Proposed amendment to the WACC percentile for the Allowed Rate of Return

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Comments on the Application of the Dobbs [2011] model

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17/9/2014

Final

17th September 2014

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1. Terms of Reference

The Dobbs [2011] model illustrates and clarifies the rationale for why it is sensible to choose a percentile significantly above the 50th for the allowed rate of return whenever some of future investment is discretionary and possibly deferrable. The Commerce Commission of New Zealand has asked me to comment on the relevance and use of this (abstract) model in the above context, and to comment specifically on whether Frontier Economics, in its detailed application of the model (a) has correctly interpreted and applied the Dobbs-framework, (b) has made reasonable assumptions when re-calibrating the model to reflect New Zealand electricity lines services, and (c) to comment on Frontier Economics' conclusions. Subsequent to this, the Commerce Commission has asked me to comment on the work in earlier submissions by Dr. Martin Lally and by NZIER. I have added commentary at various points to bring out points of agreement/disagreement (there are very few of disagreement) with this earlier work.

2. Summary and Conclusions

1. Frontier Economics implementation of the Dobbs [2011] model appears to be soundly constructed, and the adjustments to take account of pass through, fixed and variable cost proportions, and elasticity of demand seem reasonable.

2. Within the confines of the model itself, my main concern lies with the treatment of willingness to pay when demand is assumed inelastic. It is my opinion that the current implementation is likely to significantly exaggerate the loss of welfare that arises when new investment does not occur (whether the objective function is consumer surplus or total welfare); as a consequence this may exaggerate the extent of uplift predicted by the model.

3. A second issue lies with the weight put on consumer surplus *vis a vis* profit in the welfare criterion. Predictions of the Dobbs model are likely to be sensitive to this weighting, particularly when demand is assumed fairly inelastic. Within the model there is an issue with reducing the weight on profit (and it is not something that I personally advocate). However, it remains a fact that many regulators place considerably more weight on benefits to consumers relative to firm profits; within the model, the impact is clear cut – the less weight is placed on firm profit, the lower the predicted *WACC* percentile will be.

4. My other concern lies with the extent to which the model can be used as a quantitative guide to the best choice of percentile to set for the allowed rate of return. This kind of model articulates why a significant uplift is warranted, but in my opinion, it is unclear

how much ***quantitative*** significance should be placed on the model predictions. For example, there are reasons for considering the uplift should be greater (because there are sources of uncertainty, notably over future demand and technology, that are explicitly ignored in the model)[1], and reasons for why it should be smaller (because there are other ways in which reliability and investment can be influenced by the regulator, because decision makers do not necessarily behave as Neoclassical economic theory predicts etc.).

5. Thus there is a question of 'goodness of fit' of the model assumptions; there are further questions regarding 'goodness of fit' with regard to its application to the industry sectors under consideration (electricity and gas transmission and distribution). The original model assumes that new investment is in a new service for which there is independent demand – that is, demand that is independent from that for the existing service(s). In gas and electricity transmission and distribution, one might see how this might be a good fit – if for example, new investment was directed to supplying new communities, for example. However, it appears to me that it is likely that 'new' investment is more likely to be in the area of strengthening capacity and reliability of the existing network, or reducing network costs (e.g. smart grid investment). It seems odd to view there being a demand curve for this new investment, separately from the demand curve for the existing investment. Further, it is unclear how 'demand for electricity' is distinguished from 'demand for reliability'[2]; the Dobbs model is not a peak load pricing model, and it does not make this kind of distinction - and neither does Frontier Economics' extension of it. The Dobbs [2011] model actually assumes that there is a service obligation on the supplier, such that investment to maintain adequate capacity is not optional; the model does not in any way model reliability and the impact of quantity rationing. For all these reasons the precise quantitative predictions of the model should be regarded as indicative at best.

6. The primary aim of this report is to clarify issues and arguments concerning the use of the Dobbs [2011] model for estimating uplift in the allowed rate of return above the mean of the *WACC* distribution. Given my lack of familiarity with electricity/gas supply in the NZ context, I do not feel 'qualified' to make a judgement about the extent of uplift desirable in this case – that is, whether the allowed rate of return should be higher or lower than the present choice of the 75th percentile or, indeed, the draft decision choice of the 67th percentile.

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[1] These are especially important in fast growing and innovative industries (Telecoms for example).

[2] Or, too put it another way, the demand for peak load capacity and the demand for energy per se.

3. General Comments on the Dobbs model

3.1 Key Features and Assumptions

7. This section provides some non-technical exposition concerning the structure of the Dobbs [2011] model beyond what can be found in the original paper; this may prove useful for interested parties who have not worked through the model in detail.

8. The Dobbs [2011] model is presented in abstract terms, although it was originally developed with Telecoms as an expected application. Telecoms is clearly a highly innovative sector, with new services continually being developed and rolled out.

9. The model assumes that there are 3 categories of services – category 1 is 'existing (legacy) services', category 2 is new services which will be launched in the coming regulatory review period (*RRP*) or not at all[3], whilst category 3 services are those that might be launched in the coming *RRP* or deferred to future *RRP*s.

10. The model assumes essentially a monopoly provider of these services. Note that one of the reasons investment can be deferred (category 3) is because the firm has control of the investment timing – no other firm can 'jump in' and launch the new service. If there is potential competition to launch services, there is less of an option to defer investment; if competition is severe, a firm will have to launch new investment whenever it is positive *NPV* – or someone else will do so. Option value from waiting only arises if one has control over the timing of new investment.

11. The model also assumes service obligations – that when a service is launched and in operation (or already in operation, in the case of category 1), *QOS* must be maintained, and incremental investment must be made to cope with any increments in demand for that service over time. This is an important assumption because, if there is no service obligation, then ongoing investment (in all categories) becomes optional. For example, this would mean that there was a reason for some uplift in the allowed rate of return even for the ongoing delivery of existing (category 1) services. Modelling in the absence of service obligations would require modelling of the costs and benefits of allowing 'quantity rationing', or degradation in reliability in the electricity supply context. Thus, to emphasise, the Dobbs model is not a 'Peak load pricing model' of the type often used in Electricity supply in dealing with electricity demand and reliability. The model (and Frontier's use of it) supposes there is a simple

[3] My view was that the bulk of investment would be category 1, with some category 3 whilst category 2 would probably not be important – since most investment was likely to be deferrable (category 3) rather than non-deferrable. Category 2 was included in the paper mainly because it was analytically, the basis for developing the analysis for category 3.

demand for a ‘product or service’ (and this is true both for existing and new investment).

12. The model assumes that the firm supplies final retail demand. In electricity supply, clearly a portion will go as an input to commercial and industrial firms, who may then ‘pass through’ such costs to final customers. Consideration of how to model this ‘pass through’ is then needed (how Frontier deal with this point is discussed in section 4.1 below).

13. The model assumes that the regulator sets an allowed rate of return (*AROR*)[4] on investment. The optimal *AROR* is calculated for existing investment, and again for new investment that is not deferrable, and again for investment that firms may choose to defer. The optimal *AROR* is typically different as between these three categories of investment. This suggests that it may be possible to set differential *AROR*s for different types of investment. The paper also considers the case where the same *AROR* is applied to all investment. The Lally report argues strongly for the use of a single rate for the allowed rate of return, and there are good reasons for doing so (especially if the aim is relatively light touch regulation). A useful discussion of the issues is given in the Lally report (e.g. page 16).

14. The Lally report also argues against using a different percentile in different industries. Except where the ‘flow on’ benefits from regulated to unregulated operations within a firm are substantial. NZIER take an opposite view, and advocate sector specific *WACC* percentile choice when they write “We think that the regulators’ understanding of this demand – capacity relationship, by sector, is central to the consideration of which *WACC* percentile to choose. By inference the regulator needs considerable industry specific information on which to base its *WACC* estimate.” (NZIER page 8 para 1). I tend to agree with NZIER; the argument for consistency (using the same rate across sectors) is in my opinion more powerful within the public sector than in a regulated private sector.[5] I do think it is important to consider carefully what the likely impact of the choice of allowed rate of return (*AROR*) is likely to have; after all, if the choice of *AROR* is unlikely to affect the pace of new investment, there is little point in offering a higher rate.

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4 I prefer to refer the rate set by the regulator as an ‘allowed rate of return’ rather than ‘*WACC*’ since the *AROR* is unlikely to be set equal to the ‘*WACC*’, even if we take the ‘*WACC*’ to be the mean of the *WACC* distribution.

5 Consistency can promote efficiency within the public sector. If different industries within the public sectors use different valuations for a good, there is inefficiency. There is an efficiency gain if different industries in the public sector agree to reduce the dispersion in their valuations; Dobbs [1985] demonstrated this in the context of the ‘value of life’. The same arguments apply to the cost of capital.

15. Importantly, the 3 categories of investment are treated as completely independent (zero cross elasticity). This was merely a convenience in the abstract model. In practice, launch of a new service can have big impacts on the level of demand for existing services (typically economic substitutes). This means there is a need to model this; technically, this is not totally straightforward, as one needs to have a well-defined measure of economic welfare; for example simply adding (cross)elasticity to iso-elastic demand functions runs into the problem that consumer surplus is then not well defined.

16. In the current application, cross-elasticity may be a major issue – namely the extent to which 'new investment' is really just strengthening reliability and capacity of an already existing service, rather than the launch of a new service.

17. Some care also needs to be taken with the measurement of economic welfare in the case of inelastic demand.[6] The point is that an iso-elastic demand curve which is assumed inelastic will have unbounded (infinite) consumer surplus; empirically therefore it is a poor assumption to maintain that demand stays inelastic as price is increased – clearly demand elasticity must change (become more elastic at some point). The unbounded CS problem can be sidestepped by truncating demand at some upper price (assuming that demand falls to zero above an arbitrarily high but finite price level). Frontier economics in its modelling of demand adopts this approach, but it would appear that the upper limit is set too high (this issue is discussed in detail in section 4.2 below).

18. Demand is modelled as growing exponentially. Again, some care needs to be exercised with this (the original paper mainly used low or zero growth rates in the numerical computations). Assuming a high figure for growth 'forever' is clearly likely to be unwarranted (if a service is assumed to grow at a rate faster than the economy, it will grow eventually to totally dominate the economy). Also growth rate when assumed to be exponential must be assumed less than the discount rate or welfare measures will be infinite. This appears not to be an issue in the present application for electricity transmission (where growth rates are apparently quite small, around 0%).

19. The original computational results were for the unweighted 'consumer surplus plus profits' welfare criterion. Regulators typically weight consumer surplus more highly than profits, with some putting zero weight on firm profits. It is naturally important, by way of sensitivity analysis to cover the range of weightings. It is a trivial matter to

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[6] Many commentators (including Lally and NZIER) have pointed out that the original paper presented results only for the case of elastic demand, which for electricity supply (existing network at least), demand was significantly inelastic. The original reporting of results assumed elastic demand because that was convenient (inelastic demand and iso-elastic demand curves means consumer surplus is unbounded. Frontier dealt with the problem by truncating iso-elastic demand, Both Lally and NZIER consider the alternative of linear demand, which naturally has a finite choke price. I discuss the issues that arise in section 4.2 below.

adjust the welfare criterion so that the impact of alternative weightings for consumer surplus and profit are considered.

20. However, there is a real problem with focusing purely on consumer surplus within this type of model (and ignoring entirely the profit component of economic welfare). In the extreme, for existing assets (the existing network), consumer surplus is strictly decreasing in retail price, and hence in the choice of *AROR*. This point is recognised by NZIER (NZIER; para 3, page 12), but they do not then discuss the dramatic implications of the point; for existing sunk assets, the optimal solution is to reduce the *AROR* to zero. However, the Lally report very clearly points out this consequence (Lally; para 2, page 22, also Lally; para 2 page 20, commenting on the Covec report); in the absence of any new investment, the model would recommend complete exploitation of the sunk nature of the existing network. This is simply the age old conundrum – that all new investment once made becomes sunk and hence potentially exploitable by the regulator. The regulatory 'compact' is about building trust that the regulator will not (after investment) exploit the sudden shift in bargaining power as new assets revert to being sunk assets. Continuing to offer an adequate return on investment on sunk assets is crucial to the 'compact' – without it, firms would not trust the regulator not to subsequently exploit the 'now sunk' new investment and hence would not invest at all. In terms of the model, moving from putting equal weight on consumer surplus and profits to a position in which there is increased weight on consumer surplus is effectively putting some weight on being able to exploit sunk assets.[7]

21. For this reason, I am not entirely sanguine with the idea of putting greater weight on CS as a 'mechanism' for generating a lower predicted *AROR*.

22. I am also largely in agreement with the Lally report's assessment of NZIER's general equilibrium arguments that producer surplus in my analysis is illusory and should be ignored (Lally; para 2 p.22); however, I do find that there is a point behind thinking about general equilibrium impacts, given that electricity (and gas to an extent) is a pervasive input into all industry and commerce. That said, I would consider the impacts discussed by NZIER to be more of a second order effect, and one that is difficult to quantify (notwithstanding the existence of computable GE models of the NZ economy – validation and forecast precision being major issues concerning such models).

7 This is explained further in section 3.2 below. Obviously, the final *AROR* will be above the median *WACC* so there is no 'expropriation'. But if less weight is put on profit in the welfare criterion, the *reason* the *AROR* is reduced is because economic welfare associated with the existing network is more strongly increasing the lower the *AROR*. To put it another way, if there were no new investment, and if significantly lower (or zero) weight is put on profit in the welfare index, the optimal *AROR* would be significantly below the median *WACC*.

23. The model assumes that the regulator sets an allowed rate of return, and then the firm's actual cost of finance is 'observed'; ex ante, the actual cost of finance is viewed as a random variable. In practice, economic (financing) conditions evolve continuously as random processes over time; a more sophisticated approach would have had interest rates and other variables as continuous stochastic processes – the simplification in the model is that it is simply a single 'resolution of uncertainty' in each regulatory review period. In this model then, notice that if the regulator indexed the allowed rate of return (*AROR*) to account for changes in financing conditions through time (just as with fuel cost adjustment clauses for airlines), the rationale for the uplift would disappear. There are of course non-financing sources of uncertainty that give rise to option value type effects that need to be taken into account in determining a price cap/control; for example, uncertainty over demand through time, or uncertainty over the rate of technical progress generate these kind of effects – and they should be taken into account by giving an uplift in the price control (*ceteris paribus*). There is quite a literature on this – I myself wrote a paper (Dobbs [2004]) which showed that the price cap should be adjusted upward to account for uncertainty in demand growth and technology change.

24. Although not discussed in the original paper, it is also true that the idea that the uncertainty in the cost of finance is resolved totally as in the model is somewhat unrealistic. In truth, estimating the *WACC* is a theory laden process (for example, picking a number for the market premium – different modelling processes will give different estimates).[8] This means there is scope for different 'players' (the firms, the regulator) to take a different view on what the *WACC* might be – and for those players to be also uncertain regarding any point estimate. It can be argued that this tends to increase the rationale for uplift. The Lally report (p13 para4 et seq) discusses this idea– the details of his modelling may be debated, but the broad thrust of what he is saying seems to me to be correct.[9]

[8] Many regulators now subscribe to the *CAPM* methodology when estimating *WACC*, along with various gearing adjustments along the lines developed in papers by Modigliani/Miller/Miles/Ezzell (etc.). It has the comfort of offering a well-structured approach to *WACC* estimation that is relatively easy to implement. Nevertheless, there is little evidence that Beta explains much empirically, and likewise there is very little empirical evidence in favour of gearing/degearing calculations. If a firm's asset beta is significantly below unity, there is a case for concern that the implied calculation of *WACC* may be an under-estimate (certainly an under-estimate of what the managers of the firm consider the likely cost of capital to be). The Dobbs [2011] paper focuses on uncertainty in *WACC* – but not on potential BIAS associated with such estimates. Whilst regulators are typically unimpressed by the fact that regulated firms often argue that the regulator under-estimates the *WACC* (well, they would do that, wouldn't they!), there is a genuine underlying issue – namely that business decision makers may well genuinely view the *WACC* differently (and higher) than turns up in the regulator's calculation.

[9] In writing the original paper, I did initially toy with modelling the idea that neither regulator nor firms know exactly what the 'true' *WACC* is – but I found it difficult to model the idea convincingly, so took a less contentious route in the final paper.

25. The paper assumes that both the firm and regulator know, for each category of investment, the precise initial scale and the rate of growth of demand and there is no uncertainty about these values. As discussed above, these are likely to be ***significant*** and ***additional*** sources of uncertainty which should in principle be taken into account. In Telecoms regulation in the UK, the regulator Ofcom takes little account of these other sources of uncertainty. One could make a second best case for, if there is no account for them elsewhere, giving an uplift in *WACC* as an approximate way of accounting for them.

26. In reporting results in the original paper, parameter values appropriate for Telecoms in UK were used – these numbers were effectively nominal estimates (for example, a mean *WACC* of 10% was clearly a nominal figure!). Whether it is better to model in real or nominal terms is also a (minor) issue, depending in part on whether price controls take an RPI ± X format or not.

27. A major concern is the 'goodness of fit' of the model assumptions with the industry sectors under consideration (electricity and gas transmission and distribution). The original model assumes that new investment is in a new service for which there is independent demand – that is, demand that is independent from that for the existing service(s). In gas and electricity transmission, one might see how this might be a good fit – if, for example, new investment was directed to supplying new communities, for example. However, it appears to me that it is likely that 'new' investment is more likely to be in the area of strengthening capacity and reliability of the existing transmission network or in some cost reducing smart technology etc. It seems odd to view there being a demand curve for this new investment, separately from the demand curve for the existing investment. Further, it is unclear to me how 'demand for electricity' is distinguished from 'demand for reliability'[10]; my model does not make this kind of distinction, and neither does Frontier's extension of it. That is, the Dobbs [2011] model actually assumes that there is a service obligation on the supplier, such that investment to maintain adequate capacity is not optional; the model does not in any way model reliability and the idea that there may be quantity rationing.

28. The Frontier report discusses these issues to some extent, and provides some rationale for the use of the model; for example, at page 16

> *The concept of "demand served by new investment" can be ambiguous in the electricity market. This is because unlike many other industries, new investments in electricity network typically do not lead to goods and services that are physically different from existing investment. In our modelling, we treat "demand served by new investment" as demand that would be left unserved if investment in distribution and transmission networks were reduced. They include:*
> ○ *Network investment at new locations. An example for this would be a new*

[10] Or, too put it another way, the demand for peak load capacity and the demand for energy per se.

factory opening at a new connection point.
○ *Network investment at an existing location due to increased demand for network capacity. An example for this would be fast population growth in a suburb.*

Ultimately, however, the extent to which the model can be viewed as a reasonable fit comes down to whether the peak load/reliability issue discussed above can be ignored or not.

29. A final observation concerning the model; focusing exclusively on the existing network, category 1 investment, the optimal *AROR* applied to this alone would be below the median *WACC*. Thus, in a scenario where there is a 'split' *AROR*, there would be no uplift in the *AROR* – there would actually be a <u>reduction</u> relative to median *WACC*. (in my numerical calculations, often to around the 45th percentile or thereabouts). In fact it is possible to mathematically prove that the *AROR* for the existing network must lie below the mean *WACC*.[11] The reasons why this is the case have not been discussed (in my original paper, nor in subsequent reports). Essentially, the reason lies with the non-linearity of the discount factors within the model (annuity factors), and the interaction of this with the random variable (the *WACC*). This is explained further below.

30. Welfare is a discounted sum of profit plus consumer surplus over an infinite time horizon (sequence of regulatory review periods), the annuity formula $A(r)$ that features in the present value for the flow of welfare over time is a convex function of the random variable r – the *WACC* (figure 1).

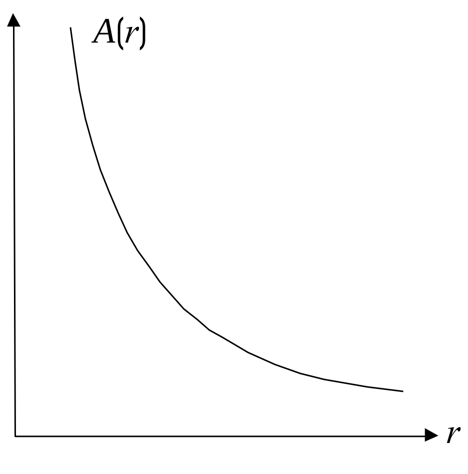

Figure 1

31. This is not surprising; both a one period discount rate $1/(1+r)$ and the infinite annuity $1/r$ also have this convex structure. The fact that the optimal *AROR* $\hat{r}^* < \bar{r}$

[11] Note, median and mean are the same value for a symmetric distribution; the proof involves the mean. The proof is available from the author.

(the optimal allowed rate of return is less than the mean of the *WACC* distribution) can be shown to be mainly due to the fact that because the annuity function $A(r)$ is strictly convex, $E[A(r)] > A(\bar{r})$ (This follows from a theorem- Jensen's inequality, originally proved around 1906). To put it another way, if (in some strange universe) discount factors where linear in the interest rate rather than convex, it would follow that $\hat{r}^* = \bar{r}$; it is the non-linearity of discounting, in conjunction with the fact that the discount rate is a random variable that drives the result that $\hat{r}^* < \bar{r}$.

32. As a simple numerical illustration, use the simple infinite horizon annuity factor[12] $A(r) = 1/r$ and suppose that the distribution of *r* is uniform and can take three values with equal probability, 5%, 10% and 15%. The mean value is obviously $\bar{r} = 10\%$, and $A(\bar{r}) = 1/0.1 = 10.0$. However, $E[A(r)] = \frac{1}{3}.\frac{1}{0.05} + \frac{1}{3}.\frac{1}{0.1} + \frac{1}{3}.\frac{1}{0.15} = 12.22$; that is $E[A(r)] > A(\bar{r})$.

3.2 Why the Weighting on Consumer Surplus Matters

33. Regulators explicitly or implicitly tend to use a welfare standard which is a weighted average of consumer surplus (CS) and profit Π ; for example,

$$W = CS + \alpha\Pi$$

where $\alpha \in [0,1]$. In the Dobbs [2011] model, if demand is fairly inelastic, this weighting on consumer surplus relative to profit is likely to be quite important. The reason for this lies with the impact of changes in *WACC* on welfare for the existing network. Basically under a total welfare criterion (when $\alpha = 1$) and inelastic demand, changes in *WACC*, leading to changes in consumer price, have relatively small impacts on total welfare. Thus, even when there is only a small amount of new investment, the welfare consequences of losing the customers that would have been served by that investment tend to outweigh any impact that price increases might have on consumers on the existing network. However as relatively more weight is put on consumer surplus (reducing α towards 0), the impact of price increases on existing customers becomes much more important. This is illustrated in a stylised way in figure 2 for a case where marginal cost is always constant. The demand curve is drawn steeply ('inelastic' at current price), and profit at price p_0 is simply $\Pi = (p_0 - MC)q_0$; consumer surplus is then the area to the left of the demand curve above the price line p_0. Consider a price increase to price p . Consumer surplus

[12] Note the annuity factors in the paper are more complex than this – but still feature convexity as in figure 1.

decreases by the amount equal to the areas '*a+c*' whilst total welfare (when $\alpha = 1$) only decreases by the relatively small amount '*b+c*'.

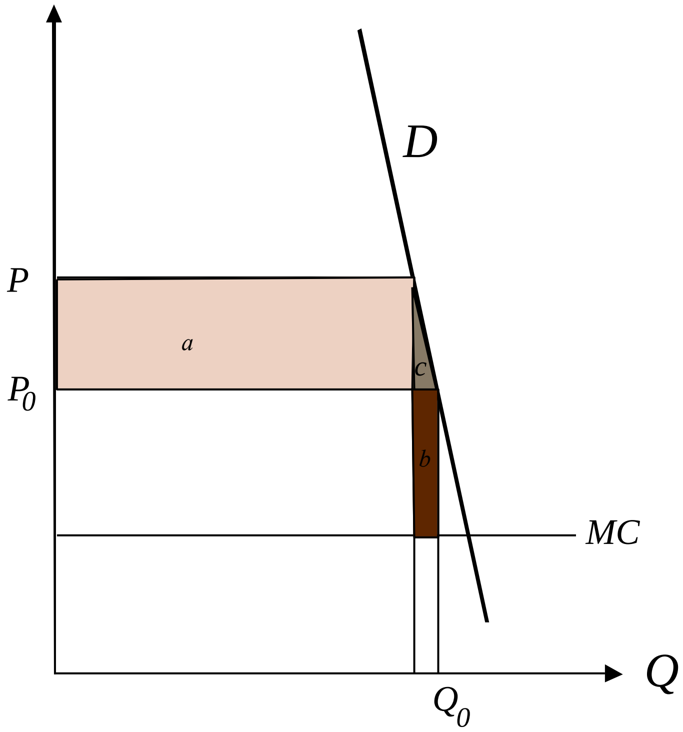

Figure 2: Components of Economic Welfare

34. Notice also that any price decrease (induced by a reduction in *AROR*) will lead to an increase in CS; this is why, as the Lally report points out, the optimal *AROR* for existing network, under a Consumer surplus welfare criterion would be a 0% *AROR*! It is easy to see that this will tend to counter-balance the welfare benefits of uplift in *AROR* for new investment if one is applying the same *AROR* across all categories of investment. That is, a lower weight on profit will inevitably reduce the overall optimal percentile.

35. To sum up, there are issues associated with moving away from the total welfare standard, and these need to be well understood.

3.3 Homo non-economicus?

36. A final observation regarding the applicability of the model concerns whether firms respond to incentives. The Dobbs model (and hence the Frontier submission)[13] assumes that they do (and do so in a 'Neo-classical economics' rational way). If they do not, then any uplift in *AROR* is simply a windfall benefit to them and a loss to consumers. A regulator may reasonably be concerned over whether this is the case or

[13] Likewise, this point applies to the models developed by Lally and NZIER.

not. There is plenty of evidence that individuals do not behave as 'homo economicus' – and there is plenty of evidence that 'competitive pressure' is less than severe, such that managers have considerable scope to pursue their own objectives – that is, managers of firms are not necessarily incentivised to make decisions in the interests of shareholders or customers, or indeed, anyone but themselves (as events in Banking industry over the last 20 years testify).[14] It then becomes a judgement call for the regulator – if the regulator believes that firms are unresponsive, then there is no reason to give them an uplift. Perhaps what is needed is to think concretely about the types of project that are on the horizon, and how firms may deal with them – to decide on whether non-investment, or undue deferment are likely to be real issues. That is, it may be that judgemental assessments of likely consequences may well be needed when finally deciding an appropriate percentile for a particular sector.

4. The Frontier Economics Implementation of the Model

37. The Frontier report briefly covers criticisms levelled at the model and then provides estimates for the allowed rate of return based on what Frontier consider to be appropriate parameter values. The limitations of the basic model have already been discussed (see above). In this section, the report and the model's implementation in its own terms is discussed.

38. The implementation (programming) is very well done indeed. Considerable care has gone into validating the model in terms of reproducing results from the original paper.[15] I do not have past experience of using R-software. Nevertheless, having gone through the Frontier program, I find the code used in implementing the model is largely intelligible to me, given that I understand what needs to be done, computationally. As far as I have been able to check, the model appears to be implemented correctly, and the code appears to be producing the kinds of numbers one would expect, given the input parameter values being used. Obviously I have not been able to conduct a full forensic examination (that would require checking that all

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[14] There is considerable empirical evidence that business decision makers are overly short termist – they seem to use 'too high' hurdle discount rates and 'too short' payback thresholds when deciding on whether to invest or not. This suggests they may not be particularly responsive to the incentives created by *WACC* uplift. There is also survey evidence that business decision makers are not very good at taking account of option value and the incentive to defer investment. Taking account of the option to defer investment can be viewed as equivalent to raising the required threshold for project internal rates of return (the extent of sub-optimality in investment decision making implied by this is discussed in Dobbs [2009]). The analysis in my model of category 3 investment presumes the firms are able to make this kind of option value type of calculation. The fact that firms do tend to use high DRs and short payback thresholds can be viewed as validating this approach to some extent, even though surveys suggest firms do not always seem to understand the idea of 'option value'.

[15] In late July, Frontier Economics contacted me about the implementation; they had largely replicated the results reported in my paper, but had found some numerical discrepancies in higher growth rate scenarios. After various email interchanges, it was agreed that there are plausible reasons for the discrepancies (associated with certain computational approximations used in my early work).

formulae are generating the correct numerical outputs at all stages of the program); all I can say is that there do not seem to be any logical or algebraic errors in the programming, as far as I can see.

39. Concerning the Frontier implementation, there are two points that need more detailed consideration; firstly, the modelling of 'pass through' (*AROR* feeds through to electricity price which then affects all industry and commerce and hence there is some 'pass through' to some extent into final consumer prices). This is not a major issue, but is worth discussing further. The second point concerns the implied assessment of consumer surplus in the Frontier model. This is a *major issue*, analysed in some depth in section 4.2 below.

4.1 Pass Through

40. Not being familiar with these industries in the NZ context, there are some detailed assumptions concerning parameter values in sections 3.2 and 3.4 of the Frontier report which I am unable to assess; the break down in fixed/variable costs, the transmission and distribution % components, how depreciation is treated and so on.

41. Transmission and distribution prices feed into final tariffs for both retail, commercial and industrial customers, so it is necessary to make assumptions about these parameters, and also to model the nature of the pass through. Frontier do this by assigning some of the price increases to 'fixed' and some to 'variable' costs for final customers (retail/commercial/industrial). I find this a reasonable and pragmatic approach. Where electricity and gas are intermediate products, this is effectively equivalent to a mark-up pricing model; such a model posits that firms set retail prices based on a mark-up on (average) variable costs. Changes in fixed costs do not alter prices, but changes in variable costs do – hence it matters what proportion of electricity/gas price is viewed as fixed/variable. Clearly a part of electricity/gas costs to industry and commerce will merely contribute to overheads, and not affect marginal/variable costs of production and hence not affect final price in this kind of pricing model. How much is variable and how much fixed will not doubt vary, and may vary considerably, from industry to industry; for major power consumers (such as aluminium smelters), much will be variable, whilst for retail stores, much will be fixed overhead. The fixed/variable cost parameter thus needs to reflect a weighted average across such firms and industries.

42. There are alternatives to the above 'model' of price formation. For example, with a full cost pricing model, all costs (fixed and variable) feed into final price. It could also be argued that in the long run, all costs must eventually be reflected in prices. Other models of price pass through are also possible; for example, in a simple model of profit maximising retail monopoly, if the monopolist is subjected to a rise in the

price of an input, the whole input price increase will not be passed through to consumers – and the same point applies in a differentiated Bertrand oligopoly.

43. To sum up, given there are alternative assumption regarding the extent of pass through, it might be sensible to consider varying the fixed/variable proportions parameter, by way of sensitivity analysis, to check whether results are robust to variations.

4.2 Maximum Willingness to Pay

44. I am unable to comment on whether the parameter values (for demand growth, demand proportions, demand elasticities) in the Frontier report Table 3 are reasonable or not (I am not an expert on electricity or gas transmission and distribution, especially as it applies in NZ).

45. Demand in the Frontier report is treated as significantly inelastic (-0.3 in the base case) both for existing *and* new investment. This is an important issue; demand elasticity, in conjunction with the assumption concerning maximum willingness to pay, is a major driver for model output; the more inelastic the demand and the higher the maximum willingness to pay, the higher the model predicts the allowed rate of return should be (the higher the percentile of the *WACC* distribution).

46. In so far as it is agreed that more inelastic demand is appropriate, there is a need to deal with how this impacts on the iso-elastic demand assumption (since consumers surplus for the iso-elastic demand curve when demand is assumed inelastic is infinite – clearly an unrealistic assumption). Frontier deal with this by setting a maximum willingness to pay figure (and considering some variation in this figure, by way of sensitivity analysis).

47. Although all commentators are in agreement concerning the inelasticity of *existing* demand, it is a moot point whether the same level of inelasticity should be used for *new* investment. In the Frontier scenarios, the elasticity is always the same for existing and for new investment; if anything, one might expect the demand associated with new investment to be more elastic and possibly, much more elastic. It is a straightforward matter to allow these to vary across categories (I actually did this in my original paper), and it would be interesting to see the consequences of such variation.

48. In the Frontier report, the concept of 'maximum willingness to pay' is not entirely clear – as it could refer to 'maximum marginal willingness to pay', or some form of 'average value'. Examining the code however clarifies that it is maximum marginal willingness to pay – that is the maximum price beyond which demand is assumed to fall from that predicated under the iso-elastic demand curve to zero (this is sometimes referred to as a 'choke price'). In my opinion, this assumption needs to be examined

carefully, as results produced by the model are likely to be highly sensitive to alternative specifications regarding maximum marginal willingness to pay. In particular, the way maximum willingness to pay is used in the modelling undertaken by Frontier in my opinion is likely to lead to a significant over-estimate of the extent of welfare loss arising from non-investment, and this will lead to an over-statement of optimal percentile for the allowed rate of return.

49. If demand is indeed inelastic at the current price, then under an iso-elastic demand assumption, consumer surplus is unbounded. Frontier rightly see that there is a need to adjust (truncate) the demand function (if the assumption of iso-elastic demand is to be retained); in the base scenario, maximum willingness to pay is set at $20,000/Mwh. Thus, in calculating consumer surplus, Frontier assume the demand curve, denoted $D_{Frontier}$, is iso-elastic everywhere up to the maximum price or choke price denoted p_M in Figure 3 below. For prices above this point, it is assumed that demand is zero. At the price p_M, technically, there is a discontinuity in the demand curve, as demand suddenly falls from a significant positive number (at prices below p_M) to zero as price is increased.

50. Frontier consider a range of choke prices, with $20,000 /Mwh as a base case, with $50,000 used in a ‘high’ scenario’ and $10,000 /Mwh regarded as a conservative figure. Other figures ($3,000 and $1,000) are also discussed in looking at what figures might need to be in order to get an optimal percentile of 67% or thereabouts – these figures are not regarded by Frontier as in any sense ‘realistic’.

51. Not being an expert in Electricity or Gas supply economics, I have no idea what a reasonable estimate for the ‘choke price’ should be.[16] All I can say is that the figure used is an important input into determining the model’s output.

52. Speaking personally, and thinking in naïve terms about my own willingness to pay for electricity, if I was faced with paying a price of say $1(NZ)/Kwh ($1,000/Mwh) I would definitely choose to not use the grid - but would use my own generators (or mix of generation sources). Surely willingness to pay for long run energy supply has to be linked to cost of alternative supply solutions, particularly where supply to new locations is involved.[17] In using such high figures ($20,000/Mwh), I wonder if there is

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[16] The Frontier reports some empirical estimates and briefly discusses other work done on maximum willingness to pay.

[17] Just to illustrate, a casual internet search turned up the following (US$):
“ A 20kW diesel generator operating at 3/4 load will burn approximately 1.3 gallons of fuel per hour. So if you only include the "variable" fuel costs to generate electricity, you are going to get 15kWh of electricity from the 1.3 gallons of fuel. If your fuel costs $3/gallon, this would give you a variable cost of $0.26/kWh. You should be able to use "off road" diesel fuel that doesn't include all of the highway taxes. And you should include the "delivered" cost of the fuel. Of course the real costs to generate electricity from a diesel generator must include all of the fixed costs. You can buy a 20kW generator

some conflation between willingness to pay for any supply at all, and willingness to pay for reliability (and unexpected loss of load).

53. Putting the above to one side, the rest of this section deals with the importance of the truncation that occurs in the Frontier model, and how it may materially affect results. The point is that, relative to the case where new investment occurs, when there is no investment, it is the consumers' surplus, the area under the demand curve that is lost.[18] The larger the consumer surplus lost, the more the model will give results at the high end of the WACC range (high percentile for *AROR*).

54. To explain this, consider Figure 3. Consumer surplus (consumer benefits) is the area to the left of the demand curve and above the price line. With iso-elastic demand (and demand inelastic) it is easy to see how consumer surplus can be infinite. It is clearly unrealistic to assume that demand is iso-elastic for all prices $p \in (0, \infty)$, but iso-elastic demand may be a reasonable approximation over a range of prices around the current price level. Thus iso-elastic demand is satisfactory for considering/predicting supply response for the price variations under consideration since these are relatively small (remember that varying the allowed rate of return *AROR* means varying price via equations like $\hat{p} = c + (\gamma + \hat{r})K$ where $\hat{p}$ is the price cap/control, and $\hat{r}$ is the *AROR*; the kind of variation in $\hat{r}$ under consideration are unlikely to induce such large changes in $\hat{p}$ that would render the assumption of iso-elastic demand unreasonable. However, the shape assumed for the demand curve has great impact on the value estimated for consumer surplus (that which is lost if the investment does not take place).

starting at about $5,000. If it lasts for 10 yrs, then that would only add about 5.5 cents to each kWh. You also need to add in maintenance costs and any installation costs."
Local generation costs ought to put a cap on maximum (average) willingness to pay.

[18] This is focusing on consumer benefit; of course the same argument applies to the total welfare measure, or a differentially weighted sum of CS plus profit; in all cases, clearly, CS is a lower bound on what is lost.

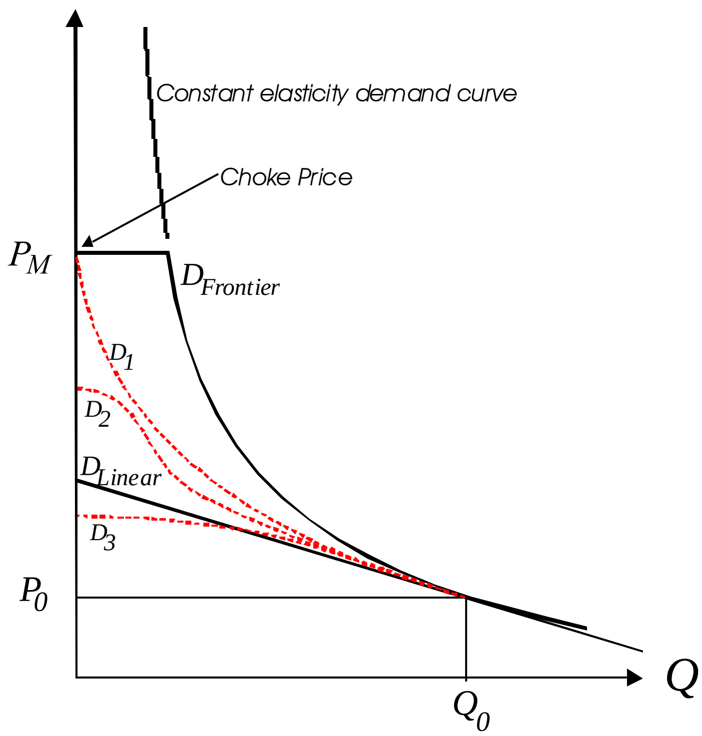

Figure 3: Consumer Surplus and Truncated Willingness to Pay

55. In figure 3, $D_{Frontier}$ represents the demand curve used in the Frontier model. The demand in this case follows the iso-elastic demand curve up to the price p_M, and then falls to zero for prices above p_M. The first point to note is that the level of *CS* (area to the left of demand D_1 and above the price line p_0) is materially affected by the choice of choke price p_M. Thus it is important, clearly, to investigate the sensitivity of results to the choice of choke price.[19]

56. Figure 3 also sketches some other potential demand curves. Notice that all these demand curves feature the same gradient and hence elasticity at the current price p_0. They all give, to first order, similar predictions for demand response in the neighbourhood of the current price p_0. What they do *not* do is give the same value for CS lost if investment does not occur; clearly, the areas below these different demand curves and above the price line p_0 are every different, and the estimate of CS lost remains very different whatever the price.

57. The Lally and NZIER reports both develop models in which demand is assumed to be linear. They argue that linear demand may be a more reasonable assumption that iso-elastic demand. It can be argued that demand curves often feature some degree of

[19] This is done by Frontier (they look at various possible choke prices, but in my opinion, the range used is likely to be far too high).

convexity (around the current price).[20] That is, in Figure 3, a demand curve something like D_2. That said, when there are good substitutes available above a certain price, it is likely that demand will tail off fast as the price is approached and exceeded. The demand curves D_2, D_3 illustrate this idea; they both show some convexity around the current price, but tail off as price is increased. I have sketched demand curve D_3 in Figure 3 to deliberately point out that if demand falls off sufficiently fast, it could even be that the choke price is less than that indicated by linear demand.

58. The key point to emphasise is that in practice, demand does not usually choke off suddenly as in demand $D_{Frontier}$. If there is a choke price, it is more likely demand will smoothly attenuate toward zero as price approaches the choke price. Note that all demand curves $D_1, D_2, D_3, D_{Linear}$ have an estimate of consumer surplus less than that under $D_{Frontier}$.

59. It is possible, and informative, to actually calculate what is implied for figures for consumer surplus that might be lost because of non-investment under the scenarios discussed by Frontier. In what follows, I calculate the consumer surplus under the current price p_0. Obviously, in the model, there is a solution for the optimal percentile for the *AROR*, which in turn implies a final price in general not equal to p_0. Nevertheless, the consumer surplus calculated using p_0 will be a good proxy for that which is at risk when the price is somewhat different (such that investment is dis-incentivised).[21]

60. As remarked above, consumer surplus in the Frontier implementation is the area to the left of the demand curve D_1 between the prices p_1 and p_M. The iso-elastic demand curve is given as $q = Bp^{\varepsilon}$ which passes through the current price/output point (p_0, q_0); this means the constant *B* satisfies $q_0 = Bp_0^{\varepsilon}$ and hence the demand curve can be written as $q = q_0 \left(p / p_0 \right)^{\varepsilon}$. Consumer surplus *CS* is then given by

$$CS = \int_{p_0}^{p_M} q dp = q_0 \int_{p_0}^{p_M} \left(p / p_0 \right)^{\varepsilon} dp = \frac{q_0 \left(p_M^{\varepsilon+1} - p_0^{\varepsilon+1} \right)}{(\varepsilon + 1) p_0^{\varepsilon}}$$

[20] Most text books draw figures in which demand and supply functions are linear – this is primarily for clarity and simplicity (it is easier to explain the structure of the marginal revenue function, for example, in the linear demand case, as marginal revenue can be badly behaved otherwise). However, when texts do stray from this simplicity, it is usually to illustrate convex demand (see e.g. Varian [1989; p. 6/7].

[21] After all, the difference in retail price induced by changes in *AROR* under consideration is not particularly large

61. Given parameter values for $p_0, q_0, p_M, \varepsilon$ this can be evaluated. Table 1 gives *CS* figures for the existing network based on the input parameter values used by Frontier; $p_0 = \$187.766 / \text{Mwh}$, $q_0 = 38847000\,\text{Mwh}$; Frontier consider $p_M = \$20,000 / \text{Mwh}$ as a base case, with $p_M = \$10,000 / \text{Mwh}$ as conservative value, but also use $50,000 as a high value (and also $3,000 and $1,000 when attempting to show what is required to get model predictions of around the 67% percentile). Accordingly, the implied Consumer surplus loss under each of these scenarios is calculated, for each of the demand elasticities considered in the Frontier report.

Table 1: Implied Consumer Surplus ($Billions per Annum): Existing Network. Frontier Model Truncated Iso-Elastic Demand

		Elasticity ε		
		-0.1	-0.3	-0.7
P_M	50000	1226.56	509.13	105.54
$/Mwh	20000	533.15	263.15	74.33
	10000	281.95	157.98	55.81
	3000	90.04	62.08	31.52
	1000	28.41	23.18	15.84

Table 2: Implied Consumer Surplus ($Billions per Annum): New Investment (1% of Existing Network). Frontier Model Truncated Iso-Elastic Demand

		Elasticity ε		
		-0.1	-0.3	-0.7
P_M	50000	12.27	5.09	1.05
$/Mwh	20000	5.33	2.63	0.74
	10000	2.81	1.57	0.55
	3000	0.90	0.62	0.31
	1000	0.28	0.23	0.16

62. Table 1 is useful for reference as it may be helpful in thinking about how realistic the numbers are. In effect, these consumer surplus figures conceptually represent the removal of the network completely. For example, on Frontier's base case, the *CS* loss is $263 Billion per annum. The Commerce Commission may wish to consider whether that reflects a sensible estimate; in considering this question it is worth pondering 'the wealth of the nation' (NZ GDP was approximately $212 billion in 2012/13), and also the fact that, for long term electricity supply, willingness to pay ought to be limited by the costs of alternative electricity/energy supply.

63. More relevantly, Table 2 represents the Frontier use of 1% of the existing network as potential new investment (that might not occur if not adequately incentivised). Again the loss of *CS* in the model is given by the figures in Table 2. For the Frontier base

case where $p_M = \$20,000/\text{Mwh}$ and $\varepsilon = -0.3$, the implied loss of consumer surplus would be $2.63 Billion per annum. No doubt it is possible for those familiar with the NZ electricity/gas sector to form a judgement as to whether such figures are likely to be plausible or not for possible new investment. As explained above, by conceiving that the demand curve looks more like D_2 or D_3, the actual loss of consumer surplus would in practice be lower, and likely, much lower than what Frontier are effectively assuming.

64. If a view is taken that the potential consumer surplus is likely to be much less, one way of capturing the fact is to choose a value for P_M that is consistent with the guesstimate of the consumer surplus at risk; this is illustrated in figure 4 below.

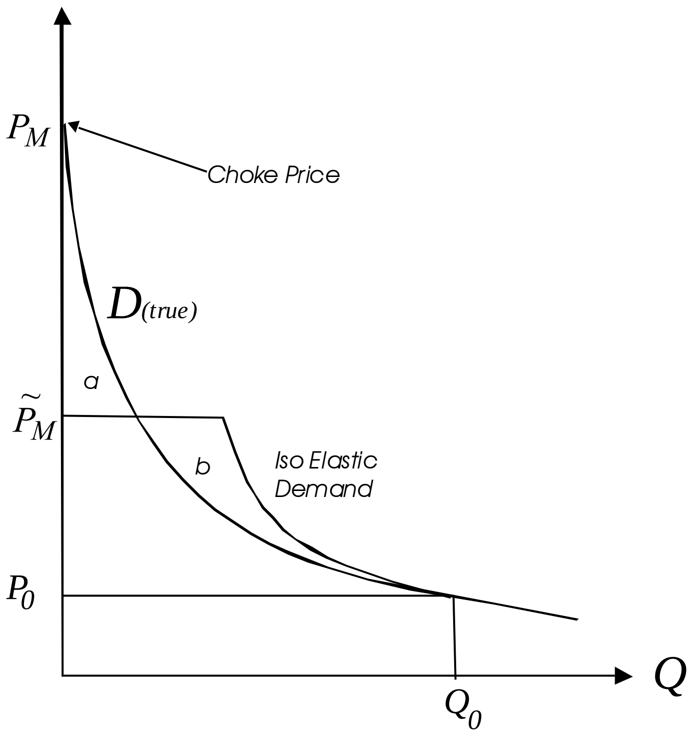

Figure 4

65. In Figure 4, the idea is that, for any estimate of maximum choke price p_M , and given that demand goes to zero as price approaches the choke price (as in demands $D_{Linear}, D_1, D_2, D_3$ in Fig. 3), then, whilst continuing to use the constant elasticity demand curve, a better estimate of the actual 'lost consumer surplus' can be had by selecting a smaller value for p_M; in figure 4 this is denoted $\tilde{p}_M$. How much smaller is of course conjectural, but it would seem that it might have to be significantly below the level of p_M. Of course, to the extent that it is smaller, this implies a lower

prediction for the WACC percentile for *AROR*.

66. Both the NZIER and the Lally report flag up the issue of likely over-estimation of lost consumer surplus under iso-elastic demand curves, and both present modified Dobbs models using *linear demand*. My discussion above was written prior to reading these reports – but it is clear that we are all in agreement that the iso-elastic demand curve (with demand inelastic at the current price) with the truncations at $10,000-$30,000/Mwh as used by Frontier is likely to seriously over-estimate the consumer surplus at risk.

67. An assumption of linear demand clearly reduces the estimate of consumer surplus lost; whilst both Lally and NZIER consider linear demand likely to be more realistic, they do not actually report figures for consumer surplus lost implied by linear demand (or the implied choke price, the point at which the linear demand hits the vertical axis in Figure 3). It is worth doing the calculations, because they are really quite illuminating.

68. The rest of this section calculates consumer surplus loss from non-investment under the Lally/NZIER assumption of linear demand. In addition, I also calculate the choke price under linear demand (the point the linear demand hits the vertical axis in Figure 3) and the value of $\tilde{p}_M$ that makes iso-elastic demand broadly equivalent to linear demand. That is, refer to Figure 4, and imagine D_{True} as a linear demand. It is possible to then calculate the truncation price $\tilde{p}_M$ that makes *CS* under the truncated iso-elastic curve equal to the *CS* under the D_{True} linear demand curve (such that the areas '*a*' and '*b*' are equalised). Doing this is interesting in itself, but also because it means that we can adjust the value of choke price p_M used in the Frontier modelling in order to emulate what the results would have been under linear demand (to a good approximation).

69. The iso-elastic demand was $q = Bp^{\varepsilon}$ which passes through the current price/output point (p_0, q_0) ; hence the demand curve can be written as $q = q_0 \left(p / p_0 \right)^{\varepsilon}$. The linear demand curve is written as $q = \alpha_0 - \alpha_1 p$. It must also satisfy $q_0 = \alpha_0 - \alpha_1 p_0$, and also that demand elasticity is ε at the current (p_0, q_0). Hence for the linear demand curve,

$$dq / dp = -\alpha_1 \text{ and } \varepsilon = (dq / dp)(p_0 / q_0) \text{ so } \alpha_1 = -q_0 \varepsilon / p_0$$

Hence $q_0 = \alpha_0 - \alpha_1 p_0 \Rightarrow q_0 = \alpha_0 + q_0 \varepsilon \Rightarrow \alpha_0 = q_0 (1 - \varepsilon)$ so the linear demand curve that passes through (q_0, p_0) and has elasticity ε at that point is

$$q = q_0 \left((1 - \varepsilon) + \varepsilon \left(p / p_0 \right) \right)$$

Consumer surplus *CS* under iso-elastic demand is given by

$$CS_{iso-elastic\,Demand} = \int_{p_0}^{p_M} q\,dp = q_0 \int_{p_0}^{p_M} \left(p / p_0 \right)^{\varepsilon} dp = \frac{q_0 \left(p_M^{\varepsilon+1} - p_0^{\varepsilon+1} \right)}{(\varepsilon+1)\, p_0^{\varepsilon}}$$

Under linear demand the choke price, denoted p_{ML}, is given by

$$0 = q_0 \left((1-\varepsilon) + \varepsilon \left(p_{ML} / p_0 \right) \right) \Rightarrow p_{ML} = -p_0 (1-\varepsilon) / \varepsilon \qquad (1)$$

so consumer surplus (0.5 times height times base for the CS triangle) is

$$\begin{aligned} CS_{Linear\,Demand} &= \tfrac{1}{2} \left(p_{ML} - p_0 \right) q_0 = -\tfrac{1}{2} \left(p_0 \left((1-\varepsilon)/\varepsilon \right) + p_0 \right) q_0 \\ &= -\tfrac{1}{2}\, p_0 q_0 / \varepsilon \qquad (2) \end{aligned}$$

Equating the consumer surplus under the two demand curves (linear and constant elasticity) enables a solution for the truncation point $\tilde{p}_M$ on the iso-elastic demand curve to be solved for: thus

$$\begin{aligned} &\frac{q_0 \left(\tilde{p}_M^{\varepsilon+1} - p_0^{\varepsilon+1} \right)}{(\varepsilon+1)\, p_0^{\varepsilon}} = -\frac{\tfrac{1}{2}\, p_0 q_0}{\varepsilon} \Rightarrow \varepsilon \left(\tilde{p}_M^{\varepsilon+1} - p_0^{\varepsilon+1} \right) = -\tfrac{1}{2} (\varepsilon+1)\, p_0^{\varepsilon+1} \\ &\Rightarrow \tilde{p}_M^{\varepsilon+1} = p_0^{\varepsilon+1} \left(\tfrac{1}{2} (\varepsilon - 1) \right) / \varepsilon \\ &\Rightarrow \left(\tilde{p}_M / p_0 \right)^{\varepsilon+1} = \left(\tfrac{1}{2} (\varepsilon - 1) \right) / \varepsilon \\ &\Rightarrow \tilde{p}_M = p_0 \left(\tfrac{1}{2} (1 - 1/\varepsilon) \right)^{1/(\varepsilon+1)} \qquad (3) \end{aligned}$$

70. Just to emphasise; referring to figure 4, $\tilde{p}_M$ is not the choke price of the 'true' demand curve; it is an estimate of what choke price needs to be used when iso-elastic demand is assumed in order for the Frontier model to produce similar results to that which would be found under linear demand (because, when applied to the constant elasticity demand curve, it gives the same consumer surplus as under a linear demand specification). Note that the demand responsiveness of the two demand curves will be roughly the same in the region of the current price (negligible difference on a neighbourhood of the current price).

71. Given parameter values for p_0, q_0, ε, it is possible to calculate $\tilde{p}_M$, p_{ML} and $CS_{Linear\,Demand}$ which of course is equal to $CS_{iso-Elastic\,Demand}$, using equations (1) - (3). Based on the input parameter values used by Frontier; $p_0 = \$187.766 / \text{Mwh}$, $q_0 = 38{,}847{,}000\,\text{Mwh}$, Table 4 shows just how low the choke price would need to be for the iso-elastic demand curve to feature the same consumer surplus as that under linear demand curve. It also reports the implied consumer surplus (\$Billion per annum) for the whole network; that is, in a thought experiment of removing the entire

network, this would be the loss of surplus under a linear demand assumption. The final column is simply 1% of the 4th column; this mimics what Frontier do in their report in assuming that new investment has same parameters as the existing network (same demand elasticity etc.) and that the new investment is simply 1% of the existing assets. Again, these are numbers anyone knowledgeable about the sectors under consideration might wish to reflect on.

Table 4: The value for $\tilde{p}_M$ needed for the Iso-Elastic demand curve in order to produce the same consumer surplus as under linear demand

ε	P_{ML}	$\tilde{P}_M$	Whole Net $CS_{Linear\ Demand}$ \$Billion	New Investment 1% of Existing: $CS_{Linear\ Demand}$ \$Billion
-0.1	\$2,065	\$1,248	36.5	0.365
-0.3	\$814	\$567	12.2	0.122
-0.5	\$563	\$422	7.3	0.073
-0.7	\$456	\$359	5.2	0.052
-0.9	\$396	\$322	4.1	0.041

72. This analysis buttresses what Lally and NZIER have to say about potential consumer surplus loss.[22] If it is accepted that linear demand is a better approximation for the shape of the demand curve, this would be equivalent to using a maximum willingness to pay in the Frontier model of $\tilde{p}_M$ =\$567 (when the demand elasticity is -0.3).

73. Note that it is also worth pondering whether the linear demand has a realistic choke price (the upper intercept of the linear demand curve, p_M.

74. If the Frontier model is run with these sorts of figure (column 3 in Table 4) for the choke price, it is likely that the predicted optimal percentile figure will be considerably lower than that under Frontier's base case (\$20,000) or even supposedly conservative case (\$10,000).

75. To sum up, there are two critical issues which influence the consumer surplus estimate – firstly the choice of choke price, and secondly the assumption of how fast demand attenuates as price is increased toward choke price. The model itself does not

[22] I should mention that I can follow the Lally model, but I am unclear as to how the NZIER model works, and why they get such extreme sensitivity of the optimal solution to parameter variations. It may well be that they have only considered the case of new category 2 investment, when the relevant category is category 3 (investment which can be undertaken in the current review period, or deferred to future review periods). No information is given in their report on how NZIER has undertaken the modelling of category3 investments.

require the assumption of iso-elastic demand, and even if this is assumed in the neighbourhood of current price, it is possible to consider alternative shapes for the demand curve above that range (as in figure 3). In the context of NZ electricity distribution and transmission, perhaps it might be possible to make some assessment (or educated guess) as to the likely shape of demand. If so, then how this affects results is something to be investigated. The key point to understand is that, for category 2 and 3 investments, the welfare loss from non-investment, or deferral of investment, is unambiguously lower, and potentially significantly lower, if demand looks more like $D_1, D_2, D_3, \text{or } D_{linear}$ rather than $D_{Frontier}$. The corollary is that the predicted optimal percentile will likewise be lower.

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