tests indicate stationarity, the PP tests indicates non-stationarity, although the the p-value is just over 0.05. On the other hand, the differenced series indicates non-stationarity with all three tests.

The `po.test` was applied to the log of the Market Index and the scaled volatility index. The de-meaned Phillips-Ouliaris test-statistic was -9.5009 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the log of the Market Index on the scaled volatility index will be spurious.

The `po.test` was also applied to the cumulative log excess returns and the scaled volatility index. The de-meaned Phillips-Ouliaris test-statistic was -8.1175 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the cumulative log excess returns on the scaled volatility index will be spurious.

7.2 Dividend Yields

The tests of stationarity and unit roots were applied to the scaled Dividend Yields. The results given in Table 11 are not consistent. While the kpss tests, ADF test and PP test indicates stationarity, the ADF test on the differenced series indicates non-stationarity.

	VIXsc		Δ(VIXsc)	
kpss Trend	0.0897			
kpss Level			0.0335	
Truncation lag parameter	2		2	
p-value	$p > 0.1$	(S)	$p > 0.1$	(S)
ADF test	-3.5148		-4.4343	
lag.order	4		4	
p-value	$p = 0.046$	(S)	$p < 0.01$	(S)
Phillips-Perron $Z(t\_alpha)$	-3.3199			
Phillips-Perron $Z(alpha)$			-58.033	
Truncation lag parameter	3		3	
p-value	$p = 0.0742$	(NS)	$p < 0.01$	(S)

Table 10: Tests for Stationarity/Unit Roots for the Monthly Data: Scaled Volatility Index

	DivYieldssc		Δ(DivYieldssc)	
kpss Trend	0.1181			
kpss Level			0.0977	
Truncation lag parameter	3		2	
p-value	$p > 0.1$	(S)	$p > 0.1$	(S)
ADF test	-4.2392		-3.0986	
lag.order	6		4	
p-value	$p < 0.01$	(S)	$p = 0.1259$	(NS)
Phillips-Perron $Z(t\_alpha)$	-3.5076			
Phillips-Perron $Z(alpha)$			-45.2947	
Truncation lag parameter	5		3	
p-value	$p = 0.0425$	(S)	$p < 0.01$	(S)

Table 11: Tests for Stationarity/Unit Roots for the Monthly Data: Dividend Yields

	IntRateSwap5yrsc		Δ(IntRateSwap5yrsc)	
kpss Trend	0.5627			
kpss Level			0.0752	
Truncation lag parameter	4		4	
p-value	$p = 0.0275$	(NS)	$p > 0.1$	(S)
ADF test	-3.68		-7.0604	
lag.order	6	6		
p-value	$p = 0.0257$	(S)	$p < 0.01$	(S)
Phillips-Perron $Z(t\_alpha)$	-31.3905			
Phillips-Perron $Z(alpha)$			-288.1305	
Truncation lag parameter	5		5	
p-value	$p = 0.01$	(S)	$p < 0.01$	(S)

Table 12: Tests for Stationarity/Unit Roots for the Monthly Data: 5 Year Interest Rate Swap Spread

The `po.test` was applied to the log of the Market Index and the scaled dividend yield index. The de-meaned Phillips-Ouliaris test-statistic was -2.1322 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the log of the Market Index on the scaled dividend yield index will be spurious.

The `po.test` was applied to the cumulative log excess returns and the scaled dividend yield index. The de-meaned Phillips-Ouliaris test-statistic was -2.9544 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the cumulative log excess returns on the scaled dividend yield index will be spurious.

7.3 Five Year Interest Rate Swap Spread

The tests of stationarity and unit roots were applied to the scaled 5 year interest rate swap spread. The results, shown in Table 12, are again inconsistent. The kpss test indicates non-stationarity, while the ADF and PP test indicate stationarity. All the tests show that the differenced series is stationary.

The `po.test` was applied to the log of the Market Index and the scaled 5 Year Interest Rate Swap Spread. The de-meaned Phillips-Ouliaris test-statistic was -2.113 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the log of the Market Index on the scaled 5 Year Interest Rate Swap Spread index will be spurious.

The `po.test` was applied to the cumulative log excess returns and the scaled 5 year swap spread index. The de-meaned Phillips-Ouliaris test-statistic was -4.8287 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the cumulative log excess returns on the scaled scaled 5 year swap spread index will be spurious.

7.4 Corporate Default Spread

Finally, the tests of stationary and unit roots were applied to the scaled corporate default spread index. The results are given in Table 13. Of all the driver variables, this series is the only one yielding consistent results, with all three tests showing that the series is non-stationary, and the differenced series is stationary.

The `po.test` was applied to the log of the Market Index and the scaled corporate default spread index. The de-meaned Phillips-Ouliaris test-statistic was -1.5574 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the log of the Market Index on the scaled corporate default spread index will be spurious.

The `po.test` was applied to the cumulative log excess returns and the scaled corporate default spread index. The de-meaned Phillips-Ouliaris test-statistic was -3.7469 with a p-value of greater than 0.15. Hence, we are unable to reject the hypothesis that the variables are not co-integrated. A regression of the cumulative log excess returns on the scaled corporate default spread index will be spurious.

	CorpDefaultSpreadsc		Δ(CorpDefaultSpreadsc)	
kpss Trend	0.3559			
kpss Level			0.1539	
Truncation lag parameter	3		3	
p-value	$p < 0.01$	(NS)	$p > 0.1$	(S)
ADF test	-2.8738		-4.3309	
lag.order	5		5	
p-value	$p = 0.2114$	(NS)	$p = 0.01$	(S)
Phillips-Perron $Z(t\_alpha)$	-1.9725			
Phillips-Perron $Z(\text{alpha})$			-123.1782	
Truncation lag parameter	4		4	
p-value	$p = 0.5878$	(NS)	$p < 0.01$	(S)

Table 13: Tests for Stationarity/Unit Roots for the Monthly Data: Corporate Default Spread

In summary, for three of the individual driver variables conflicting conclusions are obtained from the stationarity/unit root tests, while the Corporate Default Spread index is I(1). As well, none of the four driver variables are co-integrated with either the log Market Index or the cumulative log excess returns.

I have shown that the index created by the ERA performs poorly as a leading indicator of market returns and the MRP, and that each of the individual indicators perform poorly in this task on their own. However, it may be the case that some differently-weighted index of these variables can be shown to perform well as a forward indicator of market returns and the MRP, and it is to this task that I now turn.

8 A stationary linear combination

In a previous section it has been shown that the linear combination of the four potential driver variables used by the ERA (WA) is non-stationary, and hence cannot be used as a predictor of the returns, or excess returns. In this section, the question of whether there is a linear combination (or linear combinations) of the four potential driver variables that is (or are) stationary, and if there is, does it (or do they) provide any predictive capability of the returns of excess returns is addressed.

The Johansen test for co-integration, implemented with the `ca.jo()` function in the **urca** package (Pfaff, 2008) was applied to the four driver variables. The test indicates that there is one co-integrating relationship given by:

$$co2 = \text{VIXsc} - 0.27 * \text{DivYieldssc} + 2.37 * \text{IntRateSwap5yrsc} - 1.34 * \text{CorpDefaultSpreadsc}$$

Figure 13 shows a time series plot of the co-integrating relation. The graph appears to be much more stable over time than the linear combination used by the ERA (WA). Table 14 gives the results of the stationarity/unit root tests, which all indicate stationarity.

A vector autoregression model was fitted to the log returns (y_1 in the output below) and co2 (y_4 in the output below). The information criteria differed somewhat in the appropriate lag order, so lags of 1, 2, and 3 were tried. At 3 lags, the test for serial correlation was not significant, the ARCH test was not significant, the stability test was not significant, while the joint normality test was not significant (although the test for kurtosis was significant).

A summary of the fitted model is given in Tables 15, 16, and 17.

Given the vector auto-regression diagnostics are satisfactory the model can be interpreted. Granger causality tests show that the null hypothesis of no instantaneous causality between y_1 and y_4 can be rejected (13.48, p =0.00025); that the null hypothesis that y_1 does not Granger-cause y_4 cannot be rejected ($F_{3,144} = 1.685$, $p = 0.173$); and that the null hypothesis that y_4 does not Granger-cause y_1 cannot be rejected ($F_{3,144} = 1.298, p = 0.278$).

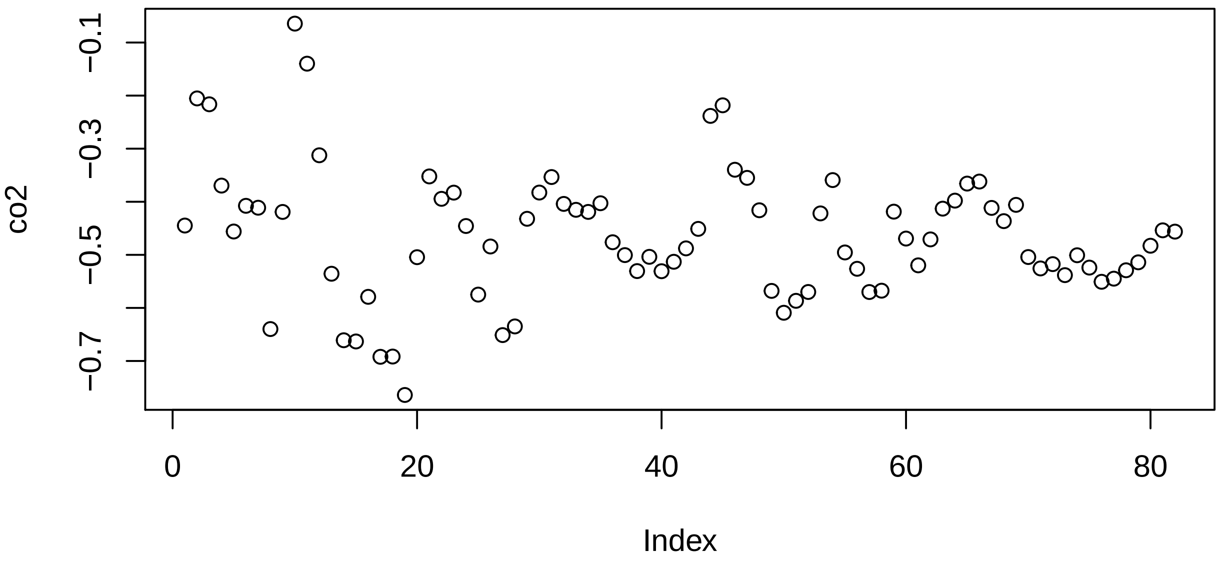

Figure 13: Linear combination of the four potential driver variables found from the Joahansen procedure.

	co2	
kpss Level	0.2	
Truncation lag parameter	2	
p-value	$p > 0.1$	(S)
ADF test	-4.0446	
lag.order	4	
p-value	$p = 0.0117$	(S)
Phillips-Perron $Z(\text{alpha})$	-123.1782	
Truncation lag parameter	3	
p-value	$p < 0.01$	(S)

Table 14: Tests for Stationarity/Unit Roots co2

These results indicate that although in the same month both variables move together (in opposite directions, although this can be changed by reversing the signs in co2), neither variable is a leading indicator of the other.

A similar analysis was conducted for the excess returns. A vector autoregression model was fitted to the log excess returns (y_2 in the output below) and co2 (y_4 in the output below). At 3 lags, the test for serial correlation was not significant, the ARCH test was not significant, the stability test was not significant, while the joint normality test was not significant (although the test for kurtosis was significant). A summary of the fitted model is given in Tables 18, 19, and 20.

Given the vector auto-regression diagnostics are satisfactory the model can be interpreted. Granger causality tests show that the null hypothesis of no instantaneous causality between y_2 and y_4 can be rejected ($\chi^2_1 = 13.3729, p = 0.00026$); that the null hypothesis that y_2 does not Granger-cause y_4 cannot be rejected ($F_{3,144} = 1.710,\ p = 0.168$); and that the null hypothesis that y_4 does not Granger-cause y_2 cannot be rejected ($F_{3,144} = 1.290, p = 0.280$).

These results indicate that although in the same month both variables move together (in opposite directions, although this can be changed by reversing the signs in co2), neither variable is a leading indicator of the other. This indicates that the index in its new form is not a leading indicator, but in-

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{1,t-1}$	0.17	0.13	1.36	0.18
$y_{4,t-1}$	-0.10	0.07	-1.49	0.14
$y_{1,t-2}$	-0.06	0.13	-0.48	0.63
$y_{4,t-2}$	0.15	0.08	1.90	0.06
$y_{1,t-3}$	0.27	0.12	2.24	0.03
$y_{4,t-3}$	-0.09	0.06	-1.57	0.12
const	-0.01	0.03	-0.50	0.62

Table 15: Results for Vector Autoregression for log Returns vs Composite Index 2

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{1,t-1}$	-0.28	0.25	-1.14	0.26
$y_{4,t-1}$	0.88	0.13	6.69	0.00
$y_{1,t-2}$	0.30	0.25	1.22	0.23
$y_{4,t-2}$	-0.40	0.16	-2.52	0.01
$y_{1,t-3}$	-0.40	0.24	-1.69	0.10
$y_{4,t-3}$	-0.01	0.11	-0.07	0.94
const	-0.25	0.06	-4.45	0.00

Table 16: Results for Vector Autoregression for log Returns vs Composite Index 2

stead may be driven by some set of external factors in a similar fashion to the market as a whole. Since it is the only cointegrating relationship that can be found, I can, with some confidence, say that there is no combination of the driver variables used by the ERA which can be used as a leading indicator of market returns or the MRP. There may be some scope to examine what factors might drive market returns and the ERAs indicator variables in a contemporaneous fashion, but this is beyond the scope of this report. For the purposes of this report, it is appropriate to conclude that, since there is no index made up of the four driver variables examined by the ERA which acts as a leading indicator of market returns there is no advantage gained from using these indicator variables instead of actual market returns (or the actual MRP) when looking to establish the most appropriate MRP for the forthcoming access arrangement period.

	y_1	y_4
R^2	0.1638	0.5443
adjusted R^2	0.0941	0.5063
$F_{6,72}$	2.3498	14.3325
p	0.0396	0
Correlation	-0.4536	
Instantaneous Causality Test: χ^2_1	13.4799	
p	2×10^{-4}	
Granger Causality: y_1 does not $\implies y_4$		
$F_{3,144}$	1.7112	
p	0.1673	
Granger Causality: y_4 does not $\implies y_1$		
$F_{3,144}$		1.2995
p		0.277

Table 17: Results for Vector Autoregression for log Returns vs Composite Index 2

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{2,t-1}$	0.18	0.13	1.41	0.16
$y_{4,t-1}$	-0.10	0.07	-1.45	0.15
$y_{2,t-2}$	-0.06	0.13	-0.44	0.66
$y_{4,t-2}$	0.15	0.08	1.91	0.06
$y_{2,t-3}$	0.27	0.12	2.28	0.03
$y_{4,t-3}$	-0.09	0.06	-1.56	0.12
const	-0.01	0.03	-0.51	0.61

Table 18: Results for Vector Autoregression for log Excess Returns vs Composite Index 2

	Estimate	Std. Error	t value	Pr(>|t|)
$y_{2,t-1}$	-0.29	0.25	-1.16	0.25
$y_{4,t-1}$	0.87	0.13	6.68	0.00
$y_{2,t-2}$	0.30	0.25	1.20	0.23
$y_{4,t-2}$	-0.40	0.16	-2.52	0.01
$y_{2,t-3}$	-0.40	0.23	-1.72	0.09
$y_{4,t-3}$	-0.01	0.11	-0.07	0.94
const	-0.25	0.06	-4.45	0.00

Table 19: Results for Vector Autoregression for log Excess Returns vs Composite Index 2

	y_2	y_4
R^2	0.1674	0.5448
adjusted R^2	0.098	0.5069
$F_{6,72}$	2.4128	14.3616
p	0.0351	0
Correlation	-0.4529	
Instantaneous Causality Test: χ^2_1	13.4452	
p	2×10^{-4}	
Granger Causality: y_2 does not $\implies y_4$		
$F_{3,144}$	1.7395	
p	0.1616	
Granger Causality: y_4 does not $\implies y_2$		
$F_{3,144}$		1.2912
p		0.2798

Table 20: Results for Vector Autoregression for log Returns vs Composite Index 2

9 Conclusion

There is no cointegration between the (log of the) Market Index and the composite variable used by the ERA (WA), i.e. there is no stable relationship between the two sets of variables. In this situation, the only thing to be done is to difference both series. The relationship between the differenced variables gives no information about likely future values of the MRP. The fact that the composite variable is historically low, does not indicate anything about the MRP. Accordingly, an estimate of the Market Risk Premium should not be based on the current or future levels of the ERA composite variable.

There is a co-integrating relationship between the returns and excess returns and a linear combination of the four driver variables used by the ERA. Despite both the returns and excess returns being correlated with the linear combination, the linear combination is not predictive of future values of the returns and excess returns and similarly the returns and excess returns are not predictive of future values of the composite index.

There is no advantage gained from using the driver variables instead of actual market returns (or the actual MRP) when looking to establish the most appropriate MRP for the forthcoming access arrangement period.

10 Statement

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld.

I acknowledge that the opinions in the report are based wholly or substantially on the specialised knowledge that I have; and that this report has been prepared in accordance with the Expert Witness Guidelines provided by the Federal Court of Australia.

11 Bibliography

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A Federal Court of Australia, Practice Note CM 7

FEDERAL COURT OF AUSTRALIA

Practice Note CM 7

EXPERT WITNESSES IN PROCEEDINGS IN THE FEDERAL COURT OF AUSTRALIA

Practice Note CM 7 issued on 1 August 2011 is revoked with effect from midnight on 3 June 2013 and the following Practice Note is substituted.

Commencement

1. This Practice Note commences on 4 June 2013.

Introduction

2. Rule 23.12 of the Federal Court Rules 2011 requires a party to give a copy of the following guidelines to any witness they propose to retain for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based on the specialised knowledge of the witness (see **Part 3.3 - Opinion** of the *Evidence Act 1995* (Cth)).

3. The guidelines are not intended to address all aspects of an expert witness's duties, but are intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is hoped that the guidelines will assist individual expert witnesses to avoid the criticism that is sometimes made (whether rightly or wrongly) that expert witnesses lack objectivity, or have coloured their evidence in favour of the party calling them.

Guidelines

1. General Duty to the Court

1.1 An expert witness has an overriding duty to assist the Court on matters relevant to the expert's area of expertise.

1.2 An expert witness is not an advocate for a party even when giving testimony that is necessarily evaluative rather than inferential.

1.3 An expert witness's paramount duty is to the Court and not to the person retaining the expert.

2. The Form of the Expert's Report

2.1 An expert's written report must comply with Rule 23.13 and therefore must

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgment that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c) above; and

(h) comply with the Practice Note.

2.2 At the end of the report the expert should declare that "[the expert] has *made all the inquiries that* [the expert] *believes are desirable and appropriate and that no matters of significance that* [the expert] *regards as relevant have, to* [the expert's] *knowledge, been withheld from the Court*."

2.3 There should be included in or attached to the report the documents and other materials that the expert has been instructed to consider.

2.4 If, after exchange of reports or at any other stage, an expert witness changes the expert's opinion, having read another expert's report or for any other reason, the change should be communicated as soon as practicable (through the party's lawyers) to each party to whom the expert witness's report has been provided and, when appropriate, to the Court.

2.5 If an expert's opinion is not fully researched because the expert considers that insufficient data are available, or for any other reason, this must be stated with an indication that the opinion is no more than a provisional one. Where an expert witness who has prepared a report believes that it may be incomplete or inaccurate without some qualification, that qualification must be stated in the report.

2.6 The expert should make it clear if a particular question or issue falls outside the relevant field of expertise.

2.7 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the opposite party at the same time as the exchange of reports.

3. Experts' Conference

3.1 If experts retained by the parties meet at the direction of the Court, it would be improper for an expert to be given, or to accept, instructions not to reach agreement. If, at a meeting directed by the Court, the experts cannot reach agreement about matters of expert opinion, they should specify their reasons for being unable to do so.

J L B ALLSOP

Chief Justice

4 June 2013

B Neil Diamond CV

Neil Diamond CV

December 2014

Academic Qualifications: B.Sc (Hons) (Monash), Ph.D. (Melbourne), A.Stat

Career History

1977-78	Statistician, ICI Explosives Factory, Deer Park
1979-86	Research Officer, Research Scientist, Senior Research Scientist And Statistics and Computing Team Leader, ICI Central Research Laboratories, Ascot Vale
1987-1989	Lecturer, Department of Mathematics, Computing and Operations Research, Footscray Institute of Technology
(1989)	Visiting Scientist, Center for Quality and Productivity Improvement, University of Wisconsin-Madison, USA.
1990-2003	Senior Lecturer, Department of Computer and Mathematical Sciences, Victoria University of Technology
2003-2004	Senior Statistician, Insureware
2004-2006	Senior Lecturer and Deputy Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2007- 2012	Senior Lecturer and Director of Consulting, Department of Econometrics and Business Statistics, Monash University.
2011- 2012	Associate Professor and Co-ordinator of Statistical Support, Victoria University.
2012-	Director, ESQUANT Statistical Consulting

Research and Consulting Experience

- A Ph.D. from the University of Melbourne entitled “Two-factor interactions in non-regular foldover designs.”

- Ten years with ICI Australia as an industrial statistician initially with the Explosives group and eventually with the research group.

- Two six month periods (Professional Experience Program and Outside Studies Program) at the Center for Quality and Productivity Improvement, at the University of Wisconsin-Madison. The Center, founded and directed by Professor George Box, conducts innovative practical research in modern methods of quality improvement and is an internationally recognised forum for the exchange of ideas between experts in various disciplines, from industry and government as well as academia.

- Extensive consulting and training on behalf of the Centre for Applied Computing and Decision Analysis based at VUT for the following companies:

Data Sciences	Initiating Explosives Systems
Analytical Science Consultants	Saftec
Glaxo Australia	Datacraft Australia
Enterprise Australia	ICI Australia
The LEK partnership	Kaolin Australia
BP Australia	AMCOR
Melbourne Water	Kinhill Group
Australian Pulp and Paper Institute	

- Operated the Statistical Consulting Service at Victoria University of Technology from 1992-2003.

- From 2003-2004 worked as a Senior Statistician with Insureware on the analysis of long-tailed liability data.

- From December 2004 to December 2006, Deputy Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.

- From January 2007 to December 2012, Director of Consulting of Monash University Statistical Consulting Service based in the Department of Econometrics and Business Statistics.

- Extensive consulting and training on behalf of the Monash University Statistical Consulting Service for the following companies and organisations:

Australian Tax Office	Department of Human Services
J D McDonald	IMI Research
Port of Melbourne Corporation	Incitec Pivot
Agricola, Wunderlich & Associates	Parks Victoria
Australian College of Consultant Physicians	ANZ
Department of Justice	CRF(Colac Otway)
Australian Football League Players' Association	United Energy
ETSA	ENA

- From May 2011 to February 2013, Associate Professor and Co-ordinator of Statistical Support, Victoria University.

- From February 2013, Extensive consulting and training as Research Director of ESQUANT Statistical Consulting for the following companies and organisations:

United Energy & Multinet Gas
Competition Economists Group
SFG Consulting
Engineered Wood Panels Association of Australasia
DBP
Deakin University Department of Psychology
Choros
Electricity Networks Association
Victoria University Office for Research
Monash University Department of Social Work
MAV

Postgraduate Supervision

Principal Supervisor

Gregory Simmons (1994-1997). M.Sc. completed. "Properties of some minimum run resolution IV designs."

Tony Sahama (1995-2003). Ph.D. completed. "Some practical issues in the design and analysis of computer experiments."

Ewa Sztendur (1999-2005). Ph.D. completed. "Precision of the path of steepest ascent in response surface methodology." [As a result of this thesis, Ewa was awarded the 2006 Victoria University Vice-Chancellor's Peak Award for Research and Research Training-Research Degree Graduate.]

Co-supervisor

Keith Hart (1996-1997). M.Sc. completed. "Mean reversion in asset prices and asset allocations in funds management."

Jyoti Behera (1999-2000). M.Eng. completed. "Simulation of container terminals."

Ray Summit (2001-2004). Ph.D. completed. "Analysis of warranty data for automobile data."

Rob Moore (2001-2007). Ph.D. completed. "Computer recognition of musical instruments.

M.Sc. Minor Theses

Milena Shtifelman (1999). Completed. (Monash University Accident Research Centre). "Modelling interactions of factors influencing road trauma trends in Victoria."

Rohan Weliwita (2002). Completed. "Modelling road accident trauma data."

Theses Examination

One M.Sc. major thesis (University of Melbourne) and one M.Sc minor thesis (Victoria University).

Workshops

Victoria University

- Experimental Design.
- Longitudinal Data Analysis.
- Statistics for Biological Sciences.
- Introductory Statistics for Research.
- Software Packages for Statistics.
- Design and Analysis of Questionnaires and Sample Surveys.
- Introductory SPSS.
- Statistics for Biological Sciences using R.
- Statistics for Biological Sciences using SPSS.
- Research Design and Statistics.

Monash University

- Expert Stats Seminars for higher degree research students on Software Packages for Statistics, Questionnaire Design, Analysis of Survey Data, and Multivariate Statistics.
- Introduction to Statistics for Pharmacy.
- Statistical Analysis for Social Workers.
- Statistical Methods for Social Workers.
- SPSS for Social Workers.

ESQUANT Statistical Consulting

- Introduction to Structual Equation Modelling using Lavaan and R.
- Introduction to Stata.
- Introduction to Structual Equatuon Modelling with Stata.

Other

- Design of Experiments for ICI Australia (One day course).
- Design of Experiments for Quality Assurance-including Taguchi Methods. A 2-day professional development short course on behalf of the Centre for Manufacturing Advanced Engineering Centre.
- Design of Experiments for the Australian Pulp and Paper Institute.
- Statistical Methods for ANZ Analytics.

Teaching Experience

Monash University

- Business Statistics (First Year), Marketing Research Analysis (Second Year), Survey Data Analysis (Third Year-Clayton and Caulfield).

Victoria University of Technology

- Applied Statistics (First Year), Linear Statistical Models, Sampling and Data Analysis (Second Year), Experimental Design (Third Year).
- Statistics for Engineers, Statistics for Nurses, Statistics for Occupational Health.
- Forecasting (Graduate Diploma in Business Science)

Sessional Teaching

- RMIT (1991, 1996-2002) Design of Experiments for Masters in Quality Management.
- AGSM (1993-1997): Total Quality Management for Graduate Management Qualification.
- Various other: The University of Melbourne, Enterprise Australia, Swinburne Institute of Technology.

Industry Projects

Over 30 projects for the following companies and organisations:

Gas and Fuel Corporation	Ford Australia
Mobil Australia	Fibremakers
ICI Australia	Western General Hospital
Data Sciences	Keilor City Council
AMCOR	Composite Buyers
Davids	Email Westinghouse
Craft Coverings	Australian Wheat Board
CSL	Holding Rubber
Viplas Olympic	Melbourne Water
Federal Airports Corporation	

Publications

Chapters in Books

1. Sztendur, E.M. and Diamond, N.T., (2001). "Inequalities for the precision of the path of steepest ascent in response surface methodology," in Cho, Y.J, Kim, J.K., and Dragomir, S.S. (eds.) *Inequality Theory and Applications Volume 1*, Nova Publications.

Journal Articles

1. Diamond, N.T., (1991). "Two visits to Wisconsin," *Quality Australia*, **7**, 30-31.
2 Diamond, N.T., (1991). "The use of a class of foldover designs as search designs," *Austral. J. Statist*, **33**, 159-166.
3 Diamond, N.T., (1995). "Some properties of a foldover design," *Austral. J. Statist*, **37**, 345-352.
4 Watson, D.E.R., Hallett, R.F., and Diamond, N.T., (1995). "Promoting a collegial approach in a multidisciplinary environment for a total quality improvement process in higher education, " *Assessment & Evaluation in Higher Education*, **20**, 77–88.
5 Van Matre, J. and Diamond, N.T., (1996). "Team work and design of experiments," Quality Engineering, 9, 343–348.
6 Diamond, N.T., (1999). "Overlap probabilities and delay detonators," *Teaching Statistics*, **21**, 52–53. Also published in "Getting the Best from Teaching Statistics", one of the best 50 articles from volumes 15 to 21 of *Teaching Statistics.*
7 Cerone, P. and Diamond, N.T., (2000). "On summing permutations and some statistical properties," *The International Journal of Mathematical Education in Science and Technology*, **32**, 477-485.
8 Behera, J.M., Diamond, N.T., Bhuta, C.J. and Thorpe, G.R.,(2000). "The impact of job assignment rules for straddle carriers on the throughput of container terminal detectors," *Journal of Advanced Transportation*, **34**, 415-454.
9 Sahama, T. and Diamond, N.T., (2001). "Sample size considerations and augmentation of computer experiments," *The Journal of Statistical Computation and Simulation*, **68**, 307-319.
10 Paul, W. and Diamond, N.T., (2001). "Designing a monitoring program for environmental regulation: Part 1-The operating characteristic curve," *Water*: Journal of Australian Water Association, October 2001, 50-54.
11 Sztendur, E.M. and Diamond, N.T., (2002). "Extension to confidence region calculations for the path of steepest ascent," *Journal of Quality Technology*, **34**, 288-295.
12 Paul, W. and Diamond, N.T., (2002). "Designing a monitoring program for environmental regulation: Part 2-Melbourne Water case study," *Water*: Journal of Australian Water Association, February 2002, 33-36.
13 Steart, D.C., Greenwood, D.R., Boon, P.I. and Diamond, N.T., (2002) "Transport of leaf litter in upland streams of Eucalyptus and Nothofagus forests in South Eastern Australia," *Archiv Für Hydrobiologie,* **156***, 43-61.*
14 Peachey, T. C., Diamond, N. T., Abramson, D. A., Sudholt, W., Michailova, A., and Amirriazi, S. (2008). "Fractional factorial design for parameter sweep experiments using Nimrod/E,"*Sci. Program.*, **16**(2-3), 217–230.

15 Sahama, T.R. and Diamond, N.T. (2009) "Computer Experiment-A case study for modelling and simulation of Manufacturing Systems," *Australian Journal of Mechanical Engineering*, **7**(1), 1–8.

16 Booth, R., Brookes, R., and Diamond, N. (2012) " The declining player share of AFL clubs and league revenue 2001-2009: Where has the money gone?," *Labour and Industry* 22:4, 433–446.

17 Booth, R., Brookes, R., and Diamond, N. (2012) "Theory and Evidence on Player Salaries and Revenues in the AFL 2001-2009," Accepted for publication in *Economics and Labour Relations Review*.

18 Chambers, J.D., Bethwaite, B., Diamond, N.T., Peachey, T.C., Ambramson, D., Petrou, S., and Thomas, E.A. (2012) "Parametric computation predicts a multiplicative interaction between synaptic strength parameters controls properties of gamma oscillations," *Frontiers in Computational Neuroscience* Volume 6, Article 53 doi:103389/fncom.2012.00053.

19 Sztendur, E.M. and Diamond, N.T. (2013). "Using fractional factorial designs for variable importance in Random Forest models," *World Academy of Science, Engineering and Technology,* **71**, 1974–1978.

20 de Bruin, C.L., Deppeler, J.M., Moore, D.W., and Diamond, N.T. (2013) "Public school-based interventions for adolescents and young adults with an autism sprectrum disorder: a meta-analysis," *Review of Educational Research* prepublished 17 September 2013. DOI: 10.3102/0034654313498621

21 Jackson, M., Sztendur, E., Diamond, N., Byles, J. and Bruck, D."Sleep Difficulties and the Development of Depression and Anxiety: A Longitudinal Study of Young Australian Women", accepted for publication in *Archives of Women's Mental Health*.

Refereed Conference Papers

1. Behera, J., Diamond, N.T., Bhuta, C. and Thorpe, G., (1999). "Simulation: a decision support tool for improving the efficiency of the operation of road vehicles in container terminals," 9th ASIM Dedicated Conference, Berlin, February 2000, 75-86.

2. Jutrisa, I., Diamond, N.T. and Cerone. P., (1999). "Frame size effects on throughput and return traffic in reliable satellite broadcast transmission, " 16th International Teletraffic Congress, Edinburgh, Scotland.

3. Diamond, N.T. and Sztendur, E.M. (2002). "The use of consulting problems in introductory statistics classes", *Proceedings of the 6th International Conference on the Teaching of Statistics.*

4. Summitt, R.A., Cerone. P., and Diamond, N.T. (2002). "Simula-

tion Reliability Estimation from Early Failure Data, *Proceedings of the Fourth International Conference on Modelling and Simulation*, 368-390.

5. Summitt, R.A., Cerone. P., and Diamond, N.T. (2002). "Simulation Reliability Estimation from Early Failure Data II, *Proceedings of the Fourth International Conference on Modelling and Simulation*, 391-396.
6. Sahama, T. And Diamond, N.T. (2008). "Computer Experiment-A case study for modelling and simulation of Manufacturing Systems," 9th Global Conference on Manufacturing and Management.
7. Jackson, M.L., Diamond, N.T., Sztendur E.M., Bruck, D. (2013). "The Role of Sleep Difficulties in the Subsequent Development of Depression and Anxiety in a Longitudinal Study of Young Australian Women, " *American Professional Sleep Societies Scientific Meeting, Baltimore, MA* (Selected for an Honorable Mention Award) and *25th Annual Scientific Meeting of the Australasian Sleep Association, Brisbane, October.*

Reports

A number of confidential reports for ICI Australia from 1977-1987.

Victoria University

VU1. Diamond, N.T (1990). "Professional Experience Program at the Center for Quality and Productivity Improvement," Footscray Institute of Technology.

VU2. Bisgaard, S. and Diamond, N.T (1991). "A discussion of Taguchi's methods of confirmatory trials," Report No. 60. Center for Quality and Productivity Improvement, University of Wisconsin-Madison.

VU3. Diamond, N.T (1996). "Outside Studies Program at the Center for Quality and Productivity Improvement," Victoria University of Technology.

VU4. Diamond, N.T (1996). "Statistical Analysis of EPA compliance of the western treatment plant," prepared for Melbourne Water on behalf of Kinhill Engineers.

VU5. Diamond, N.T (1996). "Statistical Analysis of EPA compliance of the western treatment plant," prepared for Melbourne Water on behalf of Kinhill Engineers.

VU6. Diamond, N.T (1998). “Statistical Analysis of BOD and SS compliance rates and license limits at ETP and WTP,” prepared for Melbourne Water.

VU7. Diamond, N.T (1998). “Fate of pollutants at WTP-method for determining safety margins,” prepared for Egis consulting group.

VU8. Bromley, M. and Diamond, N.T (2002). “The manufacture of Laboratory coreboard using various chip furnishes,” prepared for Orica adhesives and resins.

Monash University

M1. Hyndman, R.J, Diamond, N.T. and de Silva, A. (2004). “A review of the methodology for identifying potential risky agents,” prepared for the Australian Tax Office.

M2. Diamond, N.T. and Hyndman, R.J. (2005). “Sample Size for Maternal and Child Heath Service Evaluation,” prepared for the Department of Human Services.

M3. Diamond, N.T. (2005). “Analysis of Customer Satisfaction Survey 2005,” prepared for JD Macdonald.

M4. Diamond, N.T. (2005). “Analysis of 2005 Orientation Survey,” prepared for Monash Orientation.

M5. Diamond, N.T. (2005). “Analysis of Before and After and Sequential Monadic Concept Consumer Surveys,” prepared for IMI-Research.

M6. Diamond, N.T. and Hyndman, R.J. (2005). “The Monash Experience Questionnaire 2003: First Year Students,” prepared for CHEQ, Monash University.

M7. Diamond, N.T. and Hyndman, R.J. (2005). “The Monash Experience Questionnaire 2003: The Best and Worst, ” prepared for CHEQ, Monash University.

M8. Diamond, N.T. and Hyndman, R.J. (2005). “The Monash Experience Questionnaire 2003: The Best and Worst for First Year Students,” prepared for CHEQ, Monash University.

M9. Diamond, N.T. (2005). “Technical Document for DUKC Uncertainty Study,” prepared for Port of Melbourne Corporation.

M10. Diamond, N.T. (2005). “DUKC Uncertainty Study-Summary of Results,” prepared for Port of Melbourne Corporation.

M11. Diamond, N.T. (2005). “Number of Ship trials for DUKC Uncertainty Study,” prepared for Port of Melbourne Corporation.

M12. Diamond, N.T. (2005). “Threshold Criteria for Touch Bottom Probabilities,” prepared for Port of Melbourne Corporation.

M13. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: The Best and Worst," prepared for CHEQ, Monash University.

M14. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: The Best and Worst for First Year Students," prepared for CHEQ, Monash University.

M15. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: A Statistical Analysis," prepared for CHEQ, Monash University.

M16. Diamond, N.T. and Hyndman, R.J. (2006). "The Monash Experience Questionnaire 2005: 2005 vs. Pre-2005 Students," prepared for CHEQ, Monash University.

M17. Diamond, N.T. (2006). "Agreement of 110/116 and 111/117 items by Consultant Physicians," prepared for the Australian College of Consultant Physicians.

M18. Diamond, N.T. (2006). "Analysis of Statistical Issues regarding Cornish v Municipal Electoral Tribunal, " prepared for Agricola, Wunderlich & Associates.

M19. Diamond, N.T. (2006). "Analysis of Parks Victoria Staff Allocation," prepared for Parks Victoria.

M20. Diamond, N.T. and Hyndman, R.J. (2006). "Summary of Results of IPL Sales Forecasting Improvement Project," prepared for Incitec Pivot.

M21. Sztendur, E.M. and Diamond, N.T. (2007) "A model for student retention at Monash University", prepared for University retention committee.

M22. Sztendur, E.M. and Diamond, N.T. (2007) "An extension to a model for student retention at Monash University", prepared for University review of coursework committee.

M23. Sztendur, E.M. and Diamond, N.T. (2007) "A model for student academic performance at Monash University", prepared for University review of coursework committee.

M24. Diamond, N.T. (2007). "Analysis of IB student 1st year results at Monash University 2003-2005", prepared for VTAC.

M25. Diamond, N.T. (2008). "Effect of smoking bans on numbers of clients utilising problem gambling counselling and problem gambling financial counselling", prepared for Department of Justice

M26. Diamond, N.T. (2008). "Development of Indices Based Approach for Forecasting Gambling Expenditure at a Local Government Area Level", prepared for Department of Justice

M27. Diamond, N.T. (2008). "Orientation 2007- Analysis of Quantitative results", prepared for University Orientation committee.

M28. Diamond, N.T. (2008). "Orientation 2007- Analysis of Qualitative results, prepared for University Orientation committee.

M29. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Counselling Services-2002/03 to 2005/06", prepared for the Department of Justice.

M30. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Financial Counselling Services-2001/02 to 2005/06", prepared for the Department of Justice.

M31. Diamond, N.T. (2008). "Analysis of Clients presenting to Problem Gambling Counselling and Problem Gambling Financial Counselling Services-2006/07", prepared for the Department of Justice.

M32. Diamond, N.T. (2008). "The effect of changes to Electronic Gaming Machine numbers on gambling expenditure", prepared for the Department of Justice.

M33. Diamond, N.T. (2009). "Adjustment of Mark Distributions", prepared for the Faculty of Law.

M34. Diamond, N.T. (2009). "Summary of Results for Dyno Nobel Sales Forecasting Improvement Project," prepared for Incitec Pivot.

M35. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Multicollinearity and Reproducibility Issues", prepared for the Victorian Electricity Distributors.

M36. Booth, R., Diamond, N., and Brooks, R. (2010). "Financial Analysis of Revenues and Expenditures of the AFL and of the AFL Clubs", prepared for the Australian Football League Players' Association.

M37. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Sample Selection, and Standard Errors", prepared for the Victorian Electricity Distributors.

M38. Diamond, N. and Brooks, R. (2010). "Determining the value of imputation credits: Joint Confidence Region and Other Multicollinearity Issues", prepared for the Victorian Electricity Distributors.

M39. Diamond, N. and Brooks, R. (2010). "Reconstructing the Beggs and Skeels Data Set", prepared for the Victorian Electricity Distributors.

M40. Diamond, N. and Brooks, R. (2010). "Response to AER Final Decision", prepared for the Victorian Electricity Distributors.

M41. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Faculty Results", prepared for Victoria University (6 reports).

M42. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Campus Results", prepared for Victoria University.

M43. Diamond, N. and Sztendur, E. (2011). "The Student Barometer 2010. Qualitative analysis of comments", prepared for Victoria University (17 reports).

M44. Diamond, N. and Brooks, R. (2011). 'Review of SFG 2011 Dividend Drop-off Study'. prepared for Gilbert and Tobin on behalf of ETSA.

M45. Diamond, N. (2011). 'A review of "Using capture-mark-recapture methods to estimate fire starts in the United Energy distribution area", by Rho Environmetrics Pty.Ltd. and John Field Consulting Pty.Ltd', prepared for United Energy.

M46. Diamond, N., Brooks, R., and Macquarie, L. (2013). 'Estimation of Fair Value Curves', prepared for APA Group, Envestra, Multinet Gas, and SP AusNet. 7th February 2013.

ESQUANT Statistical Consulting

E1. Diamond, N.T. and Sztendur, E.M. (2013). "Assistance with Data Mining", prepared for confidential accounting firm. 21 January 2013.

E2. Diamond, N.T. (2013). "A review of NERA's analysis of McKenzie and Partington's EGARCH analysis,' prepared for Multinet Gas. 9 April 2013 and 5 August 2013.

E3. Gray, S., Hall, J., Diamond, N., and Brooks, R. (2013). "Assessing the reliability of regression-based estimates of risk ," prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service. 17 June 2013.

E4. Gray, S., Hall, J., Diamond, N., and Brooks, R. (2013). 'The Vasicek adjustment to beta estimation in the Capital Asset Pricing Model," prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service. 17 June 2013.

E5. Gray, S., Hall, J., Diamond, N., and Brooks, R. (2013). "Comparison of OLS and LAD regression techniques for estimating beta," prepared for Energy Networks Association in conjuction with SFG Consulting and Monash University Statistical Consulting Service. 26 June 2013.

E6. Diamond, N.T. and Young, D. (2013). "Estimating Benchmark Distributions," For Chorus, in conjuction with Competition Economists Group. 2nd September 2013.

E7. Diamond, N.T. (2013). "Design of Sampling and Testing Program for Particleboard & MDF," for Engineered Wood Products Association of Australia. 6 September 2013.

E8. Diamond, N.T. (2013). "Regression Analysis for Credit Rating," For Competition Economists Group. 17 September 2013.

E9. Diamond, N.T. (2013). "Cross-checking of ERA (WA) beta estimates," For Competition Economists Group. 18 September 2013.

E10. Diamond, N.T. and Brooks, R. (2013). "Review of ERA (WA) yield curve analysis," For United Energy and Multinet Gas. 26 September 2013.

E11. Diamond, N., Brooks, R and D. Young. The development of yield curves, zero coupon yields, and par value yields for corporate bonds. Technical report, ESQUANT Statistical Consulting in conjuction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University and Competition Economists Group, 2014. For United Energy and Multinet Gas in response to the AERs draft rate of return guidelines. 17 October 2013.

E12. N.T. Diamond. Comments on RBA measures of Australian corporate credit spread. Technical report, ESQUANT Statistical Consulting, 2014. For United Energy and Multinet Gas. 14 January 2014.

E13. N.T. Diamond and R. Brooks. Review of ERA (WA) yield curve analysis: Response to explanatory statement for the rate of return guidelines (released 16th december 2013). Technical report, ESQUANT Statistical Consulting in conjuction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University, 2014. For United Energy and Multinet Gas. 14 January 2014.

E14. N.T. Diamond and E.M. Sztendur. Design of sampling and testing program for particleboard & MDF: Developing protocol for establishing compliance part 1. Technical report, ESQUANT Statistical Consulting, 2014. For Engineered Wood Products Association of Australasia. 5 March 2014.

E15. N.T. Diamond. Paid parental leave survey: Data manipulation. Technical report, ESQUANT Statistical Consulting, 2014. For Ms Samone McCurdy, Department of Social Work, Monash University, 11 March 2014.

E16. N.T. Diamond. Mens behaviour change program: Update to comparisons of survey 1 and 2. Technical report, ESQUANT Statistical Consulting, 2014. For Professor Thea Brown and Ms Paula Fernandez Arias, Department of Social Work, Monash University, 14 March 2014.

E17. N.T. Diamond and E.M. Sztendur. Design of sampling and testing program for particleboard & MDF: Developing protocol for establishing compliance part 2. Technical report, ESQUANT Statistical Consulting, 2014. For Engineered Wood Products Association of Australasia. 28 March 2014.

E18. N.T. Diamond and E.M. Sztendur. Design of sampling and testing program for particleboard & MDF: Comments on stages B and C. Technical report, ESQUANT Statistical Consulting, 2014. For Engineered Wood Products Association of Australasia. 15 April 2014.

E19. N.T. Diamond and R. Brooks. A review of measures of Australian corporate credit spreads published by the Reserve bank of Australia: Submission to the issues paper (Return on debt: Choice of third party data service provider) released by the Australian Energy Regulator (April 2014). Technical report, ESQUANT Statistical Consulting in conjunction with Statistical Consulting Service, Department of Econometrics and Business Statistics, Monash University, 2014. For United Energy and Multinet Gas. 19 May 2014.

E20. N.T.Daimond. Comments on Incenta Economic Consulting Report: Methods for extrapolation of the debt risk premium. Technical report, ESQUANT Statistical Consulting. 10 June 2014.

Professional Service

- President, Victorian Branch, Statistical Society of Australia, 2001-2002.
  - Terms as Council Member, Vice-President, and Past President.
- Referee: *Australian and New Zealand Journal of Statistics*, *Biometrika*, *Journal of Statistical Software*