Review of NERA regime-switching framework

Report for APA Group, Envestra, Multinet Gas and SP AusNet

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1. Background and context

Author of report

1. SFG Consulting (**SFG**) has been engaged by the Victorian gas distribution and transmission businesses (APA Group, Envestra, Multinet Gas and SP AusNet) to review the regime-switching approach for estimating the market risk premium (**MRP**) that is set out in the NERA report of March 2012 and titled *Prevailing conditions and the market risk premium*.

2. We have been asked to undertake this assessment exercise in the context of Rule 87 of the National Gas Rules. We have been requested to consider whether the forward-looking estimate of the MRP that is generated by the NERA regime-switching model is at a level which is commensurate with prevailing conditions in the market for funds. Specifically, the task at hand is to assess whether the estimated required return on equity, that would result from the use of the particular MRP figure in a suitable asset pricing model, is commensurate with prevailing conditions in the market for funds and the risks involved in providing reference services.

3. This report has been authored by Professor Stephen Gray. I am Professor of Finance at the UQ Business School, University of Queensland and Director of SFG Consulting. I have honours degrees in Commerce and Law from the University of Queensland and a PhD in Finance from the Graduate School of Business at Stanford University. I have extensive experience in advising companies, government, and regulatory agencies on issues relating to weighted-average cost of capital.

4. My PhD dissertation at the Graduate School of Business at Stanford University developed a number of regime-switching models. This work was subsequently published in the top-ranked *Journal of Financial Economics*. I have published a number of papers dealing with regime-switching models in leading journals as follows:

    a) Chan, K-F., R. Brooks, S. Treepongkaruna and S. Gray, (2011), "Asset market linkages: Evidence from financial, commodity and real estate assets," *Journal of Banking and Finance*, 35, 6, 1415-1426.

    b) Dahlquist, M. and S. Gray, (2000), "Regime-Switching and Interest Rates in the European Monetary System," *Journal of International Economics*, 50(2), 399-419.

    c) Bollen, N., S. Gray and R. Whaley, (2000), "Regime-Switching in Foreign Exchange Rates: Evidence from Currency Options," *Journal of Econometrics*, 94, 239-276.

    d) Gray, S. (1996), "Modeling the Conditional Distribution of Interest Rates as a Regime-Switching Process," *Journal of Financial Economics*, 42, 27-62.

    e) Gray, S. (1996), "Regime-Switching in Australian Interest Rates," *Accounting and Finance*, 36(1), 65-88.

Declaration

5. I have been provided with a copy of the Federal Court Guidelines for Expert Witnesses and have prepared this report in accordance with them. In preparing this report, I have made all the enquiries that I believe are desirable and appropriate and no matters of significance that I regard as relevant have, to my knowledge, been withheld from the Court.

2. The NERA regime-switching model

Standard Markov switching model

6. In a regime-switching model there are two (or more) regimes or "states of the world" and the variable in question is modelled differently in each. In the NERA model, the return to the market in excess of the risk-free rate is modelled in each of the two regimes as follows:

    a) There is a *low volatility* regime in which stock returns exhibit low volatility and the MRP is relatively low, commensurate with the lower risk in that regime; and

    b) There is a *high volatility* regime in which stock returns exhibit high volatility and the MRP is relatively high, commensurate with the higher risk in that regime.

7. The relationship between stock market volatility and MRP is consistent with the model of Merton (1973).

8. The process by which MRP is generated switches between regimes from time to time. This process is a latent, unobservable process, so it is not possible to make definitive statements about which regime governs the process at any particular point in time. Rather, the relative likelihood of each regime must be inferred from the available data. This enables probabilistic statements (called "regime probabilities") to be made about which regime governs the process. The best available estimate is then a weighted average of the two regimes, where the weights are given by the regime probabilities.

9. In the NERA model, there is a high probability (94-95%) that the process tends to remain in the same regime from one year to the next. This implies that, on average, the process tends to remain in a particular regime for a long period of time (15.4 years on average for the high volatility regime and 20.4 years on average for the low volatility regime – based on the transition probability matrix reported by NERA, 2012). These durations are also linked to the unconditional (long-run average) probability of being in a particular state. NERA (2012) report that the unconditional probabilities are 43% for the high volatility state and 57% for the low volatility state (the same proportions as the average regime lengths (15.4 and 20.4 years respectively).

10. To be consistent with Merton (1973, 1980), NERA (2012) estimate the MRP in terms of continuously compounded stock returns relative to short-term CGS. This requires two adjustments to obtain the MRP as used by the AER:

    a) Conversion from continuously-compounded returns to returns that are *not* continuously compounded; and

    b) Conversion from a short-term risk-free rate proxy to a 10-year proxy.

11. After these conversions are performed, the unconditional mean estimate of MRP (using the current one-year spot interest rate and 10-year yield) can be computed as a weighted-average of the estimated means for each regime, where the weights are given by the average regime durations. The parameter estimates in the NERA Report imply a long-run unconditional mean of 6.24%.

12. According to the NERA estimates, in a long series of historical data the average (annual) excess return of a broad portfolio (over and above the return on the 10-year risk-free asset) would be close to but not identical to 6.24% p.a. It would not be identical because the gap between 10-year yields and one-year spot rates has in the past been marginally lower on average than it was at the end of 2011. 6.24% is an *unconditional* estimate of MRP.

Conditional estimate of MRP

13. We note that it is the *conditional* estimate of the MRP that is the estimate that is commensurate with the prevailing conditions in the market for funds. The use of CAPM parameter estimates that are conditional on the relevant information that is available at the time is also consistent with the framework adopted by the AER. In particular, in its SoRI, the AER concluded that the MRP could vary over time in line with different economic conditions and that the estimate that is adopted should reflect the prevailing conditions in the market at the time of each reset:

> …the MRP could avary [sic] over time in line with different economic conditions…However, due to the global economic and financial crisis, relatively stable market conditions do not currently exist. While it is conditions at the time of the reset, rather than at the time of the WACC review which are relevant, the AER has taken into account current conditions to the extent these conditions are expected to prevail over the time of reset determinations affected by this review. In other words, as the AER is reviewing the WACC parameters now—including 'locking-in' a value for the MRP—to the extent that current conditions (at the time of this review) are expected to be maintained until the time of the determinations effected [sic] by this review, then current conditions remain a relevant consideration in determining what value should be 'locked-in' for the MRP.[1]

14. Moreover, in a recent report for the AER, Davis (2011) concludes that:

> The AER approach could, I suggest, be viewed as an "implicit conditional CAPM" approach in which there is regular review of beta, the risk free rate and the MRP.[2]

and

> there is some support for a "conditional" CAPM in which forward looking expected returns depend on some stochastic factor(s) additional to the expected Market Risk Premium (which itself may be variable).[3]

15. The AER accepts this interpretation of the framework it uses to estimate the required return on equity:

> As noted by Professor Davis, the AER is using an 'implicit conditional CAPM' approach.[4]

16. Having recognised that the appropriate estimate of MRP will be above the long-run mean on some occasions and below it on others, it seems clear that the AER requires an estimate of MRP that:

    a) "reflects the conditions at the time of the reset" rather than the average conditions over the last 50 or more years;[5] and

    b) is a conditional estimate (consistent with the AER's adoption of a conditional CAPM approach)[6] and not a long-run average unconditional estimate.

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[1] SoRI, pp. 44-45.
[2] Davis (2011, p. 9).
[3] Davis (2011, p. 11).
[4] Envestra Final Decision, p. 41.
[5] SoRI, pp. 44-45.

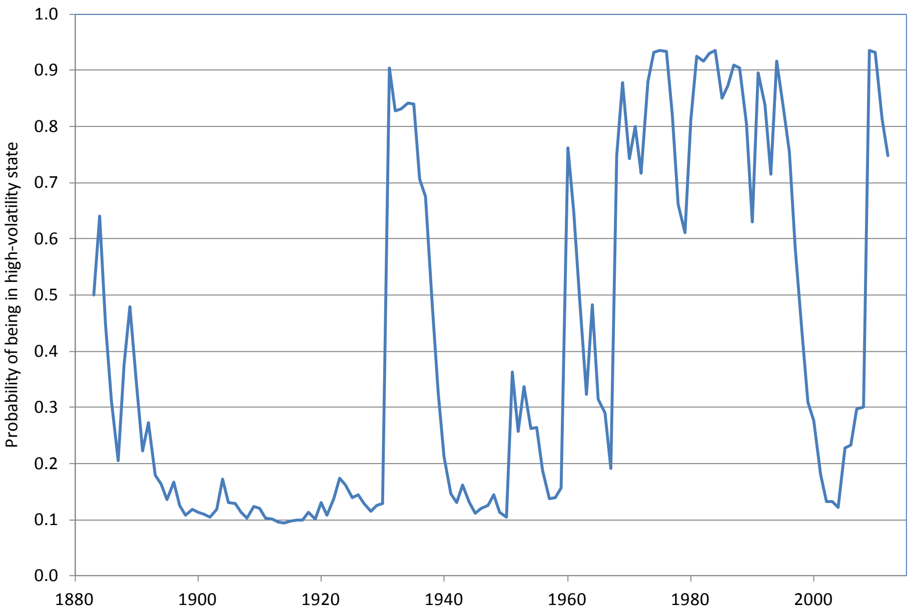
17. A regime switching model quantifies the probability that an estimate above or below the long-run unconditional mean would be appropriate in the present circumstances. It provides conditional estimates.

Role of regime probabilities

18. When interpreting regime-switching models, it is important to note that the regime that governs the process is not observable and must be inferred from the available data. That is, it is not possible to observe which regime currently governs the process and then adopt the estimate of MRP for that regime as being the one that is commensurate with the prevailing conditions in the market. Rather, the identity of the regime in question must be inferred from the observable data.

19. Inferences about which regime governs the process at a particular point in time are summarised in the form of regime probabilities, as set out in Figure 3.3 (p. 24) of the NERA Report which is reproduced below.

Figure 3.1
Probability of being in high-volatility state



Note: Data are from Brailsford, Handley and Maheswaran (2011) and Bloomberg.

20. This figure sets out the probability of the process being governed by the high-volatility regime at each point in time over the sample period. The way to interpret this figure is as a recursive process. Suppose there has been a series of large magnitude excess returns[7] over previous years. In this case, the model would assign a high probability to the process being governed by the high-volatility regime – it being much more likely that a series of large magnitude excess returns would be generated by the high volatility regime than by the low volatility regime.

[6] Envestra Final Decision, p. 41.
[7] The excess return is the difference between the return on a broad portfolio of stocks and the risk-free rate over the same period.

21. Now suppose that a moderate or average excess return is observed the next year. At this stage, there are two possibilities – either:

    a) The process remains in the high-volatility regime and this just happens to be a "low volatility" observation; or

    b) There has been a switch to the low volatility regime.

22. Because it is difficult to draw a strong conclusion from one observation, the probability of being in the high volatility regime is likely to reduce only somewhat. If the following observation is a large magnitude excess return, the model will conclude that no switch has occurred and the process remains in the high-volatility regime. If, however, the moderate excess return is followed by more moderate observations, the model will conclude that a switch has occurred and that the process is unlikely to still be in the high-volatility regime.

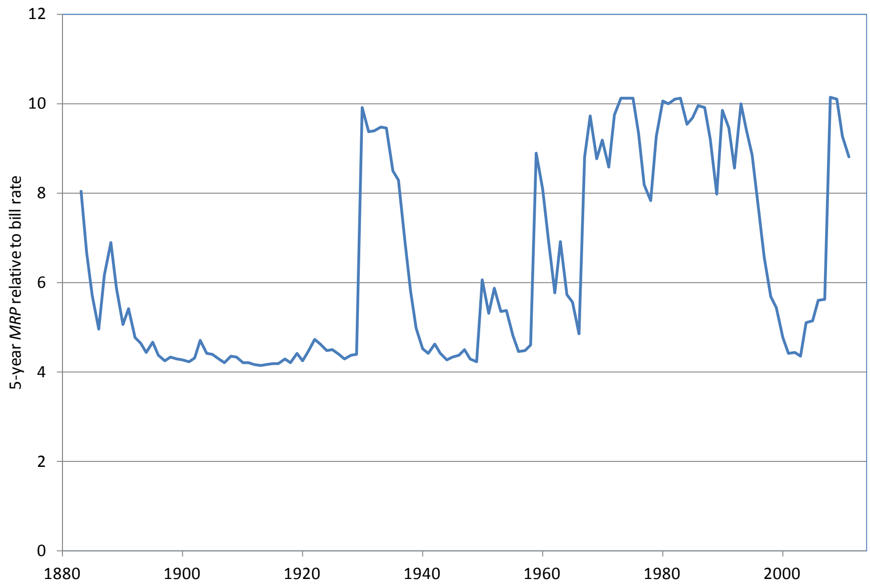
Present estimate

23. The most recent regime probability in the figure above is approximately 75%. That indicates that (given all of the available data) there is a 75% chance that the process is currently in the high-volatility regime and a higher than average estimate of MRP is appropriate and there is a 25% chance that the process is currently in the low-volatility regime and a lower than average estimate of MRP is appropriate. The NERA Report shows that the weighted-average expectation of these two values over the next year is currently 9.18%. This value is given in the last row of the first column of Table 3.2 in the NERA report.

24. The NERA report also considers estimates of the regime probabilities for each of the next five years and derives an aggregated MRP estimate of 8.44% p.a. (effectively an average value over the next five years).

25. I also note that NERA have reported a set of rolling five-year MRP estimates in their Figure 3.4 (p. 26), which is reproduced below. These are the conditional five-year ahead MRP estimates at various points in time, expressed relative to the bill rate.

Figure 3.2
5-year *MRP* relative to bill rate



26. Finally, I note that I have executed the computed code used by NERA and have been able to replicate the NERA calculations.

Use of the regime-switching estimate in the regulatory environment

27. As noted above, a regime switching model quantifies the probability that an estimate above or below the long-run unconditional mean would be appropriate in the present circumstances – it provides conditional estimates, consistent with the AER approach. A regime-switching model therefore seeks to provide an estimate of MRP that, when used in a suitable asset pricing model, produces an estimate of the required return on equity that is commensurate with prevailing conditions in the market for funds and the risks involved in providing reference services.

28. An estimate of MRP that is based on a simple average of a large sample of historical data does not take into account how the current conditions in the market might differ from the average conditions over that sample period. The AER recognised this in setting the long-run average estimate to 6%, but then adopting a (conditional) MRP estimate of 6.5% in its last WACC Review – that adjustment reflected the AER's view that the conditions in the market at that time (the peak of the GFC) differed from the average conditions over its sample period. Whereas the 50 basis point adjustment applied by the AER was arbitrary (in that no evidence was presented to support the quantum of that adjustment), the regime-switching approach quantifies the extent to which the current conditions differ from the average conditions and also quantifies an estimate of MRP that is commensurate with the current conditions in the market. By contrast, the use of a long-run historical estimate (without consideration of how the current market conditions differ from the average conditions) would be an estimate that is *irrespective of*, rather than *commensurate with*, the current conditions in the market.

29. Whereas dividend growth models require the joint estimation of growth in dividends and MRP, the regime-switching approach provides a direct estimate of the MRP in the current market conditions. The regime-switching approach effectively does this by calibrating the historical relationship between volatility and MRP (in accordance with the well-known Merton model) and then applying that relationship to current data.

30. In my view, the regime-switching approach, which produces a present estimate of 8.44%, is an appropriate method for obtaining an estimate of the market risk premium that is commensurate with the prevailing conditions in the market for funds. Such an estimate of MRP would be used in an asset pricing model that has the purpose of producing an estimate of the required return on equity.

31. It is my view that there are a number of approaches that seek to estimate the MRP that is commensurate with the prevailing conditions in the market. One of these is the regime-switching approach. Another is to use information on the levels of variables known to be related to the MRP to estimate what the MRP might be. As the SFG March 2011 report for Envestra makes clear, the finance literature provides evidence that dividend yields and default spreads are positively associated with future equity market returns relative to Treasury bill rates (Fama and French, 1988 and 1989; and Keim and Stambaugh, 1986). Low equity prices (relative to trailing dividends) and low corporate bond prices (relative to promised repayments) reflect investors' expectations for risk and therefore their required return for bearing that risk, in both the equity and debt markets. As at the end of January 2012, the dividend yield[8] was 1.02 standard deviations above its mean since 2000 while the debt yield spread[9] was 1.95 standard deviations above its mean since 2000. This information suggests, like the estimates from NERA's regime switching model, that the MRP currently lies above its long-run mean."

[8] Measured as the yield on the ASX 200 index, as reported by DataStream.

[9] Measured as the spread between the DataStream AAA and BBB yield estimates. This figure is based on redemption yields for Australian corporate bonds with approximately 3-years to maturity supplied by Merrill Lynch Bank of America.

3. Use of regime-switching models in the literature

Markov regime-switching models are well accepted

32. The literature on modelling the stochastic process of stock market returns contains many papers that employ Markov regime-switching models. The remainder of this section contains a brief summary of some examples of papers that model the returns of stock market indexes as following a Markov regime-switching process.

Kim, C., J. Morley and C. Nelson, (2004), "Is There a Positive Relationship between Stock Market Volatility and the Equity Premium," ***Journal of Money, Credit and Banking*****, 36(3), 339-360.**

33. The authors use a Markov switching model to test for a positive relationship between stock market volatility and the equity premium. Using US data from 1926 – 2000, they employ the log-linear present value framework and show how the strong evidence of a negative volatility feedback effect is equivalent to a positive relationship between market volatility and the equity premium.

34. Using monthly excess returns on a value-weighted portfolio of all NYSE stocks, they find strong evidence of Markov switching market volatility, the existence of a time-varying risk premium (that changes in response to the Markov-switching level of market volatility), and the presence of a volatility feedback effect.

35. The volatility feedback effect is the concept that if market volatility is persistent and positively related to the equity premium, then exogenous changes in market volatility will themselves lead to further volatility changes (from adjustments to future expected discount rates). Such effects need to be accounted for to accurately measure the relationship between market volatility and *expected* returns. The authors do so and document a statistically significant positive relationship between stock market volatility and the equity premium.

Turner, C., R. Startz and C. Nelson, (1989), "A Markov Model of Heteroskedasticity, Risk and Learning in the Stock Market," ***Journal of Financial Economics*****, 25, 3-22.**

36. The authors estimate a Markov switching model to explore the relation between the time-dependent variance and the market risk premium. They model two states: one low variance and the other high variance. They show that under the assumption that investors do not know immediately which state they are in, the estimates of the extra return required to compensate them for the extra risk inherent in the high variance state are consistent with the asset pricing literature.

37. The study uses monthly returns from the (value-weighted) S&P 500 Composite Index over the period 1946 – 1987. The authors find that high variance states are accompanied by high expected returns. Any measured low realized returns initially are due to investors being surprised by a transition to a high variance state from a low variance state (since the probability of doing so is so low). Since the probability of remaining in a high variance state is much larger, investors anticipate this and prices then fall to reflect the added risk premium demanded.

Schaller, H. and S. van Norden, (1997), "Regime Switching in Stock Market Returns," ***Applied Financial Economics*****, 7, 177-191.**

38. Using a Markov switching model, the authors find strong evidence of distinct regimes in stock market returns. The study covers the period 1927-1989 and uses CRSP value-weighted monthly (excess) returns. The authors document two distinct regimes for mean returns and two distinct

regimes for return variance (with substantial overlap between the two). They also document distinct regimes for switching in both mean and variance.

Mayfield, S., (2004), "Estimating the Market Risk Premium," *Journal of Financial Economics*, 73, 465-496.

39. The author develops a method for estimating the market risk premium based on the equilibrium relationship between volatility and expected returns when there are changes in volatility. In the model, market risk is characterized by periodic high volatility followed by a return to the more normal lower volatility state. The study assumes that the evolution of these volatility states follows a Markov process, and models the market risk premium as a function of the underlying process governing the evolution of the two volatility states. The expression for the equilibrium risk premium in model is a special case of the Merton (1973) ICAPM model.

40. The study demonstrates the importance of accounting for the dynamic nature of market risk when estimating the risk premium from ex post market returns. Because individuals anticipate future changes in the volatility state and corresponding changes in the level of stock prices, ex post measured returns are not equal to ex ante expected returns. When individuals place a non-zero probability on the likelihood of a future change in volatility state, expected returns include the expected change in stock prices associated with a change in volatility state. While the economy remains in the high volatility state, actual ex post returns will be lower on average than expected returns.

41. The author's results suggest that, as a result of changes in the level of market volatility, the simple historical average of excess market returns obscures significant variation in the market risk premium and that over half of the measured risk premium is associated with the risk of future changes in the level of market volatility.

Whitelaw, R., (2000), "Stock Market Risk and Return: An Equilibrium Approach," *Review of Financial Studies*, 13, 521-547.

42. The author constructs a general equilibrium model with regime switching in the consumption growth process to investigate the relationship between expected returns and conditional volatility. This approach deviates from modelling asset prices and returns directly and instead focuses on the underlying fundamental process, consumption growth.

43. The author shows that for the individual regimes within the two-period model, there is a linear relationship between volatility of return and expected return, in cases where there is zero probability of a regime shift. In other cases, his model exhibits a complex non-linear and time-varying relation between expected returns and volatility.

Lundblad, C., (2007), "The Risk Return Tradeoff in the Long Run: 1836-2003," *Journal of Financial Economics*, 85, 123-150.

44. The author argues that studies that fail to find a significant positive relation between the market risk premium and conditional volatility is due to statistical limitations placed on such studies by small samples. From simulation analysis the author is able to show that an extremely large amount of data is required to successfully detect the risk-return trade-off.

45. Using an extended data set of almost two centuries' worth of US data, the author documents a significant and positive relationship between risk and return across a variety of volatility specifications. The findings are then corroborated with UK data.

Henkel, S., S. Martin and F. Nardari, (2011), "Time-Varying Short-Horizon Predictability," *Journal of Financial Economics*, 99, 560-580.

46. Motivated by the return predictability literature, the authors use data on G7 countries, and employ a Markov regime switching vector auto-regression framework for their analysis. The authors find that the market risk premium is higher during recessions (identified by higher market volatility) in all 7 countries. Additionally, they find expected return predictors less persistent and more volatile during recessions.

Walsh, K., (2006), "Is the Ex Ante Risk Premium Always Positive? Further Evidence," *Australian Journal of Management*, 31(1), 93-113.

47. The author employs a Markov regime switching approach to Australian data from 1973 – 2001. A Bayesian approach is used in the testing, in which the author imposes negative priors (means of different signs) to drive the results. The author employs a Markov Chain Monte Carlo sampling technique. The results indicate the presence of two distinct regimes in the data, one a low volatility state, the other a much higher volatility state.

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Walsh, K., (2006), "Is the Ex Ante Risk Premium Always Positive? Further Evidence," *Australian Journal of Management*, 31(1), 93-113.

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