SFG'S APPROACH TO ESTIMATING THE COST OF EQUITY: FURTHER ANALYSIS

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EXECUTIVE SUMMARY

This paper has addressed Frontier's response to my earlier report on SFG's proposed approach to estimating the cost of capital for the GGP, and also Frontier's response to the ERAWA's draft decision on the GGP. My conclusions are as follows.

Firstly, in respect of the eleven points of criticism that I raised earlier about SFG's report, Frontier has provided no response to three of them. In particular, no response has been provided on the point that SFG unrealistically assumes that all payoffs occur in five years, that SFG's use of the market average recovery rate on defaulting bonds is likely to have overestimated the recovery rate for the GGP and therefore overestimated its cost of equity, and that the expected rate of return on equity sans default is very sensitive to the estimate of the illiquidity premium within the cost of debt. In respect of the other eight points, Frontier provides no relevant response in every case. For example, in response to my concerns that SFG's approach would violate the NPV = 0 principle, Frontier merely repeats the very SFG arguments that gave rise to my criticism. As a further example, in response to my concern that the up and down factors used by SFG are not compatible with SFG's empirical estimate of the standard deviation of market returns, Frontier merely claims that SFG's approach is not inherently incorrect. These insubstantial responses, or the absence of a response, strongly suggest that there is no defence to the points of criticism raised by me.

Secondly, and in respect of Frontier's comments on the ERAWA's Draft Decision, there are only three such points for which there is even room for possible agreement with Frontier and none of them mitigates my belief that SFG's approach to estimating the cost of capital is unviable.

Thirdly, in view of all this, my conclusion remains that SFG's approach to estimating the cost of capital is unviable.

1. Introduction

The ERAWA is currently assessing a regulatory proposal for a five year access arrangement from Goldfields Gas Transmission (GGT), relating to the Goldfields Gas Pipeline (GGP). In support of this, GGT submitted a report by SFG (2014) arguing that GGP's systematic risk is higher than typical pipeline businesses in Australia, that the comparators used by ERAWA for estimating GGP's beta are unsuitable, and therefore that a different approach is required. This approach involves the use of a binomial option pricing framework and provides an estimated cost of equity for GGP conditional upon no default occurring because this is appropriate for regulatory purposes. In response, the ERAWA sought my views, which appear in Lally (2015). This prompted a response from Frontier Economics (2016), which the ERAWA has sought my view on. I commence by describing my comments on SFG's report, and then assessing the response from Frontier. I then consider Frontier's comments on the ERAWA's (2015) draft decision.

2. Frontier Responses to Lally

2.1 Option Pricing Versus State Pricing

SFG (2014) claims that their approach is an application of option pricing and therefore is "standard finance theory". However, as argued in Lally (2015, section 2.2), SFG's approach instead involves "state pricing", deriving from Arrow (1964) and Debreu (1959), with application to capital budgeting/firm valuation by Banz and Miller (1978) and Breeden and Litzenberger (1978). In this framework, one specifies expected outcomes for a firm or project conditional upon particular states of the market, and then values these conditionally expected payoffs using state prices (which differ from SFG's risk-neutral probabilities only by the risk-free rate). This state pricing framework can be applied to situations in which the asset payoff is determined by an underlying asset, and therefore option pricing could be viewed as a special case of state pricing when the underlying asset determines the payoff on the asset of interest rather than being merely correlated with it. Since the special case does not hold here, SFG's analysis is therefore state pricing rather than option pricing. Within this state pricing framework, variations in outcomes around the expected payoffs on the firm for a given market state (good or bad) are treated as unpriced risk. However this state pricing approach to firm or project valuation is not "standard finance theory". Using SFG's (2014, para 276) own test for "standard finance theory" to be that "taught in undergraduate and master's finance courses", I have examined a collection of widely-used books in such courses: Grinblatt and Titman (2002), Brealey et al (2011), Damodaran (2011), Berk and DeMarzo (2014), Welch (2009), Ross et al (2013), and Copeland et al (2005). Of these books, only Copeland et al (2005, pp. 97-100) mentions the state pricing approach to firm or project valuation (briefly) and expresses doubts about its feasibility. SFG's addition of default and no default cases to each market outcome places them even further away from standard finance theory. Furthermore, SFG's paper does not contain even a single relevant reference to the (limited) academic literature in support of such an approach. SFG have used state pricing, which is not standard finance theory, and confused it with option pricing, which is standard finance theory.

In response, Frontier (2016, paras 42-43) cites two papers that they claim are applications of option pricing theory, and therefore constitute standard finance theory (Brennan and Schwartz, 1985; Paddock et al, 1988). This is uncontroversial. Frontier argues that SFG's analysis is similar to these papers. However, in both papers, the underlying asset is a commodity whose price exerts a causal effect on the value of a project whereas the analysis in SFG (2014) uses a portfolio (the market portfolio) that is merely correlated with the value of the project. Furthermore, Frontier does not attempt to explain how SFG's (2014) analysis differs from the papers cited in Lally (2015) as examples of state pricing theory and described above: Banz and Miller (1978) and Breeden and Litzenberger (1978). The reasonable conclusion to draw from Frontier's failure to comment on this matter is that no distinction could be identified.

Frontier (2016, para 44) also argues that this is a "debate over labels rather than the actual analysis done." However, SFG (2014) claimed that their analysis is standard finance theory, because it is an application of option pricing analysis. So, the practice of labelling was introduced by them and therefore Frontier's current claim that labels are unimportant undercuts SFG's own argument. Similarly, if person A argues that a work of art is a Picasso, and is therefore valuable, and person B responds by arguing that it is not a Picasso, any subsequent claim by A that the artist's name is unimportant and that the work of art should be assessed on its own merits undercuts their original claim.

2.2 Discrete Versus Continuous Time

As argued in Lally (2015, section 2.2), all of the returns data used by SFG is discrete time data. However, SFG's formula for converting the standard deviation for annual returns (SD_1) into that for a period of T years (five years and one month in their case) is as follows:

$$SD_T = SD_1\sqrt{T}$$

and this formula is only valid if these standard deviations are over returns expressed in continuously compounded terms. Thus, SFG have confused the two types of returns. This can be remedied through the use of continuously compounded returns.

In response, Frontier (2016, para 81) claims that "the standard deviation assumption is an approximation for the monthly standard deviation". This is not a response to the point that continuously compounded returns ought to have been used. The reasonable conclusion to draw from Frontier's failure to comment is that the criticism is conceded.

2.3 The Choice of Up and Down Factors

As argued in Lally (2015, section 2.2), in using a binomial process, there are choices in the specification of the up and down factors (*U* and *D*), as noted by Jarrow and Turnbull (1996, section 4.4). However, SFG's (2014) approach does not correspond to any of those specifications. Furthermore, if the condition $D = 1/U$ is invoked (as SFG do) so as to reduce the number of branches beyond the one-period framework, then the value for *U* and the probability of its occurrence (*q*) must be as follows in order to ensure that the mean and variance of the binomial distribution converges on the empirical estimates as the two-outcome interval goes to zero:

$$U = e^{\sigma\sqrt{T}}, \quad q = 0.5\left[1 + \frac{\mu}{\sigma}\sqrt{T}\right] \tag{1}$$

where μ is the expectation of the continuously compounded annual rate of return, σ is its standard deviation, and *T* is the time interval (in years) over which the process yields only two outcomes (Cox et al, 1979). By contrast, letting $E(R_1)$ and SD_1 denote the expectation and standard deviation for the annual returns, SFG's value for *U* is as follows

$$U = \left[1 + E(R_1)\right]^T + SD_1\sqrt{T}$$

whilst the probability of this outcome is chosen by SFG to ensure that the expected rate of return from the two-outcome distribution matches the empirical estimate:

$$p = \frac{[1 + E(R_1)]^T - D}{U - D}$$

So, in effect, SFG avoids any error in the mean at the potential expense of error in the standard deviation. Lally (2015, section 2.2) goes on to show that the consequence of SFG's error is to overstate the standard deviation by 15% over the course of one month, growing to 23% over the course of one year. This can be remedied by using equation (1).

In response, Frontier (2016, para 81) merely claims that their approach is "not inherently incorrect". This is not a response to the specific points made by Lally (2015), presumably because no defence to those points is available.

2.4 The Illiquidity Premium in the DRP

As argued in Lally (2015, section 2.2), it is implicit in SFG's (2014) analysis that the DRP estimate used by them (6.23% - 3.87%) is due entirely to the possibility of default. However there is a considerable body of literature on the DRP impact arising from the inferior liquidity of corporate bonds relative to the risk-free asset (government bonds), with Amihud et al (2005, section 3.3.2) providing a comprehensive survey. More recently, Almeida and Philippon (2007, Table II) summarise results from a number of papers, in which the proportion of the DRP due to default ranges from 34% to 71% for BBB bonds (and the rest due to illiquidity). Furthermore, like SFG, Almeida and Philippon sought to estimate the probability of default from the DRP but (unlike SFG) they deducted out an estimate of the illiquidity premium. Furthermore, in view of their failure to account for illiquidity, SFG (2014, page 13) obtain an estimate of the default probability from their analysis that is significantly more (over four times) than that of the average default rate in Moody's data for Baa bonds (8.53% in the analysis above and 9.65% in their multi-period extension, versus 1.97% in the Moody's data). Remarkably, SFG (2014, paras 62-63) seem to recognise that there is a problem here but brush it off, presumably because they did not appreciate that the discrepancy could be explained by an illiquidity premium. Equally remarkably, SFG (2014, para 77) critique the standard regulatory approach as potentially leading to inconsistencies between the observed cost of debt and the estimated cost of equity, but have committed a more egregious mistake themselves. Given that SFG invoke Moody's data to estimate the expected recovery rate in default (43%), this suggests choosing an expected default rate in their model equal to the average historical rate in the Moody's data (1.97%). Using this default rate, and therefore allowing for an illiquidity premium, Lally (2015, section 2.2) shows that the expected rate of return on debt and the expected rate conditional on no default arising from SFG's approach equate to 7.60% and 8.03% per year respectively. Both rates are significantly less than SFG's results (8.97% and 10.93%) and the difference between these two rates (8.03% - 7.60% = 0.43%) is only 20% of that obtained by SFG (10.93% - 8.97% = 1.96%) merely through recognising the existence of an illiquidity premium in corporate bonds. Furthermore the beta estimate that would have yielded an expected return of 8.03% would have been 0.62, which is now below the ERAWA's estimate of 0.70. So, this allowance for the illiquidity premium completely overturns SFG's conclusion that a beta of 0.70 is too low for GGP. This deficiency in SFG's approach can be remedied, by simply allowing for an illiquidity premium, but it will add to the number of parameters that require estimation and therefore add to the potential for error in SFG's approach.

In response, Frontier (2016, para 85) claims that "..if there are no defaults and the debt is held till maturity the debt holders are likely to earn the yield over the life of the asset." However, nothing in this (uncontroversial) claim contradicts anything in the analysis in Lally (2015, section 2.2), as described in the previous paragraph. The reasonable conclusion to draw is that Frontier is conceding the point that the cost of debt contains an illiquidity allowance, and recognition of it would materially lower the cost of equity under SFG's approach.

Frontier (2016, para 86) also claims that the default rate used in SFG's analysis lies between that of Baa and Ba debt. However, as acknowledged by SFG (2014, para 29), the debt in question is rated Baa and therefore the relevant default rate is that for Baa debt rather than something between Baa and Ba. Frontier (2016, para 86) also claims that debt risk premiums are currently high, and therefore default rates are above average. However, SFG has used a default rate over four times the historical average for Baa debt (8.53% versus 1.97%) and Frontier provides no justification for this particular multiple. Furthermore, regardless of how one determines the default rate, the DRP must still contain an allowance for the relative illiquidity of corporate bonds, SFG fails to do so, and therefore their analysis is deficient.

2.5 Payoff Dates

As argued in Lally (2015, section 2.2), even within SFG's multi-period analysis, all payoffs are assumed to occur in five years and therefore firms retain all cash flows from operations over the course of five years (rather than paying dividends) and debtholders do not receive any interest for five years. This is well outside the bounds of standard financial analysis, which assumes payment intervals no less frequently than annual. It is also far removed from the reality of business operations and is likely to have affected SFG's estimate of the cost of equity. To illustrate the problem, the deferral of interest payments to debtholders for five years will magnify the significance of any defaults and introduces a disparity between their model (which assumes payouts every five years) and the empirical data on default rates and recovery rates (which arise in a world of interest payments that are made on an annual or more frequent basis). By contrast, the Post-Tax Revenue Model (PTRM) assumes that cash flows arise annually and interest payments are also made at that frequency. This shortcoming in SFG's work could be remedied but only at the price of significantly increasing the complexity of their analysis.

Frontier (2016) offers no response to this point. The reasonable conclusion to draw is that Frontier is conceding the point.

2.6 The NPV = 0 Principle

A fundamental test that any approach to setting regulatory prices must face is the NPV = 0 principle; expected revenues must be such that their present value net of opex and capex must equal the initial investment. As argued in Lally (2015, section 2.2), SFG does not explicitly consider the issue. SFG (2014) develops a model in which there are three possible outcomes at the end of each five-year period: "good" market state, a "bad" market state without default, and default, with probabilities of 0.7565, 0.1582, and 0.0853 respectively. Per $100 of RAB, and assuming that the current values of debt and equity match the RAB, the outcomes for the firm in these three states would have to be $153.68, $122.94 and $34.90 respectively. The expectation is $138.70. Discounted at the expected rate of return per year (8.97% for equity and 5.18% for debt with weights of 40% and 60% respectively), the result is naturally a value of $100 as follows[1]:

$$V = \frac{\$138.70}{(1.0897)^5(0.4) + (1.0518)^5(0.6)} = \$100$$

Assuming no opex (to simplify the analysis), regulatory application of this cost of capital to the RAB would produce allowed revenues of $138.70. Assuming that the possible outcomes described above of $153.68, $122.94 and $34.90 (with probabilities of 0.7565, 0.1582, and

[1] The appropriate cost of debt to use here is the promised yield of 6.23% less the allowance for the default option possessed by equity holders, yielding 5.18%, because this default option is a mere transfer between the two suppliers of capital rather than a cost for suppliers in aggregate. Lally (2015, section 4) elaborates upon this point.

0.0853 respectively) reflect output levels of 153.68, 122.94, and 34.90 units respectively, and therefore an expected output of 138.70 units, the appropriate course of action for the regulator would then be to allow an output price of $1 as follows:

$$P = \frac{\$100[(1.0897)^5(0.4)+(1.0518)^5(0.6)]}{138.70} = \frac{\$138.70}{138.70} = \$1$$

By contrast, the standard regulatory practice would be to use the promised yield on debt (6.23%) rather than the actual. Regulatory application of this cost of capital to the RAB would produce allowed revenues of $142.63, and dividing by the expected output of 138.70 units would yield an allowed price of $1.03 as follows:

$$P = \frac{\$100[(1.0897)^5(0.4)+(1.0623)^5(0.6)]}{138.70} = \frac{\$142.63}{138.70} = \$1.03$$

This is too high by 3%. In effect, the standard regulatory practice of using the promised yield on debt rather than the expected rate of return violates the NPV = 0 principle in favour of regulated businesses. However, this could be justified on the grounds that the expected rate of return on debt is not observable and use of the promised yield is simply an imperfect proxy.

SFG (2014, para 85, para 24) has a different view, with two possibilities presented. One of them is that the regulatory estimate of expected output (and hence costs) is an expectation over scenarios in which default does not occur. In the context of SFG's analysis, this would involve the regulator recognising only possible output levels of 153.68 and 122.94 units, with perceived probabilities of 0.7565/0.9147 = 0.827 and 0.1582/0.9147 = 0.173. So, they would estimate an expected output level of 148.36 units. If the regulator also used the expected cost of equity (8.97%) and the promised yield on debt (6.23%), this would lead to allowed revenues of $142.36 as discussed in the previous paragraph and therefore an output price of $0.96 as follows:

$$P = \frac{\$100[(1.0897)^5(0.4)+(1.0623)^5(0.6)]}{148.36} = \frac{\$142.63}{148.36} = \$0.96 \qquad (2)$$

This is too low by 4%. SFG's proposed solution is to use an expected rate of return on equity that is also conditional upon there being no default (10.93%). Coupled with the promised yield on debt (6.23%), this would lead to allowed revenues of \$148.36 and division by the 'expected' output of 148.36 units would produce the correct output price of \$1 as follows:

$$P = \frac{\$100[(1.1093)^5(0.4) + (1.0623)^5(0.6)]}{148.36} = \frac{\$148.36}{148.36} = \$1 \qquad (3)$$

In effect, the use of an increased 'cost of equity' coupled with the promised yield on debt offsets the assumed failure by regulators to recognise the default scenario in their estimate of the expected output level.

This SFG line of argument is premised upon regulators forming an expectation about future outcomes in which the extreme cases that lead to default are disregarded, and this is a very strong assumption for which SFG present no evidence. If regulators do in fact appreciate the full distribution of possible output levels, with an expected output of 138.70 units, their use of the 'WACC' favoured by SFG would lead to them setting an output price of \$1.07 as follows:

$$P = \frac{\$100[(1.1093)^5(0.4) + (1.0623)^5(0.6)]}{138.70} = \frac{\$148.36}{138.70} = \$1.07 \qquad (4)$$

Since the correct output price is \$1, this output price of \$1.07 will be too high by 7%. SFG's (2014, para 23) alternative line of argument is that regulators use some sort of typical output level. However, if regulators do use a typical output level, this typical level must be less than the expectation conditional on no default (148.36 units). Coupled with the 'WACC' proposed by SFG, the output price set by the regulator would still be above \$1 and therefore would still be too high. For example, if the 'typical' output level were 143 units, the allowed output price would be \$1.04 as follows:

$$P = \frac{\$100[(1.1093)^5(0.4) + (1.0623)^5(0.6)]}{143.0} = \frac{\$148.36}{143.0} = \$1.04 \qquad (5)$$

In summary, SFG presents two competing claims about regulatory behaviour. The first is that regulators overestimate expected output by ignoring scenarios in which default occurs (the extreme left tail of the distribution), leading to an inadequate allowed output price as shown in equation (2). Accordingly, the use of a cost of equity that also disregards these default scenarios offsets this error, as shown in equation (3). However, SFG present no evidence that regulators ignore these default scenarios in estimating the expected output level. Thus, if regulators properly estimate expected output, their use of the cost of equity proposed by SFG would yield an output price that was too high as shown in equation (4). SFG's second (and inconsistent) argument is that regulators use a typical output level. However, if so, then regulatory use of the cost of equity proposed by SFG would still yield an output price that was too high as shown in equation (5).

In response, Frontier (2016, para 6, paras 93-97) simply repeats both of SFG's arguments as described above. No response is offered to the specific points made by Lally (2015), as described above, and the reasonable conclusion to draw is that no defence to these points is available.

2.7 Parameter Estimates

SFG's (2014) analysis requires estimates of a number of parameters, and Lally (2015, section 3) raises numerous concerns about these estimates. In respect of the market standard deviation, SFG (2014, page 7) estimate this at 16.64% per year based upon Australian market returns from 1883-2013, and then they reduce it to 14.89% for reasons of presentational convenience (SFG, 2014, para 127). They then show that a 1% change in the estimate changes the expected rate of return on equity sans default by 0.23%. Regardless of which estimate for this parameter is used, the process of estimating it raises the question of its statistical reliability. A possible response to this would be to argue that estimating it from historical returns data is comparable to estimating the MRP on the Australian market from the same period. However, I am not aware of any regulator who does so; all of them estimate the MRP from a variety of sources so as to improve the reliability of the estimate. An alternative approach to estimating the market volatility over five years is the volatility implicit in the prices of options written on the market index ("implied volatilities"), for which there is a considerable academic literature (Hull, 1997, section 11.10). SFG do not refer to this.

In response, Frontier (2016, para 83) claims only that "The concern over the market variation assumption is overstated." This is not a response to the specific points raised by Lally (2015), implying that no defence to those points is available.

In respect of the recovery rate, SFG (2014) estimate this at 43% based on Moody's data, note that the recovery rates are very similar for both Baa and Ba bonds, and that a 10% change (to 33% or 53%) would change the expected rate of return on equity sans default by 0.70% (SFG, 2014, para 175). SFG's reference to similar default rates on these two categories of bonds suggests that the estimate is reliable. However, as argued in Lally (2015, section 3), within each such category there will be wide variation in recovery rates across firms depending upon the alternative uses for the assets and the scenarios inducing default. For example, if defaults within a sector are typically induced by events that undermine the viability of all such businesses and the assets have no alternative uses, the expected recovery rate for debtholders will be close to zero. By contrast, if defaults within a sector are typically induced by poor management within individual firms, default will typically lead to new management rather than the liquidation of the business, and therefore the expected recovery rate for debtholders will be high. Alternatively, if defaults within a sector are typically induced by events that undermine the viability of all such businesses but the assets of these businesses are largely tangible and have alternative uses, default will typically lead to the collapse of the businesses but the expected recovery rate for debtholders will still be high. The situation regarding GGP is clearly not typical of businesses because there is no competition. Thus, if default occurs, it will most likely be because the business is no longer viable. Furthermore, the assets have no alternative uses. So, if default occurs, the recovery rate for debtholders is likely to be unusually low. As shown by SFG, lower recovery rates for a given cost of debt imply a lower probability of bankruptcy and therefore a lower cost of equity. Thus, not only is there considerable uncertainty about the appropriate recovery rate in default for GGP and therefore considerable uncertainty about the cost of equity when using SFG's approach but SFG's use of the market average recovery rate is likely to have overestimated the recovery rate for GGP and therefore overestimated its cost of equity.

Frontier (2016) offers no response to these points. The reasonable conclusion to draw is that no defence is available.

In respect of the range in the firm's payoff from the best to worst market states sans default, SFG (2014, para 158) assume that the firm's payoff in the top 8.5% of market outcomes over five years is 15% larger than for the 'typical' market outcome (realised market return is equal to the expectation), that the firm's payoff in the bottom 6.69% of market outcomes is 15% less than that for the 'typical' case, and that the adjustment % varies within this band of ±15% for the remaining cases in accordance with the probability of the outcome relative to that of the 'typical' outcome. The range is then from 0.85 to 1.15. SFG (2014, para 175) consider the effects of widening or narrowing this band on the estimate for the expected rate of return on equity sans default. In particular, varying the band by ±0.10 (to .80 – 1.20 or to 0.90 – 1.10) changes the expected rate of return on equity sans default by 1%. However, as argued in Lally (2015, section 3), unlike the expected recovery rate or the standard deviation of market returns, there is no empirical evidence on the appropriate width of the band. SFG (2014, section 3) determine various combinations of volume reductions and shortfalls in the capacity payments that are required from customers that are consistent with an outcome that is 15% less than 'typical', and these possibilities include shortfalls in both volume and capacity payments of 6.21%. SFG (2014, para 255) concludes that these reductions are not very substantial, goes on to highlight much more extreme possibilities arising from some customers ceasing operations (ibid, paras 257-266), but then concludes that the ±15% band is appropriate (ibid, para 272). However, nothing in this analysis supports the use of the 15% band chosen by them, as opposed to (say) 12% or 20%. The 15% band has simply been 'plucked out of the air'. Furthermore, this band is conceptually similar to the equity beta within the CAPM. SFG is critical of the estimate adopted by the ERAWA but their alternative lacks even the empirical exercise underlying the ERAWA's choice of the beta estimate.

In response, Frontier (2016, para 88) merely references SFG (2014, paras 252-253), in which a payoff that is 15% less than typical could arise from various combinations of shortfalls in both volume and capacity payments. However, nothing in Frontier's reference to SFG (2014, paras 252-253) addresses the specific points raised by Lally (2015), implying again that no defence to those points is available.

In addition to these parameter estimates, Lally (2015, section 2.2) also argues that it would be necessary for SFG to estimate the illiquidity premium embedded within the DRP on GGP's bonds, by estimating the probability of default on those bonds. SFG cites the historical default rate reported by Moody's for bonds of the relevant credit rating (Baa) but this data is averaged over a considerable period and therefore at best represents an expected outcome over the full set of future economic conditions. By contrast, the desired default probability for the present regulatory purposes is that implicit in GGP's current cost of debt and this may diverge significantly from the Moody's average. Furthermore, the Moody's data invoked by SFG averages over all firms with the same credit rating, and its use therefore presumes that regulated utilities would experience the same default rates as firms in general with the same credit rating. However, PwC (2012, Table 7) reveals that the default rates reported by Moody's for regulated utilities are markedly less than firms in general with the same credit rating. This raises the interesting question of the extent to which this disparity is chance or not, and therefore whether to use the broader Moody's data or just that for regulated utilities. Lally (2015, section 2.2) shows that the expected rate of return on equity sans default is very sensitive to the estimate of the illiquidity premium, and therefore aggravates the existing problems in SFG's approach.

Frontier (2016) offers no response to this point. Again, this suggests that there is no defence to the point.

Lally (2015, section 3) also argues that the sensitivity of SFG's WACC estimate to various parameter values must be compared with those from the CAPM, whose estimate for the cost of equity is sensitive to only estimates for the MRP and the equity beta. Prima facie, with twice as many parameters to estimate, SFG's approach seems much more sensitive to errors. Furthermore, there is a considerable body of empirical literature on estimating the CAPM parameters, and therefore considerable evidence about the extent of possible errors from its use (in the form of standard errors on the estimates of the MRP and beta). By contrast, there is much less evidence on the extent of estimation error in most of the parameters used in SFG's approach, most particularly the recovery rate in default for GGP bonds, the expected default rate on existing GGP bonds, and the range in the firm's payoff in the best to worst market states sans default. So, SFG's approach would seem to be more sensitive to estimation error and there is considerably less evidence about possible estimation errors. On this basis alone, I do not consider that it is a viable approach.

In response, Frontier (2016, para 55) argues that Lally (2015) implies that estimating the cost of equity in the usual way (with estimates of beta and the MRP) would yield "very precise estimates of the cost of equity". No such suggestion was made by Lally (2015). Estimates of the cost of equity developed in the usual way are indisputably imprecise but those from SFG's approach appear to be far more so. Frontier (2016, para 56) also argues that the variation in implied beta estimates (i.e., those consistent with its cost of equity estimates) arising from its approach is similar to that presented by the ERAWA. However, whilst Frontier reports some beta ranges for the ERAWA, they do not report any implied beta ranges for SFG's analysis.

Even if they had, the ranges would not have any value because they arise from arbitrary choices for ranges in the underlying parameters in their model. For example, as noted above in respect of the recovery rate, SFG (2014) estimate this at 43% based on Moody's data and that a 10% change (to 33% or 53%) would change the expected rate of return on equity sans default by 0.70% (SFG, 2014, para 175). SFG's choice of ± 0.10 is arbitrary. In order to properly assess how precise estimates of the cost of equity or WACC are, it is necessary to estimate the standard deviation for each underlying parameter and then convert this into an estimate of the standard deviation of the cost of equity or WACC. For example, Lally (2008, Table 5) estimates the standard deviations for the individual parameters underlying WACC and therefore estimates the standard deviation in the WACC at 1.5%. By contrast, it is not possible to do this with SFG's approach because the standard deviations of most of the underlying parameters cannot be reliably estimated.

3. Frontier Responses to the ERAWA

Frontier (2016, paras 36-37) critiques the ERAWA for failure to clarify the nature of its estimate for expected volume (and costs), i.e., is it an expectation over all possible outcomes, an expectation over only outcomes in which default does not occur, or simply a single possible outcome? However, the ERAWA never uses the word expectation in this context. Instead it uses the word "forecast", and the forecasts are drawn from GGT (ERAWA, 2015, para 174). Further detail from GGT appears in ERAWA (2015, paras 143, 146) but no clarification on Frontier's question is present there. Thus, Frontier's question should be posed to GGT and this is something Frontier could have done directly since GGT is their client. It is extraordinary, to say the least, that Frontier faults the ERAWA for lack of clarity on this important issue but fails to obtain it from their own client. Equally remarkably, despite failing to seek this information from the best source, Frontier (2016, para 39) concludes that these "forecasts" are expectations over outcomes in which default does not occur, but offers no evidence in support of it. Even more remarkably, Frontier (2016, para 6) repeatedly contradicts this claim by suggesting instead that the output figures used by the ERAWA are "the most likely single scenario".

Frontier (2016, paras 46-47) notes that the ERAWA (2015, Appendix 3, paras 76-79) rules out the idea that SFG's analysis is an application of the Black-Scholes-Merton model, but responds by claiming that SFG did not use this model, that they never claimed to have done so, and that they instead used the binomial option pricing model. It is uncontroversial that SFG did not use the analysis in Black and Scholes (1973), or Merton (1973). However, on the question of whether SFG claimed or implied that they did, SFG (2014, para 42) claimed that their analysis was "consistent" with Black and Scholes (1973) and Merton (1973), and did not cite any other paper in the option pricing literature. The usual practice amongst those involved in writing expert opinions is to cite relevant academic work when invoking an existing model. So, having presented a model, cited Black and Scholes (1973) and Merton (1973) and no others in the option pricing literature, a reasonable conclusion for any reader to draw was that SFG believed these two papers to be the most relevant academic work. Furthermore, on the question of whether SFG actually used the binomial option pricing model as Frontier claims, as discussed in Lally (2015, section 2.1), SFG's analysis is an application of state pricing and SFG's failure to cite relevant literature in this area was presumably calculated so as not to contradict their claim that their analysis was "standard finance theory".

Frontier (2016, para 51) refers to concerns by the ERAWA (2015, Appendix 3, paras 87-99) that the cost of equity arising from SFG's analysis does not converge as one moves closer to continuous time, and argues that using binomial steps of one month is sufficient for the purposes here. However, this is not a response to the concern raised by the ERAWA. An appropriate response would be to shorten the binomial interval and assess how the estimated cost of equity changes.

Frontier (2016, section 4.1.1) refers to the ERAWA's (2015) critique of the wide range in its cost of equity estimates, and argues that these ranges are similar to those arising from the ERAWA's approach to estimating the cost of equity. However, none of these comparisons by Frontier are sensible because they all involve comparison of the effect of changing only one of the (many) parameter values in SFG's analysis with one or both of the parameters in the ERAWA's approach. Furthermore, the uncertainty in a parameter should be assessed using a standard deviation for its probability distribution rather than a 'range', because the former can be estimated from empirical evidence. So, the sensible comparison would be in respect of the standard deviation in the cost of equity from SFG's approach and from the ERAWA's approach. As discussed in the last paragraph of the previous section, this is not possible for SFG's approach because the standard deviations of most of the underlying parameters cannot be estimated. Furthermore, such an analysis should be limited to parameters that must be estimated. Thus, examining the sensitivity of cost of equity estimates to changes in the risk-free rate, as both SFG (2014, Table 6) and the ERAWA (2015, Table 105) do, is pointless because the risk-free rate is observable.

Frontier (2016, para 78) notes the ERAWA's (2015, Appendix 3, para 139) criticism of SFG's (2014) risk-free rate (the rate has changed since SFG's analysis) and argues that the same would apply to any cost of capital analysis. However, it is not clear to me whether the ERAWA was merely stating the obvious or intending it to be a criticism of SFG's approach. If it is intended as a criticism of SFG's approach, it is unwarranted because an approach is not invalidated by a change in the value of an observable parameter.

Frontier (2016, para 84) notes the ERAWA's (2015, Appendix 3, para 147) criticism of SFG's (2014) cost of debt (the rate has changed since SFG's analysis) and argues that the same would apply to any cost of capital analysis. My view here is the same as in the previous paragraph.

Frontier (2016, paras 87-92) notes the ERAWA's (2015) critique of SFG's (2014) payoff assumption (±15% under the two market return scenarios), being that it is not justified, and argues that this criticism is not reasonable. However, if someone proposes to transport tourists to the moon using a radical method, and the response is extreme scepticism, there is little value in saying that the scepticism in unreasonable; one needs to demonstrate the feasibility of the proposal. Similarly, if anyone estimates a parameter in a radical fashion, the onus lies with them to demonstrate the merits of their approach rather than with others to demonstrate its demerits, and I do not think that SFG have demonstrated its merits. In particular, SFG (2014, section 3) determine various combinations of volume reductions and shortfalls in the capacity payments that are required from customers that are consistent with a payoff outcome that is 15% less than 'typical', and these possibilities include shortfalls in both volume and capacity payments of 6.21%. SFG concludes that these reductions are not very substantial (ibid, para 255), goes on to highlight much more extreme possibilities arising from some customers ceasing operations (ibid, paras 257-266), but then concludes that the ±15% band is appropriate (ibid, para 272). Nothing in this analysis supports the use of the 15% band chosen by them, as opposed to (say) 12% or 20%. The 15% band has simply been 'plucked out of the air'.

Furthermore, the most that could be said of SFG's (2014) analysis on possible payoff shortfalls is that it provides some information about the probability distribution of payoffs whereas their ±15% band requires information on the probability distribution of payoffs *conditional* on market returns, and these are quite different. As noted by SFG (2014, para 255 and Table 8), the underlying source of risk here is the prices of various commodities, especially nickel, iron ore and gold, because a big enough drop in any of them may eliminate some of the GGP's customers because their operations are no longer financially viable. Furthermore, most of the volatility in these commodity prices is not systematic risk: Engle (2013, Table 2) estimates the *R* squared for nickel against the S&P500 at only 3% and that for gold at zero. In the limit, if none of the volatility in these commodity prices were systematic, then none of the revenue risks to the GGP would be systematic, and therefore the appropriate value for this payoff sensitivity coefficient would be 1 rather than 1±15%. Neither SFG nor Frontier has given any thought to this issue, and remain focussed upon volatility rather than volatility *conditional* on market returns. Thus, SFG's estimate of 1±15% is likely to be far too high because it implicitly attributes all payoff risk to systematic risk. Accordingly, SFG's estimate of the cost of equity is likely to be too high.

Frontier (2016, para 94) notes the ERAWA's (2015, para 107) observation that SFG's (2014) implied beta estimate for the GGP of 1.10 is above the market average, interprets this observation to be a criticism of SFG's analysis, argues that an inherently low risk business could have a beta greater than 1 if leverage is sufficiently high, and therefore concludes that the beta estimate of 1.10 cannot be faulted merely because it exceeds 1. It is not clear to me why the ERAWA compared SFG's implied equity beta estimate with the market average. However, it is uncontroversial that an equity beta reflects the associated asset beta and leverage, that leverage for the GGP (at 60%) is unusually high, and therefore that it might warrant an equity beta above 1 even if the inherent risk (asset beta) was low. So, SFG's estimate of GGP's beta is not flawed merely because it exceeds the market average, as argued by Frontier.

Frontier (2016, para 108) notes the ERAWA's (2015, para 108) claim that SFG's (2014) implied beta estimate for the GGP of 1.10 differs from its estimates for other regulated utilities despite the fact that application of SFG's methodology to these other businesses would produce the same implied beta estimate, and argues instead that its methodology could produce different beta estimates for these other businesses because the value for the firm's payoff sensitivity parameter (the range in the firm's payoff from the best to worst market states sans default) could differ across regulated businesses. In principle, I agree with Frontier on this point. However, if estimates of this parameter might differ across regulated businesses, this would aggravate the difficulties in estimating it. By contrast, in respect of its counterpart in conventional analysis (the asset beta), the same estimate is generally applied to all firms within a sector in recognition of the difficulties of differentiating between individual firms.

4. Conclusions

This paper has addressed Frontier's response to my earlier report on SFG's proposed approach to estimating the cost of capital for the GGP, and also Frontier's response to the ERAWA's draft decision on the GGP. My conclusions are as follows.

Firstly, in respect of the eleven points of criticism that I raised earlier about SFG's report, Frontier has provided no response to three of them. In particular, no response has been provided on the point that SFG unrealistically assumes that all payoffs occur in five years, that SFG's use of the market average recovery rate on defaulting bonds is likely to have overestimated the recovery rate for the GGP and therefore overestimated its cost of equity, and that the expected rate of return on equity sans default is very sensitive to the estimate of the illiquidity premium within the cost of debt. In respect of the other eight points, Frontier provides no relevant response in every case. For example, in response to my concerns that SFG's approach would violate the NPV = 0 principle, Frontier merely repeats the very SFG arguments that gave rise to my criticism. As a further example, in response to my concern that the up and down factors used by SFG are not compatible with SFG's empirical estimate of the standard deviation of market returns, Frontier merely claims that SFG's approach is not inherently incorrect. These insubstantial responses, or the absence of a response, strongly suggest that there is no defence to the points of criticism raised by me.

Secondly, and in respect of Frontier's comments on the ERAWA's Draft Decision, there are only three such points for which there is even room for possible agreement with Frontier and none of them mitigates my belief that SFG's approach to estimating the cost of capital is unviable.

Thirdly, in view of all this, my conclusion remains that SFG's approach to estimating the cost of capital is unviable.

REFERENCES

Almeida, H., and Philippon, T., 2007, 'The Risk-Adjusted Cost of Financial Distress', *The Journal of Finance*, 62, pp. 2557-2586.

Amihud, Y., Mendelson, H., and Pedersen, L., 2005. 'Liquidity and Asset Prices', *Foundations and Trends in Finance*, 1, pp. 269-364.

Arrow, K., 1964. 'The Role of Securities in the Optimal Allocation of Risk Bearing', *Review of Economic Studies*, pp. 91-96.

Banz, R., and Miller, M., 1978. 'Prices for State-Contingent Claims: Some Estimates and Applications', *Journal of Business*, pp. 653-672.

Berk, J., and DeMarzo, P., 2014. *Corporate Finance*, 3rd edition, Pearson, Boston.

Black, F., and Scholes, M., 1973. 'The Pricing of Options and Corporate Liabilities', *Journal of Political Economy*, 81, pp. 637-659.

Brealey, R., Myers, S., and Allen., F., 2011. *Principles of Corporate Finance*, 10th edition, McGraw-Hill Irwin, New York.

Breeden, M., and Litzenberger, R., 1978. 'Prices of State Contingent Claims Implicit in Option Prices', *Journal of Business*, pp. 621-651.

Brennan, M., and Schwartz, E., 1985. 'Evaluating Natural Resource Investments', *Journal of Business*, 58, pp. 135-157.

Copeland, T., Weston, J., and Shastri, K., 2005. *Financial Theory and Corporate Policy*, 4th edition, Pearson Addison Wesley, Boston.

Cox, J., Ross, S., and Rubinstein, M., 1979. 'Option Pricing: A Simplified Approach', *Journal of Financial Economics*, 7, pp. 229-263.

Damodaran, A., 2011. *Applied Corporate Finance*, 3rd edition, John Wiley & Sons, New Jersey.

Debreu, G., 1959. *The Theory of Value*, Wiley, New York.

Engle, R., 2013. *Modelling Commodity Prices with Dynamic Conditional Beta* (www.commoditiessef.org/system/files/Robert-engle.pptx).

ERAWA, 2015. *Draft Decision on Proposed Revisions to the Access Arrangement for the Goldfields Gas Pipeline* (www.erawa.com.au).

Frontier Economics, 2016. *Response to the Economic Regulation Authority on the Cost of Equity*, report prepared for Goldfields Gas Transmission (www.erawa.com.au).

Grinblatt, M., and Titman, S., 2002. *Financial Markets and Corporate Strategy*, 2nd edition, McGraw-Hill Irwin, Boston.

Hull, J., 1997. *Options, Futures and Other Derivatives*, 3rd edition, Prentice Hall, Englewood Cliffs.

Jarrow, R., and Turnbull, S., 1996. *Derivative Securities*, South Western College Publishing, Cincinnati.

Lally, M., 2008. *The Weighted Average Cost of Capital for Gas Pipeline Businesses*, report prepared for the Commerce Commission (www.comcom.govt.nz).

_______ 2015. *Review of SFG's Approach to Estimating the Cost of Equity*, report prepared for the ERAWA (www.erawa.com.au).

Merton, R., 1973. 'Theory of Rational Option Pricing', *Bell Journal of Economics and Management Science*, 4, pp. 141-183.

Paddock, J., Siegel, D., and Smith, J., 1988. 'Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases', *Quarterly Journal of Economics*, vol. 103, pp. 479-508.

PwC, 2012, *Transpower New Zealand Ltd*: *Leverage and the Cost of Capital*, report prepared for Transpower (www.comcom.govt.nz).

Ross, S., Westerfield, R., and Jaffe, J., 2013. *Corporate Finance*, 10th edition, McGraw-Hill Irwin, New York.

SFG, 2014. *Cost of Equity for the Goldfields Gas Pipeline*, report prepared for Goldfields Gas Transmission.

Welch, I., 2009. *Corporate Finance*, Prentice Hall, New York.