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Dr Paul Paterson
Independent Pricing and Regulatory Tribunal (IPART)
PO Box K35
Haymarket Post Shop NSW 1240

3 July 2019

Review of equity beta estimation methodology

Dear Dr Paterson,

Thank you for the opportunity to provide Sydney Desalination Plant Pty Limited's (SDP's) views on IPART's review of its methodology for estimating the equity beta. IPART indicated in its 2018 WACC methodology decision that it would consult in due course on this issue. Therefore, the opportunity to contribute SDP's views on the equity beta estimation methodology, ahead of SDP's next price review, is welcome.

IPART's approach has a number of strengths

SDP is supportive of IPART's proposed approach to estimating the equity beta. SDP is also pleased that IPART has adopted in its proposed beta estimation approach several recommendations SDP made during the WACC methodology review, including the following:

- Review beta estimates periodically (e.g., at each price review);
- Use a broad sample of comparator firms; and
- Exclude illiquid stocks using the Amihud approach.

SDP also commends IPART on seeking to make its estimation methodology transparent and replicable—another approach that stakeholders supported strongly during the WACC methodology review. Transparency and replicability of approach promote regulatory certainty, allow stakeholders to engage meaningfully in the regulatory process, enhance accountability for regulatory decisions, and increase investor confidence in the regulatory process. This, in turn, allows regulated businesses to access capital and to invest to deliver the services that customers value.

Stability of outcomes should be a key objective in the design of the methodology

SDP values regulatory certainty highly. This facilitates long-term planning and allows businesses to invest with confidence, when it is efficient and prudent to do so.

IPART concluded in its 2018 WACC methodology the following:[1]

[1] IPART WACC methodology decision, p. 61.

We are mindful of the estimation difficulties noted by SDP, and agree with SDP and Sydney Water's suggestions only to change the equity beta estimate if there is sufficient evidence that it would improve the accuracy of the WACC estimate

SDP continues to support the view that IPART should only depart from its current estimate of beta of 0.7 if there is compelling evidence to do so, as this would promote regulatory certainty and predictability. SDP considers that when undertaking any review of its beta allowance, IPART should view the current estimate of beta as the default starting point.

The primary evidence that IPART is likely to rely on when deciding whether it should move away from its current estimate of beta is statistical estimates of beta of the sort presented in IPART's 1 April factsheet.[2]

However, accurate beta estimation is a challenging task. Beta estimates can be subject to significant measurement error and statistical 'noise'. As such, in SDP's view, it is important that any methodology adopted by IPART should promote stability and robustness of estimates and minimise random statistical noise—to ensure that any decision to depart from the prevailing beta estimate is driven by reliable evidence rather than measurement error.

Furthermore, companies' exposure to systematic risk (which is measured by beta) typically changes very slowly over time, since the fundamental risk characteristics of companies are generally stable. Therefore, any methodology that produces highly variable beta estimates over time should be viewed with caution and scepticism. Conversely, any approach that promotes stability in estimates and minimises statistical noise is likely to produce estimates that more reliably reflect the true systematic risk of the businesses that IPART regulates.

For these reasons, SDP submits that IPART should seek an approach that promotes stability of estimates over time—because such an approach is likely to produce more reliable estimates, and because such an approach would provide greater regulatory certainty to all stakeholders.

SDP recommends a small number of important areas for improvement

SDP has engaged Frontier Economics to review IPART's proposed beta estimation methodology, and to identify any areas for improvements to IPART's approach. Frontier Economics' findings and recommendations are set out in the Attachment to this submission, in a report entitled: *Review of IPART's proposed beta estimation approach.*

Frontier Economics recommends a small number of important improvements to IPART's methodology that relate to:

- Enhancement of the transparency and replicability of IPART's approach;
- Promotion of stability and statistical reliability of estimates; and
- The calculation methodology.

SDP supports all the recommendations made by Frontier Economics.

SDP considers that the changes proposed by Frontier Economics are incremental improvements to IPART's proposed approach that would potentially enhance the quality of estimates—and regulatory outcomes. The recommendations made by Frontier Economics would not require fundamental changes to IPART's proposed approach.

[2] IPART, Estimating Equity Beta - factsheet, 1 April 2019.

SDP looks forward to working constructively with IPART during its review of its methodology for estimating equity beta.

SDP would be pleased to engage with IPART further, should you wish to discuss or clarify any aspect of our proposal.

Please direct any correspondence regarding our submission to Justin De Lorenzo – Chief Financial Officer.

Yours sincerely,

[redacted]

Keith Davies
Chief Executive Officer
Sydney Desalination Plant

Attachment – Frontier Economics report
Review of proposed beta estimation approach

frontier economics

3 JULY 2019

REVIEW OF IPART'S PROPOSED BETA ESTIMATION APPROACH

A REPORT PREPARED FOR SYDNEY DESALINATION PLANT

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1 INTRODUCTION

1.1 Background

On 1 April 2019 IPART published a factsheet that set out a proposed methodology for estimating the equity beta (a key input into IPART's WACC calculation) and invited stakeholders to comment on that proposed methodology. Sydney Desalination Plant (SDP) has asked Frontier Economics to review IPART's proposed methodology and to recommend any areas for improvement that we identify.

In undertaking this analysis, we have reviewed:

- IPART's beta methodology factsheet;[1] and
- Estimation R code and associated files published by IPART as part of the consultation process.

1.2 Authors of this report

This report has been prepared by Professor Stephen Gray, Dinesh Kumareswaran and Dr. James Key.

Prof. Stephen Gray. Stephen joined Frontier Economics as a Director and Chairman in 2014. Stephen advises on issues relating to valuation, cost of capital, corporate financial strategy, and pricing issues. He has advised nearly all regulated businesses in Australia (across industries and jurisdictions) on rate of return matters. Stephen's work on empirical finance, asset-pricing and corporate finance has been published in leading academic and practitioner journals. At UQ Business School, Stephen teaches a range of award and executive education courses in financial management, asset valuation, and corporate finance. He has Honours degrees in Commerce and Law from The University of Queensland and a PhD in Financial Economics from Stanford University. He has received a number of academic awards including the Prime Minister's Award for University Teacher of the Year in the Economics and Business field in 2002.

Dinesh Kumareswaran. Dinesh has advised clients (regulators and businesses) on regulatory finance issues in Australia, the UK, France, Austria, the Netherlands, the Caribbean, Israel, South Africa and New Zealand. He has experience in cost of capital analyses across a host of industries including nuclear power generation assets, electricity lines companies, gas networks and petroleum pipeline businesses, telecommunications networks, water businesses, and rail and ports infrastructure. Between 2010 and 2012, Dinesh lectured a MSc course in regulatory finance at the Imperial College Business School, London. Dinesh has been awarded masters and honours degrees in economics from Victoria University of Wellington.

Dr. James Key. James specialises in the analysis of quantitative data and in the application of econometrics and statistical techniques. Formerly an Assistant Professor at the University of Western Australia, since joining Frontier Economics, James has assisted clients by applying econometrics to issues relating to mergers/acquisitions, telecommunications, and energy markets. James has also worked on a number of projects incorporating WACC parameters and regulation, both from the perspective of measurement of key parameters, and also the application of building block models. James assisted Electricity Networks Australia with the 2018 Rate of Return Guideline review, focusing on estimation of equity beta parameters through comparator firms. James also recently advised an

[1] IPART, Estimating equity beta – factsheet, 1 April 2019.

electricity distribution network in Great Britain (Northern Powergrid) on the robustness of alternative econometric methods to estimate beta considered by the British energy regulator, Ofgem. James has investigated other WACC parameters through the course of numerous projects, including those related to gamma, market risk premium and debt raising costs. James holds a PhD in Economics from the Pennsylvania State University. He has published several academic papers and has served as a referee for various economic publications.

1.3 Key findings and recommendations

The following Table summarises our key recommendations.

Table 1: Summary of recommendations

RECOMMENDATIONS	KEY BENEFITS
Recommendation 1: Transparency and replicability of process Clarity could be improved for certain aspects of IPART's proposed approach. IPART has not to date published sufficient information to enable stakeholders to replicate its estimation process. IPART could make its estimation process more transparent, ensure that all its steps are documented fully, and make explicit any judgments/qualitative steps that are made.	Greater clarity over estimation process and regulatory certainty.
Recommendation 2: Expansion of water sector comparators IPART's current approach is to use the Thomson Reuters system to identify comparators. IPART may be able to add to this sample any comparators identified by other classification systems (e.g., Bloomberg Industry Classification Standard (BICS) – Water Utilities; Global Industry Classification Standard (GICS) – Water Supply Networks; Standard Industry Classification Standard (SICS) – Water Supply; FTSE ICB – Water). Further manual checking could be performed to remove firms that may have been misclassified. The benefit of expanding the sample in this way is to enhance the stability of estimates over time and improve the statistical precision of the estimates. IPART could review its comparator sample from time to time (e.g., at each price review) to satisfy itself and stakeholders that the sample is up-to-date and fit-for-purpose.	Improved stability and reduced statistical noise in estimates over time.
Recommendation 3: Clarity over reasons for exclusion of Chinese comparators IPART has excluded Chinese firms from its comparator sample. The Chinese stock market is considerably more liquid than the Australian stock market, and any illiquidity in the Chinese government bond market has no material impact on beta estimates. There are 12 Chinese firms within IPART's original long list of 228 Thomson Reuters comparators that pass all of IPART's data/liquidity filters. On IPART's own tests, there appears to be no reason to exclude these firms. We recommend that IPART explain why it has chosen to exclude these firms.	Greater clarity over estimation process and regulatory certainty.
Recommendation 4: Data availability threshold for inclusion of comparators We recommend that IPART should only permit comparators that have a minimum of 60 months (rather than 36 months) of valid historical data. Doing so would improve the stability of estimates.	Improved stability and reduced statistical noise in estimates over time.

RECOMMENDATIONS	KEY BENEFITS
Recommendation 5: Estimation period We recommend that IPART should use an estimation period of at least 15 years for firms that have that length of historical data. We note that IPART currently uses 16 years of data, which we consider is reasonable. Shortening the estimation window is likely to introduce volatility in estimates over time and reduces the number of returns observations available to inform estimates.	Improved stability and reduced statistical noise in estimates over time.
Recommendation 6: Frequency of returns We recommend that IPART should use weekly returns rather than monthly returns to estimate betas. This would be computationally simpler and provide a larger number of returns observations—so the resulting estimates would be more statistically robust. If IPART is minded to continue using monthly returns data, it should use weekly returns in addition to monthly returns (e.g., by averaging the estimates derived using these two returns frequencies).	Simplicity, improved stability and reduced statistical noise in estimates over time.
Recommendation 7: Reference days If deriving estimates using weekly or monthly returns, we recommend that the overall estimate should be obtained by averaging over estimates derived using all possible reference days—to minimise sampling error that adds statistical noise to estimates.	Improved stability and reduced statistical noise in estimates over time.
Recommendation 8: The de-levering/re-levering process We have identified three aspects of the approach that IPART uses for de-levering and re-levering betas that should be corrected: (1) when the implicit assumption is that benchmark gearing will remain constant over time, corporate finance theory and practice indicates that a tax term should not be used in the re-levering process; (2) corporate finance theory and practice requires that the market value (rather than book value) of equity should be used when calculating gearing; and (3) best practice is to measure average gearing over the estimation period, rather than using gearing measured only at the end of the estimation period.	Ensure the estimation process is consistent with corporate finance theory and practice.
Recommendation 9: Considerations that IPART should have regard to when choosing whether to depart from the current estimate We recommend that IPART should factor the following considerations into its final decision on whether to depart from its prevailing beta estimate: • A decision rule that states IPART should only *consider* departure from the current estimate if IPART's prevailing estimate lies beyond 1 standard deviation either side of the sample mean of beta estimates across the comparator sample. This is akin to the decision rule IPART applies when using its uncertainty index to decide whether it should depart from its default approach of applying equal weights to 'current' and 'long-term' WACC estimates. This should not be a mechanistic rule but, rather, should be informed by the other considerations below. That is, only if the one standard deviation threshold is breached, would IPART *consider* a change to its allowed beta. • The submissions made by stakeholders and their preferences for stability in the beta allowance. • The weight and persistence of statistical evidence over time. That is, IPART should only be more inclined to depart from its prevailing beta estimate if there is persistent evidence over a long timeframe to do so.	Predictability, clarity and regulatory certainty for stakeholders.

Source: Frontier Economics

1.4 Structure of this report

This report is organised as follows:

- Section 2 presents a brief overview of the beta estimation approach proposed by IPART;
- Section 3 outlines two key principles that we consider should underpin IPART's beta estimation process;
- Section 4 discusses certain aspects of IPART's comparator selection process;
- Section 5 discusses key aspects of the estimation stage of IPART's methodology; and
- Section 6 discusses IPART's proposed post-estimation rules and recommends that IPART set out the process it will follow when determining a final beta estimate.

2 OVERVIEW OF IPART APPROACH

IPART's factsheet describes its equity beta estimation approach in three distinct stages (summarised in **Table 2** below):

1. **Pre-estimation screening rules** – these are rules designed to select a sample of candidate comparator firms with risk characteristics similar to the firms regulated by IPART;
2. **Liquidity filters and data quality rules** – these are rules designed to filter out observations and candidate comparators that are illiquid or that have insufficient data; and
3. **Post-estimation screening rules** – these are rules designed to assess whether the betas estimated using the sample of comparators that pass the pre-estimation, liquidity and data quality filters are robust and reasonable.

Table 2: Three stages of IPART's estimation process

Criteria
Pre-estimation screening rules
Industry
What industry, or industries, should be used to identify proxy firms?
Firm Characteristics
Does the firm operate in the nominated industry?
Does the firm undertake their activities in capital markets that are sufficiently similar to Australia?
Does the firm have a similar operating profile to the benchmark efficient firm?
Market
Is the sovereign's government bond market sufficiently deep and liquid?
Is the sovereign's equity market sufficiently deep and liquid?
Is the firm's international headquarters consistent with their actual operating market?
Operating Profile
Is firm revenue predominately in the nominated industry?
Liquidity filters & data quality
Remove a monthly observation for a given stock if there is less than 10 days of trading data available
Remove a monthly observation for a given stock if the calculated Amihud measure exceeds the threshold of 25.
Remove firm if it has less than 36 months of trading data available.
Post-estimation screening rules
Is the sample size sufficiently large?
Are the estimates consistent (no extreme outliers)?
Are there obvious biases in the results?

Source: IPART factsheet, Table 1

We note that IPART's factsheet provides little detail on the actual estimation process IPART proposes to use. There are many modelling choices that need to be made at the estimation stage, and the final

estimates can be highly sensitive to the particular choices made. Therefore, we consider that it is important that each of these modelling choices be selected carefully and set out transparently so that stakeholders can understand fully the approach followed by IPART. Section 5 of this report deals with our recommendations on the particular modelling choices IPART could adopt at the estimation stage.

3 KEY PRINCIPLES THAT SHOULD UNDERPIN THE APPROACH

3.1 Transparency and replicability

IPART states in its factsheet that it has automated the process for estimating beta to increase replicability of its results by stakeholders:[2]

> *We have automated the process for estimating the equity beta using an R script, which obtains financial market data directly through a Datastream API. The advantage of this approach is that it increases the replicability of our process.*

We agree that it is desirable to make the estimation process as transparent and replicable as possible so that stakeholders are able to anticipate IPART's equity beta decisions. This enhances regulatory certainty and predictability.

However, our investigations suggest that it is not possible for a stakeholder to easily understand the R-code published by IPART, or to use that code to replicate the beta estimate of 0.741 presented in the factsheet. This is because some transformations of the raw data used in the estimation process appear to be performed elsewhere (i.e., in some source outside the R-code) and/or because there appear to be some inconsistencies in the coding. For example:

- There is no explicit algorithm in the R-code for selecting the countries from which comparators are to be drawn. This choice appears to be made outside the model in a way that is not fully documented. The results of this external selection are then imported into the R-software.
- The R-code appears to de-lever and re-lever betas using country-specific tax rates. By way of example, in the case of a comparator from the UK, the code appears to de-lever using the UK corporate tax rate, and the re-lever using the UK corporate tax rate. This approach would be inconsistent with the objective of using overseas comparators to obtain re-levered equity beta estimates for a benchmark *Australian* company. By contrast, the factsheet appears to re-lever using the Australian tax rate of 30%.[3] For the avoidance of doubt, and for the reasons explained later in section 5.4.3, we recommend that IPART use de-levering and re-levering formulas that contain no tax rate term. We point this issue out here as it is an example of an apparent inconsistency in the approach documented in IPART's R-code and the approach reflected in its factsheet. Such inconsistencies have the potential to create confusion for stakeholders over IPART's approach.
- The R-code suggests that IPART is regressing stock excess returns on total market returns (rather than market excess returns). This would be an inconsistency. In principle betas should be estimated

[2] IPART factsheet, p. 8.

[3] We deduce this by comparing the un-levered and re-levered beta estimates presented in Figure 3 of the factsheet.

using excess stock returns *and* excess market returns.[4] It is not possible to verify whether the IPART calculations have in fact embedded this inconsistency as IPART has not published the calculations it has performed to generate market returns or excess returns. These calculations appear to have been performed elsewhere, and the resulting data imported into the R-software using the code.

We found that beta estimates similar to those presented in Figure 3 of the factsheet may be obtained only through some trial and error (i.e., starting with the IPART code and making a number of changes to the estimation process). This means that IPART's estimation approach is not easily replicable, even if a stakeholder were to have access to the same raw data used by IPART.

In view of IPART's stated goal of ensuring that stakeholders can replicate its estimates, we recommend that IPART should make its estimation process fully transparent by ensuring that all its calculations are performed in one place (e.g., that the R-code is self-contained and standalone), all its steps are documented fully and that any judgments or qualitative steps (particularly in the pre-estimation and estimation stages) are made explicit.

3.2 Stability over time

In its 2018 WACC methodology decision, IPART recognised that stakeholders value regulatory certainty over time and therefore decided that, whilst it would review its beta estimates from time to time, it would change its estimate only when there is sufficient evidence to do so:

> *We acknowledge stakeholders' concerns that the equity beta should only be changed in response to significant evidence, in order to maintain certainty. Therefore we have decided to review the equity beta at each price review (currently every 4-5 years), but only change it when there is sufficient evidence that our existing estimate is no longer appropriate.*[5]

This is a sensible approach, in our view. The *true* level of systematic risk exposure of regulated businesses is likely to be fairly stable over time (since the fundamental risk characteristics of firms, particularly the types of firms regulated by IPART, generally change slowly). However, it is not possible to observe the true level of systematic risk—it is only possible to estimate it, typically with material statistical imprecision. Therefore, large changes in beta *estimates* over time are more likely to be due to statistical noise and sampling error than genuine changes in systematic risk.

As such, we recommend that IPART adopt a beta estimation methodology that is likely to minimise, rather than amplify, statistical noise in beta estimates. Such a methodology will tend to produce relatively stable estimates over time, and are more likely to mirror the true systematic risk exposure of regulated businesses. In the remainder of this report, we make a number of recommendations aimed at improving the statistical reliability and stability of beta estimates over time.

[4] Many practitioners regress total stock returns on total market returns. Such an approach, whilst theoretically less consistent with the CAPM, tends to produce very similar results to estimates derived using only excess returns. The key point is that there should be consistency between stock and market returns—it is not correct to mix-and-match the use of total and excess returns.

[5] IPART, Review of our WACC method – Final report, February 2018, p. 61.

4 COMPARATOR SELECTION

The first step in IPART's estimation process is to identify a long list of candidate comparator firms. In the factsheet, IPART obtains an initial sample of 228 possible comparators, which are then filtered down to a final list of 35 comparators using various pre-estimation screening rules, and data quality and liquidity filters. In this section we discuss certain aspects of these screening rules and filters that could either be improved or clarified.

4.1 Pre-estimation screening rules

4.1.1 Expansion of comparator sample

In the factsheet, IPART identifies its initial sample of 228 potential comparators in the water industry using the Thomson Reuters Business Classification scheme. However, IPART notes that one area for future development would be to use different industry classification schemes to increase the sample size of comparator firms. Specifically, IPART noted the potential to use the Global Industry Classification Standard (GICS) and the Bloomberg Industry Classification Standard (BICS) to increase the sample size. It should be noted that the emphasis is on expanding the sample size rather than refining it, for example by only using firms that appear in all schemes.

There are likely to be a number of benefits to increasing the sample of relevant comparators, including:

- Reduced impact of statistical noise, such that the sample median beta may be closer to the true beta;
- More stable estimates over time due to a larger number of observations, which would reduce statistical noise;
- More stable estimates over time due to less sensitivity to individual firms being added or removed from sample (e.g., due to listings, de-listings or takeovers/mergers).

However, it is possible that expanding the sample set could lower the reliability of beta estimates if the firms added to the sample are inferior comparators and therefore are less informative than the original firms in the sample. Therefore, it is important to follow a careful and systematic process for expanding the comparator set.

We recommend that IPART should seek to expand the comparator sample using other classification systems, using the following process:

1. Starting with the initial sample of 228 firms identified using Thomson Reuters, add any unique firms identified using other classification systems. We note that GICS and BICS are just two of a number of alternative industry classification schemes available, which may be used to identify additional water sector comparators. Other classification schemes include the Standard Industrial Classification (SIC) and FTSE Industry Classification Benchmark (ICB).
2. Apply pre-selection screening rules and liquidity and data quality filters to identify a short list of candidate comparators.
3. Undertake further manual checking of the comparator short list to remove any firms that may have been misclassified as water businesses. This manual checking could involve qualitative assessments (such as reviewing the company descriptions provided by data services such as Thomson Reuters and Bloomberg, and in company annual reports and securities filings) and qualitative measures (such as examining the revenue shares related to water activities, if these data are available).

Appendix A of this report demonstrates how this process could be implemented in practice. For the avoidance of doubt, we do not suggest that the additional companies identified in Appendix A necessarily ought to be added to IPART's comparator sample. Further research on those firms would need to be performed before such a step is taken. We present the analysis in Appendix A as an illustration of the process that IPART might wish to follow, if it sought to expand its existing sample.

It is unlikely that the process for expanding the comparator sample described above can be automated fully. To the extent that any qualitative analysis or judgment is relied upon (e.g., to determine whether candidate comparators ought to be classified as belonging to the water sector), we recommend that IPART set this out fully so stakeholders can understand the basis on which the final comparator set has been selected.

We also suggest that IPART could review its comparator sample from time to time (e.g., at each price review) to satisfy itself and stakeholders that the sample is up-to-date and fit-for-purpose.

4.1.2 Exclusion of Chinese firms

One of the pre-estimation screening tests IPART proposes is to consider the comparability of overseas firms. In this regard, IPART states that it considers three key questions:[6]

1. Is the sovereign's government bond market sufficiently deep and liquid?
2. Is the sovereign's equity market sufficiently deep and liquid?
3. Is the firm's international headquarters consistent with their actual operating market?

IPART does not explain or define what would constitute government bond or equity markets that are "sufficiently deep and liquid." For example, it is unclear whether IPART proposes to assess the depth and liquidity of overseas markets using qualitative considerations or quantitative measures. Our investigation of the R-code and accompanying files published by IPART identified no formal rule(s) for evaluating these questions quantitatively. We recommend that IPART explain more clearly how it intends to apply its market tests and, in particular, how it will ensure that the test is applied consistently from one market to the next.

IPART goes on to state that:[7]

> *The current sample excludes companies that trade on the Chinese, Russian and a selection of African stock exchanges on the basis they exhibit sufficiently different sovereign characteristics and may bias the result.*

It is unclear exactly why the Chinese, Russian and African markets are singled out for exclusion, or in what respects these markets "exhibit sufficiently different sovereign characteristics." We surmise that IPART has sought to apply its market tests, and the result of that exercise is to exclude any Chinese, Russian and African stocks from the comparator sample.

We therefore investigated whether application of the market test, as set out by IPART in the factsheet, ought to result in the exclusion of comparators originating from the jurisdictions identified by IPART. For

[6] IPART factsheet, p. 4.

[7] IPART factsheet, p. 5.

the purposes of our analysis, we focused our analysis on the Chinese comparators. This is because, from IPART's original sample of 228 potential comparators, there are 12 companies that are listed and headquartered in China that Thomson Reuters identifies as belonging to the water sector, which pass all of IPART's data quality and liquidity filters. These companies are identified in **Table 3** below. We found no Russian or African companies in IPART's sample of 228 water companies that pass IPART's data quality and liquidity filters.

Table 3: Water companies headquartered in China that pass IPART's data quality and liquidity tests

THOMSON REUTERS CODE	COMPANY NAME
CN:NHD	GRANDBLUE ENVM.'A'
CN:BCC	BEIJING CAPITAL 'A'
CN:GNW	GUANGXI NANNING WTW.'A'
CN:WSI	WUHAN SANZHEN IND.HLDG. 'A'
CN:JJW	JIANGSU JIANGNAN WATER 'A'
CN:WTW	JIANGXI HONGCHENG WTW. 'A'
CN:TBC	TIANJIN CAP.ENV.PROTC. GP.'A'
CN:QWR	QIANJIANG WATER RES. 'A'
CN:HBD	HEILONGJIANG INTERCHINA WT.TREAT.'A'
CN:CXI	CHENGDU XINGRONG INV.'A'
CN:CWG	CHONGQING WATER GP.'A'
CN:FOS	ZHONGSHAN PUB.UTILS.GP. 'A'

Source: Thomson Reuters

It is unclear what benchmark IPART has in mind when assessing the depth and liquidity of overseas markets. We therefore assessed the Chinese stock market relative to the Australian market, since the companies for which IPART is seeking to identify comparators are Australian water businesses.

To examine the depth and liquidity of the Chinese stock market, relative to Australia, we obtained for both markets the market value and turnover (by value) for all days between 1 January 2003 and 31 December 2018 (the estimation period used by IPART). The market indices used are the same as used by IPART, available as *spreadsheet-mkt_list.csv*.[8]

For each country, for each day, we find the ratio of turnover divided by market value, for days with positive trading value (i.e., trading days). We expressed turnover as a ratio because these stock markets differ significantly in scale. Examining turnover by market value provides a measure of depth and liquidity that is normalized according to market size. The results of our calculations are presented in **Table 4**.

[8] Available at https://www.ipart.nsw.gov.au/Home/Industries/Special-Reviews/Reviews/WACC/WACC-Methodology-2017?qDh=2

Table 4: Average market turnover as a proportion of market value

MARKET	DAILY AVERAGE OF TURNOVER/VALUE
Australia	0.00343
China	0.00575

Source: Frontier

As the Table indicates, the depth and liquidity of the Chinese stock market appears to be substantially greater than that of Australia. From this result, we conclude that lack of depth and liquidity are not grounds to exclude Chinese comparators from IPART's sample.

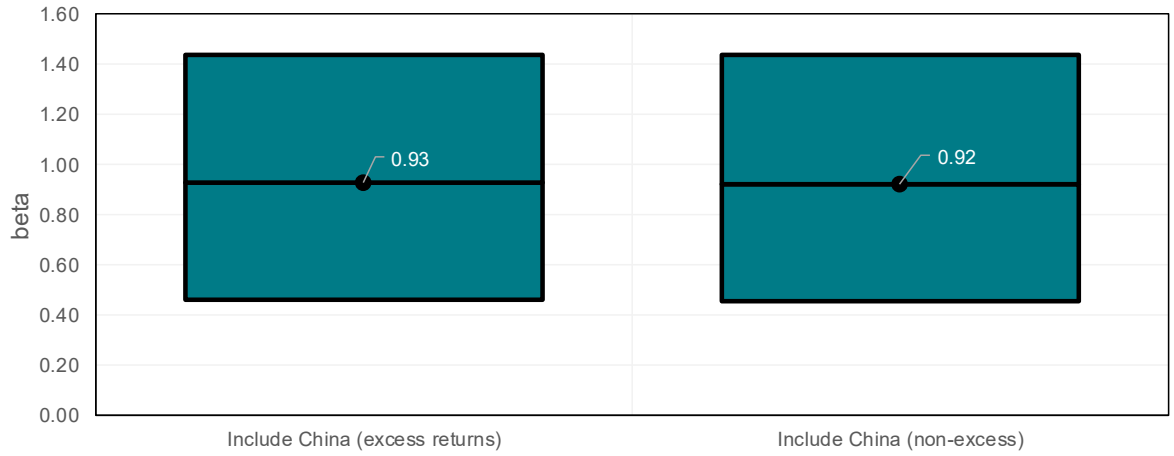
We could not find any reliable analogous data that could be used to assess the depth and liquidity of the Chinese government bond market. However, we note that the only reason to be potentially concerned about the liquidity of the government bond market, when estimating betas, is if excess returns are used to estimate betas. This is because excess returns are computed by subtracting an estimate of the risk-free rate from either the stock return or the market return, where the risk-free rate is usually estimated using government bond yields.

However, if using total returns produces similar estimates to those derived using excess returns, that would suggest that the liquidity or otherwise the government bond market has little effect on beta estimates. We therefore investigated whether there was a material difference in the median beta estimate of the comparator sample if the 12 Chinese stocks identified in **Table 3** are included in the sample and if:

- Estimates are derived using total returns; or
- Estimates are derived using excess returns.

The results presented below in **Figure 1** show that there was no discernible difference in the median re-levered beta estimate if total returns (rather than excess returns) are used.

Figure 1: Effect of liquidity of Chinese government bond market on median beta estimate of sample



Source: Frontier Economics

This suggests that any lack of depth or liquidity in the Chinese government bond markets appears to have negligible effect on beta estimates. This, in turn, implies that lack of depth or liquidity in the Chinese government bond market are not sound reasons to exclude Chinese comparators that pass all of IPART's screening tests from the sample.

Given the analysis presented above, we recommend that IPART clarify exactly why listed water companies headquartered in China that appear to pass all of IPART's data quality and liquidity tests should be excluded from its comparator sample. In particular, we recommend that IPART explain whether it considers that there are any other criteria for excluding Chinese firms.

4.2 Liquidity and data quality rules

One of the data quality rules IPART applies is to exclude from the comparator sample any companies with less than 36 months of trading data. IPART explains that:[9]

> *In our view a time series of less than three years is too short to calculate a reliable medium-run beta estimate. In many instances, a short time series will represent a newly established firm, which is likely inconsistent with our consideration of a mature benchmark efficient firm. Furthermore, short time series are more prone to measurement error, reducing the reliability of results.*

We agree with the sentiment expressed by IPART in the quote above. However, in our view even three years of data is insufficient to derive reliable beta estimates. In our experience, finance practitioners typically use at least five years of historical data to derive beta estimates. We therefore recommend that IPART apply a more stringent filtering rule by excluding any companies that have fewer than 60 months of historical data after applying liquidity filters.

Applying a more stringent rule would have two benefits:

- Firstly, increasing the minimum data requirement would reduce measurement error and improve the reliability of estimates; and
- Secondly, the median beta estimate for the sample is likely to be more stable (in part due to the reduced scope for measurement error).

[9] IPART factsheet, p. 6.

5 ESTIMATION CHOICES

As noted in section 2, the factsheet did not discuss the various modelling choices that IPART has made at the estimation stage of the process. This section discusses a number of important modelling choices—namely, the length of the estimation period, the frequency of returns data, and the way in which returns should be measured. We also identify three issues related to IPART's de-levering and re-levering betas and explain how those issues should be dealt with.

5.1 Estimation period

Our investigation of IPART's R-code indicates that IPART has used in its factsheet a 16-year historical period (2003 to 2018, inclusive) to estimate equity betas for each comparator.[10] That is, IPART has used all of the historical data on its 35 comparators (that satisfy its liquidity test) over this 16-year period to derive its beta estimates.

We agree with IPART's approach of using a relatively long estimation period. Such an approach has two key benefits:

- The resulting estimates for individual comparators are likely to be more statistically precise, since long estimation windows permit the inclusion of more data points. For instance, a 16-year period would permit the use of up to 192 monthly historical returns for a given stock. By contrast, a five-year period would permit just 60 monthly historical returns.
- As discussed in section 3 the true level of systematic risk for individual stocks tends to be fairly stable over time. Using relatively long estimation periods will tend to produce more stable estimates over time. Beta represents the average relationship between stock returns and market returns. The longer the estimation period, the greater the horizon over which this average relationship will be estimated, and the less variable the estimated relationship will be when estimates are measured periodically.

Figure 2 demonstrates the impact of shortening the estimation period. The estimation is conducted using IPART's sample of 35 comparators and our understanding of IPART's estimation methodology (based on study of the R-code and description provided in the factsheet). The first (red) bar presents the estimation outcome using the full 16-year period used by IPART. The remaining bars present the estimation outcomes for three non-overlapping five-year periods, which mimic what might occur if IPART were to re-estimate beta at each price review using just five years of historical data. Each bar represents a beta estimate range reflecting the 25th to 75th percentile of estimates, and the median estimate across the sample, for each scenario, is identified.[11]

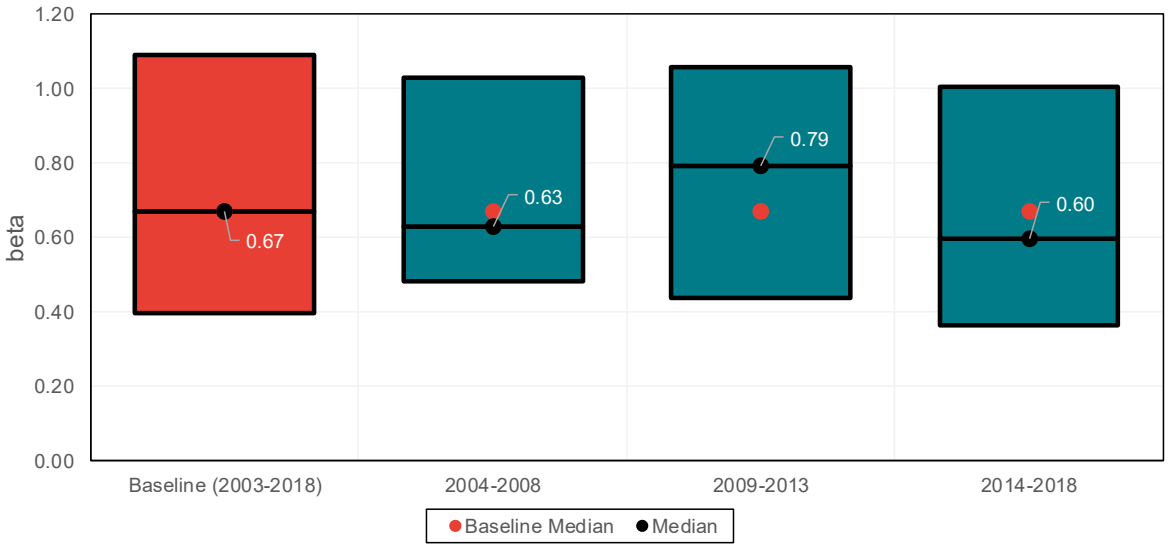
The Figure shows that the median beta estimate could be as low as 0.60 and as high as 0.79, depending on which five-year period is used in the estimation. It is noteworthy that the median estimates for each of the shorter windows are materially different from the median estimate that relates to the whole period (0.67) — notwithstanding that each of the shorter windows overlaps materially with the full period. That is, each of the shorter windows covers roughly 1/3rd of the full period. Despite this, the estimates derived

[10] The fact that IPART has used data over this particular historical period is not documented in the factsheet, but is evident only upon examination of the R-code published by IPART.

[11] Note that our baseline median estimate of 0.67 differs somewhat from the estimate of 0.741 presented in Figure 3 of the factsheet. This could be due to aspects of IPART's estimation approach that we were unable to replicate. However, the difference between our baseline estimate and the estimate presented in the factsheet is also at least partly explained by the fact that Thomson Reuters appears to have updated some of the information on some of the comparators since IPART accessed those data. The relatively minor differences between our baseline estimate and IPART's does not change the overall conclusions we draw in this report.

using the shorter windows are volatile and materially different from the estimate derived using the full 16-year period.

Figure 2: Impact of on estimates of shortening the estimation period



Source: Frontier Economics

In our view, the variability in the estimates displayed over time is likely to be largely the result of sampling and estimation error (i.e., statistical noise), rather than genuine changes in systematic risk. Hence, we recommend that IPART should not base its regulatory decisions on short-term movements in estimates over time. We recommend that IPART use an estimation period of at least 15 years to promote stability in estimates over time and to provide regulatory certainty. We consider that the 16-year period that IPART has employed in its factsheet analysis is reasonable.

5.2 Frequency of returns

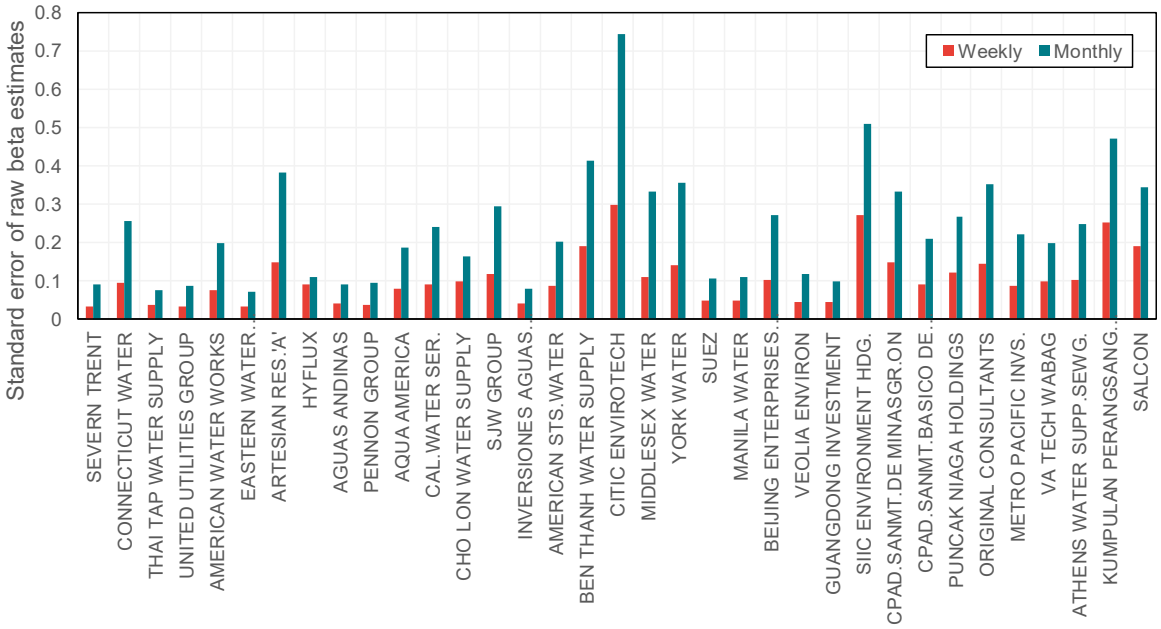
IPART's R-code shows that IPART has used monthly returns to derive the beta estimates presented in the factsheet. We note that beta estimates can also be estimated using daily and weekly returns. An important advantage of using daily and weekly returns data is that doing so permits a larger number of data points to be used in the estimation process. For instance, for a 16-year estimation period:

- Monthly returns data would permit the use of up to 192 observations for each comparator;
- Weekly returns data would permit the use of up to 832 observations for each comparator; and
- Daily returns data would permit the use of up to 3,520 observations for each comparator (assuming 220 trading days per year).

Typically, the statistical precision of estimates will improve as the number of observations within an estimation period increases. The statistical precision of a beta estimate may be measured by the standard error of the estimate. The lower the standard error, the greater the statistical precision of the estimate (all else remaining equal). **Figure 3** below compares the standard errors of the beta estimates for each of the 35 comparators in IPART's sample, estimated using weekly and monthly returns data. On average (across the sample), the standard errors of estimates derived using monthly returns are 2.3 times larger than the standard errors derived using weekly returns. That is, according to the results in

the Figure below, using weekly returns rather than monthly returns on average more than doubles the statistical precision of the beta estimates.

Figure 3: Standard errors of beta estimates derived using weekly and monthly returns



Source: Frontier Economics

Use of daily returns data would improve the statistical precision of estimates still further. However, a well-recognised problem with daily returns data is that the observed returns can be correlated over time due to 'non-trading.' Consider, for example, the case where a particular stock does not trade after say 2:00 pm on a certain day. In that case, the return on that day will be computed up to the 2:00 pm trade, which will be recorded as the closing price for the day. The measured return for the following day will be recorded from 2:00 pm the previous day through to the last trade on that day. The net effect is that two hours of return (from 2:00 pm to 4:00 pm) is shifted from one day to the next. This creates negative serial correlation in the measured returns. It is well recognised in the finance literature that this has the effect of creating a bias in beta estimates.[12] The impact of this bias is more material for daily returns than it is for weekly returns as the amount of return that is 'shifted' from one period to the next is proportionately larger when daily returns are used. Our preliminary analysis of the comparators in IPART's sample detected evidence of serial correlation in daily stock returns over the 16-year estimation period.

On the issue of returns frequency, we recommend the following:

- IPART should use weekly returns, rather than monthly returns, to estimate beta—given the benefits of improved statistical precision of estimates.
- However, if IPART is minded to retain its use of monthly returns, IPART should estimate betas using monthly and weekly returns, and then derive an overall estimate for each comparator by averaging the monthly and weekly estimates.

[12] Scholes, M. and J. Williams, 1977, Estimating betas from nonsynchronous data, *Journal of Financial Economics*, 5, 3, 309-327.

5.3 Reference days

When estimating betas using returns data of lower than daily frequency (e.g., weekly or monthly returns data), it is necessary to choose the reference day used to calculate returns (e.g., in the case of weekly data, Monday-to-Monday, Tuesday-to-Tuesday, etc.).

The resulting beta estimates can be highly sensitive to the reference days selected. The risk of estimation error due to the choice of reference day is known in the empirical finance literature as *reference day risk.* Acker and Duck (2007), who investigated the extent of reference day risk associated with five-year monthly betas for S&P500 companies using Datastream data, show that the effect of reference day risk can be very severe.[13] For example, they found that:

- the estimated beta of one stock was +2 using one reference day and -2 using another;
- between two consecutive five-year periods, the estimated beta of one stock fell by 0.93 using one reference day and rose by 3.5 using another; and
- the average difference in the beta estimate (arising from a change in the reference day used to measure returns), across all stocks in the sample, ranged between 0.70 and 0.92, depending on the five-year estimation window considered.

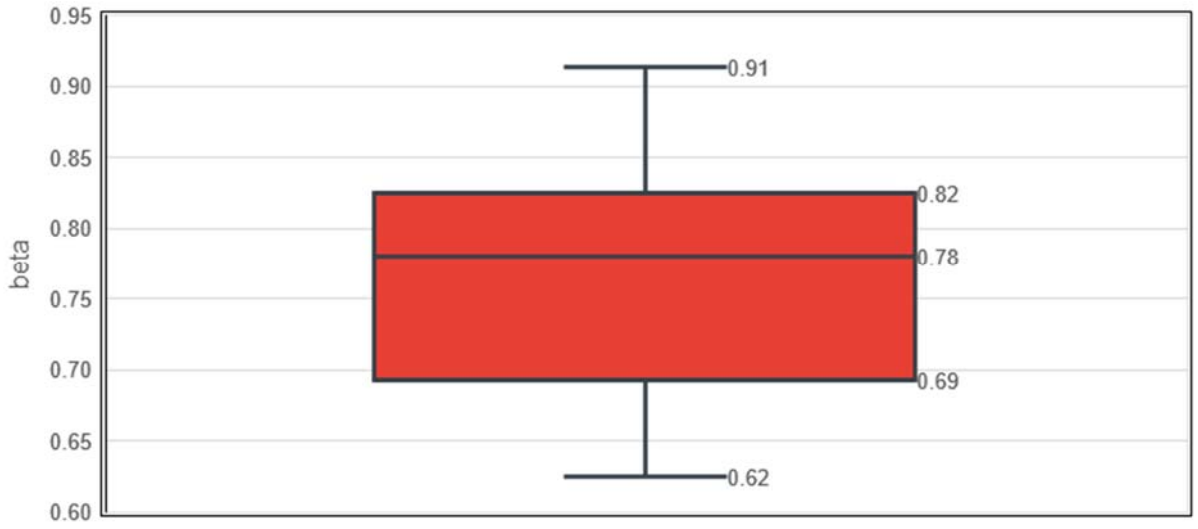
Dimitrov and Govindaraj (2007) confirm the findings of Acker and Duck using a different dataset (i.e., CRSP).[14] They found, for instance, that one stock in the sample had a monthly beta estimate of 0.38 using one reference day and 2.45 using another (a difference of +2.08), over the same estimation period. In that study, the mean difference in estimated betas (across all stocks), arising from a change in the reference day used to measure monthly returns, was +0.68, which Dimitrov and Govindaraj note is similar to the mean range found by Acker and Duck (i.e., 0.70 to 0.92).

Similar variability in estimates are evident using IPART's set of comparators. As noted above, IPART's factsheet uses monthly returns data. Examination of IPART's R-code indicates that IPART has used the last trading day of each month as the relevant reference day to measure the returns used to estimate betas. We tested empirically the effect of varying the reference day used to measure monthly returns. **Figure 4** shows the extent of variation in the median beta estimate across IPART's sample of comparators as the reference day is varied over 20 possibilities in a month.

[13] Acker, D., and N. W. Duck, 2007. "Reference-day risk and the use of monthly returns data," *Journal of Accounting, Auditing and Finance*, 22, 527–557.

[14] Dimitrov, V., and S. Govindaraj, 2007. "Reference-day risk: Observations and extensions," *Journal of Accounting, Auditing and Finance*, 22, 559–572.

Figure 4: Impact of varying monthly reference days on re-levered beta estimates



Source: Frontier Economics

This Figure shows that the median beta estimate across the same sample of firms ranged between 0.62 and 0.91, depending on which reference day was chosen. If the estimation is performed using just a single reference day (as IPART has done), then the location of the resulting beta estimate within this range would be a matter of pure chance—the estimate could have turned out as low as 0.62 or as high as 0.91, or anywhere in between – even holding constant the set of firms and the historical period. Crucially, by using just one reference day to the exclusion of all others, any information that would be contributed by utilising other available reference days would not be utilised.

Suppose that, in this instance, IPART selected a reference day that produced an estimate close to the 25th percentile of the range of possible estimates. The next time IPART repeats the estimation exercise (perhaps five years hence), the same reference day choice might produce an estimate close to the 75th percentile of the range at that time or even higher—simply due to sampling error. That is, use of a single reference day to estimate betas is likely to introduce random variation and significant volatility in estimates over time that have nothing to do with true changes in systematic risk of the underlying businesses.

A standard way to mitigate this sampling error problem is to estimate each comparator's beta as the mean of estimates derived using all possible reference days. For instance, if using weekly returns, then the estimation process for a given comparator would involve:

- deriving an estimate of beta five different reference days (Monday, Tuesday, …, Friday); and
- averaging over all five estimates to obtain a mean estimate for that comparator.

This exercise would then be repeated for each comparator.

Such a process would utilise all the information contained in the returns data for each comparator and minimise sampling error that would introduce spurious variability in estimates over time.

5.4 Ensuring that the process for de-levering and re-levering beta is consistent with corporate finance theory and best practice

When reviewing the R-code published by IPART, we identified three changes that could be made to the approach that IPART uses to de-lever and re-lever betas to ensure that the process is consistent with corporate finance theory and best practice:

1. Whereas the IPART R-code currently applies the book value of equity, corporate finance theory and best practice requires that the market value of equity should be used;
2. Whereas the IPART R-code uses gearing measured at the end of the estimation period, corporate finance theory and best practice requires that the average gearing over the estimation period should be used; and
3. The de-levering and re-levering formulas in the IPART R-code contain a tax rate term. However, IPART implicitly assumes that the gearing of the benchmark efficient entity is maintained at a constant level. Under these circumstances, corporate finance theory and best practice require that the de-levering and re-levering formulas should omit the tax rate term.

We discuss each of these issues in turn below and recommend that the estimation process should be revised.

5.4.1 Use of book value of equity rather than market value of equity

For the purposes of the re-levering calculations, IPART's R-code obtained from Thomson Reuters a variable called *TOTAL DEBT % TOTAL CAPITAL/STD*.[15] This variable is the ratio of total debt to the total capital of the comparator. Total debt is the sum of total debt and total equity. In this case, total capital used by Thomson Reuters to derive the variable *TOTAL DEBT % TOTAL CAPITAL/STD* is consistent with the sum of the book value of debt and the book value of equity. That is, the measure of gearing used by IPART in its de-levering and re-levering steps uses the book value of equity.

Corporate finance theory says that, for the purposes of measuring gearing, the market values of equity and debt ought to be used rather than the book values equity and debt. For example, Damodaran (2001) states:[16]

> *The weights assigned to equity and debt in calculating the weighted average cost of capital have to be based on market value, not book value. This is so because the cost of capital measures the cost of issuing securities—stocks as well as bonds—to finance projects, and these securities are issued at market value, not book value.*

That is, the WACC represents the market price of capital. It follows that the re-levering calculations should be based on market values rather than book values

[15] The Thomson Reuters code for this variable is *WC08221*. The variable used in the R-code to obtain this information appears to take the most recent published value of this variable; this variable may be back dated as annual reports are published.

[16] Damodaran, A. (2001), Corporate finance: Theory and practice, 2nd edition, New Jersey: John Wiley & Sons, p. 216.

Damodaran goes on to explain that the market value of equity is typically estimated as the market capitalisation of the stock:[17]

> *The market value of equity is generally the number of shares outstanding times the current stock price.*

In practice, because company debt is generally not traded in the same way equity is traded, it is difficult to establish a market value of debt. Also, book values tend to be closer to market values for corporate debt, because debt must be progressively re-issued, whereas some equity on a firm's balance sheet may have been issued more than a hundred years ago. Therefore, most practitioners use the book value of debt to estimate gearing, and as an input to the de-levering formula, alongside market capitalisation as an estimate of the market value of equity.

This approach is the standard that is accepted and applied by economic regulators as well as other practitioners. That is, the use of market value of equity is consistent with corporate finance theory and best practice.

For the reasons explained above, we recommend that IPART should use the market value of equity rather than the book value of equity when de-levering betas. The market value of equity should be estimated using the market capitalisation of the comparator firm.

5.4.2 Use of gearing measured at the end of estimation period rather than average gearing over the estimation period

When de-levering the betas presented in its factsheet, IPART appears to have used gearing measured at a point in time at the end of the estimation period (i.e., as at December 2018). By contrast, corporate finance theory and best practice is to use an average over the estimation period. This is because the estimated betas represent a measure of the *average* relationship between stock returns and market returns over the estimation period, rather than the relationship between stock returns and market returns at a specific point in time.

The appropriate measure of gearing to use when de-levering betas is the average gearing of the comparator over the estimation period. The gearing of a stock at the end of the estimation period is unlikely to be consistent with the average gearing over that period, if gearing has changed over time. Given that the estimation period used by IPART is relatively long (i.e., 16 years), it would be very surprising if the gearing of individual comparators did not vary over time.

We recommend that IPART use the average gearing measured over the estimation period, rather than a snapshot of gearing measured at the end of the regulatory period, when de-levering betas.

5.4.3 Inclusion of tax term in the de-levering and re-levering formulas

IPART's R-code shows that when de-levering betas IPART uses the following formula:[18]

[17] Damodaran, A. (2001), Corporate finance: Theory and practice, 2nd edition, New Jersey: John Wiley & Sons, p. 216.

[18] This particular formulation assumes that the systematic risk associated with debt, known as the debt beta, is zero.

$$Asset\ beta = Equity\ beta\left[1 + (1 - Tax)\frac{Debt}{Equity}\right]$$

where Tax is the corporate tax rate. This is known in the finance literature as the Hamada formula.

Symmetrically, when re-levering betas, IPART uses the following rearranged Hamada formula:

$$Equity\ beta = \frac{Asset\ beta}{1 + (1 - Tax)\frac{Debt}{Equity}}$$

However, these de-levering and re-levering formulas are appropriate only if one assumes that the firm in question maintains a constant dollar amount of debt. This is not the assumption that IPART makes. Rather, IPART assumes that the benchmark entity maintains a constant gearing ratio (that is, debt as a proportion of total capital).

Appendix B shows presents a mathematical proof that demonstrates that under such an assumption, the appropriate de-levering and re-levering formulas omit the tax term from the Hamada formulas. That is, the appropriate de-levering formula under an assumption of constant gearing is:[19]

$$Asset\ beta = Equity\ beta\left[1 + \frac{Debt}{Equity}\right]$$

This is often referred to in Australia as the Brealey-Myers de-levering formula. The analogous re-levering formula is:

$$Equity\ beta = \frac{Asset\ beta}{1 + \frac{Debt}{Equity}}$$

Given the constant gearing assumption made by IPART, we recommend that IPART adopt the Brealey-Myers formulas instead of the Hamada formulas it currently uses.

[19] Once again, this formulation assumes the debt beta is zero.

6 POST-ESTIMATION RULES

This section comments on the post-estimation rules proposed by IPART, and recommends that IPART set out clearly the considerations that will inform its overall estimate of beta.

6.1 Rules proposed by IPART

IPART proposes in its factsheet three post-estimation screening rules to decide whether it should accept its comparator sample (and, presumably the beta estimates that relate to that sample) as final. Specifically, IPART proposes to accept it comparator sample as final if:

1. The sample size is sufficiently large;
2. Estimates appear to be consistent, with no clear outliers excluded from the sample; and
3. There is no obvious bias in the results.

We comment briefly on each of these rules.

6.1.1 Sample size

We agree that sample size is an important consideration when assessing the reliability of beta estimates. As explained in section 4.1.1, there are benefits to using as large a sample of comparators as possible—principally, greater statistical precision and stability of estimates over time.

It is important to recognise that the reliability of an estimate depends on both its statistical precision and the comparability of the firms used to derive that estimate. However, there is usually a trade-off between achieving statistical precision and comparability. Generally, the larger the sample, the greater the statistical precision of estimates. However, if the size of a comparator sample is expanded beyond a certain point, the comparability of the firms within the sample may diminish. This, in turn may reduce the reliability of the resulting beta estimate, notwithstanding the improvement in precision from a purely statistical point of view.[20] Conversely, if the sample size is narrowed to permit only the most comparable firms, then the resulting sample is likely to be very small and come at the cost of greater statistical imprecision and variability in estimates over time.

Hence, when deciding on the appropriate size of the sample, IPART should strike a balance between achieving an acceptable level of statistical precision and comparability in the sample and explain how those two considerations have been weighed up. IPART has not explained how it will determine if its sample size is "sufficiently large." It would be desirable if IPART could clarify how it intends to make this determination.

[20] This is why we recommend that if IPART seeks to expand its comparator sample by considering other classification systems in addition to Thomson Reuters', some effort should be made to investigate whether any new comparators added are truly suitable water business comparators, or whether they have been inadvertently misclassified.

6.1.2 Outliers

IPART implies that the presence of outlier estimates may lead it to not accept its comparator sample. This suggests that IPART might, after the fact, consider excluding from its sample compactors that produce estimates that are seeming outliers.

In our view, IPART should not automatically reject individual comparators simply because their estimates happen to be significantly higher or lower than those of other comparators in the sample. It is possible that such firms in fact contribute some useful information that other comparators in the sample fail to provide. If that is the case, then excluding such firms from the sample would be inappropriate.

If confronted with a situation where one or more comparators produces estimates that appear out of line with other estimates in the sample, we recommend that IPART investigate those firms more closely—for example, to determine if they have been inadvertently misclassified (and therefore are not appropriate comparators after all) or if some event or change has occurred in relation to that stock that may have prompted unusual trading behaviour. We recommend that companies should be excluded from the sample only if there is sufficient evidence that the stocks characteristics or circumstances mean that it is not a suitable comparator to the benchmark entity.

If IPART decides to exclude one or more stocks from the sample, we recommend that it explain what characteristics and features of that stock (apart from the fact it has produced unusually high or low estimates) that mean that it is appropriate to remove it. The fact that a particular stock produces estimates that differ materially from that of other firms in the sample is not, in and of itself, a sufficient reason to exclude it.

6.1.3 Bias

IPART indicates that it will check if there is any "obvious bias" in the estimates, including by comparing the estimates to those obtained from data service providers such as Bloomberg or Thomson Reuters, or historical estimates by IPART and other regulators, as well as academic studies.

Our interpretation is that IPART intends to sense-check its estimates by comparing them to estimates obtained from other sources. In principle, that would be reasonable. However, when making such comparisons, it is important to take account of the quality of estimates against which IPART's estimates are being sense-checked.

For example, whilst Bloomberg and Thomson Reuters do make available beta estimates for their subscribers, the methodologies used by those providers in some areas are not transparent, and in other areas are subject to significant shortcomings (including weaknesses that our recommendations in this report seek to address). IPART recognised this in its 2018 WACC methodology decision:[21]

> *The main data sources that regulators in Australia use for equity beta estimation are Bloomberg and Thomson Reuters. These sources provide raw data (stock prices and indices for the regression analysis) as well as published beta estimates. The published equity beta estimates reflect analyst-specific methodology choices, and can vary considerably. Some of these methodology choices are not always easy to replicate. For*

[21] IPART 2018 WACC methodology decision, p. 63.

this reason, it is more common for regulators to do their own regression analysis using raw data.

In general, we would not recommend using 'off-the-shelf' estimates provided by data services such as Bloomberg and Thomson Reuters even to sense check IPART's beta estimates.

Likewise, it may be that approaches followed by other regulators are inferior to the approach used by IPART. So, the mere finding of inconsistency between IPART's estimates and those published by other regulators does not necessarily mean that IPART's estimates should be discarded or down-weighted.

6.2 Process for selecting a final estimate

The factsheet does not explain how IPART intends to use the results from its beta estimation work to determine the final beta estimate that will be used to set the WACC allowance. In our view, it would aid regulatory certainty and predictability if IPART could set out clearly the various considerations that will inform its final estimate.

These considerations might include the following:

- IPART's 2018 WACC methodology decision concluded that it would depart from the prevailing estimate of 0.7 only if there is sufficient evidence to do so. This implies that the starting point for any redetermination of beta should be the present estimate.
- IPART could adopt a decision rule (akin to its decision rule involving examination of its uncertainty index when deciding whether to depart from its default weighting of its 'current' and 'long-term' WACC estimates). For example, the rule might require that IPART not consider departure from an estimate of 0.7 unless the current estimate of 0.7 sits either 1 standard deviation above or below the sample mean of beta estimates across its comparator sample. If the prevailing estimate does fall outside these bounds, then the decision about whether to revise its beta estimate should be informed by the other considerations below.
- IPART should have regard to submissions made by stakeholders whenever it consults on revising its beta estimates. For example, NSW water businesses might put a premium on regulatory stability—in which case, the businesses may seek that IPART maintain its existing beta estimate, even if the prevailing statistical evidence suggests a departure from that estimate could be supported.
- IPART should have regard to the persistence of statistical evidence over time. For example, IPART might (for the sake of continuity and stability) maintain its existing estimate of 0.7, notwithstanding statistical evidence at the time that suggests, for example, that an increase in IPART's estimate would be warranted. If IPART repeats the analysis five years hence and finds again that the empirical evidence suggests that beta is materially higher than 0.7, then the fact that the evidence for an increase has persisted should incline IPART towards revising its beta estimate up. If, on the other hand, the evidence suggests that the estimates have declined again, then that may suggest maintaining the present estimate of 0.7 is the appropriate course (since the changes over time might be due to statistical noise and estimation error, rather than true shifts in systematic risk).

We recommend that IPART take all of these considerations into account before making a final decision on beta—and, in doing so, explain clearly its reasons for its final estimate.

A IMPLEMENTATION OF A PROCESS FOR EXPANDING COMPARATOR SAMPLE

This Appendix demonstrates how IPART could expand its sample of comparators.

We commence with the initial list of 228 comparators identified by IPART using Thomson Reuters, and add any unique firms identified in the GICS, BICS, SIC and ICB comparator sets.

We use International Securities Identification Numbers (ISINs) to identify unique stocks. In some rare instances, it is possible that duplicate ISINs can arise. Removing any such duplicates, we obtain a set of 419 comparators. We then apply the post-estimation screening rules and liquidity and data filters described by IPART in the factsheet,[22] with two key differences. For the reasons explained in the main body of this report:

- We require 60 months of valid data for inclusion in the final sample; and
- We repeat the estimation exercise over 20 possible reference days in a month, for each firm taking the mean re-levered beta for reference days that result in sufficient estimation period. Thus, each firm has 20 chances to have at least 60 valid 'months' of data.

This process results in 47 comparators, 27 of which were in the final sample of 35 comparators used by IPART in obtaining beta.[23] This means that consideration of classification systems other than Thomson Reuters identifies an additional 20 potential comparators, which are presented below in **Table 5**. We note that three of these 20 comparators were present in the initial IPART sample, and may have been dropped by IPART on the basis of conducting operations in China. However, these companies are not headquartered in China, so it is not clear that IPART ought to have excluded them.[24]

Table 5: Added comparators

NAME	MARKET
A BROWN COMPANY	Philippines
AIRPORT FACILITIES	Japan
ASIA PRECISION	Thailand
CAPITAL ENGR.NETWORK	Thailand
CHINA WATER AFFAIRS GP.	Hong Kong
CHINA WATER INDUSTRY GP.	Hong Kong
CT ENVIRONMENTAL GROUP SUSP - SUSP.01/04/19	Hong Kong
ELECTRICITY GENERATING	Thailand

[22] Removing firms located in the Russian and Chinese markets, and those in markets for which indices are not provided by IPART in the spreadsheet "mkt_list.csv", removing those firms for which Thomson Reuters returns blank "ISIN" and "INDX" fields, and applying the Amihud and trading days filters to 'months'.

[23] Eight comparators were removed from IPART's sample as a result of requiring that each comparator must have at least 60 months (rather than 36 months) of valid historical returns data for inclusion in the sample. The eight comparators removed from IPART's sample of 35 are: CPAD.SANMT.BASICO DE SAOP.ON, CPAD.SANMT.DE MINASGR.ON, SJW GROUP, ARTESIAN RES.'A', ATHENS WATER SUPP.SEWG., CITIC ENVIROTECH, SIIC ENVIRONMENT HDG. and YORK WATER.

[24] CHINA WATER AFFAIRS GP., CHINA WATER INDUSTRY GP. and EVERCHINA INTL.HOLDINGS.

NAME	MARKET
EVERCHINA INTL.HOLDINGS	Hong Kong
GLOW ENERGY	Thailand
HONG KONG AND CHINA GAS	Hong Kong
IMPD.DSRRL.ECO.DE AMLAT. DE CV	Mexico
KEPPEL INFRA UNIT	Singapore
KUO TOONG INTERNATIONAL	Taiwan
PICO HOLDINGS	United States
SAMMAKORN	Thailand
SDZ.LNG.THANH SHAREHLDG.	Vietnam
SUIDO KIKO KAISHI	Japan
YOKOTA MANUFACTURING	Japan
ZIMMITE TAIWAN	Taiwan

Source: Frontier Economics analysis

This list may be refined further by reviewing the description of activities for each company provided by Thomson Reuters and Bloomberg. For instance:

- Neither the Thomson Reuters or Bloomberg descriptions for the following companies mention water sector activities.
  - A BROWN COMPANY;
  - ASIA PRECISION;
  - CAPITAL ENGR.NETWORK;
  - ELECTRICITY GENERATING;
  - EVERCHINA INTL.HOLDINGS;
  - GLOW ENERGY; and
  - SAMMAKORN.

  It is possible that these companies have been misclassified and therefore should not be included in IPART's sample.
- KUO TOONG INTERNATIONAL, SUIDO KIKO KAISHI and YOKOTA MANUFACTURING appear to manufacture water supply equipment rather than operate as water supply utilities;
- Similarly, ZIMMITE TAIWAN is principally engaged in water treatment solution design;
- The following companies appear to be multiline utilities with some water supply operations:
  - HONG KONG AND CHINA GAS;
  - AIRPORT FACILITIES;
  - IMPD.DSRRL.ECO.DE AMLAT. DE CV;

- KEPPEL INFRA UNIT; and
- SDZ.LNG.THANH SHAREHLDG.

  Further investigation into these companies would need to be undertaken into the extent of their involvement in water sector activities to determine whether they should be included in the comparator sample.

- CHINA WATER AFFAIRS GP., CHINA WATER INDUSTRY GP., CT ENVIRONMENTAL GROUP and PICO HOLDINGS appear to be principally engaged in water supply.

B DERIVATION OF DE-LEVERING AND RE-LEVERING FORMULAS WITH CONSTANT GEARING

Setting

This Appendix contains a full derivation of formulas for the relationship between asset and equity betas for a firm with a constant leverage ratio. We show that under the assumption of constant gearing, the de-levering and re-levering formulas do not contain the tax rate term.

Consider a firm with a target leverage ratio of *L* and assume that the firm continuously adjusts its capital structure to maintain this leverage ratio at all times. That is $\frac{D_i}{V_i} = L$ for all points in time, *i*. No assumptions are made about the pattern of the firm's operating cash flows.

The effect of tax benefits on the WACC

First note that if the firm were unlevered, its value would be given by:

$$V^U = \sum_{i=1}^{N} \frac{C_i(1-\tau)}{(1+r_a)^i}, \quad (1)$$

where V^U is the value of an otherwise identical unlevered firm;

τ is the effective corporate tax rate; and

r_a is the required return on the assets of the firm, which is the same as the return required by equity holders in an otherwise identical unlevered firm.

Under the CAPM, the required return on the assets of the firm is:

$$r_a = r_f + \beta_a \, MRP, \quad (2)$$

where r_f is the risk-free rate of interest;

β_a is the asset beta or systematic risk of the firm's assets. This is the same as the equity beta for an otherwise identical unlevered firm; and

MRP is the market risk premium--the expected return on the market portfolio in excess of the risk-free rate.

The after-tax operating cash flows for an otherwise identical levered firm exceed those of the unlevered firm by the tax savings due to interest payments. Thus, the cash flows in period *i* are:

$$C_i(1-\tau) + r_d D_{i-1} \tau, \quad (3)$$

where r_d is the required return on debt; and

D_{i-1} is the value of debt at time *i - 1*.

The first component of this cash flow is identical to that of the unlevered firm, and therefore should be discounted at r_a. The second component must be discounted at a rate that reflects the risk of tax benefits. Note that at Time *i - 1* the value of debt, D_{i-1}, is known and the tax benefit at time *i*, $r_d D_{i-1} \tau$, is

a fixed multiple of the required return on debt, r_d. Thus, it is appropriate to discount the tax benefit from time *i* to time *i - 1* using r_d.

Note that we can't use r_d to discount these tax benefits right back to time 0 because the amount of debt varies over time with the cash flows of the firm. We can only use r_d to discount from time *i* to *i-1* because the tax saving at time *i* depends on the amount of debt at time *i-1*, D_{i-1}, which is only known at time *i-1*.

Now, we use induction (recursively) to determine the relationship between r_*^L and r_a. First note that at time *N*, the firm generates its last cash flow of $C_N(1-\tau)$. One period before this (at time *N - 1*, immediately *after* the cash flow at *N - 1* has been paid) the value of the unlevered firm is:

$$V_{N-1}^U = \frac{C_N(1-\tau)}{1+r_a}.$$

The value of the otherwise identical levered firm at the same time is:

$$V_{N-1}^L = \frac{C_N(1-\tau)}{1+r_a} + \frac{r_d D_{N-1}\tau}{1+r_d}.$$

Note that $D_{N-1} = L\,V_{N-1}^L$ since the firm has a constant leverage ratio of *L*. Therefore:

$$V_{N-1}^L = \frac{C_N(1-\tau)}{1+r_a} + \frac{r_d L\,V_{N-1}^L\tau}{1+r_d}.$$

So,

$$V_{N-1}^L\left[1-\frac{r_d L\tau}{1+r_d}\right] = \frac{C_N(1-\tau)}{1+r_a},$$

and,

$$V_{N-1}^L = \frac{C_N(1-\tau)}{(1+r_a)\left(1-\frac{r_d L\tau}{1+r_d}\right)}. \qquad (4)$$

Thus, when discounting from time *N* to time *N - 1*, we must use:

$$\begin{aligned}(1+r_*^L) &= (1+r_a)\left(1-\frac{r_d L\tau}{1+r_d}\right)\\ &= 1+r_a-\frac{r_d L\tau(1+r_a)}{1+r_d}.\end{aligned}$$

Consequently,

$$r_*^L = r_a - r_d L\tau\frac{1+r_a}{1+r_d}.$$

Note that at time *N - 2*, the value of the levered firm is:

$$V_{N-2}^L = \frac{C_{N-1}(1-\tau)}{1+r_a} + \frac{r_d L\,V_{N-2}^L\tau}{1+r_d} + \frac{V_{N-1}^L}{1+r_a}.$$

Now we substitute for V_{N-1}^{L} in (4):

$$V_{N-2}^{L} = \frac{C_{N-1}(1-\tau)}{1+r_a} + \frac{r_d L V_{N-2}^{L}\tau}{1+r_d} + \frac{C_N(1-\tau)}{(1+r_a)^2\left(1-\frac{r_d L\tau}{1+r_d}\right)}.$$

So,

$$V_{N-2}^{L}\left(1-\frac{r_d L\tau}{1+r_d}\right) = \frac{C_{N-1}(1-\tau)}{1+r_a} + \frac{C_N(1-\tau)}{(1+r_a)^2\left(1-\frac{r_d L\tau}{1+r_d}\right)}.$$

Also,

$$\begin{aligned} V_{N-2}^{L} &= \frac{C_{N-1}(1-\tau)}{(1+r_a)\left(1-\frac{r_d L\tau}{1+r_d}\right)} + \frac{C_N(1-\tau)}{(1+r_a)^2\left(1-\frac{r_d L\tau}{1+r_d}\right)^2} \\ &= \frac{C_{N-1}(1-\tau)}{1+r_*^L} + \frac{C_N(1-\tau)}{(1+r_*^L)^2}, \end{aligned}$$

where,

$$1+r_*^L = (1+r_a)\left(1-\frac{r_d L\tau}{1+r_d}\right).$$

We can do the same thing recursively from *N - 2* to *N - 3* and so on. In all cases, we have:

$$r_*^L = r_a - r_d L\tau\frac{1+r_a}{1+r_d}. \tag{5}$$

Note that this implies:

$$\begin{aligned} 1+r_*^L &= 1+r_a - \frac{r_d L\tau}{1+r_d}(1+r_a) \\ &= (1+r_a)\left(1-\frac{r_d L\tau}{1+r_d}\right) \\ &= \frac{(1+r_a)(1+r_d-r_d L\tau)}{1+r_d} \\ &= \frac{(1+r_a)(1+r_d(1-L\tau))}{1+r_d}. \end{aligned}$$

Constant re-balancing to the Target Leverage Ratio

Next, we note that this expression simplifies considerably if the time between each period becomes arbitrarily small. If, for example, interest compounds *m* times per year, we have the following relation:

$$\left(1+\frac{r_*^L}{m}\right)^m = \left(\frac{\left(1+\frac{r_a}{m}\right)\left(1+\frac{r_d(1-L\tau)}{m}\right)}{\left(1+\frac{r_d}{m}\right)}\right)^m.$$

Taking the limit as *m* becomes large gives:

$$\lim_{m\to\infty}\left(1+\frac{r_*^L}{m}\right)^m = \lim_{m\to\infty}\left(\frac{\left(1+\frac{r_a}{m}\right)\left(1+\frac{r_d(1-L\tau)}{m}\right)}{\left(1+\frac{r_d}{m}\right)}\right)^m,$$

which implies that:

$$e^{r_*^L} = e^{r_a+r_d(1-L\tau)-r_d} = e^{r_a-r_dL\tau}.$$

Consequently, if we assume that the firm *continuously* rebalances its capital structure to the target leverage ratio, *L*, the relationship between the cost of capital of a levered firm and an otherwise identical unlevered firm is:

$$r_*^L = r_a - r_dL\tau,$$

or,

$$r_*^L = r_a - r_d\tau\frac{D}{V}. \quad (6)$$

Classic Weighted-average Cost of Capital

The cash flow to equity at any time *N* can be written as:

$$E_N^L = C_N(1-\tau) - r_dD_{N-1} + \tau r_dD_{N-1} + (D_N - D_{N-1}) + (1-L)V_N^L.$$

That is, the equity holders receive the after-tax operating cash flow, $C_N(1-\tau)$, less the interest paid to debtholders, r_dD_{N-1}. They also receive the tax benefit on interest τr_dD_{N-1} plus any net change in the amount of debt, $D_N - D_{N-1}$. If the amount of debt financing increases $(D_N > D_{N-1})$, this additional cash is available to the equity holders and vice versa. They also receive a proportion $(1-L)$ of the present value of all future cash flows which is V_N^L at time *N*.

Substituting $D_N = LV_N^L$ yields:

$$\begin{aligned}E_N^L &= C_N(1-\tau) - r_dLV_{N-1}^L + \tau r_dLV_{N-1}^L + LV_N^L - LV_{N-1}^L + (1-L)V_N^L \\ &= C_N(1-\tau) + V_N^L - [1+r_d(1-\tau)]LV_{N-1}^L.\end{aligned}$$

Dividing all terms by the value of equity at *N - 1* gives:

$$\frac{E_N^L}{E_{N-1}^L} = \frac{C_N(1-\tau)+V_N^L}{(1-L)V_{N-1}^L} - \frac{[1+r_d(1-\tau)]LV_{N-1}^L}{(1-L)V_{N-1}^L}$$

which implies that:

$$1+r_e = \frac{1+r_*^L}{(1-L)} - [1+r_d(1-\tau)]\frac{L}{1-L},$$

because $V_{N-1}^L(1+r_*^L) = C_N(1-\tau)+V_N^L$. That is, the value of the whole firm must increase to provide a return of r_*^L over the period.

This implies that:

$$(1+r_e)(1-L) = 1+r_*^L - [1+r_d(1-\tau)]L.$$

So,

$$1+r_*^L = 1+r_e(1-L)+[1+r_d(1-\tau)]L,$$

and,

$$r_*^L = r_e(1-L)+r_d(1-\tau)L,$$

or,

$$r_*^L = r_e\frac{E}{V}+r_d(1-\tau)\frac{D}{V}, \tag{7}$$

which is the standard expression for the 'classic' definition of WACC.

Cost of Equity

Rearranging the WACC equation yields:

$$r_e = \frac{V}{E}r_*^L - r_d(1-\tau)\frac{D}{E}.$$

Recall that if the capital structure is continuously rebalanced to the target leverage ratio:

$$r_*^L = r_a - r_d\tau\frac{D}{V}.$$

So,

$$\begin{aligned} r_e &= \frac{V}{E}\left(r_a - r_d\tau\frac{D}{V}\right) - r_d(1-\tau)\frac{D}{E} \\ &= \frac{E}{E}r_a + \frac{D}{E}r_a - \frac{D}{E}r_d\tau - r_d(1-\tau)\frac{D}{E} \\ &= r_a + \frac{D}{E}r_a - \frac{D}{E}r_d\tau - \frac{D}{E}r_d + \frac{D}{E}r_d\tau. \end{aligned} \tag{8}$$

So,

$$r_e = r_a + (r_a - r_d)\frac{D}{E}.$$

Levering and Un-levering Betas

Finally, we need an expression to relate the equity beta of a levered firm to the asset beta (or equity beta of an otherwise identical unlevered firm). Combining Equations 5 and 8 yields:

$$r_*^L = r_a - r_d \tau \frac{D}{V} = r_e \frac{E}{V} + r_d (1-\tau)\frac{D}{V}.$$

Now, substituting expressions for $r_a, r_e, \text{and } r_d$ from the CAPM yields:

$$\left(r_f + \beta_a MRP\right) - \left(r_f + \beta_d MRP\right)\tau \frac{D}{V} = \left(r_f + \beta_e MRP\right)\frac{E}{V} + \left(r_f + \beta_d MRP\right)(1-\tau)\frac{D}{V}.$$

This implies that:

$$r_f\left(1-\tau\frac{D}{V}\right) + \left(\beta_a - \beta_d \tau \frac{D}{V}\right)MRP = r_f\left(\frac{E}{V} + \frac{D}{V} - \tau\frac{D}{V}\right) + \left(\beta_e \frac{E}{V} + \beta_d(1-\tau)\frac{D}{V}\right)MRP.$$

So,

$$\beta_a - \beta_d \tau \frac{D}{V} = \beta_e \frac{E}{V} + \beta_d (1-\tau)\frac{D}{V}$$

$$\beta_a = \beta_e \frac{E}{V} + \beta_d \left[\frac{D}{V} - \tau\frac{D}{V} + \tau\frac{D}{V}\right].$$

So,

$$\beta_a = \beta_e \frac{E}{V} + \beta_d \frac{D}{V}. \tag{9}$$

This implies that:

$$\beta_e = \beta_a \frac{V}{E} - \beta_d \frac{D}{V}\frac{V}{E}$$

$$\beta_e = \beta_a\left(1 + \frac{D}{E}\right) - \beta_d \frac{D}{E}.$$

So,

$$\beta_e = \beta_a + (\beta_a - \beta_d)\frac{D}{E}. \tag{10}$$

That is, when a constant leverage ratio is assumed, then the relevant de-levering and re-levering formulas contain no tax rate term.

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