Report prepared for New Zealand Airports Association

Asymmetric impact on consumers from underinvestment by airports - an indicative view

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Introduction and summary

Introduction

1. The Commerce Commission (Commission), in its *'Input Methodologies Review – Professor Yarrow report and emerging views on the airport'* paper (Emerging Views), reiterates its presumption that the potential asymmetric impact on consumers from underinvestment is likely to be weaker for airports compared to electricity and gas businesses.

2. In this paper, we discuss how the assumption adopted by the Commission as to the relative strength of any asymmetry of social cost in the airport sector may have implications for how the Commission might best develop the approach described in its Emerging Views paper.

3. We then test whether, at face value, it is reasonable for the Commission to presume that the potential asymmetric impact on consumers from under investment is likely to be weaker for airports compared to electricity and gas businesses. We do this by applying the Oxera framework used by the Commission in evaluating the WACC percentile for energy networks to some indicative estimates of the social cost (including additional payments by consumers) were airports to over or under invest.

4. Our intent in applying the Oxera framework is not to challenge, or support, the Oxera approach; nor is our analysis aimed at supporting any estimate of a WACC percentile. Rather, our purpose is to view some indicators of the likely shape of the asymmetry of social cost through the same lens (the Oxera approach) as the Commission viewed the energy networks.

5. Our analysis is not a comprehensive assessment of the costs of over and under investment in the airport sector; our objective is more modest. We consider, however, that these indicative results show that the Commission's presumption is misplaced; the asymmetry of impact on consumers from underinvestment in the airport sector, relative to the costs of over recovery of capital, would appear to be stronger, rather than weaker, than the asymmetry the Commission observed in relation to electricity network investment.

Report structure

6. The body of our report is structured into four sections as follows:

   - The first section discusses briefly the presumption adopted by the Commission in relation to the asymmetry of under and over investment and why this presumption remains important under the approach outlined in its emerging views paper.
   - The second section describes the Oxera framework and how it can be applied to the airport sector.

- The third section estimates indicative values for the costs to consumers of under investment and over recovery of capital costs by airports, and compares the resulting asymmetry estimates with the results obtained by Oxera for electricity networks.
- The fourth section summarises the analysis and concludes.

The Commission's presumption

The Commission's presumption and emerging views

7. An asymmetric social cost arises when the impact on society of any over investment are outweighed by the impact on society should a corresponding amount of under investment occur. In its Emerging Views paper, the Commission comments that it considers the potential asymmetric impacts on consumers from underinvestment are likely to be weaker for airports compared to electricity and gas businesses.[1]

8. The presumption the Commission holds in relation to the potential asymmetric social cost is likely to have implications for how the Commission adopts the principle of proportionality advised by Professor Yarrow. As Professor Yarrow observes:

> *This principle [proportionality] should apply to all aspects of the conduct of public policy, including the analysis and administration effort devoted to specific issues such as WACC determination as well as to the economic impacts of policy measures judged in relation to the magnitudes of the perceived problems at which they might be addressed.*[2]

9. If the asymmetry is stronger than the Commission currently assumes then the benefit to consumers from the Commission influencing airports to reduce returns closer to its estimate of WACC, when airports may be earning excess returns, might be comparatively smaller than the Commission currently assumes. On the other hand, the costs to consumers from the Commission influencing airports to reduce returns, when they are not earning excess returns, may be comparatively much higher than the Commission assumes.

10. There are two further features of a proportional regulatory regime which could be influenced by an assessment of the asymmetry of social cost in the airports sector:

11. Firstly, airports generally have less market power than the other entities the Commission regulates, which is why airports are subject to information disclosure while electricity, gas and telecommunication networks are subject to price control. Hence, there is a comparatively smaller risk of airports behaving in a manner (exercising market power) which is harmful to consumers. This means that there is a comparatively smaller chance of the information disclosure regime being needed

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1 Commerce Commission (2016), *IM REVIEW – Professor Yarrow report and emerging views on the airport*, 19 February 2016, paragraph 16.

2 Yarrow (2016), *Responses to questions raised by the Commerce Commission concerning WACC estimates for information disclosure purposes in the airport sector,* 19 February 2016, page 1.

to correct behaviour that would, if it occurred, cause comparatively small harm relative to the harm that could arise if the intervention was not misconceived.

12. Secondly, as is recognised by the Commission, estimates of WACC are subject to uncertainty; the risk that any given point estimate of WACC may be higher or lower than the true WACC will vary with the chosen point estimate. Hence, the greater the prospect that a chosen estimate of WACC understates the true WACC, the greater the risk, given an asymmetry of social cost, that the information disclosure regime may influence outcomes in the sector that do more harm than good.

13. The assumption adopted by the Commission as to the relative strength of any asymmetry of social cost in the airport sector has therefore several implications for how the Commission might best develop the approach described in its emerging views paper.

14. If a significant asymmetry exists, the Commission would want to be confident that in publishing its estimate of WACC for information disclosure purposes it does not unintentionally distort decisions in a manner that could cause more harm than good. This may occur where the business conduct of regulated entities, including investment programmes, are sensitive to the Commission's estimate of WACC and its estimate turns out to be below an acceptable return. The Commission can modify its Emerging Views in two regards to minimise this regulatory risk.

15. Firstly, the Commission can reduce the prospect that firms are influenced by a point estimate that turns out to be below an acceptable rate of return. The Commission can reduce this risk by, at a minimum, retaining the current interval, the 25th to the 75th percentile, as there is a 50% probability of that interval enclosing the true WACC; a reduced interval would mean it was more likely than not that the interval did not contain the true WACC.

16. A better approach, however, might be to publish WACC estimates at regular percentile estimates (e.g. every 5th percentile).[3] In this way, the Commission would ensure information is available on its estimate of the cost of capital for airports, without pushing the airports to modify their conduct in response to a particular point estimate, when the Commission cannot be sure whether the point estimate is above or below the 'true' cost of capital. This approach 'will go more easily' as the Commission distinguishes the role of publishing its estimate of the cost of capital for information disclosure, from its role of assessing the information disclosed by airports.[4]

17. Secondly, as Professor Yarrow observes, business conduct is likely to be more sensitive to the Commission's estimate of the cost of capital if the Commission is highly reactive to relatively small deviations between an airport's projected, or out-

3 The Commission raises this approach at paragraph 19 of its Emerging Views paper.

4 Yarrow, page 20.

turn, returns and the Commission's WACC estimate.[5] The Commission can reduce the risk of firms responding in ways which reduce social welfare by:

- not placing undue reliance on the midpoint of a range or a chosen measure of central tendency
- assessing any divergences between its estimate of an acceptable rate of return and outturns (actual or expected) within an evaluation which considers all of the relevant circumstances for that divergence[6]
- treating any divergence between its estimate of an acceptable rate of return and outturns (actual or expected) as one of many factors considered, and giving any such divergence no more weight than other considerations.[7]

The basis for the Commission's presumption

18. There are two distinct, but related, factors to consider in determining whether there is an asymmetry in social costs:

- the first step is to consider the total costs and benefits associated with over and under investment
- the second step is to consider the relative probabilities of over and under investment.[8]

19. The Emerging Views paper reiterates the Commission's belief that the potential asymmetric impacts on consumers from under investment are likely to be weaker for airports compared to electricity and gas businesses because airports:

- are only subject to information disclosure
- are subject to a dual-till structure
- have regular consultations with a small number of engaged customers.[9]

20. These points all concern the second step – the extent to which the Commission's estimate of WACC impacts on investment decisions by airports. How important these points are to a conclusion as to the potential asymmetry of impact of investment on consumers will depend upon the size of the asymmetry should under or over investment occur (that is, the first step). A lower probability of under investment would not necessarily result in a weaker asymmetry, relative to networks, if the social loss associated with any under investment is higher.

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5 Yarrow (2016), page 8.

6 Yarrow (2016), page 20.

7 Yarrow (2016), page 20.

8 It is possible, for example, for the net social losses associated with over and under investment to be approximately the same, but the relative probabilities to differ giving rise to an expected asymmetry.

9 Commerce Commission (2016), *IM REVIEW – Professor Yarrow report and emerging views on the airport*, 19 February 2016, paragraph 16.

Previous work by the Commission in quantifying asymmetry

21. In the WACC percentile amendment process for electricity and gas businesses, the Commission used a quantitative framework developed by Oxera.[10] As the Commission observes in its Problem Definition paper, the Commission was aiming to find the "optimal" WACC which balanced the:

- costs to consumers of an uplift, in terms of higher prices
- benefits to consumers from applying the uplift, though a reduced risk of under-investment.[11]

22. The Commission drew upon the results of the Oxera framework, and other relevant factors, when forming its conclusions regarding the WACC percentile for electricity and gas networks.[12] In its Problem Definition paper, the Commission observed that a similar approach could be considered in the airport context using alternative input assumptions which are tailored to the specific airport situation.[13] The Commission invited submissions on:

- whether the quantitative framework applied to electricity and gas businesses and UCLL/UBA services, can be adapted for use in the airport context
- quantitative analysis that supports the use of a particular percentile to balance asymmetric impacts on consumers.[14]

23. It would seem that the Commission has not commissioned its own analysis, nor received submissions, which attempt to provide quantitative guidance as to the significance of any asymmetry of impact on consumers from under and over investment by airports. The Commission, in its questions for stakeholders, sought further views on the use of a quantitative framework given its emerging views.

24. Unlike the exercise undertaken for the electricity networks, the usefulness of the quantitative exercise for airports would not be in establishing any particular percentile for estimates of WACC. Rather, it would help inform the Commission as to the risks of its interventions doing more harm than good, and hence how it may apply the concept of proportionality within its Emerging Views approach.

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10 Oxera "Input methodologies, Review of the '75th percentile' approach, Prepared for New Zealand Commerce Commission", 23 June 2014.

11 Commerce Commission, Input methodologies review: Invitation to contribute to problem definition, 16 June 2015, paragraph 398.

12 Commerce Commission "Amendment to the WACC percentile for price-quality regulation for electricity lines services and gas pipeline services: Reasons paper", 30 October 2014.

13 Commerce Commission, Input methodologies review: Invitation to contribute to problem definition, 16 June 2015, paragraph 399.

14 Commerce Commission, Input methodologies review: Invitation to contribute to problem definition, 16 June 2015, paragraphs 404.5 and 404.6.

Quantitative testing of the reasonableness of the Commission's presumption

25. In the sections below, we test whether, at face value, it is reasonable for the Commission to presume that the potential asymmetric impact on consumers from under investment is likely to be weaker for airports compared to electricity and gas businesses. We do this by applying the Oxera framework used by the Commission in evaluating the WACC percentile for energy networks to some indicative estimates of the social cost were airports to under invest.

26. Our intent in applying the Oxera framework is not to challenge, or support, the Oxera approach; nor is our analysis aimed at supporting any estimate of a WACC percentile. Rather, our purpose is to view some indicators of the likely shape of the asymmetry of social cost through the same lens (the Oxera approach) as the Commission viewed the energy networks.

27. The airport sector is of course different in important ways from the electricity network sector and the available data differs. Hence, some adaptation of the framework is needed to apply it to the airport sector, just as Oxera found it needed to modify its framework to apply it to the telecommunications sector.[15] We have tried to minimise these modifications for the purposes of this indicative exercise. However, as the Commission and Oxera found in relation to energy and telecommunications, the Oxera framework still requires judgment to be exercised on various matters - on which parties can legitimately hold different views.

28. The data limits are significant. Our analysis has been prepared using readily available data within the time period provided by the Commission for submissions. The results are indicative only.

[15] In applying its approach to the telecommunications sector, Oxera focused on how a change in WACC might influence the timing of innovative investment in telecoms, rather than on the cost of outages, Oxera (2015), *Is a WACC uplift appropriate for UCLL and UBA?,* June 2015.

The Oxera framework and energy networks asymmetry

The Oxera framework

29. The approach developed for the Commission by Oxera for its review of the WACC percentile for electricity and gas networks focused its quantitative estimates on the increased payments by consumers, and the benefits of improved reliability, as the WACC percentile increases. Oxera took the view that all other policy costs of under or over estimating WACC for electricity and gas networks were of negligible size.[16]

30. As the WACC percentile is increased from the mid-point estimate, consumers pay more for network services but face less risk of an outage because of increased investment. At some point, the gain to consumers from the reduced risk of an outage would be exceeded by the additional amount paid for network services. Hence, under the consumer benefits test adopted by Oxera, the 'optimal' WACC percentile would be set at the point which minimised the sum of the expected:[17]

- value of the additional payments by consumers, and
- expected cost of outages to consumers.

31. In quantifying these two values, Oxera made a number of simplifying assumptions, including:

- differences between the regulated WACC and true WACC of less than 0.5% would have no effect on investment decisions by the regulated entities; hence Oxera calculated, for any given WACC percentile, the probability that the estimate of WACC is less than the true WACC by a margin of at least 0.5%[18]
- the reduction in the risk of an outage can be approximated by the change in the risk that WACC will be underestimated; that is, reducing the risk of underestimating WACC reduces the risk of under investment, and reducing the risk of under investment reduces the risk of outages.[19]

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16 I Vogelsang (2014) Review of Oxera's report, Input methodologies – review of the '75th percentile' Approach. 10 July 2014, paragraph 12, page 7.

17 In reaching its decision on the WACC percentile, the Commission concluded that in principle a consumer welfare standard is more consistent with an overall objective of the long-term benefit to consumers though it may be appropriate in practice to give some weight to producer surplus, see discussion at Commerce Commission "Amendment to the WACC percentile for price-quality regulation for electricity lines services and gas pipeline services: Reasons paper", 30 October 2014, paragraphs 2.37 and 2.38.

18 Oxera (2014), *Input methodologies: review of the '75th percentile' approach*, page 6.

19 Oxera (2014), *Input methodologies: review of the '75th percentile' approach*, box 7.1, p 70, appendix 1.

32. Oxera provided no evidence to support their contention that setting a regulatory WACC up to 0.5% below actual WACC would have no impact on investment in the energy sector. There are many reasons why the relationship between the risk of underestimating WACC and the risk of outages may not hold in the manner assumed by Oxera. However, we carry these assumptions forward without amendment. This allows us to test the Commission's presumption that the potential asymmetric impact on consumers from underinvestment are likely to be weaker for airports compared to electricity and gas businesses using the Oxera framework. As noted earlier, we do not consider in this report the relative likelihoods of under versus over investment (that is, the second step in determining the asymmetry).

Rearranging Oxera results to reveal the shape of the asymmetry

33. Oxera presented its analysis to assist the Commission determine the WACC percentile for energy networks. Our interest is different; we are interested in understanding the shape of the asymmetry estimated by Oxera so that we can compare that with the shape of asymmetry we estimate for the airport sector, using the same methodology.

34. In Appendix 1 we show the results and main calculations to rearrange the Oxera outputs to reveal the shape of the asymmetry. The key steps are as follows:

- We calculate the additional amounts consumers could *expect* to pay at each WACC percentile compared to the amount they would have paid had the WACC been set equal to the 'true' WACC. This amount is calculated by estimating the extent to which the WACC could be expected to be above the 'true' WACC at each percentile (taking unchanged the Commission's and Oxera's assumptions as to standard error, and using a truncated distribution curve).[20] This amount increases as the WACC is set at higher percentiles, because the higher WACC increases the risk it has been set above the 'true' WACC.[21]
- We calculate the loss from outages consumers could expect to suffer at each WACC percentile. This amount is calculated by multiplying Oxera's estimate of the annual loss to consumers by the probability that the WACC estimate is

[20] This method of estimating the expected cost to consumers results in a higher expected cost than Oxera arrived at in its paper; the 'over payment' by consumers is the whole amount of the estimated WACC above the 'true' WACC, not just the difference between the relevant WACC percentile and the 50th percentile – this point is discussed further in the explanation of the calculations in Appendix 1.

[21] There is a small oddity in the above calculations in that we continue to apply the Oxera assumption that a difference in WACC from the true WACC of less than 0.5% has no effect on investment decisions. Because we use the same probability estimates for calculating the loss to consumers, this results in that loss being understated. This assumption is carried through in the analysis of airports and hence does not impact on the comparison of the shape of the asymmetries.

less than the true WACC. The expected loss from outages falls as the WACC increases, because the higher WACC reduces the risk of under investment.

35. These calculations allow us to calculate the resulting asymmetry; that is the ratio that shows:

- the expected additional amounts consumers would pay at each WACC percentile given the probability of WACC being over estimated at that percentile, compared to
- the expected costs of outages to consumers at each WACC percentile given the probability of WACC being under estimated at that percentile.

36. This asymmetry broadly reflects the Commission's interpretation of its purpose statement, as it takes into account additional payments by consumers (transfers) as well as economic costs where those costs impact on consumers (economic welfare).

37. Before estimating the asymmetries we make two limited adjustments to the Oxera method arising from the Commission's analysis and submissions. The adjustments are limited as they do not alter the framework nor the relationships assumed in the Oxera approach.

Two updates to the Oxera framework

Cost of additional investment

38. The first adjustment is to correct the calculations for Professor Vogelsang's observation that the Oxera quantification did not provide for the cost to consumers of the additional (over) investment that might occur if the WACC is overestimated.[22] That is, if the benefit of an improvement in quality is to be factored in, the cost of achieving that improvement should also be accounted for. Professor Vogelsang suggested an increment of 10% of the annual investment would be appropriate (which for the electricity networks amounted to an increment of $100m per annum).

39. This estimate of investment costs should be probability adjusted as the cost would not be incurred if actual WACC were below the regulated WACC (following the Oxera assumption). In making this adjustment, we apply the Oxera assumption that a difference in WACC from the true WACC of less than 0.5% has no effect on investment decisions.

[22] I Vogelsang (2014) *Review of Oxera's report, Input methodologies – review of the '75th percentile' Approach.* 10 July 2014, pages 7 – 9.

Oxera loss probabilities do not reflect variability

40. In calculating its loss probabilities, Oxera failed to recognise that not only is the true (actual) WACC unknown but the standard error of the estimator of WACC is also unknown. Using a point estimate of the standard error when setting the percentile of the estimate of the true WACC results in greater variability in the sampling distribution of that estimate of WACC. The consequence is that the probabilities reported in Table 7.3 of the Oxera report are incorrect.

41. In Appendix 2 we show formally (mathematically) the error in the probabilities and estimate corrected probabilities. The difference in probability estimates is not large.[23] Nonetheless, we consider this change important as it is unsatisfactory to proceed with an incorrect formula and, perhaps more importantly, the error is one of understanding – how to arrive at estimates in the presence of uncertainty.[24]

42. With these adjustments, notably the additional investment cost, the asymmetry produced by the Oxera analysis of energy networks is as shown in Table 1 below. This is the asymmetry that the Commission presumes is stronger than the asymmetry which a similar quantification would show for the airport sector.

Table 1 Oxera asymmetry of social cost for energy networks - adjusted

WACC percentile	Asymmetry
65%	1:2.5
67%	1:2.2
70%	1:1.9
75%	1:1.4
80%	1:1.0

23 Oxera, in their response to submissions, suggested the correction would not have changed their recommendation, see Oxera Response to Submissions on Input Methodologies Review of 75th Percentile Approach 27 October 2014.

24 Covec, on behalf of BARNZ, did not challenge the mathematics of the correction, but asserted that the estimate of WACC and the decision on the percentile would be negatively correlated; that is, if the WACC were higher the Commission would arbitrarily reduce the percentile, and if the WACC were lower, the Commission would arbitrarily increase the percentile. We can see no basis in the IMs or the Commission's application of the IMs for Covec's view, see Covec Cross Submission on WACC Percentile Issues, 11 September 2016.

Applying the Oxera framework to airports

Need to estimate three values

43. To adapt and apply the Oxera framework to airports, two values need to be estimated. These values are:

- the expected additional costs to consumers if the WACC is overestimated, consisting of the following two values:
  - the amount consumers of airport services will pay at each percentile increment WACC is overestimated
  - the cost to consumers of the additional (over) investment that might occur if the WACC is overestimated
- the cost to consumers if airports were to under invest if WACC is underestimated.

44. The first two values, the expected additional costs to consumers, are readily estimated applying the same methodology as Oxera. The other value, the cost to consumers if airports were to under invest, involves additional analysis.

Expected additional costs

Expected payments

45. Oxera assumed that regulated networks would increase prices for each increment in WACC, and for consistency we adopt the same assumption in relation to the airports.

46. The total regulated asset base (RAB) of the three airports is a little over $2 billion. We calculate the additional amounts consumers could *expect* to pay at each WACC percentile compared to the amount they would have paid had the WACC been set equal to the 'true' WACC, assuming as noted above, that airport charges increase in in line with the WACC percentile.

Cost of expected over investment

47. Professor Vogelsang argued that the Oxera framework should allow for the costs consumers would incur if the regulated WACC is over estimated, and if the regulated entities over invest as a result and recover the cost of that investment from consumers. Professor Vogelsang suggested an increment of 10% of the annual investment would be appropriate. The total average annual forecast capital expenditure by the three airports for the next 10 years amounts to $102 million, hence the expected annual cost would be $10.2 million, following Professor Vogelsang's assumption.

Cost to consumers from underinvestment

Oxera focused on a single metric - reliability

48. Oxera represented the cost to consumers from under investments by electricity and gas networks by estimating the value to consumers of changes in reliability. Oxera took the view that all other policy costs of underestimating WACC for electricity and gas networks were of negligible size.

49. Oxera arrived at its estimated value of reliability by applying some simple metrics. Several United States studies cited by Oxera found that the cost to the US economy from network outages equated to between 0.4% to 1.8% of GDP. If equivalent levels of network failure occur in New Zealand and the impact on the economy were the same, Oxera calculated that the cost to the New Zealand economy would be $0.7 billion to NZ$3.7 billion annually. Oxera adopted a range of $1billion to $3 billion as the annual cost of electricity and gas network outages in New Zealand.[25]

Multiple and complex impacts were airports to under invest

50. Airports operate in a more dynamic environment than electricity and gas networks. Under investment might impact negatively (albeit perhaps less perceptibly, at least initially) on consumers in a number of ways. These impacts would include general service shortfall across a range of dimensions, including delay, reduced choice of destinations, reduced frequency of service, higher airfares and poorer airport ambience and service quality.

51. These impacts, and examples of studies of these effects in overseas jurisdictions, were discussed in a report by Dr Harry Bush and John Earwaker, *Evidence relating to the assessment of the WACC percentile for airports,* August 2015, attached to the submission of New Zealand Airports Association, 21 August 2015. Dr Bush and Mr Earwaker suggest that these shortcomings will manifest in an incremental degradation as capacity development fails to keep up with demand. These economic costs include, for example:

- increased instances of runway and passenger terminal congestion that occur regularly during peak airport operating times
- delays
- reduced choice of destinations
- reduced frequency of service
- poorer airport ambience and service quality
- some services failing to be provided at all.

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25 Oxera only reported results for the lower bound of this range, that is $1 billion.

While these shortcomings may be less apparently catastrophic than a major outage, the cumulative effect of regular and repeated service shortfalls can be more pervasive and longer lasting than an outage. Incremental degradation can have sustained knock on effects to the wider regional and national economy.[26] As noted by Grimes (2011) a restriction in airport investment may also restrict investment by downstream activities such as airlines and suppliers of airfreight services.[27] This is because many infrastructure investments are just the first phase of a multi-stage process of infrastructure investment that creates "real options" for other businesses to undertake further investments.

52. It was not feasible to model the costs associated with incremental degradation and outages in the timeframes available for this study. However, it is feasible to arrive at indicative estimates of some aspects of the potential costs. In the examples below, we focus on the cost of delay. There would of course be other impacts should airports under-perform. By focusing on one key measure (in this case, the cost of delay), we follow Oxera's approach – Oxera focused on the loss of reliability in relation to energy networks, and delays to innovation in their analysis of telecommunication networks.

Indicative estimates of the cost of delay

Approach

53. We apply two approaches to arrive at illustrative estimates of the cost of delay. The first is most similar to that used by Oxera in their work for the Commission.[28] The process utilises existing studies on the economic costs of delays associated with air travel to the (macro) economy to derive a range of potential costs. The second approach is to apply some indicative estimates of costs to New Zealand data.

Existing estimates of the cost of delay

54. Two major papers provide the best estimates of the annualised economic costs of air travel delay. Both studies were for the United States, and calculated overall numbers for the same year of between US$31 billion and US$41 billion (see Table 2). The table also shows that the economic cost of air travel delay in the United States in 2007 was between 0.2% and 0.3% of gross domestic product for that year (around US$14.5 trillion).[29]

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[26] Dr Harry Bush and John Earwaker, *Evidence relating to the assessment of the WACC percentile for airports,* August 2015.

[27] Grimes, A (2011), Building Bridges: Treating a New Transport Link as a Real Option, Motu Working Paper 11-12, Motu Economic and Public Policy Research, December 2011.

[28] Oxera, *Op.cit.* page 44.

[29] https://www.google.co.nz/webhp?sourceid=chrome-instant&ion=1&espv=2&ie=UTF-8#q=United+States+GDP+2007

Table 2 Annual costs of air travel delay US

Author	Cost ($US)	Share of GDP
Joint Economic Committee (2010)[30]	$40.7 billion	0.281%
Airline costs	*$19.1 billion (47%)*	
Passenger delays	*$12 billion (29%)*	
Costs to wider economy	*$9.6 billion (24%)*	
National Centre of Excellence for Aviation Operations Research (2008)[31]	$31.2 billion	0.215%
Airline costs	*$8.3 billion (27%)*	
Passenger delays	*$16.7 billion (53%)*	
Costs to wider economy	*$6.2 billion (20%)*	

55. Applying those GDP share figures to New Zealand GDP in 2015 (around NZ$220 billion)[32] yields an estimate of between NZ$473 million and $618 million for the annualised economic costs of air travel delay.

56. If these values are adopted as an estimate of the annual cost of delays associated with airports in New Zealand, and assessed within the Oxera framework, we arrive at the following asymmetries.

Table 3 Asymmetry airport sector – Oxera framework, cost of delay, US data

WACC percentile	Asymmetry – annual costs $473m	Asymmetry – annual costs $618m
65%	1:8.4	1:10.9

30 Joint Economic Committee (JEC) (2008) *"Your Flight has Been Delayed Again: Flight Delays Cost Passengers, Airlines, and the US Economy Billions."*

31 National Centre of Excellence for Aviations Operations Research (2010) *"Total Delay Impact Study- A Comprehensive Assessment of the Costa and Impacts of Flight Delay in the United States."*

32 Statistics New Zealand Gross Domestic Product: September 2015 Quarter- supplementary tables, table 5 Annual values March 2015.

WACC percentile	Asymmetry – annual costs $473m	Asymmetry – annual costs $618m
67%	1:7.5	1:9.8
70%	1:6.3	1:8.2
75%	1:4.7	1:6.1
80%	1:3.4	1:4.5

57. In a more limited study, looking at one contributor to delay, the UK Airports Commission, in a 2013 report, estimated the cost to the UK economy of failing to alleviate capacity constraints at the nation's airports. The Commission estimated that a failure to alleviate these capacity constraints could cost users and providers of airport infrastructure up to £18 - £20 billion over the next 60 years, and that costs to the economy more broadly could be between £30-£45 billion. The Commission's 2015 report suggests that costs to the broader economy could be even higher.[33]

58. If we convert these figures to levelised annual numbers, and then translate the values into percentages of UK's GDP and apply those percentages to NZ's GDP. The resulting estimates suggest a cost to the economy of $71.6 million to $107.5 million per annum. We take the mid-point of these values, $90 million per annum, and assess this estimate within the Oxera framework to arrive at the following asymmetry:

Table 4 Asymmetry of airport under and over investment – Oxera framework, cost of delay

WACC percentile	Asymmetry – annual costs of capacity constraint $90m
65%	1:1.6
67%	1:1.4
70%	1:1.2

33 Airports Commission, "Recommendations for expanding aviation capacity and its assessment of short-listed options: Final Report", July 2015, p 17 and 76.

WACC percentile	Asymmetry – annual costs of capacity constraint $90m
75%	1:0.9
80%	1:0.7

59. Assessing these metrics from existing studies within the Oxera framework suggests that the asymmetry of social cost on consumers of under investment relative to over investment is:

- a little weaker for airports if the analysis is limited to the cost of capacity constraints, using the UK study
- much stronger for airports if we rely on the US studies which take into consideration a broader range of impacts causing delay in the airport sector.

Delays to flight schedules

60. Our second illustrative calculation considers the costs if incremental delays were to occur to existing flight schedules - for example, as a result of progressive service deterioration – as identified by Dr Bush and Mr Earwaker as a likely consequence of under-investment in the airport sector.[34]

61. We assume, for illustration, incremental degradation from under investment eventually results in an average delay of 5 minutes to flights departing from or arriving at Auckland, Wellington and Christchurch airports. As the delays result from airport under performance, the delays would be non-systematic; that is, unexpected. Delays would in practice be of variable, unpredictable, lengths but are modeled for simplicity at an average of 5 minutes. As the costs of delay are likely to be exponential with the length of the delay and its randomness, this assumption would seem conservative.

62. To avoid double counting we modeled the schedules for all three airports on a single day.[35] This allowed us to ensure that a delay in departure from one airport was not also counted as a delay in arrival at its destination airport – that is, each flight suffered just one delay of 5 minutes. The data includes international arrivals and departures.

63. In reality, the variable nature of delays would cause disruption to subsequent flight schedules, including the compounding effects of delay through the day. However, for simplicity, we assumed that the flight schedules would be unchanged. This

[34] Dr Harry Bush and John Earwaker, *Evidence relating to the assessment of the WACC percentile for airports,* August 2015

[35] The date was 15 September 2015. There is no particular reason for selecting this day, other than convenience as scheduling data had been gathered because disruptions occurred that day due to fog (but to be clear the delays caused by that day's fog have not impacted the data used for this indicative exercise).

assumption means the estimated costs would be significantly less than would occur, if delays of this 'average' length were to occur.

64. The scheduling data provided us with the type of plane for each scheduled departure and arrival, and hence the number of seats. We assumed an average capacity loading of 80%.

65. On the basis of these assumptions, an average delay of 5 minutes, would result in the following daily totals:

Table 5 Daily total delays

	One day
Flight minutes of delay (number of flights multiplied by minutes of delay)	4,040 minutes
Number of passengers delayed (sum of passengers on the flights that are delayed)	62,419 passengers

66. By attaching values to these daily delay totals we can estimate the daily and annual cost[36] if under investment led, on average, to a 5 minute delay for each flight.

67. There are no New Zealand-specific values of air travel time (VoTT) for passengers available. Indeed, the Australian values which are in common usage are derived from European values, which have been inflated and converted to Australian dollars.[37] We start with the relevant Australian VoTT numbers for the General Aviation passenger values (per hour) of AU$45.09 for personal travel and AU$64.29 for business travel.

68. From there we derived New Zealand dollar values by inflating the Australian estimates by 2.5 per cent per year (to reflect inflation) and then converting into New Zealand dollar values using an exchange rate of AU$0.94. The 2015/16 VoTT (per hour) figures are NZ$57.02 for personal travel and NZ$81.30 for business travel. Using an assumed business/personal travel split of 10/90 across the board, we derive a composite VoTT for passenger travel of NZ$59.45 per hour, which we use for this illustrative example.

69. Note, however, that the literature refers to "unexpected" delay, particularly as it relates to airside (flight) delay, which includes flight time delay, as well as boarding

[36] This total is arrived at by multiplying the daily total by 365. This simplification is subject to at least two sources of error. As the selected day is a weekday it would likely have more flights than weekends, leading the multiplication to overstate the annual totals. However, the September is unremarkable and would have fewer flights than peak times of the year. On balance, we suspect the number is likely to overestimate the aggregate annual minutes for a given assumed average delay.

[37] Civil Aviation Safety Authority (2010) *"Standard Economic Values Guidelines"* Australian Government, November.

time and connection times.[38] Unexpected flight time delay estimates are significantly higher than routine values such as those above. For personal travel "unexpected flight delay" is around 3.5 times the value of normal flight time VoTT, while the multiple is 5.6 for business passengers.[39] Our passenger cost assumptions effectively assume that all of the delay occurs on the ground, which would result in an underestimate of the cost to passengers.[40]

70. For the cost to the airlines, we use an estimate from a US study, converted to New Zealand dollars.[41] This estimate is approximately mid-way between two other estimates arrived at from major US studies.[42] For the costs to the wider economy, we use two estimates from the cited US studies.

Table 6 Costs of delay

	Per minute	Daily cost	Annual cost
Cost to airlines	$121	$488,840	$178,426,600
Cost to passengers	$0.99	$309,234	$112,870,457
Total direct costs		**$798,074**	**$291,297,057**
Costs to the wider economy			
At 24% of passenger costs[43]			$27,088,910
At 80% of passenger costs[44]			$90,296,366
Total annual cost			**$318 million to $382 million**

38 Airport Cooperative Research Program (2015) *"Passenger Value-of-Time, Benefit-Cost Analysis, and Airport Capital Investment Decisions; Volume 1: Guidebook for Valuing User Time Savings in Airport Capital Investment Decisions."* Contractor's Guidebook for ACRP 03-19, submitted to Transportation Research Board.

39 Ibid, Table 1, p.7.

40 The cost per hour of delay for a passenger in flight would be NZ$220.56 per hour, rather than the $59.45 per hour average assumed in this analysis.

41 http://airlines.org/data/per-minute-cost-of-delays-to-u-s-airlines/

42 The National Centre of Excellence for Aviation Operations Research (2010) set airline costs at 49.7% of the cost to passengers; whereas the Joint Economic Committee (JEC) (2008) estimated airline costs at 159% of passenger costs.

43 Proportion from National Centre of Excellence for Aviation Operations Research (2008).

44 Proportion from Joint Economic Committee (JEC) (2008).

71. Taking the mid-point of this total cost estimate, of $350 million, and applying the Oxera framework results in the following asymmetry estimates.

Table 7 Asymmetry of airport under and over investment – Oxera framework, cost of delay to NZ flight schedule

WACC percentile	Asymmetry – annual costs $350m
65%	1:6.2
67%	1:5.5
70%	1:4.6
75%	1:3.5
80%	1:2.5

Conclusion

72. The Commission currently presumes that the asymmetry of social cost from the risk of over and under investment in the airport sector is weaker than for electricity networks. This presumption has several implications for how the Commission might best develop the approach described in its Emerging Views paper.

73. If a significant asymmetry exists, the Commission would want to be confident that in publishing its estimate of WACC for information disclosure purposes it does not unintentionally distort decisions in a manner that could cause more harm than good.

74. The Commission could reduce the risk of doing more harm than good by two developments to its Emerging Views approach.

75. Firstly, the Commission could reduce the prospect that firms are influenced by a point estimate that turns out to be below an acceptable rate of return by, at a minimum, retaining the current interval, the 25th to the 75th percentile. Within this interval there is a 50% probability of the interval enclosing the true WACC; a reduced interval would mean it would be more likely than not that the interval did not contain the true WACC.

76. A better approach, however, might be to publish WACC estimates at regular percentile estimates (e.g. every 5th percentile). In this way, the Commission would ensure information is available on its assessment of the cost of capital for airports, without pushing the airports to modify their conduct in response to a particular point estimate, when the Commission cannot be sure whether the point estimate is above or below the 'true' cost of capital.

77. Secondly, the Commission can reduce the risk of firms responding in ways which reduce social welfare by:

- not placing undue reliance on the midpoint of a range or a chosen measure of central tendency
- assessing any divergences between its estimate of an acceptable rate of return and outturns (actual or expected) within an evaluation which considers all of the relevant circumstances for that divergence.[45]
- treating any divergence between its estimate of an acceptable rate of return and outturns (actual or expected) as one of many factors considered, and giving any such divergence no more weight than other considerations.

78. It would seem that the Commission has not commissioned its own analysis, nor received submissions, which attempt to provide quantitative guidance as to the significance of any asymmetry of impact on consumers from under and over investment by airports.

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45 Yarrow (2016), page 20.

79. We test whether, at face value, it is reasonable for the Commission to presume that the potential asymmetric impact on consumers from under investment is likely to be weaker for airports compared to electricity and gas businesses. We do this by applying the Oxera framework used by the Commission in evaluating the WACC percentile for energy networks to some indicative estimates of the social cost (including additional payments by consumers) were airports to over or under invest.

80. The following table summarises the asymmetries calculated in the report. That is, it shows the ratio of:

- the expected additional amounts consumers would pay at each WACC percentile given the probability of WACC being over estimated at that percentile, compared to
- the expected costs of outages (electricity) or delay (airports) to consumers and the wider economy given the probability of WACC being under estimated at that percentile.

Table 8 Relative asymmetries applying the Oxera framework

	Electricity asymmetry of cost	Airport asymmetry of cost			
WACC percentile	**Oxera - electricity**	**UK – cost of constraint data**	**US - cost of delay data (1)[46]**	**US - cost of delay data (2)[47]**	**NZ flight schedules – 5 minute delay**
65%	1:2.5	1:1.6	1:8.4	1:10.9	1:6.2
67%	1:2.2	1:1.4	1:7.5	1:9.8	1:5.5
70%	1:1.9	1:1.2	1:6.3	1:8.2	1:4.6
75%	1:1.4	1:0.9	1:4.7	1:6.1	1:3.5
80%	1:1.0	1:0.7	1:3.4	1:4.5	1:2.5

81. These estimates suggest that using metrics from existing studies within Oxera framework results in an asymmetry of social cost on consumers of under investment relative to over investment that is:

46 Joint Economic Committee (2010

47 National Centre of Excellence for Aviations Operations Research (2008)

- a little weaker for airports if the analysis is limited to the cost of capacity constraints, using the UK study
- much stronger for airports if we rely on the US studies which take into consideration a broader range of impacts causing delay in the airport sector.

82. An illustrative analysis assuming airport under performance led to a delay of 5 minutes to existing flight schedules produces a similar result to the US studies. Taken as whole, the illustrative estimates suggest that the asymmetry in the airport sector would appear to be stronger, rather than weaker, than the asymmetry the Commission observed in relation to electricity network investment.

Appendix 1: Calculation of Oxera asymmetries

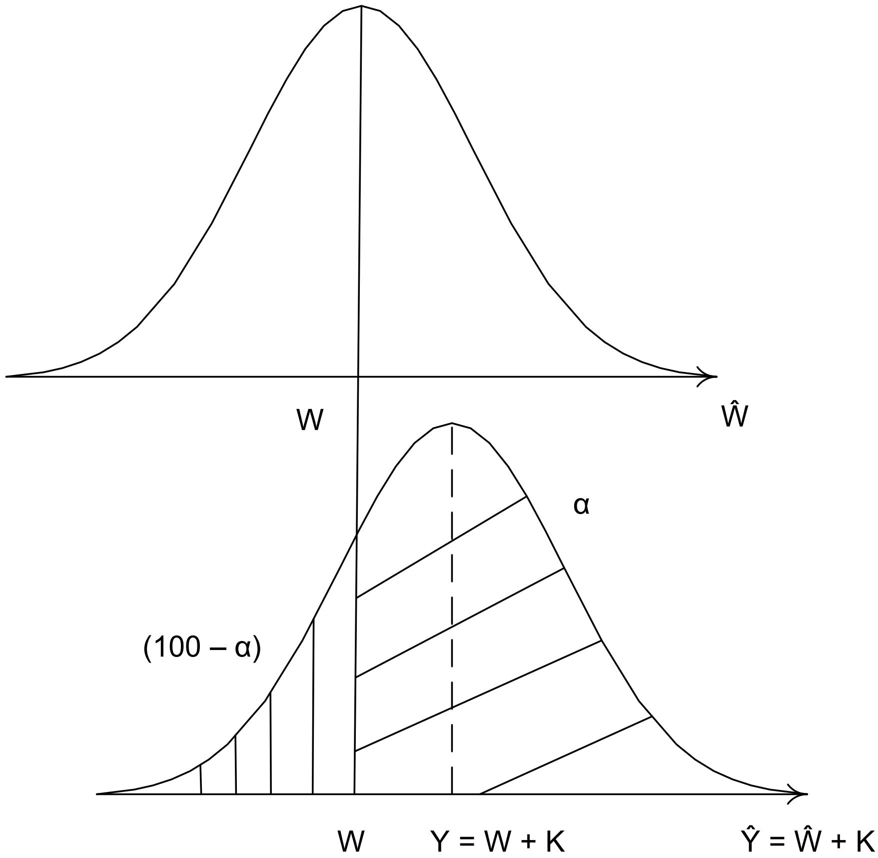
Mean	6.50%													
Standard deviation	1.07%													
Overestimate boundar	0.50%													
	Oxera results - adjusted													
		A	B	C	D	E	F	G	H	I	J	K	L	M
	Percentile	RAB ($m)	Additional investment ($m)	WACC estimate	Probability of overestimation by 0.5% or more	Expected WACC, given that true WACC is overestimated by more than 0.5%	Expected extent of overestimate, given that true WACC is overestimated by more than 0.5%	Expected overestimate of return on capital, given that true WACC is overestimated by more than 0.5% ($m)	Expected costs ($m)	Annualised reliability loss ($m)	Probability of underestimation by 0.5% or more	Expected reliability loss ($m)	Total cost to consumers ($m)	Asymmetry
	50%	$ 14,600	100	6.50%	33.4%	5.35%	1.15%	$ 168.6	$ 56.3	1000	33%	$ 334	$ 390	
	65%	$ 14,600	100	6.91%	48.4%	5.62%	1.29%	$ 189.9	$ 91.9	1000	23%	$ 228	$ 320	1: 2.5
	67%	$ 14,600	100	6.97%	50.4%	5.65%	1.32%	$ 193.7	$ 97.6	1000	22%	$ 216	$ 313	1: 2.2
	70%	$ 14,600	100	7.06%	53.4%	5.70%	1.36%	$ 199.9	$ 106.7	1000	20%	$ 198	$ 305	1: 1.9
	75%	$ 14,600	100	7.22%	58.4%	5.78%	1.44%	$ 211.3	$ 123.3	1000	17%	$ 171	$ 294	1: 1.4
	80%	$ 14,600	100	7.40%	63.4%	5.87%	1.53%	$ 224.6	$ 142.5	1000	14%	$ 145	$ 287	1: 1.0

Appendix 2: Loss probabilities and variability

- This appendix summarises the analysis presented by Professor Tony van Zijl and Kieran Murray in two reports previously submitted to the Commerce Commission.[48] It shows that using a point estimate of the standard error when setting the percentile of the estimate of the true WACC results in greater variability in the sampling distribution of that estimate of WACC. The consequence is that there is a higher probability of the Commission under estimating WACC than reported in Table 7.3 of the Oxera report.

- During the estimation of WACC, the CAPM equation is applied and thus uncertainty surrounding these estimates of the parameters translates through to the estimate of WACC (more details at the end of this Appendix):
- $\text{WACC} = \left(R_f + \text{pL}\right)(1 - t) + \emptyset\beta_e(1 - L)$
- Where R_f = risk free rate
  - p= debt premium
  - L= leverage ratio
  - t= personal and corporate tax rates
- The processes of generating the estimates of the parameters can be thought of as stochastic processes that throw up a different value each time an estimate is made, and thus the estimator of WACC, denoted by$\widehat{\text{W}}$, can also be thought of as being stochastic. That is, there is a probability distribution for $\widehat{\text{W}}$. This probability distribution is called the sampling distribution of $\widehat{\text{W}}$.
- The Commission assumes (reasonably) that (i) $\widehat{\text{W}}$ is unbiased, that is, that the expected value of $\widehat{\text{W}}$ equals the true WACC, W, and (ii) that the sampling distribution of $\widehat{\text{W}}$ is a normal distribution. That is, the sampling distribution of $\widehat{\text{W}}$ is N(W, $\sigma(\widehat{\text{W}})^2$) where $\sigma(\widehat{\text{W}})$ is the standard deviation of the distribution, which the Commission estimated as1.07.
- Thus, if the Commission sets the WACC equal to $\widehat{\text{Y}} = \widehat{\text{W}} + \text{K}$, where $\text{K} = \text{Z}\sigma\left(\widehat{\text{W}}\right)$. Z is the standard normal deviate corresponding to ∝, and the probability of under-estimation of W, that is, $\widehat{\text{Y}}$ is less than W is (100 - ∝)%, or equivalently, that the probability of over estimation of W, that is, $\widehat{\text{Y}}$ is greater than W, is ∝ %, as explained in the graph below.

48 Kieran Murray and Tony van Zijl, '*Proposed amendment to the WACC percentile – Commerce Commission's draft decision,* 29 August 2014.



- Thus, followed the Oxera's calculation, for each value of K, $\widehat{Y}$ is N(W+K, $\sigma(\widehat{W})^2$).
- For example, if we choose α=75% and $\sigma(\widehat{W})$ =1.07, then K= 0.6745×1.07 =0.7217. Therefore, $\widehat{Y}$ is N(W+0.7217, 1.07^2). The probability of the true WACC being 0.5% above the assumed WACC is 12.7%, where the z score is $\frac{(W-0.5)-(W+0.7217)}{1.07} = -1.1418$.
- However, practically if $\emptyset$ and β_e are estimated by maximum likelihood from a simple market model regression using T observations, then it can be shown that the following results hold to a good level of approximation:
- $\sigma(\hat{Y}) = \sigma(\widehat{W}) + 2Z(\frac{1-L}{T})\frac{\emptyset\beta\sigma_i^2}{V}$
- Where $\sigma(\widehat{W}) = \frac{1-L}{\sqrt{T}}\sqrt{V}$ and $V = \sigma_i^2\frac{\emptyset^2}{\sigma_m^2} + \beta^2\sigma_m^2$

- Then for each value of K, the distribution of $\hat{Y}$ is N(W+K, $\sigma(\hat{Y})^2$), where $\sigma(\hat{Y})$ is greater than $\sigma(\widehat{W})$ as the additional modelling error applied.
- For example, if we choose α=75%, then by the formula above $\sigma(\widehat{W})$ =1.1637, then K= 0.6745×1.1637 =0.7849 and $\sigma(\hat{Y})$=1.3504 (details at the end of this Appendix).Therefore, $\hat{Y}$ is N(W+0.7849, 1.3504^2). The probability of the true WACC being 0.5% above the assumed WACC is 17.1%, where the z score is $\frac{(W-0.5)-(W+0.7849)}{1.3504} = -0.9515$.
- Compared to Oxera's calculation, take α=75% as the example, the probability of the true WACC being 0.5% above the assumed WACC is 17.1%, which is 4.4% larger. This increased in loss probability is due to the uncertainty of the regression model on practical level.

From CAPM model to estimator of WACC

Using the post-tax form of the CAPM, the cost of equity,k_e, is given by:

$$k_e = R_f(1 - t_i) + \emptyset\beta_e$$

WACC and the cost of debt capital k_d are given by:

$$\text{WACC} = k_e(1 - \text{L}) + k_d(1 - t)L$$

$$k_d = R_f + p$$

Substitute k_e and k_d into WACC, then:

$$\text{WACC} = (R_f + \text{pL})(1 - t) + \emptyset\beta_e(1 - L)$$

Where the personal and corporate tax rates are assumed to be equal.to t

Where:

$$R_f = \text{risk free rate}$$

$$t_i = \text{the personal tax rate on interest}$$

$$\emptyset = k_m - R_f(1 - t_i)$$

$$k_m = \text{the expected rate of return on the market portfolio}$$

$$\beta_e = \text{the equity beta} = \beta_a(1 + \frac{L}{1 - L})$$

$$\beta_a = \text{asset beta}$$

p= debt premium

L= leverage ratio

t= personal and corporate tax rates

Assumptions for estimating the magnitude in the uncertainty of $\sigma(\hat{Y})$

$$\hat{\sigma}_m = 20\%, \text{the common annual estimate}$$

T=60

$$\hat{\sigma}_i = 30\%$$

$$\emptyset = 7\%$$

L=0.44

$$\beta_e = 0.6$$

Corrected probabilities

Oxera

paramerters	
se	1.07
margin	0.5

Percentile	K	Z	P(x<W-0.5)	Z	P(x>W+0.5)
50%	0.0000	-0.4673	32.01%	0.4673	32.01%
55%	0.1257	-0.5930	27.66%	0.3416	36.63%
60%	0.2533	-0.7206	23.56%	0.2139	41.53%
65%	0.3853	-0.8526	19.69%	0.0820	46.73%
67%	0.4399	-0.9072	18.21%	0.0274	48.91%
70%	0.5244	-0.9917	16.07%	-0.0571	52.28%
75%	0.6745	-1.1418	12.68%	-0.2072	58.21%
80%	0.8416	-1.3089	9.53%	-0.3743	64.59%
85%	1.0364	-1.5037	6.63%	-0.5691	71.54%
90%	1.2816	-1.7488	4.02%	-0.8143	79.23%
95%	1.6449	-2.1121	1.73%	-1.1776	88.05%

Corrected for additional variability

parameters			
∅	7	V	259.0900
L	0.44	s(W)	1.1637
β_e	0.61		
T	60		
σ_m	20		
σ_i	30		
margin	0.5		

Percentile	K	s(Y)	Z	P(x<W-0.5)	Z	P(x>W+0.5)
50%	0.0000	1.1637	-0.4297	33.37%	0.4297	33.37%
55%	0.1257	1.1985	-0.5392	29.49%	0.2952	38.39%
60%	0.2533	1.2338	-0.6442	25.97%	0.1663	43.40%
65%	0.3853	1.2704	-0.7465	22.77%	0.0406	48.38%
67%	0.4399	1.2855	-0.7872	21.56%	-0.0093	50.37%
70%	0.5244	1.3089	-0.8482	19.82%	-0.0842	53.36%
75%	0.6745	1.3504	-0.9515	17.07%	-0.2110	58.35%
80%	0.8416	1.3967	-1.0592	14.48%	-0.3432	63.43%
85%	1.0364	1.4507	-1.1761	11.98%	-0.4867	68.68%
90%	1.2816	1.5185	-1.3114	9.49%	-0.6528	74.31%
95%	1.6449	1.6191	-1.4910	6.80%	-0.8734	80.88%