GOLDFIELDS GAS PIPELINE

Access Arrangement Revision Proposal

Supporting Information: Attachment 7

SFG Consulting
Cost of equity for the Goldfields Gas Pipeline

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Cost of equity for the Goldfields Gas Pipeline

Report for Goldfields Gas Transmission

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1. Introduction

1.1 Overview

1. SFG Consulting has been retained by Goldfields Gas Transmission (**GGT**) to provide advice on the cost of equity capital for the Goldfields Gas Pipeline (**GGP**). APA owns 88.2% of the mainline of the GGP, running from Yarraloola to Kalgoorlie, and the lateral pipeline to Newman. The remaining 11.8% of the mainline and the Newman lateral is owned by the Alinta Energy Group (**Alinta**).

2. The GGP is regulated by the Economic Regulation Authority of Western Australia (**ERA**) under the National Gas Rules (**the Rules**). The Rules state the following with regards to the allowed rate of return.

> The allowed rate of return is to be determined such that it achieves the allowed rate of return objective.
>
> The allowed rate of return objective is that the rate of return for a service provider is to be commensurate with the efficient financing costs of a benchmark efficient entity with a similar degree of risk as that which applies to the service provider in respect of the provision of reference services (the allowed rate of return objective).[1]

3. The Rules go on to state that the allowed rate of return is to be a weighted average of the return on debt and the return on equity.[2] With regards to the return on equity, the Rules state the following.

> The return on equity for an access arrangement period is to be estimated such that it contributes to the achievement of the allowed rate of return objective.
>
> In estimating the return on equity under subrule (6), regard must be had to the prevailing conditions in the market for equity funds.[3]

4. In the current paper we are only concerned with the estimate of the cost of equity capital. On 16 December 2013 the ERA released its Rate of Return Guidelines (**the Guidelines**). In the Guidelines the ERA concluded that the only relevant model for estimating the cost of equity, in the absence of new developments in theory or empirical evidence, is the Sharpe-Lintner Capital Asset Pricing Model (**CAPM**).[4]

5. The Sharpe-Lintner CAPM, applied to the cost of equity, states that the cost of equity is the sum of the risk-free rate of interest (r_f) and a premium for bearing systematic risk. The systematic risk premium is the product of the sensitivity of equity returns to market returns (equity beta or β_e, which is the amount of risk) and the market risk premium (the *expected* market return relative to the risk-free rate or $r_m - r_f$, which is the price per unit of risk). Expressed as an equation the cost of equity from the Sharpe-Lintner CAPM is as follows.

$$r_e = r_f + \beta_e \times (r_m - r_f)$$

6. In its Guidelines the ERA states that its estimate of equity beta lies within a range of 0.5 to 0.7,[5] its estimate of the market risk premium lies within a range of 5.0% to 7.5%,[6] and the ERA intends to estimate the risk-free rate as the average yield to maturity on five year government bonds over 40 trading days prior to the release of the regulatory determination.[7] In its indicative example on constructing the return on equity, the ERA adopted an equity beta estimate of 0.7, a market risk

[1] NGR, 87(2) to 87(3).
[2] NGR, 87(4).
[3] NGR, 87(6) to 87(7).
[4] ERA Guidelines, Section 10, para. 113 to 114, p. 22. Sharpe (1964), Lintner (1965).
[5] ERA Guidelines, Section 12, para. 140, p. 27.
[6] ERA Guidelines, Section 11, para. 131, p. 25.
[7] ERA Guidelines, Section 7, para. 94 to 95, p. 18.

premium of 6.00% and a risk-free rate of 3.44%. This implied a cost of equity of 7.64%.[8] In the view of the ERA the cost of equity estimate of 7.64% "is commensurate with the efficient financing costs of the benchmark efficient entity prevailing at this time."[9]

1.2 Context for a direct estimate of the cost of equity for GGP

7. In the Guidelines, the only information used to determine the cost of equity for a benchmark entity, relative to an estimate of the cost of equity for the average firm in the market, is a beta estimate derived in the following manner. The ERA considered the relationship between historical stock returns and historical market returns for a sample of Australian-listed stocks. Stocks listed overseas are given zero consideration.[10] The sample of Australian-listed stocks in the Guidelines is a set of six stocks, namely Envestra, APA, DUET, Hastings Diversified Utilities Fund (**HDF**), SP Ausnet, and Spark Infrastructure.[11] HDF is no longer listed, having been acquired by APA, so there remains five Australian-listed stocks in the ERA sample.

8. The ERA considers beta estimates computed using ordinary least squares (OLS) regression, least absolute deviation (LAD) regression, MM regression, and Theil-Sen regression. These four regression techniques each place different weights on paired observations of stock returns and market returns, depending upon how the technique accounts for possible outliers. However, the important point to note for the current report is that all four estimation techniques generate estimates of the line of best fit between previous stock returns and previous market returns for a sample of six Australian-listed firms. Merely running four different weighted regressions on the same dataset does not substantially improve the reliability of the cost of equity estimated using beta and the Sharpe-Lintner CAPM.

9. Before outlining the approach taken in the current paper it is important to place the ERA approach in the context of analysis conducted over the past year, as part of the Guidelines process undertaken by the ERA and the Australian Energy Regulator (**AER**), and as part of submissions in regulatory determinations.

10. The single statistical technique adopted by the ERA (regression) and single dataset (stock returns and market returns for five or six Australian-listed firms) forms one approach for estimating how the benchmark cost of equity could differ from the market cost of equity. In prior work we have documented that the outcomes from this approach need to be treated with caution, for a number of reasons.

a) There is a substantial body of evidence that the application of this technique (regression) and dataset (stock returns and market returns) leads to cost of equity estimates that have little or no relationship with realised stock returns.[12]

b) Beta estimates from regression are unstable over time and vary substantially across small samples of firms in the same industry. The use of five or six firms in regression analysis to estimate the cost of equity leads to risk estimates that are highly unreliable.[13]

c) When applied to a sample of stock returns and market returns to estimate beta, the LAD regression technique has a downward bias which is approximately 0.15 for the average sample firm.[14]

d) If regression-based estimates of beta are to be used to estimate risk, they are more reliable if constructed using the Vasicek adjustment.[15] But even with the Vasicek adjustment,

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[8] ERA Guidelines Appendix 30, para. 17, 24, 26, and 32 to 33, pp. 215 to 218. $r_e = r_f + \beta_e \times (r_m - r_f) = 0.0344 + 0.7 \times (0.0944 - 0.0344) = 0.0344 + 0.7 \times 0.0600 = 0.0344 + 0.0420 = 7.64\%$.

[9] ERA Guidelines Appendix 30, para. 33, p. 218.

[10] ERA Guidelines, Section 12, para. 138, p. 27.

[11] ERA Guidelines Appendix 18, p. 155.

[12] SFG Consulting: Black CAPM (2014).

[13] Brooks, Diamond, Gray and Hall: Reliability (2013)

[14] Brooks, Diamond, Gray and Hall: LAD (2013)

regression-based estimates of beta have little or no ability to explain the variation in realised stock returns.[16]

e) Evidence from U.S.-listed firms implies a regression-based beta estimate that is materially above 0.7.[17]

f) Cost of equity estimates derived using the dividend discount model, applied to Australian-listed network businesses, are consistent with a beta estimate between 0.9 and 1.0.[18]

g) For Australian-listed firms (which have lower beta estimates than U.S.-listed firms), cost of equity estimates from the Fama-French three-factor model[19] are substantially higher than cost of equity estimates from the Sharpe-Lintner CAPM; and for U.S.-listed firms (which have higher beta estimates than Australian-listed firms) there is a smaller incremental return associated with the Fama-French factors.[20]

11. In aggregate, the ERA conclusion that the beta estimate for a benchmark gas pipeline lies within a range of 0.5 to 0.7, and has a best estimate of 0.7, relies upon the ERA view that the evidence summarised in the paragraph above is irrelevant. This emphasises that the ERA conclusions on the equity risk of a benchmark gas pipeline are based entirely upon (1) regression analysis of stock returns as the sole risk measurement technique; (2) analysis of only five or six firms; (3) analysis only of Australian-listed firms; and (4) the use of just one model for the cost of equity. In our view, the ERA conclusions on the cost of equity for a benchmark gas pipeline are framed with reference to a very small subset of the available evidence which has led to an understatement of the cost of equity in the Guidelines.

12. In the current paper we extend our analysis to a direct estimate of the cost of equity for a benchmark gas pipeline with a similar degree of risk to the GGP. We consider the *expected* return outcomes to a benchmark gas pipeline in different market situations using standard finance theory. We document that the cost of equity for a benchmark gas pipeline is likely to be above the cost of equity implied by the Sharpe-Lintner CAPM, populated with a beta estimate of 0.7.

13. The way we approach the issue is to ask the question, "What is the *expected* outcome to equity holders in a gas pipeline investment under different market conditions?" The answers to this question lead directly to an estimate of the required return to equity holders, given assumptions about the risk-free rate, yield on debt, market risk premium and equity market volatility.

14. As far as we are aware, this is the first time that our approach has been used in making an estimate of the cost of equity for a regulated energy network in Australia. But this does not mean that our approach is in any way out of line with conventional finance theory. Instead, our approach is entirely consistent with the standard approach for pricing any asset with payoffs that depend upon outcomes for any other asset. We estimate the equity value and cost of equity for a gas pipeline as a function of the outcomes for the market. The finance theory is exactly the same as that used to price an option as a function of the outcomes for an underlying asset (for example, pricing a call option as a function of a stock price, or pricing equity as a function of asset value).

15. We have used a similar approach in the context of estimating the profit margin for electricity and gas retailers in New South Wales. This approach has been adopted by the Independent Pricing and Regulatory Tribunal (**IPART**) on a consistent basis from 2007 to 2013.[21] The starting point for

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[15] Vasicek (1973).

[16] Brooks, Diamond, Gray and Hall: Vasicek (2013)

[17] SFG Consulting: Parameters (2013), SFG Consulting: Beta (2014).

[18] SFG Consulting: DDM (2013), SFG Consulting: DDM reconciliation (2013), SFG Consulting: DDM versions (2014).

[19] Fama and French (1993).

[20] SFG Consulting: Parameters (2013), SFG Consulting: Fama-French (2014).

[21] IPART (2013a, 2013b, 2010a, 2010b, 2007).

estimating the profit margin is to ask, "What is the *expected* outcome to equity holders in an energy retailer under different market conditions?"

16. **Given current information, and based upon the framework relied upon in this paper, our best estimate of the cost of equity for a benchmark gas pipeline (with similar risk to the GGP) is 11.24%.** This cost of equity estimate can be contrasted with other assumptions adopted in this paper, namely a risk-free rate of 3.87%, and a yield to maturity on debt of 6.23%. So our conclusion is that the cost of equity is 7.37% higher than the risk-free rate and 5.01% higher than the cost of debt.

17. We make a distinction between the *expected return*[22] to equity holders across all possible outcomes, and the *expected return to equity holders in the absence of default*. Our cost of equity estimate of 11.24% corresponds to the *expected return to equity holders in the absence of default*. This is the return that is input into a typical post-tax revenue model that is based upon a *no default* scenario.

18. Once the probability of default is accounted for, the *expected return* to equity holders across all scenarios is estimated at 9.33%. In other words, if equity holders *expect* to earn a return of 11.24% across *no default* scenarios, on average, equity holders will expect to earn a return of 9.33% across all possible contingencies. In contrast, the *expected return* on government bonds is 3.87%, the *expected return* on debt is 5.03% and the *expected return* on the equity market is 10.54%. So the *expected return* on equity in a benchmark gas pipeline is a 4.30% premium to the *expected return* on debt and a 5.47% premium to the risk-free rate.[23] But for this return to be earned on average requires an input into a *no default* pricing model of 11.24% for the cost of equity.

19. Our analysis is not restricted by an assumption that the Sharpe-Lintner CAPM is the model via which assets are priced. But the results can be framed with reference to the Sharpe-Lintner CAPM for comparison with conclusions of the ERA.

20. As an input into a *no default* post-tax revenue model, the cost of equity of 11.24% corresponds to an equity beta of 1.10.[24] The *expected return* to equity holders of 9.33% corresponds to an equity beta of 0.82.[25] So the risk premium *expected* to be earned by equity holders is 0.82 times the market risk premium assumption of 6.67%. But for this risk premium to be earned, on average, requires an input into a *no default* post-tax revenue model of an equity beta of 1.10.

1.3 Outline

21. In Section 2 of the report we document our estimation method and provide estimates of the cost of equity for a benchmark gas pipeline with leverage of 60.00% and a yield to maturity on debt of 6.23%. In Section 3 we consider specific risks faced by the GGP. We present conclusions in Section 4.

[22] Throughout the paper the terms *expected* and *expectation* have their statistical meaning, which in an average outcome. Thus can be contrasted with common usage of the term expected to mean most likely or predicted.

[23] *Expected return* on equity – *expected return* on debt = 9.33% – 5.03% = 4.30%. *Expected return* on equity – risk-free rate = 9.33% – 3.87% = 5.47%.

[24] $\beta_e = (r_e - r_f) \div (r_m - r_f) = (0.1124 - 0.0387) \div (0.1054 - 0.0387) = 0.0737 \div 0.0667 = 1.10$.

[25] $\beta_e = (r_e - r_f) \div (r_m - r_f) = (0.0933 - 0.0387) \div (0.1054 - 0.0387) = 0.0547 \div 0.0667 = 0.82$.

2. Cost of equity implied by debt yields and market returns

2.1 Introduction

22. The fundamental valuation principle applied in the regulation of gas networks is that the present value of *expected* cash flows, discounted at the risk-adjusted cost of capital, is equal to the asset base. This is the same principle we adopt in estimating the cost of equity for a benchmark gas network. We estimate the cost of equity that sets the present value of cash flows to equity holders equal to the initial value of equity.

23. The manner in which regulated prices are typically set is on the basis of a scenario, embedded in a post-tax revenue model. The scenario incorporates assumptions about volume, capital expenditure, operating costs, taxation, and parameter inputs into the weighted average cost of capital. This scenario is not necessarily the same as an *expectation,* which is the probability-weighted average of possible outcomes. The scenario upon which regulated prices are generally set is closer to the most likely case, as opposed to the average case.

24. Another view of a typical post-tax revenue model used in regulation is that it represents an average outcome across situations that do not envisage default on debt. We refer to this as the average *no default* outcome.

25. Regardless of whether a post-tax revenue model is considered to be a single most likely scenario, or an average scenario, it is clearly a scenario that encompasses only *no default* outcomes. The payments to debt holders and taxation payments are all based upon full repayment of debt and full payment of taxation. In a true average outcome the payments to debt holders are less than promised payments (because there are situations of default but not cases in which debt holders receive extra compensation) and taxation payments are less than in a full profit case (because tax losses are only used to offset profits at some future time).

26. In our analysis we consider more closely the concept of the *expected* outcome. The reason the *expected* outcome is important is because the benchmark gas pipeline is exposed to risks of customer defaults that have a low probability of occurrence, but which are likely to increase during periods of market downturns. So just considering the most likely scenario, or just the average *no default* outcome, will not provide a sufficient understanding of risk to estimate the cost of capital.

27. At the outset we need to establish that the assumptions which underpin the cost of capital estimate must be internally consistent. This makes economic sense and is also required under the Rules, which state that:

> In determining the allowed rate of return, regard must be had to:
>
> (a) relevant estimation methods, financial models, market data and other evidence;
> (b) the desirability of using an approach that leads to the consistent application of any estimates of financial parameters that are relevant to the estimates of, and that are common to, the return on equity and the return on debt; and
> (c) any interrelationships between estimates of financial parameters that are relevant to the estimates of the return on equity and the return on debt.[26]

28. For the purpose of this paper we have made the following assumptions in order to estimate the cost of equity on a consistent basis with other parameter inputs. We provide sensitivity analysis to demonstrate how the analysis would change under alternative assumptions. We have not yet demonstrated the estimation approach. But the estimation approach is best explained with reference to specific computations, so we present the following assumptions at the outset.

[26] NGR 87(5).

29. It should also be noted that the key points made in this paper still hold, regardless of whether we use the assumptions adopted below, or the assumptions adopted by the ERA in the Guidelines. The assumptions are as follows.

a) **The risk-free rate is estimated at 3.87% per year.**

This is the average annualised yield to maturity on the estimated yield on 10 year government bonds published by the Reserve Bank of Australia (**RBA**) for the 40 trading days ending on 10 June 2014.[27]

b) **The *expected* market return is estimated at 10.54% per year, which represents a premium of 6.67% above the risk-free rate of interest. Imputation credits are not considered.**

The *expected* market return is a weighted average of outcomes from four estimation approaches. Excluding consideration of imputation credits, the market return estimates and assigned weights are as follows:

(1) analysis of historical average excess returns (20% weight) implies r_m = 10.38%, based upon a 6.51% premium to the risk-free rate;[28]

(2) analysis of historical average real returns adjusted for current inflation expectations, also termed the Wright approach (20% weight), implies r_m = 11.58%, based upon historical average real returns of 8.86% and inflation expectations of 2.50%.[29];

(3) dividend discount model analysis (50% weight) implies r_m = 10.32% (SFG Consulting: Dividend discount model, 2014); and

(4) assumptions used in independent expert reports (10% weight) imply r_m = 9.87% based upon a 6.00% market risk premium (SFG Consulting: Cost of equity, 2014, Section 3).

The reason we do not consider imputation credits is that, if imputation credits are assumed to have value (that is, imputation credits are reflected in market prices) then this simply forms one part of the total return to equity holders required for consistency between the risk-free rate, cost of debt, market return and leverage. Put another way, an assumption about imputation credit value alters how the return to equity holders is allocated amongst dividends, capital gains and imputation credits, but we are concerned here with the total return.

We have previously expressed the concern, in several reports, that the manner in which the AER post-tax revenue model (and any other post-tax revenue model that relies upon the same equations) accounts for imputation credits is different to the manner in which imputation credits are considered when estimating the market return from historical returns and the dividend discount model. We maintain that concern but addressing this issue in the current report would add a layer of complexity that distracts from the key point – that the

[27] The ERA has stated that it considers a five year term to maturity to be appropriate for estimating the risk-free rate of interest (Explanatory Statement, Sub-section 7.2.2, para. 444, p. 85). The corresponding average yield to maturity based upon a term to maturity of five years is 3.27% per year, which represents a difference of 0.60%. We disagree with the conclusion by the ERA to use a term to maturity of five years in estimating the risk-free rate on a number of grounds, and disagree with the ERA's reasoning in its Guidelines, Explanatory Statement and Appendices. Debate over this issue is outside the scope of this report. Both the AER (AER Explanatory Statement, Sub-section 6.1.2, p. 74) and IPART (IPART, 2013c, Sub-section 4.2, p. 12) have now reverted to using a 10 year term to estimate the risk-free rate of interest (so Table 3 of the ERA Explanatory Statement, p. 85, is now out of date with respect to the AER and IPART approaches).

[28] 6.51% is the historical average market returns, relative to the yield to maturity on 10-year government bonds at the beginning of the year, from 1883 to 2013, using data compiled by NERA (2013) which updates and adjusts the data relied upon by Brailsford, Handley and Maheswaran (2012).

[29] Nominal return = (1 + real return) × (1 + inflation) – 1 = 1.0886 × 1.0250 – 1 = 11.58%. The time series of real returns is also compiled by NERA (2013).

cost of equity can be estimated with reference to the information in government bond yields, corporate bond yields, leverage and the market risk premium.

c) **The cost of debt is estimated at 6.23% per year, which represents a premium of 2.36% to the risk-free rate.**

The cost of debt was estimated with reference to the estimated yield on 10 year BBB rated non-financial corporate debt provided by the RBA for the end of May 2014 (6.08% effective annual rate),[30] plus a premium of 0.15% for debt raising and hedging costs.[31]

In its submission, the GGP relies upon a cost of debt based upon a trailing average of historical debt yields. There is no inconsistency between the GGP incorporating a trailing average cost of debt into its regulated rate of return proposal, and our use of current debt yields. The question we are trying to answer is, "If debt investors are prepared to lend today at rates of 6.23% what return would equity investors require for them to make an investment in the same pipeline?"

The use of a trailing average debt yield as part of the regulated rate of return is consistent with aligning regulated cash flows with the actual debt repayments on previously issued debt of a benchmark entity. The cost of debt issued in the past does not provide us with information about what the cost of debt or equity is, if new capital was raised today. The Rules allow for the cost of debt to be set on the basis of a trailing average of past debt yields and for the cost of equity to be set on the basis of the prevailing cost of funds.

d) **Benchmark leverage is 60% and the benchmark credit rating is BBB.**

Benchmark leverage of 60% and a benchmark credit rating of BBB are consistent with the ERA Guidelines.[32]

e) **The standard deviation of market returns is estimated at either 14.89% per year or 16.64% per year.**

The standard deviation of market returns is an input into our analysis. The figure of 16.64% is the standard deviation of annual returns on the Australian share market over 130 years from 1883 to 2013.[33] We perform analysis in two ways, and the latter approach relies upon the lower standard deviation figure of 14.89%. The reason for using this figure is that it means that one particular scenario corresponds to the market return expectation of 10.54% per year. So for expositional purposes we can refer to one particular scenario as the *typical* case. Sensitivity analysis shows that the results are not particularly sensitive to different assumptions regarding the volatility of market returns.

2.2 Cost of equity estimates from two possible market outcomes over five years

2.2.1 Framework

30. Given the assumptions above, the question is, "What is the cost of equity that, when incorporated into the post-tax revenue model for setting regulated prices, will allow equity holders to, on average, earn a return commensurate with the prevailing cost of funds?" This question needs to be considered carefully because, as mentioned above, the scenario used in setting regulated prices does not necessarily represent the average outcome for equity investors. Nor does it represent the average outcome for

[30] The RBA estimates a nominal yield to maturity of 5.99% for 10 year BBB rated corporate debt at the end of May 2014. As an effective annual rate this is $(1 + 0.0599 \div 2)^2 - 1 = 6.08\%$. Adding 0.15% for debt raising and hedging costs implies a cost of debt of 6.23% per year.

[31] The premium for debt raising and hedging costs is consistent with the ERA Guidelines (Appendix 30, paragraph 39).

[32] ERA Explanatory Statement, Sub-section 5.1, para. 257, p. 45 for leverage, and Sub-section 8.1, para. 472, p. 91 for credit rating.

[33] Data was compiled by NERA (2013) which updates and adjusts the data relied upon by Brailsford, Handley and Maheswaran (2012).

lenders. The scenario is a representative outcome assuming no defaults. In the post-tax revenue model equity holders earn an assumed return after payments to lenders are taken into account.

31. The case described in the current section is as simple as possible, in order to directly estimate the cost of equity on the basis of different market outcomes. There is one interval of time (five years), and two market outcomes (*good* and *bad*). We make the analysis incrementally more sophisticated in Sub-section 2.3 (in which we extend the analysis to 61 possible market outcomes) and in Section 3 (in which we consider the risks of the GGP more specifically).

32. The ERA has expressed a view that it prefers "simple approaches to estimating the rate of return over complex approaches where appropriate."[34] The current approach of the ERA to estimating the cost of equity could be classified as simple or complex depending upon someone's point of view. It is relatively simple to run a regression of stock returns on market returns and multiply a beta coefficient and an assumed market risk premium. So on a mechanical basis the ERA approach is simple. But analysing the results to reach a conclusion, if done rigorously, is complex. Making a decision on the appropriateness of different firms, the reliability of regression-based risk coefficients, evaluating issues of bias, and determining whether the model and approach are useful at all are complex tasks if addressed in a quantitative manner. The current approach of the ERA to estimating the cost of equity only appears to be straightforward if we just consider the mechanical part of the task.

33. Once the complexity of reaching decisions is accounted for, we consider that the approach adopted in the current paper is no more complex than the ERA's existing approach. The cost of equity in the current paper is estimated as a direct result of a series of input assumptions and the application of standard finance theory.

34. Even if the existing cost of equity estimation approach of the ERA was considered to be simple, the ERA states that it prefers simple over complex approaches "where appropriate." It is worth re-stating that cost of equity estimates from the Sharpe-Lintner CAPM, populated with regression-based estimates of beta, have never been demonstrated to have a reliable association with realised stock returns.[35] So even if the ERA's current approach to estimating the cost of equity is considered to be simple, it is **not appropriate** to use as the sole basis for determining the cost of equity.

35. Consider a five year period in which there are two possible market outcomes. We can label the highest market outcome the *good* outcome in which the market performs better than expected. In the *good* market outcome the market return exceeds the *expected* market return of 10.54% per year. This is also a situation in which the Australian economy and the global economy perform well, so we would predict above-average commodity prices and volumes for the mining customers of the gas pipeline.

36. The other market outcome represents a poor sharemarket return. We can label this market outcome as the *bad* outcome in which the market performs worse than expected. The market return is less than the *expected* market return of 10.54% per year. The Australian economy and the global economy perform relatively poorly, so we would predict below-average commodity prices and volumes for the mining customers of the gas pipeline.

37. For the providers of capital to the pipeline, there are two possible results in the bad market outcome:

   a) *no default*, in which the debt holders are repaid in full and the equity holders receive any residual value of the assets; and

   b) *default*, in which the debt holders are not repaid in full and the equity holders receive zero residual value.

38. To estimate the cost of equity we will work through the following three steps.

[34] ERA Guidelines (2013), Section 2, para. 37, p. 9.

[35] SFG Consulting: Black CAPM (2014).

39. **First, we will estimate the market return in the *good* and *bad* outcomes, and the probabilities of those two outcomes.** The returns and probabilities of *good* and *bad* market outcomes need to be consistent with the market volatility (16.64% per year), the average market return (10.54% per year) and the risk-free rate (3.87% per year).

40. **Second, we will estimate the payoffs to debt holders and equity holders in the *good* market outcome, the *bad* market outcome without default, and the *bad* market outcome including default.** The probability of default, and the payoffs to debt and equity holders need to be consistent with the probabilities of *good* and *bad* market outcomes, the yield to maturity on debt (6.23% per year) and leverage (60%).

41. **Third, we will estimate the average return to equity holders across all three scenarios, and the average return to equity holders across the *no default* scenarios.** The latter average return, across the *no default* scenarios, is consistent with the scenario approach used to set regulated prices in practice. So we basically estimate what return equity holders would earn in the absence of default, in order for equity holders to achieve an average return across all outcomes that is appropriate, given benchmark firm risk and prevailing conditions in the market for funds.

42. We emphasise that this approach is entirely consistent with the framework used to price any asset on the basis of outcomes for another asset, such as pricing call options on the basis of outcomes for stock prices, as used in the Black-Scholes-Merton option pricing model.[36] All we do in this instance is apply a general theory of asset pricing to the specific instance of an equity investment in a gas pipeline. The underlying asset is the asset value of the pipeline (just like a stock is the underlying asset in pricing a call option) and equity value is determined as a function of changes in the value of the underlying asset and the fixed claim of debt holders.

43. The basis for the analysis is that there is information in the market return, risk-free rate, leverage and yield on debt that is informative about the cost of equity capital. An investment in a corporate bond, offering a risk premium of 2.36% per year,[37] is a risky investment. For debt to be priced at this yield, there must be some chance that lenders will not be repaid in full, which also means there is some chance that equity holders will lose their entire investment. For the benchmark gas pipeline to default on its obligations to lenders, there must be a risk that the pipeline's own customers default.

44. If the payments from pipeline customers were considered an entirely safe stream of cash flows, the benchmark debt premium would be lower than 2.36% per year and/or the benchmark leverage would be more than 60.00%. The potential for customer defaults occurs in the *bad* market outcome, when commodity prices and volumes are low, and this leads to the systematic risk exposure faced by equity holders.

2.2.2 Step 1. Market outcomes and probabilities

45. A useful way to construct two outcomes for the market is to think about the market return in the *good* outcome being one standard deviation above expectations. Over five years the *expected* market return is 65.03%[38] and the standard deviation of market returns is 37.20%.[39] This means that the market return in the good scenario is 102.23% over five years.[40] So for an investment of $1.00 in the market, the outcome in the *good* market is a payoff of $2.0223.

[36] Black and Scholes (1973) and Merton (1973).

[37] The risk premium of 2.36% per year is the difference between the yield to maturity on debt of 6.23% per year and the risk-free rate of 3.87% per year.

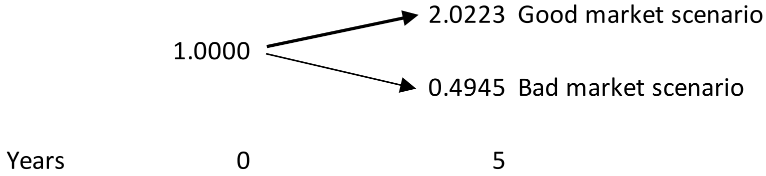
[38] The expected market return over 5 years = $(1.1054)^5 - 1 = 65.03\%$.

[39] The standard deviation of market returns over 5 years = $0.1664 \times \sqrt{5} = 0.1664 \times 2.2361 = 37.20\%$.

[40] The expected market return plus one standard deviation = $0.6503 + 0.3720 = 102.23\%$.

46. In constructing a binomial tree, we write that U (or the *up factor*) is 2.0223. The simplest way to construct a binomial tree is to set D (or the *down factor*) equal to $1 \div U$.[41] This means that $D = 1 \div 2.0223 = 0.4945$. So the market return in the *bad* market outcome is –50.55%. The market payoffs to a *good* and *bad* market outcome are illustrated in the binomial tree below.

Figure 1. Market payoffs in the good and bad market outcomes



47. If the *expected* market return is 65.03%, and the returns in the *good* and *bad* markets are 102.23%, and –50.55%, respectively, we have enough information to estimate the probabilities of the two outcomes. The *expected* market return (65.03%) is a weighted average of the *good* market return (102.23%) and the *bad* market return (–50.55%), so we can solve the following equation.

$$\textit{Expected return} = \text{Probability of a } \textit{good} \text{ market outcome} \times \text{return in a } \textit{good} \text{ market} + (1 - \text{Probability of a } \textit{good} \text{ market outcome}) \times \text{return in a } \textit{bad} \text{ market}$$

$$1 + \textit{Expected return} = p \times U + (1 - p) \times D$$

$$1 + \textit{Expected return} = p \times U + D - p \times D$$

$$1 + \textit{Expected return} = p \times (U - D) + D$$

$$p = \frac{1 + Expected\ return - D}{U - D} = \frac{1.6503 - 0.4945}{2.0223 - 0.4945} = \frac{1.1558}{1.5279} = 75.65\%$$

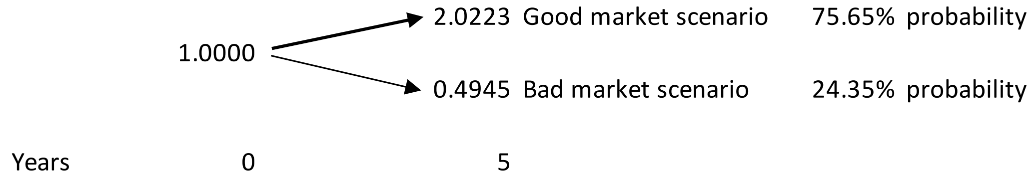
48. The solution to this equation means that there is a 75.65% chance of the *good* market outcome and a 24.35% chance of the *bad* market outcome. At these probabilities the *expected* market return is 65.03% over five years (or 10.54% per year).[42] In the figure below we have augmented the previous binomial tree with the real-world probabilities[43] of *good* and *bad* market outcomes.

[41] When the binomial tree is extended to more than one period, setting $D = 1 \div U$ means that the tree re-combines every second step. In other words, an up movement followed by a down movement will lead to the same asset value as a down movement followed by an up movement.

[42] To verify, note that 0.7565 × 102.23% + 0.2435 × –50.55% = 77.34% – 12.31% = 65.03%.

[43] The term "real-world probabilities" is used to distinguish the probabilities from "risk-neutral probabilities" that are used later in computations.

Figure 2. Real-world probabilities of *good* and *bad* market outcomes



49. In order to estimate the cost of equity capital, we will need to rely upon "risk-neutral probabilities." The concept of risk-neutral probabilities is the fundamental basis upon which assets are priced on the basis of prices of other assets. In other words, risk-neutral probabilities are the fundamental basis of derivative pricing. The basic theory of valuing any asset is that we discount *expected* cash flows at the risk-adjusted cost of capital. In some circumstances, we do not know the risk-adjusted cost of capital. This is the situation we currently face because we are trying to estimate the risk-adjusted cost of capital for equity. This was the same problem faced by people trying to value derivatives – they did not know the appropriate discount rate for derivatives because the risk of a derivative is different to the risk of the underlying asset.

50. The advance made in derivatives pricing was to discount *risk-neutral expected cash flows* at the risk-free rate, which we **can** estimate. The risk-neutral *expected* cash flows are those cash flows formed on the basis of risk-neutral probabilities. And risk-neutral probabilities are just real world probabilities that lead to the same value for the underlying asset, when discounting is done at the risk-free rate.

51. In our situation, we need to estimate what probabilities, when applied to market payoffs of 2.0223 and 0.4945 would lead to the same initial value of 1.0000, if discounting was done at the risk-free rate of interest (3.87% per year). Put another way, real-world probabilities of 75.65% and 24.35% lead to an average market outcome of 65.03%. In estimating risk-neutral probabilities we ask, "What probabilities lead to an average market outcome of 20.90% (the risk-free rate of 3.87% per year cumulated over five years)?"[44]

52. To answer this question, we simply perform the same probability computation as previously performed, but use the risk-free rate of return rather than the *expected* market return in the equation. So the risk-neutral probabilities of *good* and *bad* market outcomes are computed according to the equation below.

Risk free return = Risk-neutral probability of a *good* market outcome × return in a *good* market + (1 – Risk-neutral probability of a *good* market outcome) × return in a *bad* market

$1 + risk\ free\ return = p^{RN} \times U + (1 - p^{RN}) \times D$

$1 + risk\ free\ return = p^{RN} \times U + D - p^{RN} \times D$

$1 + risk\ free\ return = p^{RN} \times (U - D) + D$

$$p^{RN} = \frac{1 + risk\ free\ return - D}{U - D}$$

$$= \frac{1.2090 - 0.4945}{2.0223 - 0.4945}$$

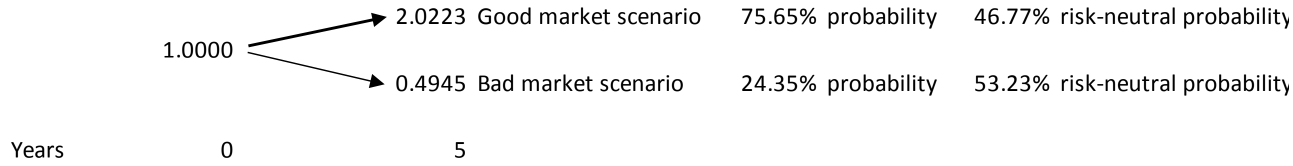
$$= \frac{0.7145}{1.5279}$$

$$= 46.77\%$$

[44] $(1 + 0.0387)^5 - 1 = 20.90\%$.

53. This solution to this equation means that there is a 46.77% risk-neutral probability of the *good* market outcome, and a 53.23% risk-neutral probability of the *bad* market outcome. It is important to point out that the real-world probabilities have not changed (there is still a 24.35% chance of the *bad* market outcome) and we are still assuming investors are risk averse. The use of the term "risk-neutral" does not mean that we have changed the standard view that investors prefer less risk to more risk for the same *expected* return (risk aversion). The use of risk-neutral probabilities is a computational device that allows us to correctly value the equity in the gas pipeline and arrive at an estimate of the cost of equity. It is the same computational device used to price derivatives. In the figure below we have augmented the binomial tree to display risk-neutral probabilities.

Figure 3. Risk-neutral probabilities of *good* and *bad* market outcomes



2.2.3 Step 2. Payoffs to debt and equity holders in different market outcomes

54. In the second step we consider the possible payoffs to debt and equity holders in different market outcomes. We begin with payoffs to debt holders because equity holders are the residual claimant on the assets. Equity holders simply receive whatever residual value remains after the debt is repaid in full, or zero value if the debt is not repaid in full.

55. Suppose debt holders invest \$60.00 in the asset and equity holders invest \$40.00, consistent with the leverage assumption of 60.00%. The yield to maturity on debt is 6.23%. So for the \$60.00 investment, a full repayment of the debt would see a payment to debt holders at the end of year five of \$81.17.[45] For the purposes of this analysis we have assumed that debt is repaid at the end of five years, rather than via the receipt of coupons at annual, semi-annual or quarterly intervals, and a bullet repayment at maturity. This is equivalent to assuming that any coupon payments are reinvested in debt of the same business.

56. There is some chance that the debt will not be repaid. Given the real-world probabilities, and risk-neutral probabilities computed in step 1, and an assumption about the recovery rate in the event of default, there is a unique estimate of the probability of default.

57. We have already estimated that there is a 46.77% risk-neutral probability of the *good* market outcome and a 53.23% risk-neutral probability of the *bad* market outcome. On average, these probabilities would allow debt holders to earn the risk-free rate of interest (20.90% over 5 years). We have assumed that default does not occur in the *good* market, so there is a 46.77% chance that debt holders receive the promised yield of 35.28%.[46] So we can solve for the average return to debt holders in the *bad* market by solving the following equation.

1 + *Risk free return* = Risk-neutral probability of a *good* market outcome × average payoff to debt holders in the *good* market + (1 – Risk-neutral probability of a *good* market outcome) × *average payoff to debt holders in the bad market*

1.2090 = 0.4677 × 1.3528 + 0.5323 × *average payoff to debt holders in the bad market*

$$Average\ payoff\ to\ debt\ holders\ in\ the\ bad\ market = \frac{1.2090 - 0.4677 \times 1.3528}{0.5323}$$

[45] \$60.00 × 1.0623^5 = \$60.00 × 1.3528 = \$81.17.

[46] $(1 + 0.0623)^5 - 1 = 35.28\%$.

$$= \frac{1.2090 - 0.6326}{0.5323}$$
$$= \frac{0.5764}{0.5323}$$
$$= 1.0827$$

58. This equation means that the average return for every $1.00 of debt investment is 8.27% over five years (1.2% per year) when the market outcome is *bad*. This average return is a combination of the yield in the absence of default (35.28%), and the return earned in the event of default. For the return earned in the event of default, we have assumed a recovery rate of 43.00%. This is consistent with historical recovery rates reported by Moody's for Baa rated debt.[47]

59. The debt holders have been promised a payoff of $1.3528 for every dollar of investment. In the event of default the debt holders only recover 43.00% of this promised payoff, or $0.5817 per dollar of investment.[48] We have already worked out that, on average, debt holders receive a payoff of $1.0827 per dollar of investment in the event of default. So now we can work out the real world probability of default according to the following equation.

Average payoff in the *bad* market = (1 – Probability of default if there is a *bad* market) × Payoff in the *bad* market without default + Probability of default if there is a *bad* market × Payoff in the *bad* market in the event of default

1.0827 = (1 – p^{DEF}|Bad market) × 1.3528 + (p^{DEF}|Bad market) × 0.5817

1.0827 = 1.3528 + p^{DEF}|Bad market × (0.5817 – 1.3528)

1.0827 – 1.3528 = p^{DEF}|Bad market × (0.5817 – 1.3528)

$$p^{DEF}|\text{Bad market} = \frac{1.0827 - 1.3528}{0.5817 - 1.3528}$$
$$= \frac{-0.2701}{-0.7711}$$
$$= 35.03\%$$

60. This equation means that, in the event of a *bad* market, there is a 35.03% chance of default. We have already estimated that the probability of a *bad* market is 24.35%. So the overall probability of default is the probability that a *bad* market occurs multiplied by the probability of default in the event of a *bad* market. This means that the overall chance of default is 0.2435 × 0.3503 = 8.53%.

61. This default rate is high for Baa rated debt, compared to historical average default rates. On average the default rate for Baa rated debt is about to 1.97% over a five year period.[49] In the historical data available from Moody's the highest default rate over five years for Baa rated debt is 5.85% for the cohort of bonds formed in 1986, and there were no defaults over five years for the cohort of bonds formed in 1975 and 1992. So the range of default rates over five years is 0.00% to 5.85%.

62. The default rates on Ba rated corporate debt are much higher, with an average default rate over five years of 9.73% and a range of 0.00% to 23.28%. So the default rate of 8.53% used in computations lies between the average default rates on Baa rated debt and Ba rated debt.

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[47] Moody's reports that, over the period 1982 to 2013, the recovery rate for Baa rated debt was 42.90%, measured five years prior to default using post-default trading prices. There was very little difference in recovery rates across debt with different credit ratings, with recovery rates of 44.29% for A rated debt and 42.10% for Ba rated debt.

[48] 0.4300 × $1.3528 = $0.5817.

[49] Moody's reports default rates over five year periods for cohorts of bonds formed on an annual basis from 1970 to 2013. On average across the 40 years for which five year default rates can be computed the default rate for Baa rated debt is 1.97%.

63. The default rate used in computations needs to be internally consistent with the other parameter inputs in order to estimate the cost of equity that is also consistent with those parameter inputs. In other words, while the average historical default rate on Baa rated debt over five years is close to 2%, we need to estimate a default rate that is consistent with the risk-free rate of 3.87% per year, a debt spread of 2.36% per year, and a 6.67% annual market risk premium.

a) If the debt spread was lower, the estimated default rate would decline. A 1.00% reduction in the yield on debt to 5.23% would reduce the estimated default rate by 3.47% to 5.06%.

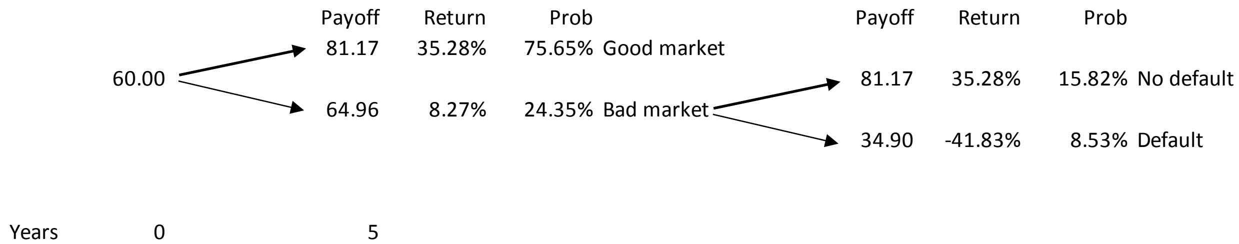
b) If the risk-free rate was higher, the estimated default rate would decline. A 1.00% increase in the risk-free rate to 4.87% would reduce the estimated default rate by 3.13% to 5.41%.

c) If the estimated market return was higher, the estimated default rate would decline. A 1.00% increase in the expected market return to 11.54% would reduce the estimated default rate by 0.73% to 7.80%.

64. Sensitivity analysis is considered in more detail in Sub-section 2.2.5. But for the moment the key point is that the default rate reflects the relatively low risk-free rate of 3.87% per year, in comparison to the debt premium of 2.36% per year.

65. We can now extend the binomial tree to show the payoffs to debt holders in three possible situations – a *good* market (75.65% probability, payoff = \$81.17 on a \$60.00 investment, return = 35.28%), a *bad* market but no default (15.82% probability, payoff = \$81.17, return = 35.28%) and a *bad* market with default (8.53% probability, payoff = \$34.90, return = –41.83%). This is illustrated in the figure below.

Figure 4. Payoffs to debt holders



66. This information can be used to estimate the *expected* return on debt, as opposed to the yield to maturity. On average, debt holders earn a return of 28.70% over five years, or 5.18% per year. The average return is 0.7565 × 35.28% + 0.1582 × 35.28% + 0.0853 × –41.83% = 26.69% + 5.58% – 3.57% = 28.70%.[50]

67. This means that the yield to maturity on debt is comprised of a risk-free component (3.87% per year), an *expected* risk premium (1.31% per year) and a default premium (1.05% per year). To earn the *expected* return of 5.18% per year, debt is priced at a yield to maturity of 6.23% per year, because there is some chance of default but no chance the debt holders receive additional payoffs from the asset.

68. At this stage we have estimates of the payoffs to debt holders, given their \$60.00 investment. Now we need to estimate the payoffs to equity holders, given their \$40.00 investment. We already know the payoff to equity holders in the default situation – this is zero because there is no value remaining after debt holders are paid. What we need to do is estimate the residual claims to equity holders in the other two situations – a *good* market, and a *bad* market but without default.

69. To make this computation we start with asset returns in the three different situations – a *good* market, a *bad* market and a *bad* market combined with a default. In the latter situation, we already have an estimate of what the asset payoff is. The payoff to debt holders of \$34.90 is the entire value of the asset, and this occurs with 8.53% probability.

[50] The annualised return is $1.2870^{(1/5)} - 1 = 5.18\%$.

70. To estimate the asset payoffs in the other two situations, we need to make an assumption about how different the asset payoff would be in a *bad* market compared to a *good* market. We have assumed that in a *bad* market, the asset payoff is 80.00% of the payoff that would occur in the *good* market. For example, if the asset paid off $100.00 in a *good* market, it would pay off $80.00 in a *bad* market with no default. In subsequent analysis we show the sensitivity of the results to this assumption. At the moment, it should be noted that the minimum ratio that is mathematically possible, given other assumptions, is 43.97%. At a ratio below this level there would not be enough value in the asset to repay the debt. So our 80.00% payoff ratio is at the upper end of a range of 43.97% to 100.00% that is mathematically possible.

71. There is now enough information to determine a single asset payoff in the *good* market that is mathematically consistent with all other assumptions. This single solution allows us to estimate the average returns to debt and equity holders across all possible outcomes, and the average returns to debt and equity holders across the *no default* outcomes. The return on the asset in the good market is given by the following equation, the derivation of which is presented in an appendix. The logic behind this equation is presented below.

$$r_a^G = \frac{1+r_f}{p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def}+p^{Def}}(1-p^{RN})} - \frac{L\frac{\left(1+r_d^{No\ def}\right)Rp^{Def}}{p^{B,No\ def}+p^{Def}}(1-p^{RN})}{p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def}+p^{Def}}(1-p^{RN})} - 1$$

where:

r_a^G is the asset return in the good market;

r_f is the risk-free rate of interest (20.90%);

$r_d^{No\ def}$ is the return to debt holders in the absence of default, that is, the yield to maturity on debt (35.28%).

x is the ratio of the asset payoff in the bad market with no defaults to the asset payoff in the good market (80.00%);

p^{RN} is the risk-neutral probability of a good market (46.77%);

$p^{B,No\ def}$ is the probability of a bad market but with no default (15.82%);

p^{Def} is the probability of default (8.53%);

L is the market value leverage, debt/(debt + equity) (60.00%); and

R is the recovery rate for debt holders in the event of default (43.00%).

72. If this equation is populated with the inputs reported so far, the asset return in the *good* market is 53.68% (8.97% per year). The asset return in the *bad* market but with no default is 22.94% (4.22% per year) (this is 80.00% of the asset return in the *good* market), and the asset return in the default situation is –65.10% (–18.98% per year) (we already estimated that in default debt holders receive a payoff of $34.90 and this is the entire asset value). The computation of the asset return in the *good* market is shown below.

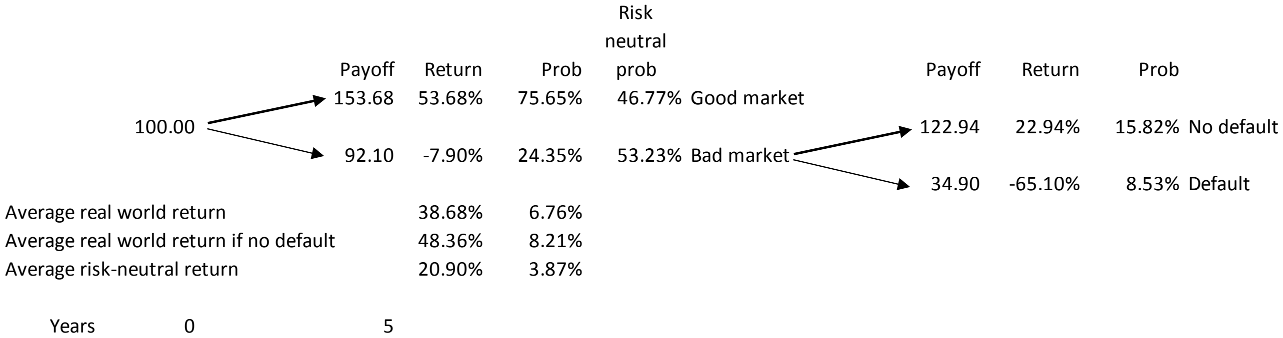
$$\begin{aligned}
r_a^G &= \frac{1.2090}{0.4677 + \frac{0.8000\times 0.1582}{0.1582+0.0853}\times(1-0.4677)} - \frac{0.6000\times\frac{1.3528\times 0.4300\times 0.0853}{0.1582+0.0853}\times(1-0.4677)}{0.4677+\frac{0.8000\times 0.1582}{0.1582+0.0853}(1-0.4677)} - 1 \\
&= \frac{1.2090}{0.7443} - \frac{0.0651}{0.7443} - 1 \\
&= 1.6242 - 0.0874 - 1 \\
&= 1.5368 - 1 \\
&= 53.68\%
\end{aligned}$$

73. The reason the asset return in the *good* market is 53.68% is that this is the only input that sets the risk-neutral *expected* return equal to the risk-free rate of interest (20.90%). This is illustrated in the figure below, in which the binomial tree now illustrates the payoffs on the asset in the *good* and *bad* markets. This binomial tree represents the outcome of the equation that was solved above and illustrates why this equation holds.

74. Starting from the right of the figure, there are two possible payoffs on the investment of \$100.00 in a *bad* market, namely \$34.90 in the default situation, and \$122.94 in the absence of default. The *expected* payoff in the *bad* market is a weighted average of these two payoffs. On average, in a *bad* market, the asset has a payoff of \$92.10.[51]

75. The *expected* payoff in the *bad* market of \$92.10 is shown to the right of the first down arrow on the left hand side, and the *expected* payoff in the *good* market of \$153.68 is shown to the right of the first up arrow on the left hand side. Applying the risk-neutral probabilities of *good* and *bad* markets, the *expected* payoff is \$120.90, which represents a return equal to the risk-free rate of interest.[52].

Figure 5. Payoffs on the asset



76. Any asset payoff other than \$153.68 in the *good* market would have resulted in an asset value at time zero different to \$100.00. For instance, suppose we had assumed that the asset payoff was \$160.00 in the *good* market, and \$128.00 in the *bad* market with no default (80.00% × \$160.00 = \$128.00). Under this assumption the risk-neutral *expected* payoff in five years would have been \$125.60 (0.4677 × \$160.00 + 0.5323 × \$95.39 = \$74.82 + \$50.78 = \$125.60). A risk-neutral *expected* payoff of \$125.60 has a present value of \$103.89 (\$125.60 ÷ 1.2090 = \$103.89) which, of course, is not equal to the correct asset value of \$100.00.

77. The key point of the analysis presented above is that the information in *expected* market returns, the volatility of market returns, the risk-free rate, the yield on debt, and the recovery rate on debt, allows us to compute the asset return that is consistent with these assumptions. The reason this is important for estimating the cost of capital is that parameter inputs are often estimated using different data sources and estimation techniques. As an example, standard practice is to estimate the yield to maturity on government bonds and corporate bonds using current trading prices, and to estimate the cost of equity using risk estimates (like β, s and h) and risk premiums (like *MRP*, *SMB* and *HML*) from historical returns.[53] This can lead to inconsistency in parameter estimates and risk premiums because one set of inputs is estimated from past data and another set of inputs is estimated from current data. While the use of current and historical information can both be useful to mitigate estimation error, what the current analysis does is achieve internal consistency between inputs.

78. Consider the following outcomes from the analysis presented above.

[51] Average asset payoff in a bad market = probability of no default in a bad market × payoff if no default + probability of default in a bad market × payoff if default in a bad market= 0.1582 ÷ (0.1582 + 0.0853) × \$122.94 + 0.0853 ÷ (0.1582 + 0.0853) × \$34.90 = 0.6497 × \$122.94 + 0.3503 × \$34.90 = \$79.87 + \$12.23 = \$92.10.

[52] Risk-neutral expected payoff = Risk-neutral probability of a *good* market × payoff in a *good* market + Risk-neutral probability of a *bad* market × payoff in a *bad* market = 0.4677 × \$153.68 + 0.5323 × \$92.10 = \$71.87 + \$49.03 = \$120.90.

[53] These are the risk exposures and risk premiums associated with the Sharpe-Lintner CAPM and the Fama-French model.

a) For debt holders, on average across all three scenarios, the return over five years is 28.70%, that is, 5.18% per year.[54]

On average, in the absence of default, the return over five years is 35.28%, that is, 6.23% per year. In setting regulated prices it is a *no default* scenario that is incorporated into a post-tax revenue model by either a regulator or a regulated entity.

b) For the asset as a whole, on average across all three scenarios, the return over five years is 38.68%, that is, 6.76% per year.[55] On an annualised basis, this average asset return is a 2.89% premium to the risk-free rate, compared to the market risk premium of 6.67%.

On average, in the absence of default, the asset return over five years is 48.36%, that is, 8.21% per year.[56] On an annualised basis, the *expected return in the absence of default* is a premium of 4.34% to the risk-free rate, compared to the market risk premium of 6.67%.

The implication is that, if regulated prices are set according to the average *no default* scenario (which is approximately what is modelled in a typical post-tax revenue model) the rate of return input to that model is 8.21%. This is the rate of return that is consistent with the other assumptions.

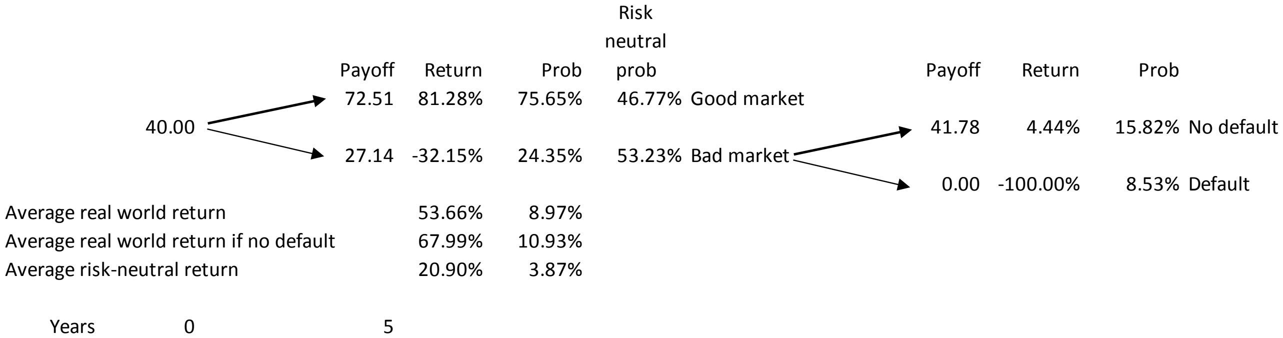
79. The last part of step two is to consider the payoffs to equity holders from the three situations described above. The payoff to equity holders in each situation is simply the residual claim on assets after debt holders have been paid. The payoffs to equity holders are illustrated in the binomial tree below.

a) We have already estimated that, in a good market, the asset payoff will be $153.68. Debt holders receive a payoff of $81.17, which leaves a payoff to equity holders of $72.51 on a $40.00 investment. This represents a return of 81.28%, that is, 12.63% per year.

b) In a bad market with no default, we have estimated that the asset payoff is $122.94. After paying debt holders the $81.17 they are owed, equity holders are left with a payoff of $41.78 from a $40.00 investment. This represents a return of 4.44%, that is, 0.87% per year.

c) Finally, in the default scenario, equity holders receive zero payout. The return is –100.00%.

Figure 6. Payoffs received by equity holders



[54] Average return across all three scenarios = probability of the *good* market × return in the *good* market + probability of the *bad* market but no default × return in the *bad* market but no default + probability of default × return in the presence of default = 0.7565 × 35.28% + 0.1582 × 35.28% + 0.0853 × –41.83% = 28.70%.

[55] Average return across all three scenarios = probability of the *good* market × return in the *good* market + probability of the *bad* market but no default × return in the *bad* market but no default + probability of default × return in the presence of default = 0.7565 × 53.68% + 0.1582 × 22.94% + 0.0853 × –41.83% = 38.68%.

[56] Average return in the absence of default = (probability of the *good* market × return in the *good* market + probability of the *bad* market but no default × return in the *bad* market but no default) ÷ (probability of the *good* market + probability of the *bad* market but no default) = (0.7565 × 53.68% + 0.1582 × 22.94%) ÷ (0.7565 + 0.1582) = (40.61% + 3.63%) ÷ 0.9147 = 44.24% ÷ 0.9147 = 48.36%.

2.2.4 Step 3. Returns to equity holders

80. Given the payoffs and returns to equity holders in different scenarios we can compute the *expected return to equity holders* across all scenarios, and the *expected return to equity holders in the absence of default*.

81. Across all three scenarios, the average return to equity holders is 53.66%, that is, 8.97% per year.[57] The annualised average return to equity holders of 8.97% per year can be compared to the risk-free rate of 3.87% per year, the average return to debt holders of 5.18% per year, and the average market return of 10.54% per year.

82. The analysis presented above did not rely upon the Sharpe-Lintner CAPM as the underlying asset pricing model. The analysis did rely upon the concept of systematic risk, but it was not restricted by a particular equation. However, if the Sharpe-Lintner CAPM was to be used as the underlying asset pricing model for the cost of equity, the average return is consistent with an equity beta of 0.77.[58]

83. What this demonstrates is that the *expected return to equity holders* is 8.97%, which is consistent with an equity risk premium of 5.10% and which is also consistent with a beta input of 0.77 in the Sharpe-Lintner CAPM. However, for equity holders to earn this return **on average** requires a different input into a model that only considers the no default situation, as shown below.

84. On average, in the absence of default, the equity return over five years is 67.99%, that is, 10.93% per year.[59] On an annualised basis, the *expected return to equity holders in the absence of default* is a premium of 7.06% to the risk-free rate, compared to the market risk premium of 6.67%. If the Sharpe-Lintner CAPM was adopted as the asset pricing equation for setting regulated prices, the *expected* return to equity holders in the absence of default is consistent with an equity beta of 1.06.[60]

85. To place the equity returns and payoffs in context, regulated prices are set using a model that accounts for full payment to debt holders. Essentially, the regulated revenue stream is estimated such that equity holders earn a fair return after debt holders have been paid. The analysis presented above suggests that the fair return in this situation is 10.93% per year (and an equivalent Sharpe-Lintner CAPM beta of 1.06).

86. If the model used to estimate regulated prices accounted for average outcomes (which includes the *expected return to debt holders* of 5.18%), the fair return to equity holders in that model would be 8.97% (and an equivalent Sharpe-Lintner CAPM beta of 0.77). The equity return input to the model would be lower in this latter model, but **the estimated revenue stream would be the same for both models.**

87. In the first model (in which prices are set according to a *no default* scenario) there is a higher cost of equity but this return is offset by the higher payments to debt holders. In the second model (in which prices are set according to the average outcome) there is a lower cost of equity but there are also lower payments for debt holders because the model only incorporates their average return. There would need to be a computation of what price and revenue stream is appropriate in the *no default* or business as usual situation.

2.2.5 Sensitivity analysis

88. In this sub-section we document the sensitivity of the analysis presented above to input assumptions. We perform sensitivity analysis in two ways. We first present the sensitivity of the results to changes in

[57] Average return across all three scenarios = probability of the *good* market × return in the *good* market + probability of the *bad* market but no default × return in the *bad* market but no default + probability of default × return in the presence of default = 0.7565 × 81.28% + 0.1582 × 4.44% + 0.0853 × –100.00% = 53.66%.

[58] $\beta_e = (r_e - r_f) \div (r_m - r_f) = (0.0897 - 0.0387) \div (0.1054 - 0.0387) = 0.0510 \div 0.0667 = 0.77$.

[59] Average return in the absence of default = (probability of the *good* market × return in the *good* market + probability of the *bad* market but no default × return in the *bad* market but no default) ÷ (probability of the *good* market + probability of the *bad* market but no default) = (0.7565 × 81.28% + 0.1582 × 4.44%) ÷ (0.7565 + 0.1582) = (61.49% + 0.70%) ÷ 0.9147 = 62.19% ÷ 0.9147 = 67.99%.

[60] $\beta_e = (r_e - r_f) \div (r_m - r_f) = (0.1093 - 0.0387) \div (0.1054 - 0.0387) = 0.0706 \div 0.0667 = 1.06$.

individual input assumptions, holding all other assumptions constant. We then present different outcomes when more than one input assumption changes at the same time.

89. In the first type of analysis, changing one assumption at a time, results are presented for the following alternative input assumptions.

a) The risk-free rate of 3.87% per year is shifted ±1.00% to 2.87% per year and 4.87% per year.

b) The yield to maturity on debt of 6.23% is shifted ±1.00% to 5.23% per year and 7.23% per year.

c) The market return of 10.54% is shifted ±1.00% to 9.54% per year and 11.54% per year.

d) The standard deviation of market returns of 16.64% per year is shifted ±1.00% to 15.54% per year and 17.64% per year.

e) Leverage of 60.00% is shifted ±10.00% to 50.00% and 70.00%.

f) The recovery rate on debt in the event of default of 43.00% is shifted ±10.00% to 33.00% and 53.00%.

g) The ratio of asset returns in the *bad* market without defaults of 80.00% is shifted ±10.00% to 70.00% and 90.00%.

90. In Table 1 we present estimates of the cost of capital under alternative input assumptions, in which just one assumption has been changed from the base case each time. In the upper section of the table we present average returns on the asset, and average returns to debt and equity holders (along with the beta estimate that is consistent with the Sharpe-Lintner CAPM). In the lower section of the table we present average returns provided there are no defaults. The base case results are highlighted in the first column and the assumption changed in each instance is presented in bold.

91. The key outcome from the analysis is the *expected return to equity holders in the absence of default,* because this approximates the scenario accounted for in a post-tax revenue model used to set prices for regulated assets. The table presents the following ranges for the *expected return to equity holders in the absence of default,* and the equivalent Sharpe-Lintner CAPM equity beta.

a) At a risk-free rate within the range of 2.87% to 4.87% per year, the *expected return to equity holders in the absence of default* is 12.08% to 9.84% per year (and the equivalent equity beta lies within a range of 1.20 to 0.88). All else equal, a 1.00% increase in the risk-free rate reduces the cost of equity by 1.12% and reduces the equivalent equity beta by 0.16.[61]

The reason for this sensitivity is that all other assumptions are held constant, so reducing the risk-free rate but holding the yield on debt and market return constant means that a higher risk premium is being factored into the returns to debt and equity holders. If the risk-free rate, yield on debt and market return are **all** lowered the *expected return to equity holders in the absence of default* falls and the beta estimate barely changes.

b) At a yield to maturity on debt within the range of 5.23% to 7.23% per year, the *expected return to equity holders in the absence of default* is 9.25% to 12.65% per year (and the equivalent equity beta lies within the range of 0.81 to 1.32). All else equal, a 1.00% increase in the yield on debt increases the cost of equity by 1.70% and increases the equivalent equity beta by 0.25.

The reason for this sensitivity is that the pricing of debt tells us something about the risks and returns faced by equity holders. As the returns offered to debt holders increase, the only way

[61] In computing the sensitivity to a change in assumption we take an average of the sensitivity to shifts up and down in the assumption. For example, a 1.00% lower risk-free rate results in the *expected return to equity holders excluding default* increasing by 1.15% to 12.08%; and a 1.00% higher risk-free rate results in the *expected return to equity holders excluding default* decreasing by 1.09% to 9.84%. So, on average, the cost of equity changes by 1.12% for every 1.00% change in the risk-free rate (the average of 1.15% and 1.09% is 1.12%).

in which debt value can be maintained at 60.00% of asset value is if asset returns and returns to equity holders are also higher.

c) At a market return within the range of 9.54% to 11.54% per year, the *expected return to equity holders in the absence of default* is 10.61% to 11.23% per year (and the equivalent equity beta lies within the range of 1.19 to 0.96). All else equal, a 1.00% increase in the *expected* market return increases the cost of equity by 0.30% and reduces the equivalent beta by 0.11.

   The reason for this sensitivity is that payoffs to on the asset are associated with market outcomes. So higher average market returns also leads to higher average asset returns.

d) At a standard deviation of market returns within the range of 15.64% to 17.64%, the *expected return to equity holders in the absence of default* is 10.95% to 10.91% (and the equivalent beta is approximately 1.06 in both situations). All else equal, a 1.00% increase in the standard deviation of market returns reduces the cost of equity by 0.02% and reduces the equivalent beta by 0.003. So the estimated cost of equity is largely insensitive to the assumption about the standard deviation of market returns.

e) At leverage within the range of 50.00% to 70.00% per year, the *expected return to equity holders in the absence of default* is 10.44% to 11.74% (and the equivalent equity beta lies within the range of 0.98 to 1.18). All else equal, a 10.00% increase in leverage increases the cost of equity by 0.65% and increases the equivalent beta by 0.10.

   This reason for this sensitivity is that the increased leverage increases the risk to equity holders, who now require higher returns before they are prepared to invest in the asset. At higher leverage, equity holders contribute less of the initial investment, so retain higher residual value in good market conditions. But there is also lower residual value in bad market conditions and the increase in the cost of equity is just enough return to offset this increased risk.

f) At a debt recovery rate in the event of default within the range of 33.00% to 53.00% the *expected return to equity holders in the absence of default* is 10.33% to 11.83% (and the equivalent equity beta lies within the range of 0.97 to 1.19). All else equal, a 10.00% increase in the recovery rate in the event of default increases the cost of equity by 0.75% and increases the equivalent beta by 0.11.

   The reason for this sensitivity is that a higher recovery rate assumption is offset by an increase in the default rate, which leads to higher risk to equity holders. In this sensitivity analysis the yield on debt is being held constant, and the yield on debt reflects the aggregate risk to debt holders. The aggregate risk to debt holders is not changed, so higher recovery rates in the event of default equates to greater incidence of default. If recovery rates increase and this flows through to lower cost of debt then the cost of equity will fall.

g) The last sensitivity is with respect to the proportion of asset returns in the *bad* market excluding default, which has a base case estimate of 80.00% (so the asset payoff is 80.00% of what it would have been in a *good* market). At a range of 70.00% to 90.00% the *expected return to equity holders in the absence of default* is 12.36% to 9.56% (and the equivalent equity beta is 1.27 to 0.85). All else equal, a 10.00% increase in the proportion of asset returns in the bad market excluding default reduces the cost of equity by 1.40% and reduces the equivalent beta by 0.21.

   The reason for this sensitivity is that the higher the asset returns in a *bad* market, the higher is equity holders' residual claim on the assets in a *bad* market. Equity holders face less risk when a higher proportion of asset value is retained in a *bad* market scenario, and the lower *expected* return is the fair compensation for bearing this reduced risk.

92. The discussion presented immediately above shows the impact of changing input assumptions in isolation. The results are broadly consistent with the conclusions the ERA reached in 2010, when it

determined that an equity beta estimate of 0.8 to 1.0 was appropriate.[62] The base case equity beta equivalent is 1.06 and the range of equity beta estimates from the sensitivity analysis is from 0.81 to 1.32.

93. In the discussion reported by the ERA in 2010, the ERA stated that the equity beta could be calculated from asset beta estimates from suitable comparators,[63] or the equity beta could be determined on the basis of a first principles analysis which accounts for the characteristics of the GGP and the associated level of risk.[64] The basis for the ERA's 2010 decision (beta of 0.8 to 1.0) included consideration of take or pay contracts, inelastic demand for revenue, and the GGP's small customer base. The same characteristics apply today to the GGP.

94. In the ERA Guidelines released at the end of 2013, the ERA determined that an appropriate range for equity beta is from 0.5 to 0.7. This range is formed entirely with respect to regression-based estimates of beta with respect to six Australian-listed firms.[65] As mentioned previously, the ERA has conducted more regression-based analysis of risk using four different weighting schemes. But running a larger number of regression types on the same underlying data does not necessarily lead to the beta estimates from that data being more and more reliable. The ERA's selection of 0.7 in the Guidelines as its best estimate of beta reflected the concern that regression-based beta estimates could lead to a cost of equity that had a downward bias.[66]

95. The analysis presented above, and the analysis which follows, demonstrates that a beta estimate within the range of 0.5 to 0.7 is unlikely to reflect the risks faced by equity holders, as implied by all the other inputs into the cost of capital estimate. The analysis shows that if investors price government bonds at yields below 4% per year and corporate bonds at yields above 6% per year they will also price stocks at returns close to 11% per year for an investment with 60% leverage. This would allow equity investors in the pipeline, on average, to earn returns of close to 9%.

96. It is worth re-iterating the difference between the *expected return* across all scenarios and the *expected return in the absence of default*. Equity holders would *expect* to earn returns of close 8.97% per year, just as debt holders would *expect* to earn returns of 5.18% per year. But regulated prices will only be consistent with these average returns if the *no default* pricing model incorporates equity returns of 10.93% per year and debt returns of 6.23% per year. The average equity return of 8.97% per year is consistent with an equity beta in the Sharpe-Lintner CAPM of 0.77, and the average asset return of 6.76% per year is consistent with an asset beta of 0.43.

97. To extend this analysis further we considered situations in which more than one assumption is allowed to vary in a given situation. We consider several joint sets of assumptions.

98. The first set of assumptions we consider is drawn from the 2005 ERA determination for the GGP.[67] In that decision, the ERA considered the following parameter ranges to be reasonable, a risk-free rate of 5.45% per year, a yield to maturity on debt of 6.43% to 6.68% per year (based upon a debt margin of 0.980% to 1.225% per year), a market return of 10.45% to 12.45% per year (based upon a market risk premium of 5.00% to 7.00% per year) and an equity beta within the range of 0.80 to 1.33. In our analysis the risk-free rate, the yield to maturity on debt and the market return are inputs, and the cost of equity and implied equity beta are outputs.

99. Given the above ranges for debt yield and market return, we performed our analysis using four combinations from the extreme ends of these ranges, and report results in Table 2. The table shows the following results, which ultimately imply a range for the cost of equity of **9.52% to 10.60%** per year

[62] ERA (2010), para. 250, p. 51.
[63] ERA (2010), para. 238, p. 50.
[64] ERA (2010), para. 240, p.50.
[65] ERA Explanatory Statement, Section 12.
[66] ERA Explanatory Statement, Appendix 30, para. 25 to 27, p. 217.
[67] ERA (2005), para. 284, p. 64.

(and an implied equity beta range of 0.68 to 0.90). This represents an equity risk premium above the risk-free rate of **4.07% to 5.15%**, and a premium of **3.09% to 3.93% compared to the yield on debt.**

a) **At a debt yield of 6.43% per year (debt premium = 0.98% per year) and market return of 10.45% per year (*MRP* = 5.00% per year), the cost of equity is 9.52% per year and the implied equity beta is 0.81.** So the implied equity beta approximates the lower bound of the ERA equity beta range from 2005. There is also a 3.09% premium between the cost of equity and the cost of debt.

   On average across all scenarios investors would *expect* to earn annual returns of 5.45% from investing in government debt, 5.92% from investing in corporate bonds, 7.02% from investing in the assets of a gas pipeline, and 8.59% from buying the equity in a gas pipeline.

b) **At a debt yield of 6.68% per year (debt premium = 1.23% per year) and market return of 10.45% per year (*MRP* = 5.00% per year), the cost of equity is 9.93% per year and the implied equity beta is 0.90.** So the implied equity beta lies within the ERA equity beta range from 2005. There is also a 3.25% premium between the cost of equity and the cost of debt.

   On average across all scenarios investors would *expect* to earn annual returns of 5.45% from investing in government debt, 6.04% from investing in corporate bonds, 7.17% from investing in the assets of the gas pipeline, and 8.77% from buying the equity in a gas pipeline.

c) **At a debt yield of 6.43% per year (debt premium = 0.98% per year) and market return of 12.45% per year (*MRP* = 7.00% per year), the cost of equity is 10.21% per year and the implied equity beta is 0.68.** The cost of equity has increased but the implied equity beta has fallen because of the increase in the market risk premium. Under this set of assumptions there is a 3.78% premium between the cost of equity and the cost of debt.

   On average across all scenarios investors would *expect* to earn annual returns of 5.45% from investing in government debt, 6.01% from investing in corporate debt, 7.44% from investing in the assets of the gas pipeline, and 9.44% from buying the equity in a gas pipeline.

d) **At a debt yield of 6.68% per year (debt premium = 1.23% per year) and market return of 12.45% per year (*MRP* = 7.00%), the cost of equity is 10.60% per year and the implied equity beta is 0.74.** As with the previous scenario the decline in the equity beta reflects the increase in the market risk premium. Under this set of assumptions there is a 3.93% premium between the cost of equity and the cost of debt.

   On average across all scenarios investors would expect to earn returns of 5.45% from investing in government debt, 6.16% from investing in corporate bonds, 7.61% from investing in the assets of the gas pipeline, and 9.65% from buying the equity in a gas pipeline.

100. The implication of this analysis is that the ERA's 2005 joint set of assumptions regarding the risk-free rate (5.45%), market return (10.45% to 12.45%), yield on debt (6.43% to 6.68%) and equity beta (0.80 to 1.33) are, for the most part, internally consistent. The upper part of the equity beta range is high, compared to the other assumptions, which support an implied equity beta within the range of 0.68 to 0.90. The variation in the equity beta estimate is largely due to the range for the *MRP*. **The key outcome from the analysis is a cost of equity range of 9.52% to 10.60% per year, which is a premium to the risk-free rate of 4.07% to 5.15% per year and a premium to the cost of debt of 3.09% to 3.93% per year.**

101. The second set of assumptions we consider is drawn from the 2010 ERA determination for the GGP.[68] In that decision the ERA considered the following parameter ranges to be reasonable – a risk-free rate of 5.79% per year, a yield to maturity on debt of 8.75% per year (based upon a debt margin of 2.96%

[68] ERA (2010), Table 7, p. 63.

per year), a market return of 10.79% to 12.79% per year (based upon a market risk premium of 5.00% to 7.00% per year) and an equity beta within the range of 0.80 to 1.00.

102. We performed our analysis using the upper and lower bounds of the market return, and report results in the two columns under the "ERA 2010" heading in Table 2. The table shows a range for the cost of equity of **13.13% to 13.77%.** This represents an equity risk premium above the risk-free rate of **7.34% to 7.98%** and a premium of **4.38% to 5.02%** compared to the yield on debt.

103. This means that, in comparison to the results from using the 2005 determination inputs, the yield on debt increased by 2.07% to 2.32%[69], and the cost of equity increased by 3.17% to 3.61%.[70] This is consistent with the normal situation observed when debt yields increase – riskier debt experiences larger increases in yields than safer debt. Low grade and unsecured debt is riskier than high grade and secured debt, and equity is riskier than low grade and unsecured debt.

104. Across all scenarios investors would *expect* to earn annual returns of 5.79% from investing in government debt, 7.25% to 7.53% from investing in corporate bonds, 8.53% to 9.18% from investing in the assets of a gas pipeline, and 10.34% to 11.48% from investing in the equity of a gas pipeline. This means that, on average, debt holders would *expect* to earn 1.33% and 1.37% higher returns[71] under the 2010 assumptions, compared to the 2005 assumptions, while equity holders would *expect* to earn 1.74% to 1.83% higher returns under 2010 assumptions.

105. These outcomes are not consistent with the assumption that the market risk premium has remained constant from 2005 to 2010. The implication of maintaining the same, constant market risk premium is that the market return on equity has only increased by the increase in the risk-free rate of 0.34%. It is counterintuitive to think that the yield on corporate debt would increase by more than 2% while the average stock in the market offered higher returns of less than 0.5%. In addition, the increased yield on corporate debt suggests that the average return on corporate debt increased by 1.33% to 1.37%, and the average return on equity in a gas pipeline increased by 1.74% to 1.83%. This is consistent with there being an increase in the *expected* return to equity in the average firm.

106. The figures computed above were based upon a range for the market risk premium of 5.00% to 7.00% per year. At the low end for the market risk premium, this implies an equivalent equity beta of 1.47; and at the high end for the market risk premium, this implies an equivalent equity beta of 1.14. We do not suggest that an appropriate equity beta for the GGP is as high as 1.47. Rather, the equity beta outcome of 1.47 suggests that a market risk premium of 5.00% per year appears low in comparison to other assumptions. It should also be noted that the equity beta range of 1.14 to 1.47 does not correspond to the return equity holders would *expect* to earn, on average. As mentioned previously, there is a difference between the average outcome in *no default* situations, and the average outcome across all situations. Considering the average return to equity holders in a gas pipeline across all scenarios (10.34% to 11.48% per year) the implied equity beta is 0.81 to 0.91.

107. This means that equity holders in a gas pipeline would still *expect* to earn returns less than they would *expect* from an equity investment in the average listed firm. So the ERA's equity beta range (0.80 to 1.00) and *MRP* range (5.00% to 7.00% per year) makes sense in the context of the other assumptions, but **only** if the model used to set regulated prices allows for these returns to be the average outcome. Regulated prices are actually set after adopting a beta range of model 0.80 to 1.00 and *MRP* range of 5.00% to 7.00% per year for what the ERA considers a likely *no default* scenario.

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[69] That is, in 2010 the yield on debt was estimated by the ERA at 8.75%, compared to a range of 6.43% to 6.68% in 2005, which represents an increase in the yield on debt of 2.07% to 2.32%.

[70] Using the 2005 parameter inputs, the cost of equity had a lower bound of 9.52% and an upper bound of 10.60%. Using the 2010 parameter inputs, the lower bound cost of equity increased by 3.61% to 13.13%, and the upper bound cost of equity increased by 3.17% to 13.77%.

[71] The average return to debt holders under the 2005 assumptions was estimated at 5.92% to 6.16%, compared to a corresponding range of 7.25% to 7.53% under the 2010 assumptions. The average return to equity holders under the 2005 assumptions was estimated at 8.59% to 9.65%, compared to a corresponding range of 10.34% to 11.48% under the 2010 assumptions.

108. The third set of assumptions we consider is drawn from the 2013 Guidelines released by the ERA.[72] In the Guidelines the ERA adopted a risk-free rate of 3.44% per year, a yield to maturity on debt of 5.62% per year (based upon a debt margin of 2.18% per year), a market return of 8.44% to 10.94% per year (based upon a market risk premium of 5.00% to 7.50% per year) and an equity beta within the range of 0.50 to 0.70.

109. The Guidelines do not refer specifically to the GGP and the ERA is not bound by the Guidelines in making a determination. But the manner in which the Guidelines have been written suggests that parameter inputs will be constrained to the boundaries of the ranges relied upon in the Guidelines. This means that the position of the ERA in 2005 and 2010 was that the **minimum** equity beta of a benchmark gas pipeline was 0.80, but that in 2013 the **maximum** equity beta of a benchmark gas pipeline is 0.70. This is a substantial change in position, and as mentioned earlier, is based entirely upon regression analysis of six Australian-listed firms. If there was any weight applied to firms listed in the U.S., or any weight applied to the Fama-French model, or any weight applied to the dividend discount model, the upper bound of the ERA range for the equivalent Sharpe-Lintner CAPM equity beta would lie above 0.70.

110. From 2010 to 2013, there has been no material change in the ERA's view as to the amount of leverage that a benchmark gas pipeline can sustain, and no material change in the ERA's view as to the benchmark credit rating. The only analysis relied upon by the ERA in the Guidelines to support a change in its view on equity beta is that the ERA has run different types of regressions of stock returns on market returns.

111. The ERA's best estimates of equity risk parameters are an equity beta of 0.70 and market risk premium of 6.00% per year, for a total equity risk premium of 4.20% per year.[73] In combination with the risk-free rate of 3.44% per year this implies a cost of equity of 7.64% per year. This represents a premium to the yield on debt of 2.02% per year.

112. We performed our analysis using the upper and lower bounds of the market return, and report results in the two columns under the "ERA 2013" heading in Table 2. The table shows a range for the cost of equity of **9.69% to 10.34% per year.** This represents an equity risk premium above the risk-free rate of **6.25% to 6.90% per year** and a premium of **4.07% to 4.72% per year** compared to the yield on debt.

113. This means that, in comparison to the results from using the 2010 determination inputs, there is a decrease in the yield on debt of 3.13% per year[74], and a decrease in the cost of equity of 3.42% to 3.44% per year.[75] As with the movement in cost of capital estimates over 2005 to 2010, these changes are consistent with a normal situation in which the cost of capital for all risky assets moves in the same direction, and the riskiest assets experience larger declines in risk premiums than the safest assets.

114. Across all scenarios investors would *expect* to earn annual returns of 3.44% from investing in government debt, 4.46% to 4.67% from investing in corporate bonds, 5.74% to 6.30% from investing in the assets of a gas pipeline, and 7.54% to 8.57% from buying the equity of a gas pipeline. This means that, on average, debt holders would *expect* to earn 2.79% and 2.88% lower returns[76] under the 2013 Guidelines assumptions, compared to the 2010 determination assumptions, while equity holders would *expect* to earn 2.79% to 2.91% lower returns under 2013 Guideline assumptions.

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72 ERA Guidelines Appendix 30, pp. 214 to 220.

73 ERA Guidelines Appendix 30, para. 32, p. 218.

74 That is, in the 2013 Guidelines the yield on debt was estimated by the ERA at 5.62%, compared to 8.75% in the 2010 determination, which represents a decrease in the yield on debt of 3.13%.

75 Using the 2010 determination parameter inputs, the cost of equity had a lower bound of 13.13% and an upper bound of 13.77%. Using the parameter inputs in the 2013 Guidelines, the lower bound cost of equity decreased by 3.44% to 9.69%, and the upper bound cost of equity decreased by 3.42% to 10.34%.

76 The average return to debt holders under the 2005 assumptions was estimated at 5.92% to 6.16%, compared to a corresponding range of 7.25% to 7.53% under the 2010 assumptions. The average return to equity holders under the 2005 assumptions was estimated at 8.59% to 9.65%, compared to a corresponding range of 10.34% to 11.48% under the 2010 assumptions.

115. The cost of equity estimates from using the 2013 Guideline inputs are now close to the cost of equity estimates from using the 2005 determination inputs if overall equity market returns are held at the same level. Consider the following.

a) From the 2005 determination assumptions, if the market return assumption is 10.45% per year (*MRP* = 5.00% per year) the cost of equity is estimated at 9.52% to 9.93% per year, and the average return to equity holders is estimated at 8.59% to 8.77% per year.

b) From the 2013 Guidelines assumptions, if the market return assumption is 10.44% per year (*MRP* = 7.00% per year) the cost of equity is estimated at 10.34% per year, and the average return to equity holders is estimated at 8.57% per year.

116. Table 2 shows that the estimated equity beta is within a range of 0.99 to 1.25, with the lower bound associated with the market risk premium of 7.00% per year and the upper bound associated with the market risk premium of 5.00% per year. Again, we are not suggesting that the ERA adopt an equity beta estimate as high as 1.25 for the GGP. Rather, this outcome suggests that at government bond yields as low as 3.44%, the *MRP* is at the upper end of the ERA's range of 5.00% to 7.00% per year.

117. It should also be noted that the equity beta associated with the average return to equity holders for a benchmark gas pipeline is estimated at 0.73 to 0.82. So if regulated prices were set on the basis of average returns to debt and equity holders, an equity beta range of 0.73 to 0.82 would be appropriate. But the ERA and other regulators do not set regulated prices on the basis of an average outcome model. Regulated prices are set on the basis of a model that approximates the average *no default* outcome.

118. In the left panel of Figure 7 we illustrate the breakdown of the cost of equity into three components – the risk-free rate, debt premium and equity premium relative to the cost of debt. The market risk premium that underpins the computations is held constant in all three situations at 6.00%.[77] The figure illustrates that as the debt premium rises from 1.10% to 2.96% per year, the equity margin over the debt yield increases from 3.52% to 4.71% per year. When the debt premium falls again to 2.18% per year, the equity margin over the debt yield falls to 4.41% per year.

119. In contrast, had the cost of equity been computed using the Sharpe-Lintner CAPM, and a beta estimate of 0.7, we would have observed the following results. From 2005 to 2010 the equity margin over the cost of debt would have **fallen** from 3.10% to 1.24%.[78] Then, from 2010 to 2013, the equity margin over the cost of debt would have **risen** from 1.24% to 2.02%.[79]

120. Applying a constant market risk premium and beta estimate leads to variation in the cost of equity capital that is inconsistent with what we would predict, given movements in the cost of debt. In 2005 and 2010 the ERA did not apply an equity beta estimate of 0.70. Previous beta estimates for the GGP were ranges of 0.80 to 1.33 in 2005, and 0.80 to 1.20 in 2010. But the ERA's discussion of equity risks in the 2013 Guidelines suggests that the ERA's interpretation of the evidence has changed, not that the ERA considers the fundamental risk exposure of a gas pipeline has changed.

121. In the right hand panel of Figure 7 we present the *expected* returns to investment in government debt, corporate debt, equity in a gas pipeline and equity in the market. As the *expected* debt premium increases from 0.59% to 1.61% per year from 2005 to 2010, the *expected* return on equity relative to debt increases from 3.09% to 3.54% per year. Then as the *expected* debt premium falls to 1.13% in 2013, the *expected* return on equity relative to debt also falls to 3.51% per year.

[77] Also, for the 2005 computations we use the mid-point of the ERA's estimate of the debt yield, which is 6.55% per year.

[78] Using 2005 figures, $\beta_e \times (r_m - r_f)$ – (Yield on debt – r_f) = 0.70 × 6.00% – (6.55% – 5.45%) = 4.20% – 1.10% = 3.10%. Using 2010 figures $\beta_e \times (r_m - r_f)$ – (Yield on debt – r_f) = 0.70 × 6.00% – (8.75% – 5.79%) = 4.20% – 2.96% = 1.24%.

[79] Using 2013 figures $\beta_e \times (r_m - r_f)$ – (Yield on debt – r_f) = 0.70 × 6.00% – (5.62% – 3.44%) = 4.20% – 2.96% = 2.02%.

Figure 7. Cost of capital under alternative risk-free rate and debt yield assumptions

122. The green part of the figure shows the incremental *expected* return on the market compared to the *expected* equity return in a gas pipeline. This figure is 2.32% per year in 2005, 0.85% per year in 2010 and 1.36% per year in 2013. The only reason for the narrowing of this *expected* return difference in 2010 is that we held the market risk premium constant at 6.00% throughout. Had we allowed a lower market risk premium in 2005 and a higher market risk premium in 2010, there would have been a rise in the *expected* market return compared to the *expected* return to equity holders from 2005 to 2010.

2.2.6 Summary of framework with two possible market outcomes

123. The sensitivity analysis demonstrates three implications from the framework we rely upon in this paper.

a) There is a set of internally consistent parameter estimates relating to yields on government bonds, yields on corporate bonds, market returns, leverage and the cost of equity.

   The way the cost of capital components are currently estimated in regulation is to draw primary inferences from data sets and research methods that are entirely separate. For example, the manner in which equity risks are estimated using historical stock returns is an entirely different approach to the estimation of government and corporate bond yields. Internal consistency amongst parameter estimates is considered only to make secondary inferences, and there is no systematic framework for making those inferences.

   What we illustrate is that there is a mechanism for quantifying the consistent relationship between parameter inputs. Adopting a quantitative framework for internal consistency between parameter inputs mitigates against estimation error in any one technique. When an inconsistency arises, there is a clear signal that one or more parameter inputs needs to be re-considered.

b) We make clear the distinction between *expected returns* across all possible outcomes, and *expected returns in the absence of default*.

   In setting regulated prices, both regulated entities and regulators rely upon a post-tax revenue model with a single scenario that incorporates full debt repayment and full taxation of corporate profits. It is an approximation of the average outcome across *no default* scenarios.

   We solve for the *expected return in the absence of default* as well as the average return across all scenarios. It is the *expected return in the absence of default* that would need to be incorporated into a post-tax revenue model in order for equity holders to, on average, earn the *expected* cost of equity capital.

c) The third implication specifically relates to the ERA Guidelines. It is highly unlikely that setting the cost of equity equal to the five year government bond yield plus 0.70 × 6.00%

would allow equity holders to earn a return commensurate with prevailing conditions in the market for funds. This understates the average return equity holders expect to earn in the absence of default and, in most sets of assumptions, even understates the *expected* return to equity holders across all situations.

At present, an average equity return of around 11% per year in the absence of default is consistent with corporate and government bond yields of more than 6% and less than 4%, respectively. The specific estimate of the cost of equity is 10.93% per year.[80]

[80] Fourth-last row of Table 1

Table 1. Cost of capital under alternative input assumptions holding all other assumptions constant

Assumptions	Base	Rf ±1%		Yield ±1%		R_m ±1%		SD R_m ±1%		Lev ±10%		Rec rate ±10%		Asset ret ±10%	
Risk-free rate (%)	3.87	**2.87**	**4.87**	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87
Yield on debt (%)	6.23	6.23	6.23	**5.23**	**7.23**	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23
Market return (%)	10.54	10.54	10.54	10.54	10.54	**9.54**	**11.54**	10.54	10.54	10.54	10.54	10.54	10.54	10.54	10.54
Std. dev. mkt. ret. (%)	16.64	16.64	16.64	16.64	16.64	16.64	16.64	**15.64**	**17.64**	16.64	16.64	16.64	16.64	16.64	16.64
Leverage (%)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	**50.00**	**70.00**	60.00	60.00	60.00	60.00
Rec. rate on debt in def. (%)	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	**33.00**	**53.00**	43.00	43.00
% asset ret. bad mkt. ex. def. (%)	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	**80.00**	**90.00**
Outcomes															
Expected ret. scenarios:															
Average return on assets (%)	6.76	6.79	6.83	6.08	7.47	6.48	7.01	6.82	6.70	6.88	6.64	6.63	6.95	7.38	6.18
Average return on debt (%)	5.18	4.85	5.57	4.62	5.75	5.07	5.27	5.21	5.14	5.18	5.18	5.18	5.18	5.18	5.18
Average return on equity (%)	8.97	9.46	8.63	8.12	9.86	8.46	9.44	9.06	8.88	8.48	9.77	8.68	9.42	10.38	7.63
Equiv. SL CAPM asset beta	0.43	0.51	0.35	0.33	0.54	0.46	0.41	0.44	0.42	0.45	0.42	0.41	0.46	0.53	0.35
Equiv. SL CAPM debt beta	0.20	0.26	0.12	0.11	0.28	0.21	0.18	0.20	0.19	0.20	0.20	0.20	0.20	0.20	0.20
Equiv. SL CAPM equity beta	0.77	0.86	0.66	0.64	0.90	0.81	0.73	0.78	0.75	0.69	0.88	0.72	0.83	0.98	0.56
Expected ret. if no default															
Average return on assets if no def. (%)	8.21	8.72	7.73	6.91	9.53	8.07	8.34	8.22	8.20	8.41	8.00	7.94	8.61	8.85	7.61
Average return on debt if no def. (%)	6.23	6.23	6.23	5.23	7.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23
Average return on equity if no def. (%)	10.93	12.08	9.84	9.25	12.65	10.61	11.23	10.95	10.91	10.44	11.74	10.33	11.83	12.36	9.56
Equiv. SL CAPM asset beta	0.65	0.76	0.51	0.46	0.85	0.74	0.58	0.65	0.65	0.68	0.62	0.61	0.71	0.75	0.56
Equiv. SL CAPM debt beta	0.35	0.44	0.24	0.20	0.50	0.42	0.31	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Equiv. SL CAPM beta	1.06	1.20	0.88	0.81	1.32	1.19	0.96	1.06	1.06	0.98	1.18	0.97	1.19	1.27	0.85

Table 2. Cost of capital under alternative sets of input assumptions

Assumptions	Base	ERA 2005				ERA 2010		ERA 2013	
Risk-free rate (%)	3.87	5.45	5.45	5.45	5.45	5.79	5.79	3.44	3.44
Yield on debt (%)	6.23	6.43	6.68	6.43	6.68	8.75	8.75	5.62	5.62
Market return (%)	10.54	10.45	10.45	12.45	12.45	10.79	12.79	8.44	10.44
Std. dev. mkt. ret. (%)	16.64	16.64	16.64	16.64	16.64	16.64	16.64	16.64	16.64
Leverage (%)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Rec. rate on debt in def. (%)	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
% asset ret. bad mkt. ex. def. (%)	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00	80.00
Outcomes									
Expected ret. scenarios:									
Average return on assets (%)	6.76	7.02	7.17	7.44	7.61	8.53	9.18	5.74	6.30
Average return on debt (%)	5.18	5.92	6.04	6.01	6.16	7.25	7.53	4.46	4.67
Average return on equity (%)	8.97	8.59	8.77	9.44	9.65	10.43	11.48	7.54	8.57
Equiv. SL CAPM asset beta	0.43	0.31	0.34	0.28	0.31	0.55	0.48	0.46	0.41
Equiv. SL CAPM debt beta	0.20	0.09	0.12	0.08	0.10	0.29	0.25	0.20	0.18
Equiv. SL CAPM equity beta	0.77	0.63	0.66	0.57	0.60	0.91	0.81	0.82	0.73
Expected ret. if no default									
Average return on assets if no def. (%)	8.21	7.71	8.03	8.00	8.31	10.59	10.87	7.32	7.61
Average return on debt if no def. (%)	6.23	6.43	6.68	6.43	6.68	8.75	8.75	5.62	5.62
Average return on equity if no def. (%)	**10.93**	**9.52**	**9.93**	**10.21**	**10.60**	**13.13**	**13.77**	**9.69**	**10.34**
Equiv. SL CAPM asset beta	0.65	0.45	0.52	0.36	0.41	0.96	0.73	0.78	0.60
Equiv. SL CAPM debt beta	0.35	0.20	0.25	0.14	0.18	0.59	0.42	0.44	0.31
Equiv. SL CAPM equity beta	1.06	0.81	0.90	0.68	0.74	1.47	1.14	1.25	0.99

2.3 Cost of equity estimates from 61 possible outcomes over five years

2.3.1 Framework

124. In Sub-section 2.2 we presented a framework for estimating the cost of equity that relied upon two possible market outcomes over five years. The market could either earn returns of 15.13% per year (with 75.65% chance) or returns of –13.14% per year (with 24.35% chance). This resulted in an average return of 10.54% per year.

125. In the current section we extend the analysis to account for more potential variation in market movements over time. We allow for monthly stock market returns to be either positive or negative over a five year period. This generates a binomial tree with 61 possible market outcomes at the end of five years.[81] This larger binomial tree allows us to estimate, with greater precision, the cost of equity that is internally consistent with other parameter inputs.

126. The three basic steps that were considered in the previous sub-section are repeated here, but with some additional computations to account for the larger number of potential outcomes. Specifically, the three basic steps are as follows.

127. **First, we estimate the market return across a number of outcomes.** In this more detailed analysis, rather than there being just two market outcomes (which we previously labelled *good* and *bad)* we have 61 outcomes to consider. The returns and probabilities of these 61 outcomes need to be consistent with assumptions regarding market volatility and the average market return (10.54% per year). In this instance we adjust the market volatility downwards slightly to 14.89% per year (4.30% per month)[82] because this means that there is an individual outcome that corresponds to the market return of 10.54% per year. This is useful for explaining the method and results because we can point to an individual outcome which we refer to as the *typical* market return case.

128. **Second, we estimate the *expected* payoffs to debt holders and equity holders across the 61 market outcomes.** In the previous analysis, in a *bad* market, there was a scenario based upon there being no default, and a scenario based upon there being a default. This allowed us to compute average outcomes to debt and equity holders in a *bad* market based upon the *no default* and default scenarios.

129. In the detailed analysis considered here, for each of the 61 market outcomes there is a scenario based upon there being no default, and a scenario based upon there being a default. So for each of the 61 market outcomes, there is an *expected* payoff to debt and equity holders based upon the no default and default payoffs. The chances of a default occurring increase when the market performs poorly, but not all defaults are concentrated in the worst market conditions.

130. **Third, we estimate the *expected return* to equity holders across all 61 market outcomes, and the *expected return to equity holders in the absence of default.*** As emphasised above, regulated prices are based upon a model that does not account for the probability of default. So in estimating the cost of equity to be incorporated into a post-tax revenue model of this type, the question is "What is the *no default* return on equity that, on average, will allow equity holders to earn a return that is commensurate with prevailing conditions in the market for funds?"

131. For expositional purposes, we split the 61 market outcomes into three groups, which are labelled as *good, most* (because this covers most situations), and *bad.* The *good* market outcomes span all the market outcomes within the top 8.50% of market returns, the *bad* market outcomes span all the market outcomes within the bottom 6.69% of market returns, and *most* market outcomes span the middle

[81] The binomial tree re-combines each month. This means that a positive market movement followed by a negative market movement results in the same market value as a negative movement followed by a positive movement. So there are two possible outcomes after one month, three possible outcomes after two months, and so on. The number of possible outcomes is one more than the number of steps. So with 60 months there are 61 possible outcomes.

[82] The annual standard deviation of market returns is converted to a monthly standard deviation of market returns according to the equation that monthly standard deviation = annual standard deviation × $\sqrt{1/12}$, that is, $0.1489 \times \sqrt{1/12} = 0.1489 \times 0.2887 = 4.30\%$.

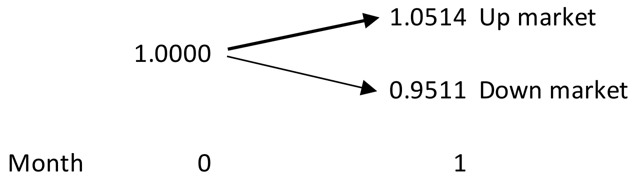
84.81% of market returns.[83] This makes it easier to explain outcomes resulting from the majority of situations compared to the *good* and *bad* market return situations. According to the assumptions we make, across the *good* market outcomes the average market return is 25.54% per year, across the *bad* market outcomes the average market return is –6.09% per year, and across *most* market outcomes the average return is 9.52% per year.[84]

132. We reiterate that our framework is entirely consistent with existing finance theory. It is a formal mechanism to reconcile a set of cost of capital assumptions already being made about a benchmark gas pipeline. Put another way, it provides a link between the risk-free rate, the cost of debt and the cost of equity. This can be contrasted with an approach typically adopted in regulation in which there is no quantitative relationship between the estimate of the cost of debt (derived from corporate bond yields) and the estimate of the cost of equity (derived from analysis of historical returns).

2.3.2 Step 1. Market outcomes and probabilities

133. We begin with potential market movements over one month, in which an up movement is one standard deviation above expectations (so U = 1 + *expected* monthly market return + standard deviation of monthly market returns; and $D = 1 \div U$). The *expected* market return is 10.54% per year, so the *expected* market return is 0.84% per month.[85] The standard deviation of market returns is assumed to be 4.30% per month, as discussed in Sub-section 2.3.1. So on a monthly basis we have $U = 1.0514$, and $D = 1 \div U = 0.9511$. This means that market returns can either by +5.14% in the month, or –4.89%. The potential market movements over one month are illustrated in the binomial tree below.

Figure 8. Market outcomes in up and down markets over one month



134. We need to estimate the real-world probabilities of the up and down market movements, along with the risk-neutral probabilities. The one-month probabilities will be compounded over 60 months so we can estimate the probabilities associated with 61 possible market outcomes at the end of five years. There will be a trivial probability that the market has 60 consecutive up market movements, or 60 consecutive down market movements, and a large probability that market returns are close to the average figure of 10.54% per year.

135. If the *expected* market return is 0.84% per month, and the outcomes in the up and down markets are +5.14% and –4.89%, respectively, we can estimate the probabilities of these two outcomes by solving the following equation.

Expected return = Probability of a positive market return × return in a rising market + (1 – Probability of a positive market return) × return in a falling market

$$1 + \textit{Expected return} = p \times U + (1 - p) \times D$$

$$1 + \textit{Expected return} = p \times U + D - p \times D$$

$$1 + \textit{Expected return} = p \times (U - D) + D$$

[83] The manner in which the probabilities are computed is considered below.

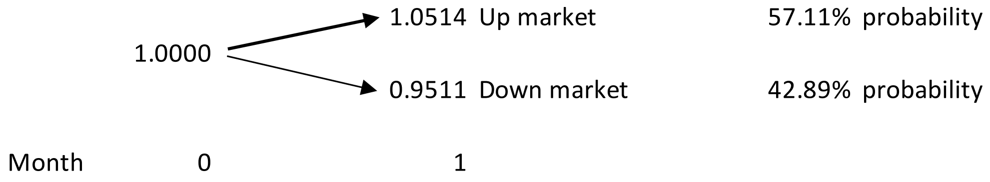
[84] The computation of market returns in each market outcome is also considered below.

[85] That is, $1.1054^{(1/12)} - 1 = 0.84\%$.

$$p = \frac{1 + 0.0084 - 0.9511}{1.0514 - 0.9511}$$
$$= \frac{1.0084 - 0.9511}{1.0514 - 0.9511}$$
$$= \frac{0.0572}{0.1002}$$
$$= 57.11\%$$

136. The solution to this equation means that there is a 57.11% chance of a positive market return in the month and a 42.89% chance of a negative market return. At these probabilities the *expected* market return is 0.84% per month (or 10.54% per year).[86] In the figure below we have augmented the previous binomial tree with the real-world probabilities of up and down markets.

Figure 9. Real-world probabilities of up and down markets



137. We perform the same computation in order to estimate risk-neutral probabilities of up and down markets. Recall that the reason to estimate risk-neutral probabilities is that we can use risk-neutral probabilities in valuation in circumstances in which we do not have a risk-adjusted cost of capital input (like the present case in which the risk-adjusted cost of capital is what we are trying to estimate). In other words, in a typical valuation an estimate of the discount rate is used in order to value an asset. But we face the opposite situation. In our case we know the value of equity ($0.40 for every dollar of assets) but we do not know the discount rate for equity. So we can use risk-neutral probabilities as an intermediate step to estimate the cost of equity.

138. Risk-neutral probabilities are the probabilities attached to asset payoffs that result in the *expected* return being equal to the risk-free rate (just like the real world probabilities attached to asset payoffs resulted in the *expected* return being equal to the risk-adjusted cost of capital). The risk-free rate is 0.32% per month (equivalent to 3.87% per year)[87] So we estimate the risk-neutral probabilities of up and down markets according to the following equation.

Risk-free return = Risk-neutral probability of a positive market return × return in a rising market + (1 – Risk-neutral probability of a positive market return) × return in a falling market

1 + risk-free return = $p^{RN} \times U + (1 - p^{RN}) \times D$

1 + risk-free return = $p^{RN} \times U + D - p^{RN} \times D$

1 + risk-free return = $p^{RN} \times (U - D) + D$

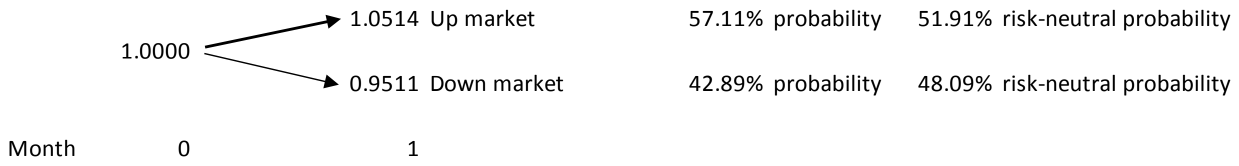
$$p^{RN} = \frac{1 + risk\ free\ return - D}{U - D}$$
$$= \frac{1.0032 - 0.9511}{1.0514 - 0.9511}$$

[86] To verify, note that 0.5711 × 5.14% + 0.4289 × –4.89% = 2.93% – 2.10% = 0.84%.
[87] $1.00387^{(1/12)} - 1 = 0.32\%$.

$$= \frac{0.0520}{0.1002}$$
$$= 51.91\%$$

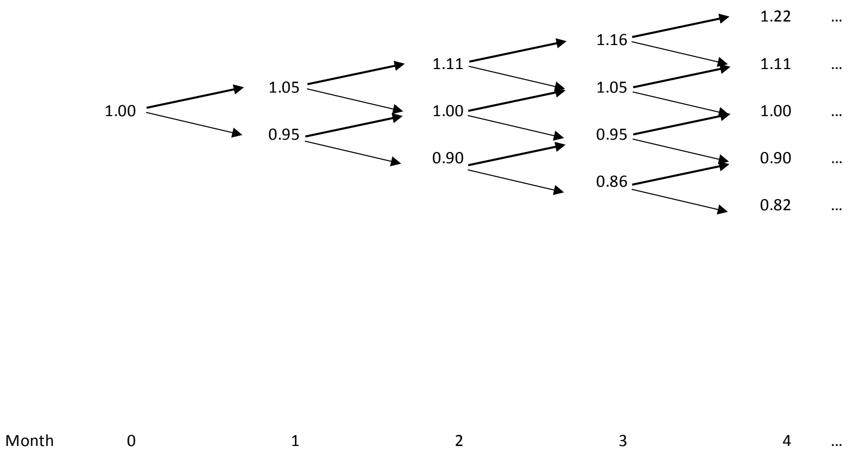
139. This equation means that there is a 51.91% risk-neutral probability of a positive market return and a 48.09% risk-neutral probability of a negative market return. We reiterate that the real-world probabilities have not changed and we are still assuming investors are risk averse. Applying risk-neutral probabilities allows us to answer questions about value and discount rates. It does not mean that investors are risk-neutral in valuing assets. In the figure below we have augmented the binomial tree to display risk-neutral probabilities.

Figure 10. Risk-neutral probabilities of up and down markets



140. In Figure 10 we present the market payoffs and probabilities associated with market movements over one month. We then extend this binomial tree to 60 months, which leads to 61 potential payoffs at the end of five years. In Figure 11 we present an extract of the potential market movements over 60 months. At the right of the figure we present every fifth node, from the best possible outcome to the worst possible outcome. The full set of market payoffs, returns and probabilities at the end of five years is presented in an appendix.

Figure 11. Extract of market outcomes over 60 months



Payoff	Return	Prob	RN Prob
20.20	82% pa	0.0000%	0.0000%
…	…	…	…
12.24	65% pa	0.0000%	0.0000%
…	…	…	…
7.42	49% pa	0.0011%	0.0000%
…	…	…	…
4.49	35% pa	0.1835%	0.0139%
…	…	…	…
2.72	22% pa	3.4536%	0.7470%
…	…	…	…
1.65	11% pa	10.2131%	6.3148%
…	…	…	…
1.00	0% pa	5.5553%	9.8188%
…	…	…	…
0.61	-10% pa	0.5823%	2.9420%
…	…	…	…
0.37	-18% pa	0.0112%	0.1621%
…			
0.22	-26% pa	0.0000%	0.0014%
…			
0.13	-33% pa	0.0000%	0.0000%
…			
0.08	-39% pa	0.0000%	0.0000%
…			
0.05	-45% pa	0.0000%	0.0000%

141. The binomial tree illustrates how most of the potential market outcomes are concentrated around the average market return of 10.54%. For example, there is a 10.21% chance of a market return equal to 10.54% per year (payoff of $1.65 for every $1.00 invested). The potential market outcomes can be summarised with reference to groups classified as *good*, *most* and *bad* market outcomes as follows.

a) *Good* market outcomes, comprising the top 8.50% of potential market outcomes, have an average return of 25.54% per year. This comprises the top 21 nodes in the binomial tree. It spans market returns of +22.91% per year to +82.42% per year.[88]

b) *Most* market outcomes, comprising the middle 84.81% of potential market returns, have an average return of 9.52% per year. This comprises the next 11 nodes of the binomial tree. It spans market returns of +19.76% per year to –1.98% per year.

c) *Bad* market outcomes, comprising the bottom 6.69% of potential market outcomes, have an average return of –6.09% per year. This comprises the bottom 31 nodes of the binomial tree. It spans market returns of –3.93% per year to –45.18% per year.

142. Risk-neutral probabilities are displayed in the right of Figure 11. The risk-neutral probabilities are set such that the *expected* market return from applying those probabilities is equal to the risk-free rate of 3.87% per year. This concept can be illustrated with reference to the average outcome associated with *good*, *most* and *bad* market outcomes as follows.

a) *Good* market outcomes have a 1.48% risk-neutral chance of occurring, and the risk-neutral *expected* return is 24.54% per year across *good* market outcomes (199.61% return over five years).

b) *Most* market outcomes have a 73.82% risk-neutral chance of occurring, and the risk-neutral *expected* return is 6.12% per year across *most* market outcomes (34.59% return over five years).

c) *Bad* market outcomes have a 24.70% risk-neutral chance of occurring, and the risk-neutral *expected* return is –7.07% per year across *bad* market outcomes (–30.71% return over five years).

143. To illustrate how this results in an average return equal to the risk-free rate of 3.87%, we compute 1.48% probability × 199.61% return + 73.82% probability × 34.59% return + 24.70% probability × –30.71% return = 2.95% + 25.54% –7.59% = 20.90% return over five years. This is equivalent to 3.87% per year, computed as $1.2090^{(1/5)} - 1 = 3.87\%$.

2.3.3 Step 2. Payoffs to debt and equity holders in different market outcomes

144. In the second step we consider the possible payoffs to debt and equity holders in different market outcomes. As with the previous analysis we first consider what the payoffs are for debt holders because equity holders are the residual claimant on the assets. Recall that the debt holders will receive $81.17 at the end of five years if the debt is repaid in full.[89]

145. We need to form a view about the market conditions likely to lead to defaults. In the previous analysis we simply said that defaults were concentrated in the *bad* market, which directly lead to estimates of the probability of default overall and the probability of default in the *bad* market. Now we have 61 market outcomes so need to incorporate a process via which the overall probability of default is consistent with the yield on debt, and which has relatively more defaults in worse markets.

146. We already have enough information to estimate the risk-neutral probability of default, which is 18.65%, as shown below.

$$
\begin{aligned}
&1 + risk\ free\ return \\
&\qquad = (1 - risk\ neutral\ prob.of\ def.) \times (1 + yield\ on\ debt) \\
&\qquad + risk\ neutral\ prob.of\ def. \times (1 + yield\ on\ debt) \times recovery\ rate
\end{aligned}
$$

[88] Note that there is a trivial chance of a market return of 82.42% per year. There is a 0.70% chance that market returns over five years are 32.83% per year or better, and a 0.02% chance that market returns over five years are 43.43% per year or better.
[89] $\$60.00 \times 1.0623^5 = \$60.00 \times 1.3528 = \$81.17$.

$$1 + risk\ free\ return$$
$$= (1 + yield\ on\ debt) - risk\ netural\ prob.of\ def. \times (1 + yield\ on\ debt)$$
$$+ risk\ netural\ prob.of\ def. \times (1 + yield\ on\ debt) \times recovery\ rate$$
$$1 + risk\ free\ return$$
$$= (1 + yield\ on\ debt) - risk\ netural\ prob.of\ def. \times (1 + yield\ on\ debt)$$
$$\times (1 - recovery\ rate)$$
$$risk\ free\ return - yield\ on\ debt$$
$$= -risk\ netural\ prob.of\ def. \times (1 + yield\ on\ debt) \times (1 - recovery\ rate)$$
$$risk\ neutral\ prob.of\ def. = \frac{yield\ on\ debt - risk\ free\ return}{(1 + yield\ on\ debt) \times (1 - recovery\ rate)}$$
$$= \frac{0.3825 - 0.2090}{1.3528 \times (1 - 0.4300)}$$
$$= \frac{0.1438}{0.7711}$$
$$= 18.65\%$$

147. What we need to estimate is what the default rates are likely to be across the 61 different market outcomes. Moody's provides historical information on default rates which we use to estimate default rates in different market conditions. For Baa rated debt and Ba rated debt we compiled the cumulative default rates over five years based upon bond cohorts formed annually from 1970 to 2009. For Baa rated debt the highest default rate occurred for the 1986 cohort. Five years later this cohort of bonds had a default rate of 5.85%. For Ba rated debt the default rate over five years was highest for the cohort formed in 1989. Five years later the default rate for this cohort of bonds was 23.28%. On average, the default rate for Baa rated debt was 1.97% for the 40 cohorts formed from 1970 to 2009, and the average default rate for Ba rated debt was 9.73%.[90]

148. For the Baa rated debt cohorts and the Ba rated debt cohorts we compiled the default rates at each percentile of the historical distribution (the historical distribution is the 40 default rates over time compiled from cohorts formed from 1970 to 2009). We then assigned default rates to the percentiles of market performance. For example, the top quartile of market returns in the binomial tree is a return of 15.06% per year. The corresponding top quartile of default rates on Baa rated bonds is 1.24% and the top quartile of default rates on Ba rated bonds is 4.72%. The bottom quartile of market returns in the binomial tree is a return of 4.09% per year. The corresponding bottom quartile of default rates on Baa rated bonds is 3.00% and the bottom quartile of default rates on Ba rated bonds is 14.27%.

149. This means that not all defaults are assumed to occur in the worst market conditions. In outcomes of high market returns there are some defaults and in outcomes of low market returns there are some defaults. But the likelihood of default increases when market returns are low.

150. Then, in computing a default rate that corresponds to a particular market outcome we assigned a 25% weight to the Baa default rate and a 75% weight to the Ba default rate. The relatively greater weight

[90] Note that in computing averages the cohorts are overlapping. For example, for the 1970 cohort we observe the proportion of defaults at the end of 1974, and for the 1971 cohort we observe the proportion of defaults at the end of 1975, and so on. This makes no material difference to the average default rates. If we formed five sets of non-overlapping cohorts, the lowest average default rate for Baa rated bonds would have been 1.70% and the highest average default rate for Baa rated bonds would have been 2.17%. For Ba rated bonds the lowest average default rate amongst non-overlapping cohorts would have been 9.46% and the highest average default rate amongst non-overlapping cohorts would have been 9.94%.

assigned to Baa rated debt is required because we need to compile default rates that are consistent with a debt yield of 6.23% and a risk-free rate of 3.87%. The aggregate default rates used in the analysis are higher than typically observed for Baa rated debt. But the default rate assumption is only an intermediate step to estimating the cost of equity. The default rate assumption is not an end in itself, rather, it allows us to estimate what cost of equity is consistent with all the other assumptions in the cost of capital, including bond yields.

151. An exception to the 25% versus 75% weighting assigned to the default rates on Baa rated debt and Ba rated debt is for the lowest 2.19% of market outcomes. These are market outcomes in which the market earns returns of –33.02% to –95.05% over five years. They are extremely low market outcomes in which we would expect default rates to be very high. For these extreme low market outcomes the default rate is assumed to be 70.51%. This is the default rate that prices the debt at the correct value, given the risk-free rate of 3.87% per year and the associated risk-neutral probabilities.

152. We can summarise the assumptions regarding debt with reference to *good*, *most* and *bad* market outcomes.

a) Across *good* market outcomes (the top 8.50% of market outcomes) the average default rate is 1.86%. This means that, on average, in *good* market outcomes debt holders *expect* to earn a return of 33.84% over five years, equivalent to 6.00% per year.[91]

b) Across *most* market outcomes (the middle 84.81% of market outcomes) the average default rate is 8.38%. This means that, on average, in *most* market outcomes debt holders *expect* to earn a return of 28.82% over five years, equivalent to 5.20% per year.[92]

c) Across *bad* market outcomes (the bottom 6.69% of market outcomes) the average default rate is 35.66%. This means that, on average, in *bad* market outcomes debt holders *expect* to earn a return of 7.78% over five years, equivalent to 1.51% per year.[93]

d) Across all market outcomes the average default rate is 9.65%. This means that, on average, debt holders *expect* to earn a return of 27.84% over five years, equivalent to 5.03% per year.[94]

153. The overall average default rate of 9.65% is just below the average historical default rate over five years for Ba rated debt (9.72%) and exceeds the average historical default rate over five years for Baa rated debt (1.97%). But we reiterate that the default rate used in analysis must be internally consistent with the debt yield and the risk-free rate. The default rate is merely an intermediate assumption used to estimate the cost of equity, given an assumption about the yield on debt.

154. In Table 3 we present an extract of the payoffs and returns to debt holders across the 61 market outcomes. The full set of outcomes is presented in an appendix. In the table we show all the debt payoffs for *most* market outcomes, the highest and lowest payoffs in *good* and *bad* market outcomes, and the *expected* payoffs across *good, most* and *bad* market outcomes. For instance, outcome 26 is the *typical* market case in which the market return is 10.54% per year. This outcome has a 10.21% chance of occurring.

[91] Average payoff to debt holders across *good* market outcomes per dollar of debt = 98.14% × 1.3528 + 1.86% × 1.3528 × 43.00% = 1.3276 + 0.0108 = 1.3384; and $1.3384^{(1/5)}$ – 1 = 1.0600 – 1 = 6.00%.

[92] Average payoff to debt holders across *most* market outcomes per dollar of debt = 91.62% × 1.3528 + 8.38% × 1.3528 × 43.00% = 1.2395 + 0.0487 = 1.2882; and $1.2882^{(1/5)}$ – 1 = 1.0520 – 1 = 5.20%.

[93] Average payoff to debt holders across *bad* market outcomes per dollar of debt = 64.34% × 1.3528 + 35.66% × 1.3528 × 43.00% = 0.8704 + 0.2074 = 1.0778; and $1.0778^{(1/5)}$ – 1 = 1.0151 – 1 = 1.51%.

[94] Average payoff to debt holders across all market outcomes per dollar of = 90.35% × 1.3528 + 9.65% × 1.3528 × 43.00% = 1.2223 + 0.0561 = 1.2784; and $1.2784^{(1/5)}$ – 1 = 1.0503 – 1 = 5.03%.

Table 3. Payoffs to debt holders according to market outcomes

		Market per $1.00		Debt payoff per $60.00				
Outcome	**Prob**	**Payoff**	**Ret (pa)**	**Def prob**	**No def**	**Default**	**Avg.**	**Ret (pa)**
1	0.00%	20.20	82.42%	0.00%	81.17	34.90	81.17	6.23%
…	…	…	…	…	…	…	…	…
21	3.45%	2.72	22.19%	2.34%	81.17	34.90	80.09	5.95%
22	4.94%	2.46	19.76%	2.68%	81.17	34.90	79.93	5.90%
23	6.58%	2.23	17.39%	3.26%	81.17	34.90	79.66	5.83%
24	8.16%	2.02	15.06%	3.85%	81.17	34.90	79.39	5.76%
25	9.44%	1.82	12.78%	5.30%	81.17	34.90	78.72	5.58%
26	**10.21%**	**1.65**	**10.54%**	**6.45%**	**81.17**	**34.90**	**78.18**	**5.44%**
27	10.32%	1.49	8.35%	7.50%	81.17	34.90	77.70	5.31%
28	9.76%	1.35	6.20%	9.52%	81.17	34.90	76.76	5.05%
29	8.64%	1.22	4.09%	11.45%	81.17	34.90	75.87	4.81%
30	7.16%	1.11	2.02%	14.50%	81.17	34.90	74.46	4.41%
31	5.56%	1.00	0.00%	14.87%	81.17	34.90	74.29	4.37%
32	4.04%	0.90	-1.98%	18.02%	81.17	34.90	72.83	3.95%
33	2.75%	0.82	-3.93%	18.54%	81.17	34.90	72.59	3.88%
…	…	…	…	…	…	…	…	…
61	0.00%	0.05	-45.18%	70.51%	81.17	34.90	48.55	-4.15%
Good	8.50%	3.12	25.54%	1.86%	81.17	34.90	80.30	6.00%
Most	**84.81%**	**1.58**	**9.52%**	**8.38%**	**81.17**	**34.90**	**77.29**	**5.20%**
Bad	6.69%	0.73	-6.09%	35.66%	81.17	34.90	64.67	1.51%
All	**100.00%**	**165.03**	**10.54%**	**9.65%**	**81.17**	**34.90**	**76.70**	**5.03%**

155. The probability of default in the *typical* market case is 6.45%. So there is a 93.55% chance that the debt holders receive their promised payment of $81.17 per $60.00 of investment, and a 6.45% chance the debt holders only receive $34.90, a 43.00% recovery. This means that, on average, the debt holders *expect* to receive a payoff of $78.18 in the *typical* market case.[95] This represents an *expected* return in the *typical* market case of 5.44% per year.[96]

156. Now that we have estimates of the *expected* payoffs to debt holders in each market outcome we need to estimate *expected* payoffs to equity holders in each market outcome, given their $40.00 investment. In different market outcomes there will be different *expected* payoffs on the asset, and this will lead to different *expected* payoffs to equity holders as the residual claimant. So we need to form a view as to what the potential asset payoffs are in different market outcomes. The asset payoffs are constrained in two ways.

a) First, it must be the case that the risk-neutral *expected* return on the asset is equal to the risk-free rate. So a higher asset payoff in one market outcome must be offset by a lower asset payoff in another market outcome.

b) Second, it must be the case that the present value of *expected* payoffs to equity holders is 40% of the present value of *expected* payoffs on the asset. This flows directly from the leverage assumption.

157. In the previous analysis in which we considered just two market outcomes we made an assumption that, in the *bad* market, if there was no default the asset payoff was 80% of the asset payoff in the *good* market. This assumption allowed us to directly estimate the asset return in a *good* market, a *bad* market, and on average across both market outcomes.

158. In the current analysis in which there are 61 potential market outcomes, the same idea applies. But we have more variation in potential asset payoffs in different market outcomes. We consider the relative

[95] Average payoff to debt holders in the *typical* market case = 93.55% × $81.17 + 6.45% × $81.17 × 43.00% = $75.93 + $2.25 = $78.18.
[96] $78.18 ÷ $60.00 – 1 = 30.30%; and $1.3030^{(1/5)} – 1 = 5.44\%$.

asset payoff compared to the typical market case (outcome 26 in Table 3). So the typical market case is analogous to the most likely scenario used in a post-tax revenue model for setting regulated prices. We then consider potential asset payoffs in comparison to the asset payoffs in this *typical* case. These are asset payoffs that occur in the absence of default.

a) For the *good* market outcomes (the top 8.50% of market outcomes) we assume that the payoff on the asset is 115.00% of the asset payoff in the *typical* case. For example, if in the *typical* case the payoff on the asset was $1.61 per dollar of investment (a return of 10.00% per year), we assume that across all *good* market outcomes the payoff on the asset is $1.85 per dollar of investment ($1.61 × 1.15 = $1.85, a return of 13.12% per year).

b) For the *bad* market outcomes (the bottom 6.69% of market outcomes) we assume that the payoff on the asset is 85.00% of the asset payoff in the *typical* market case. For example, if in the *typical* case the payoff on the asset was $1.61 per dollar of investment (a return of 10.00% per year), we assume that across all bad market outcomes the payoff on the asset is $1.37 per dollar of investment ($1.61 × 0.85 = $1.37, a return of 6.48% per year).

c) Across *most* market outcomes (the middle 84.81% of market outcomes) the asset payoff compared to the typical case ranges between 85.00% and 115.00%. The asset payoff varies depending upon the probability of each outcome, compared to the *typical* case. We measure how far the probability of a different market outcome is from the *typical* case, and apply this distance to the gap between either 85.00% and 100.00%, or 115.00% and 100.00%.

   For instance, consider outcomes 22 to 26 in Table 3. These five market outcomes have, in aggregate, a 39.33% chance of occurring. The highest market outcome within this set has a 4.94% chance of occurring, so represents 12.56% of the distance between the *typical* market case and a *good* market (that is, 4.94% ÷ 39.33% = 12.56%). So we assume that the ratio of asset returns in this instance is 12.56% of the distance between 1.15 and 1.00, which is 1.13.[97] The next best market outcome (number 23) has a 6.58% chance of occurring, so represents 29.28% of the distance between 1.15 and 1.00 [that is, (4.94% + 6.58%) ÷ 39.33% = 29.28%]. So we assume that the ratio of asset returns in this instance is 29.28% of the distance between 1.15 and 1.00, which is 1.11.[98]

   The asset payoffs associated with each market outcome will be presented shortly, jointly with our discussion of the asset return in the *typical* case.

159. The asset payoffs associated with each market return outcome, compared to the typical case, now allow us to estimate the asset return in the absence of default in the *typical* market outcome. In the previous analysis we solved an equation for r_a^G which was the asset return in a *good* market. In the current analysis we solve for the asset return in the typical market (market outcome 26 in Table 3). There is a unique asset return which sets the risk-neutral *expected* asset return across all market outcomes equal to the risk-free rate.

160. The solution to this analysis is an asset return in the typical case is 8.55% per year in the absence of default. This means that the asset return in a *good* market is 11.63% per year,[99] the asset return in a *bad* market is 5.08% per year, and the asset return in *most* markets lies between 5.08% per year and 11.63% per year.

161. In Table 4 we present an extract of payoffs and returns on the asset in different market conditions. The full table is presented in an appendix. The first four columns are the same as those reported in Table 3. These first four columns present the probabilities and market payoffs.

[97] 1.15 – 12.56% × (1.15 – 1.00) = 1.15 – 0.02 = 1.13

[98] 1.15 – 29.28% × (1.15 – 1.00) = 1.15 – 0.04 = 1.11.

[99] At an asset return of 8.55% per year, the total return over five years is 50.70%, computed as $1.0855^5 – 1 = 50.70\%$. In a *good* market, the asset payoff is 1.5070 × 1.15 = 1.7330; and $1.7330^{(1/5)} – 1 = 11.63\%$. In a *bad* market, the asset payoff is 1.5070 × 0.85 = 1.2809; and $1.2809^{(1/5)} – 1 = 5.08\%$.

Table 4. Payoffs to the asset according to market outcomes

Outcome	Prob	Market per $1.00 Payoff	Market per $1.00 Ret (pa)	Asset payoff per $100.00 Ratio	No def	Avg.	Ret no def (pa)	Ret avg (pa)
1	0.00%	20.20	82.42%	115.00%	173.30	173.30	11.63%	11.63%
…	…	…	…	…	…	…	…	…
21	3.45%	2.72	22.19%	115.00%	173.30	170.07	11.63%	11.21%
22	4.94%	2.46	19.76%	113.12%	170.46	166.83	11.26%	10.78%
23	6.58%	2.23	17.39%	110.61%	166.69	162.40	10.76%	10.18%
24	8.16%	2.02	15.06%	107.50%	162.00	157.11	10.13%	9.46%
25	9.44%	1.82	12.78%	103.89%	156.57	150.12	9.38%	8.46%
26	**10.21%**	**1.65**	**10.54%**	**100.00%**	**150.70**	**143.23**	**8.55%**	**7.45%**
27	10.32%	1.49	8.35%	97.25%	146.55	138.18	7.94%	6.68%
28	9.76%	1.35	6.20%	94.47%	142.36	132.13	7.32%	5.73%
29	8.64%	1.22	4.09%	91.84%	138.40	126.55	6.72%	4.82%
30	7.16%	1.11	2.02%	89.51%	134.89	120.39	6.17%	3.78%
31	5.56%	1.00	0.00%	87.58%	131.99	117.56	5.71%	3.29%
32	4.04%	0.90	-1.98%	86.09%	129.73	112.65	5.34%	2.41%
33	2.75%	0.82	-3.93%	85.00%	128.09	72.59	5.08%	2.08%
…	…	…	…	…	…	…	…	…
61	0.00%	0.05	-45.18%	85.00%	128.09	48.55	5.08%	2.01%
Good	8.50%	3.12	25.54%	115.00%	173.30	170.72	11.63%	11.29%
Most	**84.81%**	**1.58**	**9.52%**	**98.58%**	**148.56**	**139.54**	**8.24%**	**6.89%**
Bad	6.69%	0.73	-6.09%	85.00%	128.09	94.86	5.08%	−1.05%
All	**100.00%**	**165.03**	**10.54%**	**99.07%**	**149.29**	**139.20**	**8.34%**	**6.84%**

162. The fifth column presents the asset return ratio. This is the ratio of the asset payoff in the absence of default in different market conditions, compared to the *typical* case. In the *typical* market case (outcome 26) the asset return ratio is 100.00%. Across the set of *most* market conditions the asset return ratio spans the range of 86.09% to 113.12%. So the asset payoff, absent default, is up to 13% better and up to 14% worse than in the typical case. In the *good* and *bad* markets the asset return ratio is constrained at 115% and 85%, respectively.

163. The sixth column presents the asset payoff per $100.00 of investment, in the absence of default. In the *typical* case the asset payoff is $150.70 (equivalent to a return of 8.55% per year). At the upper end of *most* market outcomes the asset payoff is $170.46 (that is $150.70 × 1.1312 = $170.46), and at the lower end of *most* market outcomes the asset payoff is $129.73 (that is, $150.70 × 0.8609 = $129.73).

164. The seventh column presents the *expected* asset payoff in each different market outcome. This is a weighted average of the asset payoffs from the *no default* and default scenarios. The probabilities of default are listed in column five of Table 3. Throughout, we have assumed that the recovery rate on debt in the event of default is 43.00%, regardless of market conditions. So in the event of default, the assets are always worth $34.90 (that is $60.00 × 1.0623^5 × 43.00% = $34.90).

165. In the *typical* market case, the probability of default is 6.45%. So in the typical market, the *expected* payoff on the asset is 93.55% × $150.70 + 6.45% × $34.90 = $140.97 + $2.25 = $143.23. This can be compared to the payoff in the asset in the absence of default of $150.70. The difference of $7.47 represents how much investors in the asset stand to lose because the business as usual situation is not an expectation. On average, across all market outcomes as shown in the final row, the *expected payoff in the absence of default* is $149.29, while the *expected* payoff is $139.20.

166. In the final two columns we present the returns associated with the asset payoffs on an annualised basis. For the typical market case, the *no default* return is 8.55% per year compared to the *expected* return of 7.45% per year. On average across *most* market outcomes the *expected return in the absence of default* is 8.24% per year compared to an *expected* return of 6.89% per year. And across all market outcomes the *expected return in the absence of default* is 8.34% compared to an *expected* return of 6.84% per year.

167. The reason there is a unique solution (asset return in the typical case of 8.55% per year in the absence of default) is because this is the only solution in which the risk-neutral *expected* return will be equal to the risk-free rate of interest. If the risk-neutral probabilities are applied to the *expected* payoffs in column seven, the *expected* payoff is $120.90, which is the payoff over five years from investing in the risk-free asset at a rate of 3.87% per year.

168. The key point from this table is that we have a set of internally consistent parameter inputs that can be used for setting regulated prices. If regulated prices are set on the basis of a *no default* post-tax revenue model, that model needs to be consistent with an asset return that also excludes default. There are three options that could be relevant from Table 4, depending upon the basis for the post-tax revenue model.

a) The asset return in the *typical* market, in the absence of default, is 8.55% per year. If incorporated into the Sharpe-Lintner CAPM this is equivalent to an asset beta of 0.70.[100] An asset return of 8.55% per year would be appropriate if the post-tax revenue model was constructed on the basis of a single most-likely scenario that is predicted to occur in a typical market.

b) The average asset return in the absence of default across *most* market outcomes, is 8.24% per year. If incorporated into the Sharpe-Lintner CAPM this is equivalent to an asset beta of 0.66.[101] An asset return of 8.24% per year would be appropriate if the post-tax revenue model was constructed as an approximation of the average scenario that occurs in *most* market conditions.

c) The average asset return in the absence of default across all market outcomes, is 8.34% per year. If incorporated into the Sharpe-Lintner CAPM this is equivalent to an asset beta of 0.67.[102] An asset return of 8.34% per year would be appropriate if the post-tax revenue model was constructed as an approximation of the average scenario across all market conditions.

2.3.4 Step 3. Returns to equity holders

169. The final step in the analysis is to consider the payoffs to equity holders, which we present in Table 5. As with the payoffs for the asset as a whole, there are payoffs in the absence of default, and average payoffs that account for the risk of default. The payoffs to equity holders are simply the difference between the asset payoffs and the payoffs to debt holders. In the last two columns the equity payoffs are presented as annualised returns, compared to an initial investment of $40.00. The table shows the following results.

a) In the *typical* market in the absence of default the return to equity holders is 11.69% per year. If incorporated into the Sharpe-Lintner CAPM this is equivalent to an equity beta of 1.17.[103] In the *typical* market, equity holders would still *expect* to earn a return of 10.21%, given the risk of default. In the Sharpe-Lintner CAPM this is equivalent to an equity beta of 0.95.[104]

This means that, in a post-tax revenue model which is based upon the most likely market scenario that does not account for default, allowing a cost of equity of 11.69% is consistent with allowing an *expected* return to equity holders of 10.21%. The difference between the cost of equity and the *expected* return to equity holders is largely attributable to the difference between the yield on debt and the risk-free rate of interest.

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100 $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.0855 - 0.0387) \div (0.1054 - 0.0387) = 0.0468 \div 0.0667 = 0.70$. Note that this does not mean that the Sharpe-Lintner CAPM needs to be used for analysis. It simply means that if the Sharpe-Lintner CAPM is used, the equivalent asset beta is 0.70.

101 $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.0824 - 0.0387) \div (0.1054 - 0.0387) = 0.0437 \div 0.0667 = 0.66$.

102 $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.0834 - 0.0387) \div (0.1054 - 0.0387) = 0.0448 \div 0.0667 = 0.67$.

103 $\beta_e = (r_e - r_f) \div (r_m - r_f) = (0.1169 - 0.0387) \div (0.1054 - 0.0387) = 0.0782 \div 0.0667 = 1.17$.

104 $\beta_e = (r_e - r_f) \div (r_m - r_f) = (0.1021 - 0.0387) \div (0.1054 - 0.0387) = 0.0634 \div 0.0667 = 0.95$.

Table 5. Payoffs to equity holders according to market outcomes

Outcome	Prob	Market per $1.00 Payoff	Market per $1.00 Ret (pa)	Asset ret ratio	Equity payoff per $40.00 No def	Equity payoff per $40.00 Avg.	Ret no def (pa)	Ret avg (pa)
1	0.00%	20.20	82.42%	115.00%	92.14	92.14	18.16%	18.16%
…	…	…	…	…	…	…	…	…
21	3.45%	2.72	22.19%	115.00%	92.14	89.98	18.16%	17.60%
22	4.94%	2.46	19.76%	113.12%	89.30	86.90	17.42%	16.79%
23	6.58%	2.23	17.39%	110.61%	85.52	82.73	16.41%	15.64%
24	8.16%	2.02	15.06%	107.50%	80.83	77.72	15.11%	14.21%
25	9.44%	1.82	12.78%	103.89%	75.40	71.41	13.52%	12.29%
26	**10.21%**	**1.65**	**10.54%**	**100.00%**	**69.53**	**65.04**	**11.69%**	**10.21%**
27	10.32%	1.49	8.35%	97.25%	65.39	60.48	10.33%	8.62%
28	9.76%	1.35	6.20%	94.47%	61.20	55.37	8.88%	6.72%
29	8.64%	1.22	4.09%	91.84%	57.23	50.68	7.43%	4.85%
30	7.16%	1.11	2.02%	89.51%	53.73	45.94	6.08%	2.81%
31	5.56%	1.00	0.00%	87.58%	50.82	43.27	4.90%	1.58%
32	4.04%	0.90	-1.98%	86.09%	48.57	39.82	3.96%	-0.09%
33	2.75%	0.82	-3.93%	85.00%	46.93	38.23	3.25%	−0.90%
…	…	…	…	…	…	…	…	…
61	0.00%	0.05	-45.18%	85.00%	46.93	13.84	3.25%	−19.13%
Good	8.50%	3.12	25.54%	115.00%	92.14	90.42	18.16%	17.72%
Most	**84.81%**	**1.58**	**9.52%**	**98.58%**	**67.39**	**62.24**	**11.00%**	**9.25%**
Bad	6.69%	0.73	-6.09%	85.00%	46.93	30.19	3.25%	-5.47%
All	**100.00%**	**165.03**	**10.54%**	**99.07%**	**68.12**	**62.50**	**11.24%**	**9.33%**

b) Across *most* market outcomes in the absence of default the average return to equity holders is 11.00% per year. If incorporated into the Sharpe-Lintner CAPM this is equivalent to an equity beta of 1.07.[105] On average in *most* market outcomes equity holders would earn an *expected* return of 9.25% per year. In the Sharpe-Lintner CAPM this is equivalent to an equity beta of 0.81.[106]

c) Across all market outcomes in the absence of default the average return to equity holders is 11.24% per year. If incorporated into the Sharpe-Lintner CAPM this is equivalent to an equity beta of 1.10.[107] On average across all market outcomes equity holders would earn an *expected* return of 9.33% per year. In the Sharpe-Lintner CAPM this is equivalent to an equity beta of 0.82.[108]

170. The direct implication of this analysis for setting regulated prices is as follows. The allowed return to equity holders in a model should be set such that the *expected* return to equity holders is commensurate with the prevailing cost of funds. The manner in which regulated prices are typically set is that there is a model which incorporates one scenario of volume, operating costs, capital expenditure, payments to debt holders and taxation. This scenario does not represent an *expected* outcome in a statistical sense because it accounts for full payments to debt holders, and full taxation on profits after accounting for operating costs and full interest payments. It could be considered a likely *no default* scenario, or an average *no default* scenario, or an average *no default* scenario across the most plausible outcomes. But there is no doubt that a typical post-tax revenue model is not a model based upon the *expected* outcome.

171. So the issue is what cost of equity input should be incorporated into such a *no default* model. The possibilities considered above suggest cost of equity inputs of 11.69%, 11.00% and 11.24% per year.

[105] $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.1100 - 0.0387) \div (0.1054 - 0.0387) = 0.0713 \div 0.0667 = 1.07$.

[106] $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.0925 - 0.0387) \div (0.1054 - 0.0387) = 0.0538 \div 0.0667 = 0.81$.

[107] $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.1124 - 0.0387) \div (0.1054 - 0.0387) = 0.0737 \div 0.0667 = 1.10$.

[108] $\beta_a = (r_a - r_f) \div (r_m - r_f) = (0.0933 - 0.0387) \div (0.1054 - 0.0387) = 0.0547 \div 0.0667 = 0.82$.

The respective *expected* equity returns from these cost of equity inputs are 10.21%, 9.25% and 9.33% per year. Debt holders are projected to earn a return of 6.23% in the absence of default, and their respective *expected* returns are 5.44%, 5.20% and 5.03%.

172. It is worth repeating that the estimated revenue stream would be the same for two different models – one that was based upon one or more no default scenarios, and the other that incorporated the potential for default. Both models are used to set the price a regulated asset can charge for access to the asset. The price must be sufficient to generate enough revenue in a business as usual case so that, on average once default is accounted for, the *expected* return to equity holders is fair compensation for risk.

2.3.5 Sensitivity analysis

173. In this sub-section we document the sensitivity of the analysis to input assumptions. As with the previous analysis we first present the sensitivity of the results to changes in individual input assumptions, holding all other assumptions constant. Results are presented in Table 6. We then present different outcomes from sets of assumptions previously adopted by the ERA in GGP determinations from 2005 and 2010 and the 2013 Guidelines. Results are presented in Table 7.

174. In the tables we present the *expected* returns to debt and equity holders, the *expected returns in the absence of default,* and the returns in the *typical* scenario in the absence of default. Depending upon the basis for the post-tax revenue model, it is one of the two latter sets of results that is relevant for determining the cost of capital inputs to the model.

175. In Table 6 we document the following ranges for the *expected return to equity holders in the absence of default,* and the equivalent Sharpe-Lintner CAPM equity beta.

a) At a **risk-free rate** within the range of 2.87% to 4.87% per year, the *expected return to equity holders in the absence of default* is **12.44% to 10.19% per year** (and the equivalent equity beta lies within a range of 1.25 to 0.94). All else equal, a 1.00% increase in the risk-free rate reduces the cost of equity by 1.13% and reduces the equivalent equity beta by 0.15.[109]

b) At a **yield to maturity on debt** within the range of 5.23% to 7.23% per year, the *expected return to equity holders in the absence of default* is **9.66% to 12.97% per year** (and the equivalent equity beta lies within the range of 0.87 to 1.36). All else equal, a 1.00% increase in the yield on debt increases the cost of equity by 1.65% and increases the equivalent equity beta by 0.25.

c) At a **market return** within the range of 9.54% to 11.54% per year, the *expected return to equity holders in the absence of default* is **10.71% to 11.73% per year** (and the equivalent equity beta lies within the range of 1.21 to 1.02). All else equal, a 1.00% increase in the *expected* market return increases the cost of equity by 0.51% and reduces the equivalent equity beta by 0.09.

d) At a **standard deviation of market returns** within the range of 13.89% to 15.89%, the *expected return to equity holders in the absence of default* is 11.48% to 11.01% (and the equivalent equity beta lies within the range of 1.14 to 1.07). All else equal, a 1.00% increase in the standard deviation of market returns reduces the cost of equity by 0.23% and reduces the equivalent beta by 0.03. So the estimated cost of equity is largely insensitive to the assumption about the standard deviation of market returns.

e) At **leverage** within the range of 50.00% to 70.00% per year, the *expected return to equity holders in the absence of default* is **10.69% to 12.13%** (and the equivalent equity beta lies within the range

[109] In computing the sensitivity to a change in assumption we take an average of the sensitivity to shifts up and down in the assumption. For example, a 1.00% lower risk-free rate results in the *expected return to equity holders in the absence of default* increasing by 1.21% to 12.44%; and a 1.00% higher risk-free rate results in the *expected return to equity holders in the absence of default* falling by 1.05% to 10.19%. So, on average, the cost of equity changes by 1.13% for every 1.00% change in the risk-free rate (the average of 1.21% and 1.05% is 1.13%).

of 1.02 to 1.24). All else equal, a 10.00% increase in leverage increases the cost of equity by 0.72% and increases the equivalent equity beta by 0.11.

f) At a **debt recovery rate** in the event of default within the range of 33.00% to 53.00% the *expected return to equity holders in the absence of default* is **10.69% to 12.09% per year** (and the equivalent equity beta is 1.02 to 1.23). All else equal, a 10.00% increase in the recovery rate in the event of default increases the cost of equity by 0.70% per year and increases the equivalent beta by 0.10.

g) The last sensitivity is with respect to the **asset payoffs excluding default** that occur in *good* and *bad* markets, compared to the *typical* market outcome. Recall that our base assumption is that, in a *good* market, the payoff on the asset is 1.15 times the payoff on the asset in the *typical* case; in a *bad* market the payoff on the asset is 0.85 times the payoff on the asset in the *typical* case; and in *most* market outcomes the payoff on the asset lies between 0.85 and 1.15 times the payoff in the *typical* case. If the range of payoffs is increased then equity holders will bear more risk so the cost of equity will increase, and the cost of equity will fall if the range of payoffs decreases.

   If the range of asset payoffs increases by 10.00% (so lies between 80.00% and 120.00% of the asset payoffs in the *typical* market outcome) the *expected return to equity holders in the absence of default* is **12.25% per year**, consistent with an equity beta of 1.26. If the range of asset payoffs decreases by 10.00% (so lies between 90.00% and 110.00%) the *expected return to equity holders in the absence of default* is **10.23% per year**, consistent with an equity beta of 0.95. So all else equal, a 10.00% increase in the range of asset payoffs compared to the *typical* case increases the cost of equity by 1.01% and increases the equivalent equity beta by 0.15.

176. The discussion presented immediately above shows *expected return to equity holders in the absence of default* within the range of **9.66% to 12.97%** per year, and equivalent equity betas within the range of 0.87 to 1.36. It is worth comparing these cost of equity estimates to the *expected* returns that include the risk of default. The corresponding *expected* return to equity holders including default from Table 6 is within the range of **8.23% to 10.44% per year**, and the equivalent equity beta lies within the range of 0.65 to 0.98.

177. This means that, in order for equity holders to expect to earn a fair return on average (of around 8.23% to 10.44% per year) a model that accounts for the *expected no default* outcome would incorporate a cost of equity of around 9.66% to 12.97%. This is exactly the same concept as incorporating the yield to maturity on debt into a *no default* model, in order for debt holders to *expect* to earn a return commensurate with the risks of debt.

178. In Table 7 we present results after incorporating assumptions adopted by the ERA in GGP determinations in 2005 and 2010 and the Guidelines in 2013.

a) With respect to the assumptions used in the **2005 determination** (risk-free rate of 5.45%, debt yield of 6.43% to 6.68%, and market return of 10.45% to 12.75%), the cost of equity lies within a range of **9.79% to 11.20%** and the equivalent equity beta lies within a range of 0.76 to 0.95.

   These cost of equity estimates are the *expected return to equity holders in the absence of default*. They are consistent with *expected* returns to equity holders across all scenarios of 8.71% to 8.93%, consistent with an equity beta range of 0.62 to 0.68.

   The cost of equity range is also consistent with an equity risk premium of 4.34% to 5.75%, compared to the debt premium of 0.98% to 1.23% and the market risk premium of 5.00% to 7.00%.

b) With respect to the assumptions used in the **2010 determination** (risk-free rate of 5.79%, debt yield of 8.75% and market return of 10.79% to 12.79%), the cost of equity lies within a range of **13.32% to 14.35%** and the equivalent equity beta lies within a range of 1.22 to 1.51.

These cost of equity estimates across *no default* scenarios are consistent with *expected* returns to equity holders across all scenarios of 10.45% to 11.81%, consistent with an equity beta within the range of 0.86 to 0.93.

The cost of equity range is also consistent with an equity risk premium of 7.53% to 8.56%, compared to the debt premium of 2.96% and the market risk premium of 5.00% to 7.00%.

c) With respect to the assumptions used in the **2013 Guidelines** (risk-free rate of 3.44%, debt yield of 5.62% and market return of 8.44% to 10.44%), the cost of equity lies within a range of **9.64% to 10.69%** and the equivalent equity beta lies within a range of 1.04 to 1.24.

These cost of equity estimates are the *expected* returns to equity holders across *no default* scenarios. They are consistent with *expected* returns to equity holders across all scenarios of 7.70% to 8.87%, consistent with an equity beta range of 0.78 to 0.85.

The cost of equity range is also consistent with an equity risk premium of 6.20% to 7.25%, compared to the debt premium of 2.18% and the market risk premium of 5.00% to 7.00%.

179. The equity beta ranges reported in the paragraph above are 0.76 to 0.95 for 2010, 1.22 to 1.51 for 2013, and 1.04 to 1.24. We do not contend that the equity beta for a gas pipeline fluctuated over this period to such a degree. These equity beta ranges result from holding the market risk premium range constant from 5.00% to 7.00%. The beta estimates are presented because the ERA estimates the cost of equity in terms of the Sharpe-Lintner CAPM. Had the *MRP* range varied over this time in the same direction as corporate bond yields, which we would expect to be true, the equity beta estimates would have exhibited less variation.

180. If we consider the cost of equity compared to the cost of debt we observe that the difference in returns to these two providers of capital is relatively stable. The difference in the cost of equity and the yield to maturity on debt lies within the range of 3.36% to 4.52% using 2005 inputs, 4.57% to 5.60% using 2010 inputs, and 4.02% to 5.07% using 2013 inputs. Across all sets of inputs, the minimum difference between the cost of equity and the cost of debt is 3.36% and the maximum difference is 5.60%.

181. In terms of *expected* returns across all outcomes the difference between the *expected* returns to debt holders and *expected* returns to equity holders is 2.97% to 4.04% using 2005 inputs, 3.51% to 4.64% using 2010 inputs and 3.32% to 4.39% using 2013 inputs. So across all sets of inputs, the minimum difference in the *expected* returns to equity holders and *expected* returns to debt holders is 2.97% to 4.64%.

182. The ranges reported immediately above would be narrower if we allowed the market risk premium inputs to vary in different market conditions. But the purpose of this paper is not to enter into debate on the market risk premium.

183. Under the analysis conducted here, as the debt premium increases, the equity premium also increases and the gap between the cost of equity and cost of debt increases. This is illustrated in Figure 12. The composition of the cost of equity capital is presented on the left hand side and the composition of the *expected* return to equity holders is presented on the right hand side.[110]

184. Referring to the left hand side we see that as the debt premium increases from 1.10% to 2.96% and then falls to 2.18%, the cost of equity relative to the cost of debt rises from 3.95% to 5.09% and then falls to 4.56%. On average across the three sets of inputs the cost of equity is 4.53% higher than the cost of debt.[111]

185. Referring to the right-hand side we see that as the *expected* return to debt holders compared to the risk-free rate rises from 0.36% to 1.29% and then falls to 1.00%, the *expected* return to equity holders

[110] The figures are based upon the mid-point of the market risk premium (6.00% per year) and, for 2005, the mid-point of the two estimates for the yield to maturity on debt (6.55% per year).

[111] The average of 3.95%, 5.09% and 4.56% is 4.53%.

compared to the *expected* return to debt holders rises from 3.51% to 4.09% and then falls to 3.87%. On average across the three sets of inputs the *expected* return to equity holders is 3.82% higher than the *expected* return to debt holders.[112]

186. The green shading represents the incremental *expected* return from investing in the average stock in the market. The only reason this incremental *expected* return falls from 2.13% to 0.62% and then rises to 1.13% is because the market risk premium is being held constant despite fluctuations in market conditions. On average across the three sets of inputs the *expected* return on the market compared to the *expected* return on a gas pipeline is 1.29%.[113]

187. This means that equity investors in the gas pipeline would, on average, earn a return that is 1.29% less than an investment in the equity market, which corresponds to an equity beta of 0.78.[114] But for this expectation to hold, prices would need to be set such that the allowed return on equity is 0.61% above the *expected* market return. That is, on average across the 2005, 2010 and 2013 input sets, the *expected return to equity holders in the absence of default* is 11.51% per year,[115] compared to the average market return assumption of 10.89%.[116] This corresponds to an equity beta of 1.10.[117]

Figure 12. Cost of capital under alternative risk-free rate and debt yield assumptions

[112] The average of 3.51%, 4.09% and 3.87% is 3.82%.

[113] The average of 2.13%, 0.62% and 1.13% is 1.29%.

[114] $\beta_e = (r_e - r_f) \div (r_m - r_f) = 1.29\% \div 6.00\% = 0.78$.

[115] The average of 10.50%, 13.84% and 10.18% is 11.51%.

[116] The average of 11.45%, 11.79% and 9.44% is 10.89%.

[117] $\beta_e = (r_e - r_f) \div (r_m - r_f) = 6.61\% \div 6.00\% = 1.10$.

Table 6. Cost of capital under alternative input assumptions holding all other assumptions constant

Assumptions	Base	R_f ±1%		Yield ±1%		R_m ±1%		SD R_m ±1%		Lev ±10%		Rec rate ±10%		Asset ret ±10%	
Risk-free rate (%)	3.87	**2.87**	**4.87**	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87	3.87
Yield on debt (%)	6.23	6.23	6.23	**5.23**	**7.23**	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23
Market return (%)	10.54	10.54	10.54	10.54	10.54	**9.54**	**11.54**	10.54	10.54	10.54	10.54	10.54	10.54	10.54	10.54
Std. dev. mkt. ret. (%)	14.89	14.89	14.89	14.89	14.89	14.89	14.89	**13.89**	**15.89**	14.89	14.89	14.89	14.89	14.89	14.89
Leverage (%)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	**50.00**	**70.00**	60.00	60.00	60.00	60.00
Rec. rate on debt in def. (%)	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	**33.00**	**53.00**	43.00	43.00
% asset ret. bad mkt. ex. def. (%)	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	**80.00**	**90.00**
% asset ret. good mkt ex. def. (%)	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	**120.00**	**110.00**
Outcomes															
Expected ret. scenarios:															
Average return on assets (%)	6.84	6.96	6.69	5.96	7.51	6.57	7.12	6.98	6.73	6.95	6.73	6.57	7.13	7.33	6.36
Average return on debt (%)	5.03	4.72	5.28	4.34	5.53	4.99	5.09	5.07	5.02	5.03	5.03	4.90	5.11	5.03	5.03
Average return on equity (%)	9.33	10.00	8.67	8.23	10.22	8.77	9.90	9.62	9.10	8.74	10.30	8.89	9.90	10.44	8.24
Equiv. SL CAPM asset beta	0.45	0.53	0.32	0.31	0.55	0.48	0.42	0.47	0.43	0.46	0.43	0.40	0.49	0.52	0.37
Equiv. SL CAPM debt beta	0.17	0.24	0.07	0.07	0.25	0.20	0.16	0.18	0.17	0.17	0.17	0.15	0.19	0.17	0.17
Equiv. SL CAPM equity beta	0.82	0.93	0.67	0.65	0.95	0.86	0.79	0.86	0.78	0.73	0.96	0.75	0.90	0.98	0.66
Expected ret. if no default															
Average return on assets if no def. (%)	8.34	8.89	7.88	7.09	9.67	8.11	8.56	8.45	8.25	8.55	8.14	8.10	8.73	8.80	7.90
Average return on debt if no def. (%)	6.23	6.23	6.23	5.23	7.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23
Average return on equity no def. (%)	**11.24**	**12.44**	**10.19**	**9.66**	**12.97**	**10.71**	**11.73**	**11.48**	**11.01**	**10.69**	**12.13**	**10.69**	**12.09**	**12.25**	**10.23**
Equiv. SL CAPM asset beta	0.67	0.78	0.53	0.48	0.87	0.75	0.61	0.69	0.66	0.70	0.64	0.63	0.73	0.74	0.60
Equiv. SL CAPM debt beta	0.35	0.44	0.24	0.20	0.50	0.42	0.31	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Equiv. SL CAPM beta	1.10	1.25	0.94	0.87	1.36	1.21	1.02	1.14	1.07	1.02	1.24	1.02	1.23	1.26	0.95
Ret. in the typical case if no def.															
Average return on assets if no def. (%)	8.55	9.09	8.09	7.29	9.88	8.48	8.61	8.51	8.58	8.75	8.34	8.31	8.93	9.07	8.04
Average return on debt if no def. (%)	6.23	6.23	6.23	5.23	7.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23
Average return on equity if no def. (%)	11.69	12.89	10.65	10.12	13.42	11.53	11.83	11.61	11.76	11.06	12.71	11.15	12.54	12.85	10.54
Equiv. SL CAPM asset beta	0.70	0.81	0.57	0.51	0.90	0.81	0.62	0.70	0.71	0.73	0.67	0.67	0.76	0.78	0.62
Equiv. SL CAPM debt beta	0.35	0.44	0.24	0.20	0.50	0.42	0.31	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Equiv. SL CAPM equity beta	1.17	1.31	1.02	0.94	1.43	1.35	1.04	1.16	1.18	1.08	1.33	1.09	1.30	1.35	1.00

Table 7. Cost of capital under alternative sets of input assumptions

Assumptions	Base	ERA 2005				ERA 2010		ERA 2013	
Risk-free rate (%)	3.87	5.45	5.45	5.45	5.45	5.79	5.79	3.44	3.44
Yield on debt (%)	6.23	6.43	6.68	6.43	6.68	8.75	8.75	5.62	5.62
Market return (%)	10.54	10.45	10.45	12.45	12.45	10.79	12.79	8.44	10.44
Std. dev. mkt. ret. (%)	14.89	14.89	14.89	14.89	14.89	14.89	14.89	14.89	14.89
Leverage (%)	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Rec. rate on debt in def. (%)	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
% asset ret. bad mkt. ex. def. (%)	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00	85.00
% asset ret. good mkt ex. def. (%)	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00	115.00
Outcomes									
Expected ret. scenarios:									
Average return on assets (%)	6.84	6.97	7.07	7.47	7.58	8.41	9.13	5.76	6.33
Average return on debt (%)	5.03	5.74	5.83	5.80	5.89	6.95	7.17	4.38	4.48
Average return on equity (%)	9.33	8.71	8.84	9.78	9.93	10.45	11.81	7.70	8.87
Equiv. SL CAPM asset beta	0.45	0.30	0.32	0.29	0.30	0.52	0.48	0.46	0.41
Equiv. SL CAPM debt beta	0.17	0.06	0.08	0.05	0.06	0.23	0.20	0.19	0.15
Equiv. SL CAPM equity beta	0.82	0.65	0.68	0.62	0.64	0.93	0.86	0.85	0.78
Expected ret. if no default									
Average return on assets if no def. (%)	8.34	7.83	8.14	8.26	8.58	10.67	11.13	7.30	7.76
Average return on debt if no def. (%)	6.23	6.43	6.68	6.43	6.68	8.75	8.75	5.62	5.62
Average return on equity no def (%)	**11.24**	**9.79**	**10.20**	**10.79**	**11.20**	**13.32**	**14.35**	**9.64**	**10.69**
Equiv. SL CAPM asset beta	0.67	0.48	0.54	0.40	0.45	0.98	0.76	0.77	0.62
Equiv. SL CAPM debt beta	0.35	0.20	0.25	0.14	0.18	0.59	0.42	0.44	0.31
Equiv. SL CAPM equity beta	1.10	0.87	0.95	0.76	0.82	1.51	1.22	1.24	1.04
Expected return in the typical case									
Average return on assets if no def. (%)	8.55	8.04	8.36	8.16	8.49	10.84	10.98	7.85	7.98
Average return on debt if no def. (%)	6.23	6.43	6.68	6.43	6.68	8.75	8.75	5.62	5.62
Average return on equity if no def. (%)	11.69	10.30	10.70	10.57	10.99	13.70	14.02	10.88	11.17
Equiv. SL CAPM asset beta	0.70	0.70	0.52	0.58	0.39	0.43	1.01	0.74	0.88
Equiv. SL CAPM debt beta	0.35	0.35	0.20	0.25	0.14	0.18	0.59	0.42	0.44
Equiv. SL CAPM equity beta	1.17	1.17	0.97	1.05	0.73	0.79	1.58	1.18	1.49

3. Accounting for risks faced by the GGP

3.1 Introduction

188. Our conclusion from Sub-section 2.3 was an estimate for the cost of equity of 11.24% per year, which can be compared to the risk-free rate of 3.87% per year and the debt yield of 6.23% per year. At this cost of equity input, the *expected* return to equity holders is 9.33% per year, which can be compared to the *expected* return to debt holders of 5.03% per year and the *expected* return on the average listed firm of 10.54% per year.

189. In this section we consider more specifically the risks faced by the equity investors in the GGP. One basis for the estimates reported in Sub-section 2.3 was how much asset returns could vary in *good* and *bad* market conditions. Compared to the *typical* case we assumed that asset payoffs could be 15.00% higher or 15.00% lower over five years.

190. In this section we consider this assumption more closely with reference to specific risks associated with the GGP. We are still evaluating the cost of equity of a benchmark gas pipeline. But the benchmark needs to have risks that are consistent with those faced by the GGP, and our best proxy for measuring benchmark risk is to consider the GGP itself.

191. This analysis is aided by a model presented to us by GGT in which the projections of volume, capacity allocations and costs represent the base case for the pipeline in a typical market outcome. We use this model in order to estimate how asset returns to the pipeline deviate from the base case when market outcomes are different to the typical case.

3.2 Consistency of cost of capital parameters

3.2.1 Relationship between *expected* returns to debt and equity holders

192. At the outset we need to ensure that whatever analysis is conducted with respect to the GGP, cost of capital parameters are estimated on a consistent basis. This necessarily places constraints on what the cost of equity could be for a benchmark gas pipeline with similar risk to the GGP.

193. The first issue to consider is the relative risks faced by debt holders and equity holders. Debt holders face less risk than equity holders. Both providers of capital will only receive a return on investment if the assets generate positive cash flows, but equity holders are the residual claimant on those cash flows. So the *expected* return to equity holders will be greater than the *expected* return to debt holders.

194. It is also the case that a debt holder is exposed to less risk than the equity holders of the same asset, if there was no debt. An equity holder in an ungeared asset holds a fractional claim on the asset value. If debt is introduced, the debt holder holds a fractional claim on the **first** cash flows from the asset.

195. For example, suppose an equity investor invests $1.00 in a $100.00 asset that has no debt. If the asset is worth $50.00 in a year the equity investor receives $0.50, and if the asset is worth $150.00 in a year the equity investor receives $1.50. If the same asset is financed with $60.00 of debt at a rate of 6.00% and an investor invests $1.00 in the debt, what happens at the end of the year? If the asset is worth $50.00 the investor receives $0.83 ($1.00 ÷ $60.00 × $50.00 = $0.83), and if the asset is worth $150.00 the investor receives $1.06.

196. So in this example the potential payoffs to the equity investor in the ungeared asset are $0.50 and $1.50, compared to $0.83 and $1.06 for the debt investor in the leveraged asset. The debt investment is a lower risk prospect than taking equity in an otherwise comparable project with no debt.

197. In our analysis, the *expected* return to equity investors in an ungeared asset is the asset return. So the *expected* return to debt holders is less than the *expected* return on the assets, which is less than the *expected* return on the equity in a levered firm.

198. To summarise, we must have the following relationship amongst *expected* returns on debt, equity and the assets:

Expected returns to debt holders < Expected returns on the asset < Expected returns to equity holders

199. In the computations performed in Sub-section 2.3 this was true. The *expected* return to debt holders was 5.03%, the *expected* return on the asset was 6.84% and the *expected* return to equity holders was 9.33%. The relationship between these *expected* returns is actually given by the equation below, although we did not rely upon this equation to perform the computations. The figures used for illustration are the five year returns because this is the period used in computation.

$$\begin{aligned} r_e &= r_a + (r_a - r_d) \times Debt/Equity \\ &= 0.3920 \times (0.3920 - 0.2784) \times 0.60/0.40 \\ &= 0.3920 + 0.1704 \\ &= 0.5624 \\ &= 9.33\%\ per\ year \end{aligned}$$

200. In this equation the *expected* return on assets of 39.20% (6.84% per year) is the *expected* return from bearing the risks associated with the asset, and the incremental *expected* return of 17.04% (2.50% per year) is the fair *expected* return associated with the risks of taking on debt finance. By allowing debt holders first claim on the assets, and offering a fixed repayment, equity holders increase their *expected* returns by 2.50% per year.

3.2.2 Relationship between *expected returns in the absence of default* to debt and equity holders

201. We must also have the same relationship directional relationship amongst *expected* returns to debt holders, the asset and equity holders to hold for the *expected returns in the absence of default*. This is necessarily true because the scenarios faced by the asset can be grouped into two segments – there is either a default or there is not a default.

202. If a default occurs we know that debt holders fare better than equity holders, who earn a return of –100%. So the *expected* return in the event of default is higher for debt holders than for equity holders. The *expected* return to debt holders in the event of default is also higher than the *expected* return equity holders in an ungeared asset would earn if the asset value fell by the same amount (as in the example in which debt holders received \$0.83 per dollar of investment and equity holders in an ungeared asset received \$0.50 per dollar of investment).

203. So if the average return to equity holders is higher than the average return to debt holders across all scenarios, and equity holders are worse off in the event of default, the equity holders must be better off, on average, if there is no default. The same is true for asset returns. On average across all scenarios asset returns are higher than debt returns, and asset returns are lower than debt returns in default situations. So on average asset returns must be higher than debt returns in the absence of default.

204. To summarise, we must have the following relationship amongst *expected* returns on debt, equity and the assets across default and no default scenarios:

Expected returns to debt holders in the absence of default < Expected returns on the asset in the absence of default < Expected returns to equity holders in the absence of default

Expected returns to debt holders if default occurs > Expected returns on the asset if default occurs > Expected returns to equity holders if default occurs

205. In the results reported in Sub-section 2.3 this relationship was true as reported below.

a) In the absence of default we have the following *expected* returns: debt return of 35.28% (6.23% per year), asset return of 49.29% (8.34% per year) and equity return of 70.31% (11.24% per year).

b) If default occurs we have the following *expected* returns: debt return of –41.83% (–10.27% per year), asset return of –65.10% (–18.98% per year) and equity return of –100.00%.

3.3 Risks

3.3.1 Framework

206. To understand the risks faced by equity holders in the GGP we begin with the post-tax revenue model compiled by the GGP for the covered pipeline. The GGP can be disaggregated into two components, referred to as the covered pipeline (which is subject to regulation by the ERA) and the uncovered pipeline (which is not subject to regulation by the ERA).

207. Our conclusions on the cost of capital relate to the whole of the GGP, not just the covered pipeline. There is no reason to think that the risks associated with some sections of the pipeline are different to other sections of the pipeline. The sections of the pipeline are not categorised as covered or uncovered on the basis of differences in risk. Rather, whether a section of the pipeline is regulated or not regulated is a matter for the pipeline owners, pipeline users and the ERA. In its most recent determination on this issue, the ERA (2014) determined that an expansion of the GGP was not covered.

208. The post-tax revenue model provided by the GGP is used to estimate pipeline tariffs, given inputs regarding the cost of capital, taxation, operating costs and capital expenditure. The basis for the model is that the present value of cash flows to equity holders is set to equal the equity investment in the assets (40% of the asset base). The model is based upon 50 years of remaining asset life, so the asset value is the present value of cash flows over the 50 years ending in 2064. The actual model provided to us relies upon quarterly projections for volumes and capacity. But we have re-constructed the model so our calculations are performed on an annual basis. We re-estimate tariffs every five years such that the present value of *expected* cash flows over each five year period is equal to the estimated asset base at the start of that five year period.

209. We use the GGP post-tax revenue model as a computational device, to examine how asset and equity value change in response to changes in volume and shortfalls in capacity charges. So we extrapolate from these sensitivities to draw conclusions about the GGP pipeline as a whole.

210. Our first step was to populate the post-tax revenue model with cost of capital input assumptions, namely a risk-free rate of 3.87% per year, yield to maturity on debt of 6.23% per year, cost of equity of 11.24% per year, and market return of 10.54% per year.

211. We also assume a value for imputation credits of 0.25 because this is the value proposed by GGT, and in this model we need to make an assumption about imputation credit value. In the prior analysis we considered total returns to equity holders and made no distinction about how those returns were earned. The effective impact of a positive value for imputation credits is to lower the tax payable. So the higher the assumed value for imputation credits, the lower the tariffs. But our primary concern is how asset and equity value will vary according to volume and capacity charge adjustments, not with the overall level of tariffs or revenue.

212. Our analysis relies upon an assumption regarding the variation in asset returns over five years, compared to the *typical* case. The asset return variation resulting from market outcomes that are better or worse than expected. The baseline cost of capital assumptions listed above represent the assumptions in the *typical* case. Recall from Sub-section 2.3 that our assumption is that asset returns over five years, in the absence of default, could be 85.00% to 115.00% of asset returns in the *typical* case. The objective of the Section 3 is to examine how variation in asset returns of this magnitude can occur with specific reference to the GGP.

213. Revenue from the pipeline is supported by long-term contracts and the majority of revenue is for tariffs relating to pipeline access, rather than volume. Revenue categories are described below.

a) The largest revenue component is the **capacity reservation charge**, which comprises 72.20% of the present value of projected revenue. The capacity reservation charge for each user is based upon the product of the petajoules of capacity reserved and the distance from the receipt point.

For example, suppose a user reserved capacity of 10 terajoules per day over 365 days in a year, and the distance from the receipt point was 800 kilometres. We have 10 TJ per day × 365 days × 800 kilometres = 2,920 PJ km. If the per unit capacity reservation charge was $0.0020 per gigajoule km then the total capacity reservation charge for the year = 2,920 PJ km × $0.0020 per GJ = $5.840 million.

b) The second charge relating to access is the **toll charge**, which comprises 11.30% of the present value of projected revenue. The toll charge for each user is based upon the petajoules of reserved capacity, independent of the distance from the receipt point.

Continuing the example above, in which the user reserved capacity of 10 terajoules per day over 365 days in a year, suppose the toll charge was $0.3000 per gigajoule. Total reserved capacity = 10 TJ per day × 365 days = 3.650 petajoules. This means that the toll charge for the year = 3.650 PJ × $0.3000 per GJ = $1.095 million.

c) The final component of revenue is the **throughput charge**, which comprises 16.50% of the present value of projected revenue. The throughput charge is based upon the product of petajoules of throughput and the distance from the receipt point.

Suppose in the example that throughput is 7 terajoules per day over 365 days in a year, and the throughput charge is $0.0005 per gigajoule km. Total throughput km = 7 TJ per day × 365 days × 800 kilometres = 2,044 PJ km. This means that the throughput charge for the year = 2,044 PJ km × $0.0005 per GJ km = $1.022 million.

d) In aggregate for this example there is a capacity reservation charge of $5.840 million, a toll charge of $1.095 million and a throughput charge of $1.022 million, for total projected revenue of $7.957 million.

3.3.2 Sensitivity to volume changes provided capacity charges are paid

214. In this first sub-section we examine the sensitivity of revenue and asset return to volume fluctuations, under the assumption that capacity charges are paid in full. In the next sub-section we introduce the potential for some shortfall in capacity charge payments.

215. Based upon information supplied by GGT, at the time of writing for the covered pipeline throughput km is projected to be 76.28% of capacity km. So based upon existing pipeline capacity, the maximum potential increase in revenue associated with volume increases is 5.13%. The computation for this revenue increase is as follows. Suppose total projected revenue is $100.00, comprised of a capacity charge of $72.20, a toll charge of $11.30 and a throughout charge of $16.50. If throughput increases from 76.28% of capacity to 100.00% of capacity, then the throughput charge would increase to 100.00% ÷ 76.28% × $16.50 = $21.63. This would result in total revenue of $105.13, which is a 5.13% increase in projected revenue.

216. By the reverse analogy, the maximum potential decrease in revenue associated with volume declines is 16.50%. At zero volume the revenue is equal to the capacity charge.

217. So at the outset we can establish that if customers meet their capacity charge obligations the potential difference in revenue from base case projections associated with volume changes is –16.50% to +5.13%. This is not meant to imply that zero volume and volume equal to 100.00% of capacity are equally likely. It is only meant to provide the maximum possible revenue variation in a simple scenario

in which existing customers meet their capacity charge obligations, but either use 100.00% or 0.00% of capacity.

218. Based upon the post-tax revenue model, we can also estimate how sensitive asset and equity values are to changes in volume, provided capacity charges are paid. Pipeline costs can be considered almost entirely fixed, which is the reason capacity charges account for 83.50% of projected revenue. This means that a small change in revenue implies a relatively large change in after-tax profits and therefore equity value, especially given the additional fixed costs associated with high leverage.

219. As a starting point, suppose volume was 10.00% lower than projected over the 50 year life of the pipeline and prices are unchanged from the baseline projection. In this event, the present value of revenue falls by 1.65%. But this leads to a 3.35% fall in the value of the asset and an 8.37% fall in equity value. There is a symmetric impact on asset and equity value in the event that volume is 10.00% higher than projected. In this case, volume 10.00% higher than projected with no changes to tariffs leads to an increase in the present value of revenue of 1.65%, a rise in asset value of 3.35% and a rise in equity value of 8.37%.

220. The ±8.37% change in equity value associated with a ±10.00% change in volume represents an instantaneous change. It means that, if equity was initially valued at $40.00 by investors and debt was valued at $60.00 and investors revised their volume projections by ±10.00%, equity value would change by ±8.37% at the same time.

221. For the purposes of our evaluation framework we are concerned with asset and equity returns over a five year period. In the base case the internal rate of return to equity holders over five years is 11.24%, equivalent to a return of 70.31% in aggregate over five years. This is necessarily true because the cost of equity input was 11.24%.

222. In the case in which volume falls by 10.00%, there are lower cash flows to equity holders over the next five years and a lower value of equity at the end of five years.[118] Given the cash flows to equity holders over five years and the equity value at the end of five years, the return earned by equity holders on their $40.00 investment is 10.24% per year, equivalent to 63.12% over five years.

223. This means that, in the event of a 10.00% volume decline and no change in prices, equity holders are 4.22% worse off than in the base case after five years. That is, an equity investment of $40.00 was projected to be worth $68.12 at the end of five years with the reinvestment of dividends.[119] The volume decline means that the equity investment is worth $65.25 at the end of five years with the reinvestment of dividends.[120] Hence, equity returns are 95.78% of what was projected in the base case.[121]

224. The same computation can be performed for asset returns. In the base case the projected asset return is 8.23% per year, which is a weighted average of the returns on debt (6.23% per year) and equity (11.24% per year).[122] So the asset is projected to earn a return of 48.52% over five years. If volume falls 10.00% below projections and prices are unchanged the internal rate of return on assets would be 7.35% per year (42.54% over five years). So a $100.00 investment in the asset was projected to be worth $148.52 with the reinvestment of cash flows. The volume reduction leads to an asset worth just $142.54, so asset returns are 95.97% of the base case projection.

225. The key point is that asset and equity returns have some sensitivity to volume fluctuations, even if capacity charges are fully paid, and the impact of volume fluctuations on asset and equity returns can be measured. Further, volume differences from the baseline estimate are only likely to result from economic events. The volume demands on the GGP are ultimately determined only by the demands of

118 Technically, there is also an increase in the cost of equity because leverage is now higher, but we ignore this aspect so as not to make the analysis more complex.

119 $40.00 × 1.7031 = $68.12.

120 $40.00 × 1.6312 = $65.25.

121 $65.25 ÷ $68.12 = 95.78%.

122 6.23% × 0.6000 + 11.24% × 0.4000 = 3.74% + 4.49% = 8.23%.

operating mining companies and towns that serve operating mining companies. So the variation in asset and equity returns will be due to variation in global economic demand.

226. Recall that in the analysis presented in Sub-section 2.3 we considered asset returns over five years that were 85.00% to 115.00% of asset returns in the *typical* case over five years. The upper bound corresponded to a *good* market outcome and the lower bound corresponded to a *bad* market outcome. We can use information in the post-tax revenue model to determine the feasibility of this range.

227. With just consideration of volume fluctuations we can determine the **maximum** asset return on the GGP, compared to the base case. This occurs in the situation in which volume is 100.00% of capacity, prices are unchanged and there are zero defaults. In this event the internal rate of return on the asset over five years is 9.97% per year, equivalent to 60.81% over five years. This represents a total asset return that is 8.27% above the base case return of 48.52% over five years.[123]

228. This maximum asset return is unlikely to be achieved because it is based upon the assumption that prices are locked in for 50 years. In reality, prices are reset at the beginning of each contract and contracts last for less than 50 years. For regulated assets, each regulatory period is analogous to a contract in which the regulator states the terms that it considers to be fair.

229. Suppose all prices outside of the first five year regulatory period were re-set by the regulator such that the present value of cash flows is equal to the asset base at the end of five years. The new assumption adopted by the regulator is that throughput of 100.00% of capacity is projected for the last 45 years. This leads to reductions in the throughput charge.

230. In this situation, the increase in volume assumption results in an internal rate of return on the asset of 8.74% per year, equivalent to 52.03% over five years. This represents a total asset return that is 2.36% above the base case return of 48.52% over five years.[124]

231. So we know that the upside to asset returns, based entirely on volume being above projections, is within the range of **2.36% to 8.27% over five years.** Either extreme is unlikely to occur, but this represents a full spectrum of possibilities. With respect to the upper end, it is not the case that prices are locked in for 50 years. So with volume increases we would expect some price falls. At the lower end, it is also not the case that volume increases will be entirely offset by price reductions after the five year period. It is highly unlikely that just because volumes were at 100.00% of capacity in one period that prices will be re-set with observed volume as the future projection.

232. This upside range of 2.36% to 8.27% relative to base case asset returns is based entirely on volume changes and full capacity payments. There is no reason to think that this upside potential would occur for any reason other than strong economic conditions.

233. The impact on returns in a low volume case are approximately symmetric to those for the high volume case. If there was a volume shortfall equal to the difference between capacity and volume, and no change in prices, the internal rate of return on the asset would be 6.41% per year, equivalent to 36.44% over five years. This represents a total asset return that is 8.13% lower than in the base case.[125] In the event of price re-sets, in which volume is projected to be at the same low level for the remaining 45 years, the internal rate of return on the assets would be 7.65% per year, equivalent to 44.58% over five years. This represents a return over five years that is 2.65% lower than in the base case.[126]

234. **In summary, the potential upside and downside to asset returns from volume fluctuations, provided all capacity charges are paid, lies within the range of ±3% to ±9%, compared to a base case projection.** This means that, in a *good* market, the potential upside in asset returns from

[123] \$160.81 ÷ \$148.52 – 1 = 8.27%.
[124] \$152.03 ÷ \$148.52 – 1 = 2.36%.
[125] \$136.44 ÷ \$148.52 – 1 = 8.13%.
[126] \$144.58 ÷ \$148.52 – 1 = 2.65%.

better than projected volume lies somewhere from 3% to 9%; and, in a bad market, the potential downside in asset returns from worse than projected volume lies somewhere from 3% to 9%.

3.3.3 Risks associated with capacity charges and risks associated with equity and debt

235. At the outset it needs to be understood that the receipt of capacity charges in not guaranteed. It is true that the customer base of the GGP includes mining companies earning high margins on production, including BHP and Rio Tinto, and the risk that high margin mining companies suddenly stop paying capacity charges is low. However, the inputs into the cost of capital include assumptions of 60.00% leverage and a yield to maturity on debt of 6.23% per year, compared to the risk-free rate of 3.87% per year.

236. The debt premium of 2.36% per year is the incremental return to debt holders, relative to the risk-free rate, in a *no default* situation. The debt premium compensates debt holders for risk exposure. Fluctuations in the value of debt result from changes in the probability of default, and changes in discount rates. If the probability of default increases, bond prices fall. If discount rates increase because debt investors require more compensation per unit of risk, bond prices also fall.

237. If debt holders were immune from risks associated with a gas pipeline they would lend at the risk-free rate of interest. Given the positive debt premium there must be some chance that the pipeline defaults on its obligations to debt holders. Debt holders must also face some systematic risk because for debt holders to have an *expected* return equal to the risk-free rate would require a very high default rate or a very low recovery rate in the event of default.

238. There is only one scenario that could lead to default by the pipeline, which is the non-payment of capacity charges by pipeline customers. Even if volume suddenly fell to zero, and customers only paid their capacity charges to the pipeline, the pipeline assets are worth slightly more than the value of debt.[127]

239. In our analysis we have considered the potential for the value of assets to fall below the value of debt. This is the circumstance in which the return to equity holders is –100.00%. For this to occur in the post-tax revenue model there needs to be a revenue shortfall of 19.72% compared to the base case. If revenue is projected to be 19.72% lower than the base case assumption over the life of the asset, the asset value falls by 40.00%.

240. The average revenue shortfall in a default situation is larger than 19.72%, and the average decline in asset value in a default situation is larger than 40.00%. The reason for this is that debt holders only recover a proportion of their investment.

241. Recall that historical average recovery rates suggest a recovery rate in the event of default of 43.00%. This means, on average, the asset value would decline by 74.20% in the event of default. That is, the asset is initially worth \$100.00 comprised of \$60.00 debt and \$40.00 equity. If the there is an immediate change in asset value such that the debt holders recover 43.00% of their \$60.00 investment, the value of asset is 43.00% × \$60.00 = \$25.80. This is a decline in the value of assets of 74.20%.

242. For the value of assets to decline by 74.20% there needs to be a revenue shortfall of 36.58% compared to the base case. If revenue is projected to be 36.58% lower than the base case assumption over the life of the asset, the asset value falls by 74.20%.

243. This is why bond yields tell us that there is some material chance that capacity charges will not be paid in full by customers.

   a) For the pipeline to default on its debt obligations requires a revenue decline of at least 19.72%, and on average revenue would decline by 36.58% in the event of default.

[127] The estimated value of the pipeline assets in this instance is 11% more than the initial debt value.

b) Even if volume-based charges are set to zero, revenue would only fall by 16.50% – the remaining charges are capacity charges.

c) So there must be some material chance that one or more customers reneges on their capacity charges.

244. This means that a leverage assumption of 60.00%, and a debt premium of 2.36%, can only be consistent with there being some material chance that capacity charges are not met. If there was no realistic chance this would occur, leverage would be above 60.00% and lenders would be prepared to invest at lower yields.

245. In addition, we have been informed by GGT that customers are unwilling to provide parent company guarantees of capacity charges. This is another signal that there is a material chance of capacity charges not being met. If customers considered there to be no material chance of capacity charges not being paid, parent companies would be willing to provide guarantees in order to secure lower access charges.

246. A customer could offer to provide a parent company guarantee of capacity charges, and use this guarantee to secure lower prices. For a customer to prefer the higher price/no guarantee option means the customer must consider there to be some downside to providing the parent guarantee – namely that the parent might actually need to make good on this promise.

247. Further, the non-payment of capacity charges can only plausibly occur as the result of a market downturn. The customers of the GGP will continue to pay capacity charges so long as the net present value of their cash inflows exceeds the net present value of their cash outflows from continuing their operations.

248. This means that there is some chance that market economic conditions are so poor that non-payment of capacity charges leads to default by the GGP. This also means that there is some chance that not all capacity charges are met but the payments are not so low that the GGP defaults on its debt.

249. These are the very scenarios that we analysed in Section 2 in order to estimate the cost of equity. We accounted for differences in asset returns compared to the typical case that lead to low asset payoffs (but the pipeline remains solvent) and even lower asset payoffs (that lead to default by the pipeline on its debt). We assumed that, in the absence of default, asset returns over five years could be as low as 85.00% of asset returns in the *typical* case. We also assumed a recovery rate on debt of 43.00% if default occurs. In paragraph 240 we estimated that a recovery rate was consistent with a decline in the value of the assets of 74.20%, or in other words, the asset value is 25.80% of the base case asset value.

250. Our cost of equity estimates have been framed with reference to returns over a five year period, and an important assumption is the asset return over five years, relative to the typical case. So we consider what revenue shortfall would be required for asset returns to be 85.00% of returns in the *typical* case over a five year period.

251. This revenue shortfall can be a combination of a shortfall in capacity charges and shortfall in volume compared to base case projections. But the volume shortfall is capped at the capacity charge shortfall because it is highly unlikely that capacity charge revenue would fall by a higher percentage than volume based revenue. A customer that does not pay capacity charges will certainly not pay volume charges. So the only circumstance in which capacity charge revenue falls by more than volume based revenue is if one customer takes on volume to more than offset the reduction in volume from the non-paying customer.

252. If the revenue shortfall over the 50 year asset life is 6.21% compared to the base case, the five year internal rate of return on the assets is 4.77% per year. This is equivalent to an asset return of 26.24% over five years. In comparison to the base case return over five years (48.52%) this represents a relative asset return of 85.00%.[128]

[128] $126.24 ÷ $148.52 = 85.00%.

253. Given the allocation of revenue to capacity charges (83.50%) and volume-based charges (16.50%), a revenue shortfall of 6.21% could result from the following combinations of capacity charge payments and volume reductions.

a) No shortfall in capacity charges and a volume shortfall of 37.64%.[129]

b) A 3.11% shortfall in capacity charges and a volume shortfall of 21.92%.

c) A 6.21% shortfall in capacity charges and a volume shortfall of 6.21%.

254. This means that asset returns could be 85.00% of base case asset returns if revenue is 6.21% below projections over the asset life, which could occur if capacity charges are 0.00% to 6.21% below projections, and volumes are 6.21% to 37.64% below projections.

255. These are not large revenue shortfalls. Revenue shortfalls of this magnitude could occur as a result of non-payment of capacity charges by a single customer alongside volume shortfalls below projections. It is not unreasonable to consider that lower margin customers could fail to meet capacity charges in the event of a downturn in commodity prices. It was the very rise in commodity prices in recent years that led to the development of lower grade deposits in Western Australia that were considered uneconomic at low commodity prices.

256. [Paragraphs 256 to 266 are provided to the ERA on a confidential basis.]

3.3.4 Implications

267. The capacity charges under the GGP cannot be considered guaranteed. In most circumstances capacity charges will be paid. But in the event of a material reduction in commodity prices there is a material risk that capacity charges will not be paid. The commodity prices falls that would trigger such a shortfall are not unreasonably large – prices would need to fall to levels observed just five years ago.

268. As documented in the cost of capital estimates in Section 2 this has a material impact on the cost of equity capital. All that is required for the cost of equity to approximate the cost of equity for the average firm is for asset returns to be 15.00% worse than in a *bad* market compared to the base case.

269. It should also be noted that the status of the GGP being regulated does not mean that it is somehow immunised from risk, in comparison to an otherwise unregulated pipeline. For an unregulated pipeline, long-term contracts are entered into and the prices payable under those contracts are the result of a negotiation. If the same pipeline was regulated there are two main differences – there is the equivalent of a contract re-negotiation every five years, and the contract terms are determined by the regulator.

270. The pipeline is only regulated because of the concern that the contract terms for the unregulated pipeline would be unreasonably generous to the asset owner. Asset owners do not generally ask to be subject to regulation. Put another way, a pipeline is regulated because there is a concern that the pipeline owner would otherwise achieve too high a return for the level of risk. This means that, all else being equal, the asset owner is subject to a worse risk-reward trade-off than if the pipeline was unregulated.

271. This means that it is not the case that the five-year regulatory period of revenue and price resets immunises the asset owner against risk. In the absence of regulation, the pipeline owner would be in a better reward-for-risk position. The regulator is attempting to put the asset owner and customers in positions that the regulator considers provide the fair reward-for-risk trade-off. Estimation error could place either asset owners in a better or worse position than what is just right for this fair trade-off. But it is not the case that regulation somehow places the asset owner in a better reward-for-risk position

[129] Revenue ÷ Base case revenue = Base case capacity charge ÷ Base case revenue × Percentage of base case capacity charge received + Base case volume charge ÷ Base case revenue × Percentage of base case volume charge received = 83.50% × Percentage of base case capacity charge received + 16.50% × Percentage of base case volume charge received = 93.79%. So if 100% of the base case capacity charge is received, then the percentage of base case volume charge received = 62.36%. If 99.00% of the base case capacity charge is received then the percentage of base case volume charge received = 92.91%, and so on.

that would have existed in the absence of regulation. In short, the five-year price reset mechanism does not immunise the asset owner against risks that would have been otherwise faced in the absence of regulation. The overall reward-for-risk trade-off for the owner will be lower as a result of regulation. If regulation made asset owners better off on a reward-for-risk basis, it is asset owners who would ask for regulation and customers who would argue against regulation.

272. **In summary, consideration of the specific aspects of the GGP and its customer base suggest that the important assumption underpinning our cost of capital analysis is reasonable (the ±15.00% variation in asset returns compared to the *typical* case). So our best estimate of the cost of equity for the GGP's benchmark gas pipeline is 11.24%.**

4. Conclusion

273. A limitation of cost of equity estimation in regulation is the inconsistent approaches to estimating the cost of equity and the cost of debt. The cost of equity is typically estimated using risk estimates from analysis of historical returns on listed stocks. In the case of regulation of the GGP by the ERA, the risk estimate is the beta coefficient from a regression of stock returns on market returns for five or six Australian-listed stocks. There is no other technique or dataset relied upon to estimate the risk to equity holders, despite considerable evidence that the cost of equity estimate generated by this approach has almost no documented association with realised returns. The market risk premium estimate is also estimated largely with respect to historical stock returns.

274. In contrast the cost of debt is typically estimated with reference to the yield to maturity on corporate bonds. So the cost of equity estimate relies almost entirely on analysis of historical stock returns and the cost of debt estimate relies entirely on analysis of current debt prices.

275. This inconsistency in approach means that the estimates of the cost of equity and the cost of debt can move in different directions over time, and that the spread between the cost of equity estimate and the cost of debt is not constrained in any quantitative manner. The ERA has noted that it would not make sense for the cost of equity to be less than the cost of debt. But apart from constraining the cost of equity estimate at a lower bound, movement in debt yields are not used to estimate the cost of equity.

276. Our approach to estimating the cost of equity provides a direct link between the cost of equity, the cost of debt, the risk-free rate, the market return and leverage. The cost of equity estimates are formed with respect to conventional finance theory on options pricing taught in undergraduate and master's finance courses.

277. We also explicitly consider the *expected* returns to equity holders across all potential scenarios, and the *expected return to equity holders in the absence of default*. This distinction is important to understand because a standard post-tax revenue model used to set prices for regulated assets is not an *expected* returns and *expected* cash flow model. It is a model that relies upon a no default scenario. Depending upon the model compiled it could be considered the most likely scenario, or the average *no default* scenario, but it is certainly not a model that accounts for the average case.

278. Our analysis shows that the cost of equity to be incorporated into a *no default* post-tax revenue model is close to the estimated market return. **Our specific cost of equity estimate is 11.24% per year compared to our market return assumption of 10.54% per year.** The assets of the benchmark gas pipeline have low risk but this is offset by the high financial risk of taking on 60.00% leverage.

279. The ERA has a view that the finance risk associated with 60.00% leverage does not offset the benchmark gas pipeline's low asset risk (the ERA's equity beta estimate is 0.70). But it should be re-iterated that the single quantitative metric that supports this conclusion is the beta coefficient from a regression of stock returns on market returns for a very small sample of firms. The conclusion that low asset risk is not offset by high financial risk cannot be reached on a qualitative basis.

280. The quantitative analysis presented in this paper suggests that the high financial risk approximately offsets the benchmark pipeline's low asset risk. The results are consistent with cost of capital estimates resulting from analysis of a larger sample of U.S.-listed firms, or the application of the Fama-French model to Australian-listed firms, or the application of the dividend discount model to Australian-listed firms. The only quantitative analysis inconsistent with the analysis presented here is the beta estimates from a regression of stock returns on market returns for a sample of six firms.

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6. Appendices

6.1 Appendix 1: Return on assets in a good market

281. In this appendix we derive the return on assets in a good market for the case in which there are two possible market outcomes (*good* and *bad*). We begin with the following definitions.

r_a^G is the asset return in the good market;

r_f is the risk-free rate of interest (20.90%);

$r_d^{No\ def}$ is the return to debt holders in the absence of default, that is, the yield to maturity on debt (35.28%).

x is the ratio of the asset payoff in the bad market with no defaults to the asset payoff in the good market (80.00%);

p^{RN} is the risk-neutral probability of a good market (46.77%);

$p^{B,No\ def}$ is the probability of a bad market but with no default (15.82%);

p^{Def} is the probability of default (8.53%);

A is the market value of assets;

L is the market value leverage, debt/(debt + equity) (60.00%); and

R is the recovery rate for debt holders in the event of default (43.00%).

282. The risk-free expected payoff on the assets is a weighted average of the payoff in the *good* market and the average payoff in the *bad* market. The average payoff in the *bad* market is an average of the asset payoff in the absence of default $[A(1 + r_a^G)xp^{B,No\ Def}]$ and the average payoff if default occurs $[D(1 + r_d^{No\ Def})Rp^{Def}]$.

$$A(1+r_f) = A(1+r_a^G)p^{RN} + \left[\frac{A(1+r_a^G)xp^{B,No\ Def} + D(1+r_d^{No\ def})Rp^{Def}}{p^{B,No\ Def} + p^{Def}}\right](1-p^{RN})$$

283. The remaining steps are simply re-arranging the equation in order for the return on assets in the *good* market to appear on the left-hand side.

$$A(1+r_f) = A(1+r_a^G)p^{RN} + \left[\frac{A(1+r_a^G)xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}\right](1-p^{RN}) + \left[\frac{D(1+r_d^{No\ def})Rp^{Def}}{p^{B,No\ Def} + p^{Def}}\right](1-p^{RN})$$

$$A(1+r_f) - \left[\frac{D(1+r_d^{No\ def})Rp^{Def}}{p^{B,No\ Def} + p^{Def}}\right](1-p^{RN}) = A(1+r_a^G)\left[p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}(1-p^{RN})\right]$$

$$(1+r_f) - \frac{D}{A}\left[\frac{(1+r_d^{No\ def})Rp^{Def}}{p^{B,No\ Def} + p^{Def}}\right](1-p^{RN}) = (1+r_a^G)\left[p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}(1-p^{RN})\right]$$

$$\frac{(1+r_f)}{\left[p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}(1-p^{RN})\right]} - \frac{L\left[\frac{(1+r_d^{No\ def})Rp^{Def}}{p^{B,No\ Def} + p^{Def}}\right](1-p^{RN})}{\left[p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}(1-p^{RN})\right]} = (1+r_a^G)$$

$$r_a^G = \frac{\left(1 + r_f\right)}{\left[p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}(1 - p^{RN})\right]} - \frac{L\left[\frac{\left(1 + r_d^{No\ def}\right)Rp^{Def}}{p^{B,No\ Def} + p^{Def}}\right](1 - p^{RN})}{\left[p^{RN} + \frac{xp^{B,No\ Def}}{p^{B,No\ Def} + p^{Def}}(1 - p^{RN})\right]} - 1$$

6.2 Appendix 2: Market outcomes and payoffs to capital providers

Table 8. Market outcomes, probabilities and debt payoffs

	Market per $1.00			Debt payoff per $60.00				
Outcome	Prob	Payoff	Ret (pa)	Def prob	No def.	Def	Avg.	Ret avg (pa)
1	0.00%	20.20	82.42%	0.00%	81.17	34.90	81.17	6.23%
2	0.00%	18.27	78.80%	0.00%	81.17	34.90	81.17	6.23%
3	0.00%	16.53	75.25%	0.00%	81.17	34.90	81.17	6.23%
4	0.00%	14.96	71.78%	0.00%	81.17	34.90	81.17	6.23%
5	0.00%	13.53	68.37%	0.00%	81.17	34.90	81.17	6.23%
6	0.00%	12.24	65.03%	0.00%	81.17	34.90	81.17	6.23%
7	0.00%	11.07	61.75%	0.00%	81.17	34.90	81.17	6.23%
8	0.00%	10.02	58.55%	0.00%	81.17	34.90	81.17	6.23%
9	0.00%	9.06	55.40%	0.00%	81.17	34.90	81.17	6.23%
10	0.00%	8.20	52.32%	0.00%	81.17	34.90	81.17	6.23%
11	0.00%	7.42	49.30%	0.00%	81.17	34.90	81.17	6.23%
12	0.00%	6.71	46.33%	0.00%	81.17	34.90	81.17	6.23%
13	0.01%	6.07	43.43%	0.00%	81.17	34.90	81.17	6.23%
14	0.03%	5.49	40.59%	0.00%	81.17	34.90	81.17	6.23%
15	0.08%	4.97	37.80%	0.00%	81.17	34.90	81.17	6.23%
16	0.18%	4.49	35.06%	0.00%	81.17	34.90	81.17	6.23%
17	0.39%	4.07	32.38%	0.00%	81.17	34.90	81.17	6.23%
18	0.75%	3.68	29.76%	0.00%	81.17	34.90	81.17	6.23%
19	1.35%	3.33	27.18%	2.00%	81.17	34.90	80.24	5.99%
20	2.24%	3.01	24.66%	2.26%	81.17	34.90	80.12	5.95%
21	3.45%	2.72	22.19%	2.34%	81.17	34.90	80.09	5.95%
22	4.94%	2.46	19.76%	2.68%	81.17	34.90	79.93	5.90%
23	6.58%	2.23	17.39%	3.26%	81.17	34.90	79.66	5.83%
24	8.16%	2.02	15.06%	3.85%	81.17	34.90	79.39	5.76%
25	9.44%	1.82	12.78%	5.30%	81.17	34.90	78.72	5.58%
26	**10.21%**	**1.65**	**10.54%**	6.45%	81.17	34.90	78.18	5.44%
27	10.32%	1.49	8.35%	7.50%	81.17	34.90	77.70	5.31%
28	9.76%	1.35	6.20%	9.52%	81.17	34.90	76.76	5.05%
29	8.64%	1.22	4.09%	11.45%	81.17	34.90	75.87	4.81%
30	7.16%	1.11	2.02%	14.50%	81.17	34.90	74.46	4.41%
31	5.56%	1.00	0.00%	14.87%	81.17	34.90	74.29	4.37%
32	4.04%	0.90	-1.98%	18.02%	81.17	34.90	72.83	3.95%
33	2.75%	0.82	-3.93%	18.54%	81.17	34.90	72.59	3.88%
34	1.75%	0.74	-5.83%	18.93%	81.17	34.90	72.41	3.83%
35	1.04%	0.67	-7.70%	70.51%	81.17	34.90	48.55	-4.15%
36	0.58%	0.61	-9.53%	70.51%	81.17	34.90	48.55	-4.15%
37	0.30%	0.55	-11.33%	70.51%	81.17	34.90	48.55	-4.15%
38	0.15%	0.50	-13.09%	70.51%	81.17	34.90	48.55	-4.15%
39	0.07%	0.45	-14.81%	70.51%	81.17	34.90	48.55	-4.15%
40	0.03%	0.41	-16.50%	70.51%	81.17	34.90	48.55	-4.15%
41	0.01%	0.37	-18.16%	70.51%	81.17	34.90	48.55	-4.15%
42	0.00%	0.33	-19.78%	70.51%	81.17	34.90	48.55	-4.15%
43	0.00%	0.30	-21.37%	70.51%	81.17	34.90	48.55	-4.15%
44	0.00%	0.27	-22.93%	70.51%	81.17	34.90	48.55	-4.15%
45	0.00%	0.25	-24.46%	70.51%	81.17	34.90	48.55	-4.15%
46	0.00%	0.22	-25.96%	70.51%	81.17	34.90	48.55	-4.15%
47	0.00%	0.20	-27.43%	70.51%	81.17	34.90	48.55	-4.15%
48	0.00%	0.18	-28.87%	70.51%	81.17	34.90	48.55	-4.15%
49	0.00%	0.16	-30.28%	70.51%	81.17	34.90	48.55	-4.15%
50	0.00%	0.15	-31.66%	70.51%	81.17	34.90	48.55	-4.15%
51	0.00%	0.13	-33.02%	70.51%	81.17	34.90	48.55	-4.15%
52	0.00%	0.12	-34.35%	70.51%	81.17	34.90	48.55	-4.15%

	Market per $1.00			Debt payoff per $60.00				
Outcome	**Prob**	**Payoff**	**Ret (pa)**	**Def prob**	**No def.**	**Def**	**Avg.**	**Ret avg (pa)**
53	0.00%	0.11	-35.65%	70.51%	81.17	34.90	48.55	-4.15%
54	0.00%	0.10	-36.93%	70.51%	81.17	34.90	48.55	-4.15%
55	0.00%	0.09	-38.18%	70.51%	81.17	34.90	48.55	-4.15%
56	0.00%	0.08	-39.40%	70.51%	81.17	34.90	48.55	-4.15%
57	0.00%	0.07	-40.61%	70.51%	81.17	34.90	48.55	-4.15%
58	0.00%	0.07	-41.78%	70.51%	81.17	34.90	48.55	-4.15%
59	0.00%	0.06	-42.94%	70.51%	81.17	34.90	48.55	-4.15%
60	0.00%	0.05	-44.07%	70.51%	81.17	34.90	48.55	-4.15%
61	0.00%	0.05	-45.18%	70.51%	81.17	34.90	48.55	-4.15%
Good	8.50%	3.12	25.54%	1.86%	81.17	34.90	80.30	6.00%
Most	84.81%	1.58	9.52%	8.38%	81.17	34.90	77.29	5.20%
Bad	6.69%	0.73	-6.09%	35.66%	81.17	34.90	64.67	1.51%
All	100.00%	165.03	10.54%	9.65%	81.17	34.90	76.70	5.03%

Table 9. Market outcomes, probabilities and asset payoffs

	Market per $1.00			Asset payoff per $100.00				
Outcome	Prob	Payoff	Ret (pa)	Ratio	No def.	Avg.	Ret no def (pa)	Ret avg (pa)
1	0.00%	20.20	82.42%	115.00%	173.30	173.30	11.63%	11.63%
2	0.00%	18.27	78.80%	115.00%	173.30	173.30	11.63%	11.63%
3	0.00%	16.53	75.25%	115.00%	173.30	173.30	11.63%	11.63%
4	0.00%	14.96	71.78%	115.00%	173.30	173.30	11.63%	11.63%
5	0.00%	13.53	68.37%	115.00%	173.30	173.30	11.63%	11.63%
6	0.00%	12.24	65.03%	115.00%	173.30	173.30	11.63%	11.63%
7	0.00%	11.07	61.75%	115.00%	173.30	173.30	11.63%	11.63%
8	0.00%	10.02	58.55%	115.00%	173.30	173.30	11.63%	11.63%
9	0.00%	9.06	55.40%	115.00%	173.30	173.30	11.63%	11.63%
10	0.00%	8.20	52.32%	115.00%	173.30	173.30	11.63%	11.63%
11	0.00%	7.42	49.30%	115.00%	173.30	173.30	11.63%	11.63%
12	0.00%	6.71	46.33%	115.00%	173.30	173.30	11.63%	11.63%
13	0.01%	6.07	43.43%	115.00%	173.30	173.30	11.63%	11.63%
14	0.03%	5.49	40.59%	115.00%	173.30	173.30	11.63%	11.63%
15	0.08%	4.97	37.80%	115.00%	173.30	173.30	11.63%	11.63%
16	0.18%	4.49	35.06%	115.00%	173.30	173.30	11.63%	11.63%
17	0.39%	4.07	32.38%	115.00%	173.30	173.30	11.63%	11.63%
18	0.75%	3.68	29.76%	115.00%	173.30	173.30	11.63%	11.63%
19	1.35%	3.33	27.18%	115.00%	173.30	170.54	11.63%	11.27%
20	2.24%	3.01	24.66%	115.00%	173.30	170.17	11.63%	11.22%
21	3.45%	2.72	22.19%	115.00%	173.30	170.07	11.63%	11.21%
22	4.94%	2.46	19.76%	113.12%	170.46	166.83	11.26%	10.78%
23	6.58%	2.23	17.39%	110.61%	166.69	162.40	10.76%	10.18%
24	8.16%	2.02	15.06%	107.50%	162.00	157.11	10.13%	9.46%
25	9.44%	1.82	12.78%	103.89%	156.57	150.12	9.38%	8.46%
26	**10.21%**	**1.65**	**10.54%**	**100.00%**	**150.70**	**143.23**	**8.55%**	**7.45%**
27	10.32%	1.49	8.35%	97.25%	146.55	138.18	7.94%	6.68%
28	9.76%	1.35	6.20%	94.47%	142.36	132.13	7.32%	5.73%
29	8.64%	1.22	4.09%	91.84%	138.40	126.55	6.72%	4.82%
30	7.16%	1.11	2.02%	89.51%	134.89	120.39	6.17%	3.78%
31	5.56%	1.00	0.00%	87.58%	131.99	117.56	5.71%	3.29%
32	4.04%	0.90	-1.98%	86.09%	129.73	112.65	5.34%	2.41%
33	2.75%	0.82	-3.93%	85.00%	128.09	110.82	5.08%	2.08%
34	1.75%	0.74	-5.83%	85.00%	128.09	110.46	5.08%	2.01%
35	1.04%	0.67	-7.70%	85.00%	128.09	62.39	5.08%	-9.01%
36	0.58%	0.61	-9.53%	85.00%	128.09	62.39	5.08%	-9.01%
37	0.30%	0.55	-11.33%	85.00%	128.09	62.39	5.08%	-9.01%
38	0.15%	0.50	-13.09%	85.00%	128.09	62.39	5.08%	-9.01%
39	0.07%	0.45	-14.81%	85.00%	128.09	62.39	5.08%	-9.01%
40	0.03%	0.41	-16.50%	85.00%	128.09	62.39	5.08%	-9.01%
41	0.01%	0.37	-18.16%	85.00%	128.09	62.39	5.08%	-9.01%
42	0.00%	0.33	-19.78%	85.00%	128.09	62.39	5.08%	-9.01%
43	0.00%	0.30	-21.37%	85.00%	128.09	62.39	5.08%	-9.01%
44	0.00%	0.27	-22.93%	85.00%	128.09	62.39	5.08%	-9.01%
45	0.00%	0.25	-24.46%	85.00%	128.09	62.39	5.08%	-9.01%
46	0.00%	0.22	-25.96%	85.00%	128.09	62.39	5.08%	-9.01%
47	0.00%	0.20	-27.43%	85.00%	128.09	62.39	5.08%	-9.01%
48	0.00%	0.18	-28.87%	85.00%	128.09	62.39	5.08%	-9.01%
49	0.00%	0.16	-30.28%	85.00%	128.09	62.39	5.08%	-9.01%
50	0.00%	0.15	-31.66%	85.00%	128.09	62.39	5.08%	-9.01%
51	0.00%	0.13	-33.02%	85.00%	128.09	62.39	5.08%	-9.01%
52	0.00%	0.12	-34.35%	85.00%	128.09	62.39	5.08%	-9.01%
53	0.00%	0.11	-35.65%	85.00%	128.09	62.39	5.08%	-9.01%
54	0.00%	0.10	-36.93%	85.00%	128.09	62.39	5.08%	-9.01%
55	0.00%	0.09	-38.18%	85.00%	128.09	62.39	5.08%	-9.01%
56	0.00%	0.08	-39.40%	85.00%	128.09	62.39	5.08%	-9.01%
57	0.00%	0.07	-40.61%	85.00%	128.09	62.39	5.08%	-9.01%

	Market per $1.00			Asset payoff per $100.00				
Outcome	**Prob**	**Payoff**	**Ret (pa)**	**Ratio**	**No def.**	**Avg.**	**Ret no def (pa)**	**Ret avg (pa)**
58	0.00%	0.07	-41.78%	85.00%	128.09	62.39	5.08%	-9.01%
59	0.00%	0.06	-42.94%	85.00%	128.09	62.39	5.08%	-9.01%
60	0.00%	0.05	-44.07%	85.00%	128.09	62.39	5.08%	-9.01%
61	0.00%	0.05	-45.18%	85.00%	128.09	62.39	5.08%	-9.01%
Good	8.50%	3.12	25.54%	115.00%	173.30	170.72	11.63%	11.29%
Most	84.81%	1.58	9.52%	98.58%	148.56	139.54	8.24%	6.89%
Bad	6.69%	0.73	-6.09%	85.00%	128.09	94.86	5.08%	-1.05%
All	100.00%	165.03	10.54%	99.07%	149.29	139.20	8.34%	6.84%

Table 10. Market outcomes, probabilities and equity payoffs

	Market per $1.00			Equity payoff per $100.00				
Outcome	Prob	Payoff	Ret (pa)	Ratio	No def.	Avg.	Ret no def (pa)	Ret avg (pa)
1	0.00%	20.20	82.42%	115.00%	92.14	92.14	18.16%	18.16%
2	0.00%	18.27	78.80%	115.00%	92.14	92.14	18.16%	18.16%
3	0.00%	16.53	75.25%	115.00%	92.14	92.14	18.16%	18.16%
4	0.00%	14.96	71.78%	115.00%	92.14	92.14	18.16%	18.16%
5	0.00%	13.53	68.37%	115.00%	92.14	92.14	18.16%	18.16%
6	0.00%	12.24	65.03%	115.00%	92.14	92.14	18.16%	18.16%
7	0.00%	11.07	61.75%	115.00%	92.14	92.14	18.16%	18.16%
8	0.00%	10.02	58.55%	115.00%	92.14	92.14	18.16%	18.16%
9	0.00%	9.06	55.40%	115.00%	92.14	92.14	18.16%	18.16%
10	0.00%	8.20	52.32%	115.00%	92.14	92.14	18.16%	18.16%
11	0.00%	7.42	49.30%	115.00%	92.14	92.14	18.16%	18.16%
12	0.00%	6.71	46.33%	115.00%	92.14	92.14	18.16%	18.16%
13	0.01%	6.07	43.43%	115.00%	92.14	92.14	18.16%	18.16%
14	0.03%	5.49	40.59%	115.00%	92.14	92.14	18.16%	18.16%
15	0.08%	4.97	37.80%	115.00%	92.14	92.14	18.16%	18.16%
16	0.18%	4.49	35.06%	115.00%	92.14	92.14	18.16%	18.16%
17	0.39%	4.07	32.38%	115.00%	92.14	92.14	18.16%	18.16%
18	0.75%	3.68	29.76%	115.00%	92.14	92.14	18.16%	18.16%
19	1.35%	3.33	27.18%	115.00%	92.14	90.30	18.16%	17.69%
20	2.24%	3.01	24.66%	115.00%	92.14	90.05	18.16%	17.62%
21	3.45%	2.72	22.19%	115.00%	92.14	89.98	18.16%	17.60%
22	4.94%	2.46	19.76%	113.12%	89.30	86.90	17.42%	16.79%
23	6.58%	2.23	17.39%	110.61%	85.52	82.73	16.41%	15.64%
24	8.16%	2.02	15.06%	107.50%	80.83	77.72	15.11%	14.21%
25	9.44%	1.82	12.78%	103.89%	75.40	71.41	13.52%	12.29%
26	**10.21%**	**1.65**	**10.54%**	**100.00%**	**69.53**	**65.04**	**11.69%**	**10.21%**
27	10.32%	1.49	8.35%	97.25%	65.39	60.48	10.33%	8.62%
28	9.76%	1.35	6.20%	94.47%	61.20	55.37	8.88%	6.72%
29	8.64%	1.22	4.09%	91.84%	57.23	50.68	7.43%	4.85%
30	7.16%	1.11	2.02%	89.51%	53.73	45.94	6.08%	2.81%
31	5.56%	1.00	0.00%	87.58%	50.82	43.27	4.90%	1.58%
32	4.04%	0.90	-1.98%	86.09%	48.57	39.82	3.96%	-0.09%
33	2.75%	0.82	-3.93%	85.00%	46.93	38.23	3.25%	-0.90%
34	1.75%	0.74	-5.83%	85.00%	46.93	38.05	3.25%	-1.00%
35	1.04%	0.67	-7.70%	85.00%	46.93	13.84	3.25%	-19.13%
36	0.58%	0.61	-9.53%	85.00%	46.93	13.84	3.25%	-19.13%
37	0.30%	0.55	-11.33%	85.00%	46.93	13.84	3.25%	-19.13%
38	0.15%	0.50	-13.09%	85.00%	46.93	13.84	3.25%	-19.13%
39	0.07%	0.45	-14.81%	85.00%	46.93	13.84	3.25%	-19.13%
40	0.03%	0.41	-16.50%	85.00%	46.93	13.84	3.25%	-19.13%
41	0.01%	0.37	-18.16%	85.00%	46.93	13.84	3.25%	-19.13%
42	0.00%	0.33	-19.78%	85.00%	46.93	13.84	3.25%	-19.13%
43	0.00%	0.30	-21.37%	85.00%	46.93	13.84	3.25%	-19.13%
44	0.00%	0.27	-22.93%	85.00%	46.93	13.84	3.25%	-19.13%
45	0.00%	0.25	-24.46%	85.00%	46.93	13.84	3.25%	-19.13%
46	0.00%	0.22	-25.96%	85.00%	46.93	13.84	3.25%	-19.13%
47	0.00%	0.20	-27.43%	85.00%	46.93	13.84	3.25%	-19.13%
48	0.00%	0.18	-28.87%	85.00%	46.93	13.84	3.25%	-19.13%
49	0.00%	0.16	-30.28%	85.00%	46.93	13.84	3.25%	-19.13%
50	0.00%	0.15	-31.66%	85.00%	46.93	13.84	3.25%	-19.13%
51	0.00%	0.13	-33.02%	85.00%	46.93	13.84	3.25%	-19.13%
52	0.00%	0.12	-34.35%	85.00%	46.93	13.84	3.25%	-19.13%
53	0.00%	0.11	-35.65%	85.00%	46.93	13.84	3.25%	-19.13%
54	0.00%	0.10	-36.93%	85.00%	46.93	13.84	3.25%	-19.13%
55	0.00%	0.09	-38.18%	85.00%	46.93	13.84	3.25%	-19.13%
56	0.00%	0.08	-39.40%	85.00%	46.93	13.84	3.25%	-19.13%
57	0.00%	0.07	-40.61%	85.00%	46.93	13.84	3.25%	-19.13%

	Market per $1.00			Equity payoff per $100.00				
Outcome	**Prob**	**Payoff**	**Ret (pa)**	**Ratio**	**No def.**	**Avg.**	**Ret no def (pa)**	**Ret avg (pa)**
58	0.00%	0.07	-41.78%	85.00%	46.93	13.84	3.25%	-19.13%
59	0.00%	0.06	-42.94%	85.00%	46.93	13.84	3.25%	-19.13%
60	0.00%	0.05	-44.07%	85.00%	46.93	13.84	3.25%	-19.13%
61	0.00%	0.05	-45.18%	85.00%	46.93	13.84	3.25%	-19.13%
Good	8.50%	3.12	25.54%	61.14%	92.14	90.42	18.16%	17.72%
Most	84.81%	1.58	9.52%	44.72%	67.39	62.24	11.00%	9.25%
Bad	6.69%	0.73	-6.09%	31.14%	46.93	30.19	3.25%	-5.47%
All	100.00%	165.03	10.54%	45.20%	68.12	62.50	11.24%	9.33%