Estimation of Seqwater’s productivity growth rate

A report prepared for Seqwater | 24 June 2021

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1 Introduction

1.1 Background

The Queensland Competition Authority (QCA) applies a base-step-trend approach to set Seqwater's operating expenditure (opex) allowances over a regulatory period. This involves:

- First establishing an efficient level of base year opex (in a selected base year);
- Making adjustments to that efficient base year level of opex to account for step changes in opex that are expected to occur over the regulatory period, which are not reflected in the base year level of opex; and
- Finally, trending the base year level of opex forward (accounting for expected changes in input costs, output growth and productivity) to develop a forecast of opex for each year of the forthcoming regulatory period.

In order to implement the 'trend' component of the base-step-trend approach, the QCA must make a determination on the expected rate of productivity improvement in opex over the period.

In its regulatory proposal for the 2018-21 regulatory period, Seqwater proposed a cumulative productivity growth rate of +0.2% p.a. KPMG, the QCA's adviser during that price review on the efficiency and prudency of Seqwater's expenditures, considered that the productivity growth rate proposed by Seqwater was low compared to the efficiency targets set by other regulators. However, in its final report to the QCA, KPMG recommended that, in the absence of "more sophisticated analysis of efficiency", the QCA should adopt Seqwater's proposed productivity growth rate of +0.2% p.a.

The QCA accepted KPMG's recommendation and noted KPMG's advice that the QCA might "consider undertaking further analysis before the next review using techniques such as total factor productivity, stochastic frontier or data envelopment analysis."[1]

1.2 Our instructions

We have been asked by Seqwater to develop an appropriate estimate of the productivity growth rate for application in the QCA's base-step-trend framework for setting opex allowances for its next regulatory submission. Seqwater has asked us to have regard to the following, where feasible and appropriate, when developing our estimate of an appropriate productivity growth rate:

- the techniques suggested by KPMG in its advice to the QCA; and
- recent regulatory precedent.

1.3 Key findings

In this report, we have:

[1] QCA, Seqwater Bulk Water Price Review 2018–21, Final Report, March 2018, p. 31.

- Considered the data available for developing empirical estimates of an appropriate productivity growth rate. These data include:
  - Information collected directly from Seqwater; and
  - Data compiled from the National Performance Review (NPR) dataset.

  We use data collected from Seqwater to derive Seqwater-specific estimates of the productivity growth rate. We concluded that the NPR data are not sufficiently reliable to derive robust estimates of the productivity growth rate for bulk water suppliers. However, the NPR data are sufficiently reliable and complete to derive productivity growth rate estimates for urban water distribution businesses (i.e., businesses in a closely-related industry to Seqwater's).

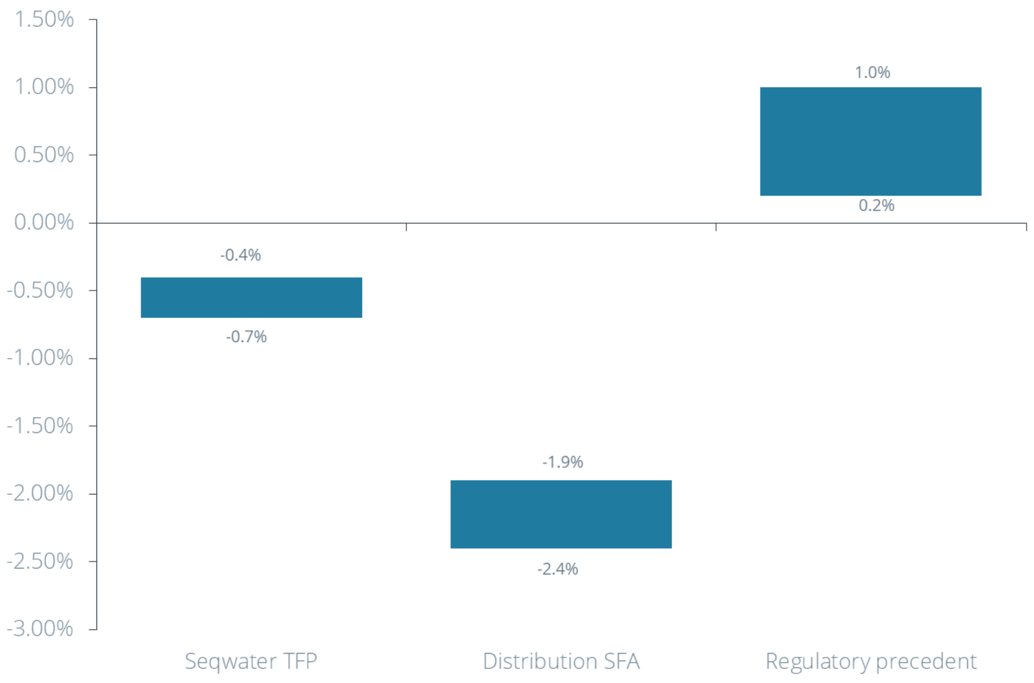
- Considered the techniques that are feasible for developing estimates of the productivity growth rate, including:
  - Total Factor Productivity (TFP) analysis;
  - Stochastic Frontier Analysis (SFA); and
  - Data Envelopment Analysis (DEA).

  In this report, we use TFP analysis to derive productivity growth rate estimates for Seqwater and SFA to derive productivity growth rate estimates for water distribution businesses of similar scale to Seqwater. We conclude that there are insufficient data to estimate reliably the productivity growth rate for Seqwater or water distribution businesses using DEA.

- Considered the productivity growth rates applied in several regulatory decisions relating to water businesses between 2017 and 2020.

The estimates of the productivity growth rate using these different methods are summarised in **Figure 1** below.

Figure 1: Summary of annual productivity growth rate estimates from different sources



Source: Frontier Economics

Given this evidence, we consider that it would be reasonable for the QCA to apply an annual cumulative productivity growth rate (reflecting frontier shift efficiency) of no higher than +0.2% p.a.

We note that this productivity growth rate would be consistent with the productivity growth rate applied by the QCA to:

- Seqwater when setting its bulk water charges over the 2018-21 regulatory period; and
- Seqwater and Sunwater when setting prices relating to the supply of water for rural irrigation services.

1.4 Structure of this report

The remainder of this report is organised as follows:

- Section 2 provides an overview of the methods and approaches available for estimating the productivity growth rate, and the data available to us to undertake this task;
- Section 3 presents our estimates of the productivity growth rate for Seqwater using data obtained directly from Seqwater;
- Section 4 presents estimates of the productivity growth rate for major bulk water suppliers in Australia derived using the NPR dataset. We conclude that these estimates are not sufficiently reliable to inform an estimate of the productivity growth rate for Seqwater, due to severe limitations in the NPR data relating to bulk water suppliers;
- Section 5 presents estimates of the productivity growth rate for Australian water distribution businesses of a similar scale to Seqwater;
- Section 6 surveys and interprets the productivity growth rates applied in a sample of recent regulatory decisions; and
- Section 7 presents our overall conclusions, given the evidence compiled in this report, and provides our recommended productivity growth rate for Seqwater.

2 Methods for estimating the productivity growth rate

2.1 Frontier shift versus catch-up

As explained in section 1, when applying a base-step-trend framework for determining the opex allowance for a regulatory period, the QCA makes a determination on efficiency targets for the regulated business. The efficiency target is often broken down into two separate components:

- A shift in the industry production frontier due to changes in technology, input costs, regulatory requirements and other cost drivers that affect all businesses in the industry. This 'frontier shift' is referred to as the productivity growth rate or "continuing efficiency".
- Catch-up in efficiency, which refers to the improvements in efficiency that an inefficient business is expected to make to catch up to businesses on the efficient production frontier.

The QCA has itself recognised this distinction. For example, in its recent decision for the Gladstone Area Water Board, the QCA explained that:[2]

> *Regulators typically apply two types of efficiency adjustments to controllable opex:*
>
> - *a catch-up efficiency—a firm-specific target to move a business closer to the efficient frontier (typically measured as the best performing comparable businesses)*
> - *a continuing efficiency—an industry-wide target reflecting the movement of the efficient frontier over time as productivity improves, for example, due to innovation.*

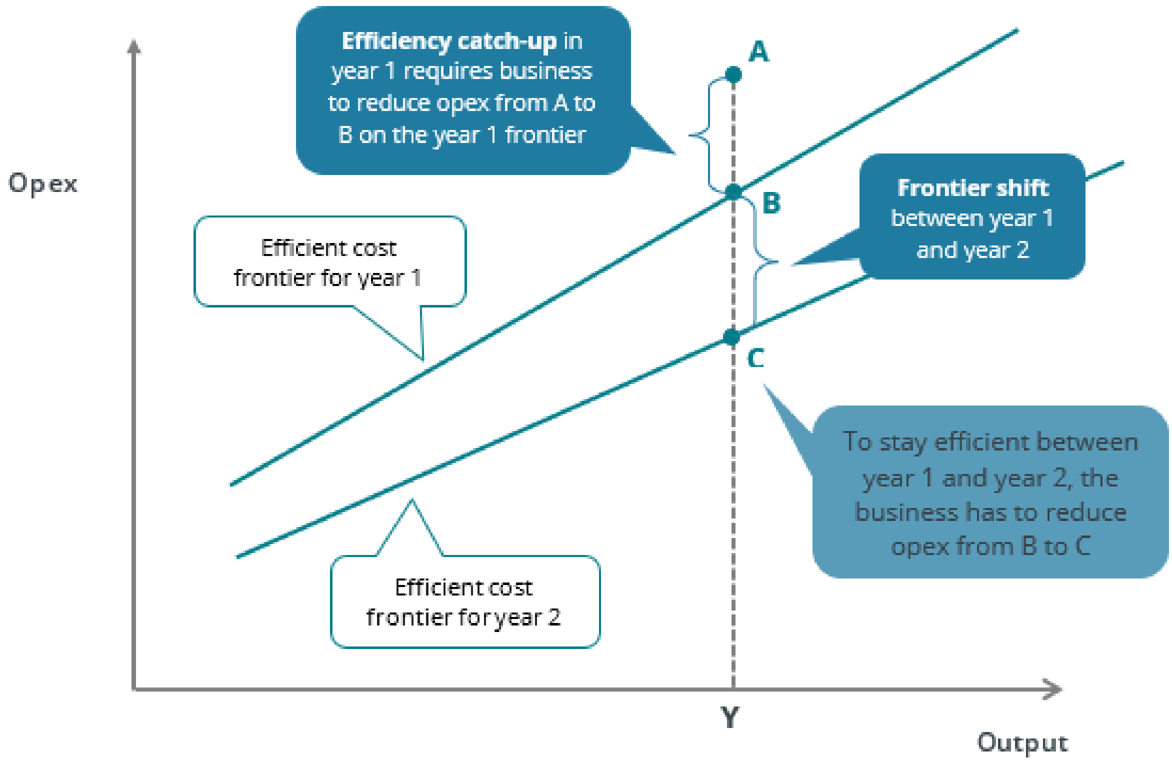
These two aspects of the efficiency target are illustrated in **Figure 2**. The Figure shows the efficient opex cost frontiers for two years, year 1 and year 2. The cost frontier in year 2 is lower than in year 1 due to improvements in productivity. This is referred to as frontier shift.

If, in year 1, a business had output at Y and opex at A, then its opex would be larger than the efficient level of opex for an output of Y (shown as B). For the business to reach the opex frontier in year 1 it would have to reduce its opex in year 1 from A to B in order to "catch up" with the efficient frontier.

A business with output Y in year 1 and opex at B is efficient in year 1 since it is operating on the efficient opex frontier. If output doesn't change between years 1 and 2, then in order to stay efficient in year 2, the business will have to reduce its opex to C to keep up with the downward "frontier shift" for opex due to productivity improvements.

2 QCA, *Gladstone Area Water Board price monitoring 2020–25 Part A: Overview, Final Report*, May 2020, p. 43.

Figure 2: Efficiency catch-up and frontier shift



Source: Frontier Economics

In the base-step-trend regulatory framework, the catch-up element of efficiency improvement is considered when determining the level of efficient opex in the base year for the regulatory period. The frontier shift component (or the "continuing efficiency" factor, as the QCA refers to it) is accounted for in the trend term. In this report we focus on this second aspect of the efficiency target, namely, the shift in the efficient production frontier over the forthcoming regulatory period (i.e., frontier shift).

A forecast of frontier shift during the upcoming regulatory period may be informed by an estimate of the historical change in productivity. However, the ability to estimate the historical rate of productivity accurately is typically limited by:

- Incomplete historical data;
- Uncertainty over how the inputs and outputs of the business are to be measured;
- The ability to control properly for factors unrelated to productivity changes that could influence a business's inputs and outputs; and
- The shortcomings of the models available to estimate the historical rate of productivity (noting that there are many different techniques for estimating the historical rate of productivity, each with their own strengths and weaknesses).

Furthermore, it is important to recognise that the historical change in productivity may not be reflective of what is achievable or realistic over the forthcoming regulatory period for two main reasons:

- The estimated historical rate of productivity change may include an element of catch-up as well as a shift in the cost frontier. In practice, it can be challenging to separate these two effects using the standard techniques and models available for measuring the historical rate of productivity. The forecast of the productivity growth rate should only reflect expected frontier shift, and should exclude any contribution to historical estimates of productivity growth due to catch-up. Conflating the two is likely to result in the achievable future productivity growth rate being overstated. This would result in the business receiving an opex allowance that is lower than the efficient level.

- The impact on opex of changes in technology and other cost drivers over the forthcoming regulatory period may not be the same as over the historical period used to estimate the past change in productivity.

This means that even if one could estimate the historical productivity growth rate with complete certainty (which is generally not possible, for the reasons explained above), there may be still be uncertainty over the extent of continuing efficiency achievable by a regulated business over a future regulatory period. Therefore, a considerable degree of caution and judgment is required when determining the continuing efficiency targets that are to be imposed on a regulated business when setting its expenditure allowances for a future regulatory period.

2.2 Key approaches for estimating productivity growth rate

There are three main approaches to estimating the productivity growth rate:

- Approaches based on index numbers, which can be split in Total Factor Productivity (TFP) and Partial Factor Productivity (PFP)
- Econometric approaches – one of the most common being Stochastic Frontier Analysis (SFA); and
- Data envelopment analysis (DEA).

The QCA has indicated that it may consider these three approaches as part of its review process.[3] We discuss each of these in turn.

2.2.1 Index based approaches

Index based approaches to productivity measurement take an index of a measure of output and divide it by an index of a measure of input. Changes in this ratio over time provide a measure of the change in productivity over time.[4] If the measure of output is an aggregate measure that captures the levels of all outputs produced by a business, and the measure of input is an aggregate measure of the levels of all the inputs used by that business to produce those outputs, then the index is referred as a total factor productivity (TFP) index.

Examples of outputs often considered for water utilities are the volume of water delivered, customer numbers and network size. Examples of inputs are opex and capital. Both opex and the capital input may be broken down further into sub-categories, e.g. labour, chemicals and energy, or water treatment plants and pipes.

3 "However, the QCA may consider undertaking further analysis before the next review using techniques such as total factor productivity, stochastic frontier or data envelopment analysis." QCA (2018), *Seqwater Bulk Water Price Review 2018–21*, p.31.

4 The approach can also be applied to several businesses at the same point of time (cross-sectional productivity comparisons), or several businesses across time (multilateral productivity comparisons).

The rate of change in the TFP index is a measure of the total productivity growth factor. This can provide information on performance from one year to the next, and when averaged over a number of years, it provides an indication of longer-term growth in productivity. We note, however, that changes in TFP capture the combined effect of catch-up in efficiency and the shift in the frontier function. Nevertheless, while there are no formal methods for separating these two aspect of a change in productivity, by inspecting the year to year changes in the TFP index, one may be able to identify periods when catch-up seems to dominate the change in TFP versus periods where frontier shift is more likely to be the driving factor.

It is also possible to construct a range of partial factor productivity (PFP) indices. The most common examples are the PFP index for opex and the PFP index for capital input. In each of these cases, the numerator of the index ratio is the aggregate measure for total output, while the denominator is either opex or a measure of capital input. These PFPs provide an indication of the productivity of the business in terms of opex spending or the use of capital.

We note that TFP and PFP analysis can be performed for an individual firm or for a number of firms collectively, e.g., the industry as a whole. It is also worth noting that when combining different outputs into a single output measure, or different inputs into a single input measure, it is necessary to use appropriate weights. There are a number of different approaches to calculating these weights. The most commonly used approach is a method known as the Törnqvist Index. This is the approach we have adopted in this report.

2.2.2 Econometric methods

There are several econometric techniques that are used by regulators to undertake benchmarking analysis, for example:

- Least Squares estimation of an average cost function;
- Corrected Ordinary Least Squares (COLS);
- Least Squares panel estimation with fixed effects (FE) or random effects (RE); and
- Stochastic Frontier Analysis (SFA).

All these methods involve essentially the same idea:

- Assume that costs are a function of one or more cost drivers and a time trend $\boldsymbol{t}$ to capture changes in productivity over time:

(1) $$\boldsymbol{Cost_{it} = \beta_0 + \beta_1 OutputOne_{it} + \beta_2 OutputTwo_{it} + \beta_3 t + residual_{it}}$$

- Estimate this econometric relationship between costs and cost drivers
- Use the fitted relationship to define an efficient frontier or reference cost function
- Interpret the distance between the firm in question and the fitted frontier/reference function as an estimate of efficiency. In the case of SFA, allowance is also made for random statistical noise in the differences between the firm in question and the estimated efficiency frontier.

The estimated coefficient on the time trend $\boldsymbol{t}$ can be interpreted as an estimate of the productivity growth rate. However, we note that, as with any statistical analysis, estimates of efficiency and the productivity growth rate will only be reliable if all relevant cost drivers are accounted for properly in the model, and if the data used in the analysis are reliable.

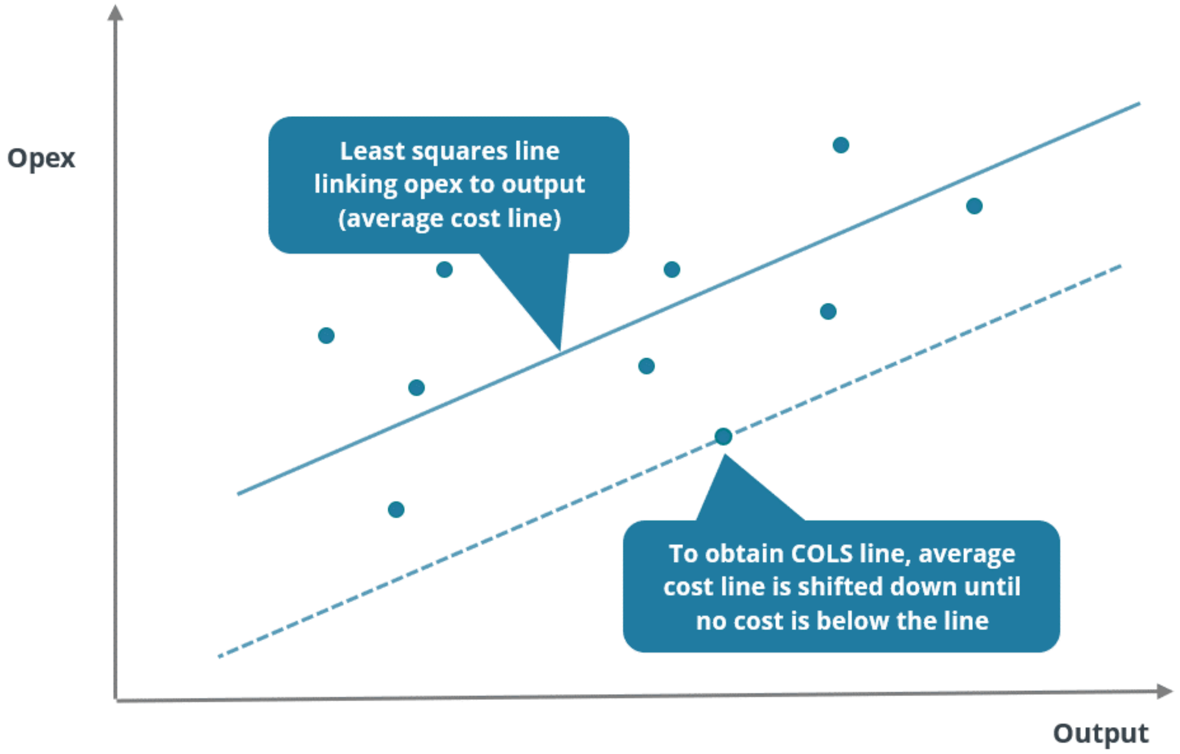
Least squares (LS) and Corrected Ordinary Least Squares (COLS)

Figure 3 illustrates the first two of the above approaches. The least squares (average) cost function is indicated by the solid line in the chart. Based on a sample of observations (which could be a single business over a period of time, or several businesses at the same point in time, or a combination) it shows the estimated average opex used in the sample to produce different levels of output. We have drawn this average cost line as a straight line, but in practice non-linear functions are often used to fit the relationship between costs and cost drivers.

By comparing the opex of individual observations with the average cost line, one can determine whether a business is using more or less opex than the average business would use to produce the same level of output.

The Corrected Ordinary Least Squares (COLS) function is obtained from the average cost line by shifting the average cost line down in a parallel fashion until there are no points below the line, and there is one point (or several points) exactly on the line. This is illustrated in **Figure 3** by the dashed line. The businesses on the dashed line are regarded as being efficient. For other observations, the vertical distance between the point and the dashed line is a measure of the business' inefficiency.

Figure 3: Least squares (LS) and Corrected Ordinary Least Squares (COLS)



Source: Frontier Economics

If panel data are available, that is, data on several businesses over a number of years, then variants of the COLS approach can be estimated. In this approach, each business is assumed to have an efficiency factor that is constant over time, that can be represented by either a fixed effects or random effects approach. Rather than evaluating the efficiency of each individual observation relative to the frontier or average cost function, this approach produces estimates of each business' average efficiency over the sample period relative to the most efficient business.

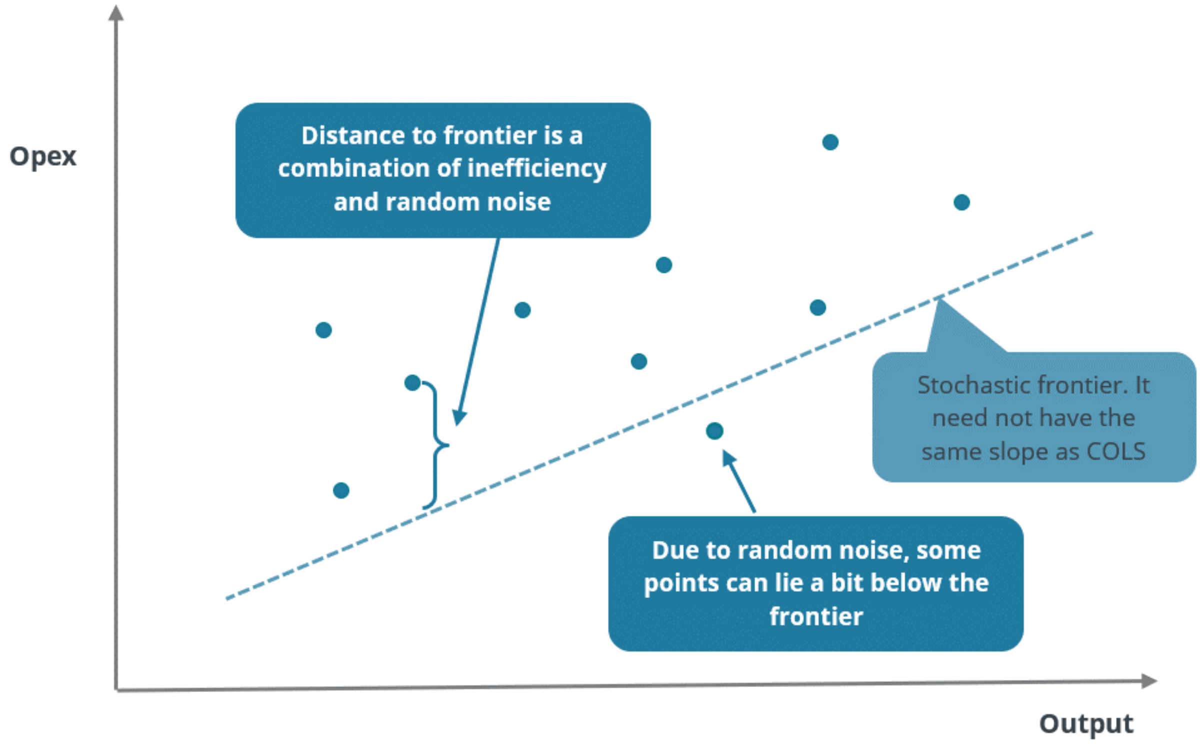
Stochastic frontier analysis (SFA)

Stochastic frontier analysis (SFA) is a more sophisticated econometric approach to estimating efficiency. Instead of interpreting the residual term in equation (1) above as representing only inefficiency, this term is now interpreted as a combination of an inefficiency component as well as random noise. This is illustrated in **Figure 4** below. Note that because allowance is made for a random noise term in the model, it is possible that some observations lie slightly below the frontier cost line.

Estimating a model that decomposes the residual term in this way requires additional statistical assumptions and a more advanced estimation technique than least squares estimation. It also requires a larger sample to achieve reliable results. However, if the assumptions underlying the model are satisfied, the estimates of the inefficiency terms and the productivity growth rate are likely to be more precise than when using the least squares and COLS methods.

The Australian Energy Regulator (AER) has relied on SFA models in its recent regulatory reviews for electricity distribution utilities. SFA studies for urban water distribution utilities have also been undertaken on behalf of the Essential Services Commission of Victoria (ESC).

Figure 4: Stochastic frontier analysis (SFA)



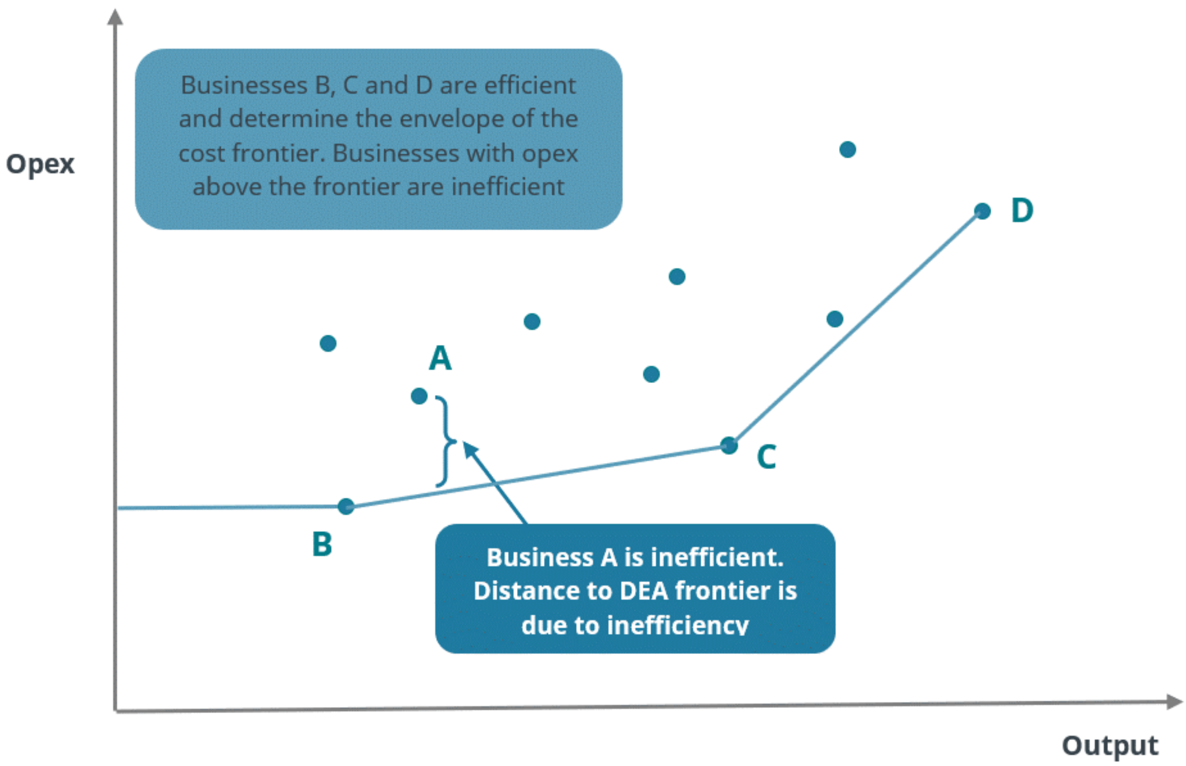
Source: Frontier Economics

2.2.3 Data envelopment analysis (DEA)

Another technique widely used for benchmarking is data envelopment analysis (DEA). This is a non-parametric technique in that it does not specify a particular functional form for the relationship between cost and the cost drivers. Instead it uses linear programming to fit a piece-wise linear envelope to the data to derive the efficient frontier, as illustrated in **Figure 5**. Any business whose cost is higher than the efficient frontier is considered to be inefficient. The DEA technique does not make any allowance for random noise in the data.

If DEA is applied over time, the shift in the frontier over time can be used to estimate the rate of productivity growth. However, this requires a considerable amount of data since separate frontiers need to be estimated for each point in time.

Figure 5: Data envelopment analysis (DEA)



Source: Frontier Economics

2.3 Data availability

The analysis in this report has relied on the following data sources:

- The National Performance Report (NPR) database produced by the Bureau of Meteorology;[5]
- Information provided directly by Seqwater; and
- Information contained in QCA determinations for Seqwater.

The NPR database provides data on Australian water utilities, including bulk water providers and water distribution networks, which is a closely related industry. The most recent release of the data was used, which provides data up to and including the 2019-20 financial year, and going as far back as 2002-03 for some utilities/variables.

5 Bureau of Meteorology, National Performance Report database, available at http://www.bom.gov.au/water/npr/docs/The_complete_dataset_2019_20.xlsx

While the NPR database does provide opex data for bulk water utilities, there are significant gaps in this dataset. For WaterNSW there are no opex data for 2015-16 through 2017-18, and for Seqwater opex data are missing for 2014-15 and 2016-17. Moreover, the opex for Seqwater in 2015-16 is reported as $821,190, which is implausibly low. The opex data provided is the total across all cost categories – there is no decomposition into different cost categories such as labour or electricity.

In view of this, we requested more detailed data from Seqwater. The data we were provided covered the period 2014 to 2019 and contained information on the quantity and cost of a range of inputs, as well as on several outputs.

While we were able to collect data directly from Seqwater, given the timeframe available to prepare this report and likely challenges in gaining cooperation from the businesses, we did not consider it feasible to collect data directly from the other bulk water providers.

2.4 Conclusion

In light of the data available to us and the data requirements of different methodological approaches, we concluded that it would be feasible to undertake the following quantitative analyses to obtain estimates of the rate of growth in productivity:

- Calculate the TFP and opex PFP indices for Seqwater using data obtained directly from Seqwater. These indices would provide an indication of Seqwater's total factor productivity and opex productivity over time. Changes in historical productivity from one year to the next and the average rate of productivity over a number of historical years can be estimated using these indices.
- Use the NPR dataset to calculate the opex PFP index for the major bulk water suppliers captured in the NPR dataset (Seqwater, Melbourne Water, WaterNSW, SA Water and Water Corp). This would potentially provide a comparison of the rate of productivity over time of Australian businesses whose operations are very similar to those of Seqwater. As explained in section 4.3, we were unable to construct TFP indices for bulk water suppliers using the NPR dataset since the NPR dataset does not contain the information on capital inputs that we required to implement such an approach. We also concluded that the sample of bulk water supply businesses is too small to reliably estimate an SFA model or any other econometric model.
- Estimate an SFA model for urban water distribution businesses using the NPR dataset. This would provide an estimate of average productivity growth over the sample period in an industry that is closely related to bulk water supply, with similar cost drivers. We chose SFA over other econometric approaches because SFA enables operational inefficiency to be considered separately from random noise, and because the QCA has previously indicated its intention to consider relevant SFA evidence. We also considered that the sample of urban water distribution businesses in the NRP dataset is large enough to make SFA feasible.[6]

We did consider the DEA approach to estimate the productivity growth rate for the urban distribution businesses. However, we concluded that DEA modelling would present technical challenges, as it would require estimation of separate efficient frontiers for each historical year in

[6] While the NPR data for the water distribution businesses also has some quality issues, given there is a much larger sample of distribution businesses than bulk supply businesses, and the fact that the SFA model allows for random errors in the data, data quality issues will have much less impact on the results for the distribution businesses than for the bulk supply businesses.

the dataset. The productivity growth rate would then need to be estimated by analysing the change in the efficient frontier between years. However, due to gaps in the dataset, the frontiers for different years would be based on samples of different sizes and comprised of different businesses. Hence the efficient frontiers in different years would not be comparable.[7] This would, in our view, make the estimate of the productivity growth rate using DEA unreliable.

7 For a discussion of the difficulties in comparing the results of separate DEA analyses carried out on samples of different sizes see Zhang, Y. and Bartels, R. (1998), "The effect of sample size on the mean efficiency in DEA with an application to electricity distribution in Australia, Sweden and New Zealand", *Journal of Productivity Analysis*, 9, 187-204.

3 Estimating the productivity rate using data obtained from Seqwater

3.1 Introduction

Our first approach to estimating the productivity growth rate for Seqwater is to undertake an analysis of the historical growth rates in Seqwater's partial productivity indices (PFPs) and the total factor productivity index (TFP). While efficiency and productivity studies frequently focus on a business' operating expenditure, in our view it is helpful to also consider productivity in the use of capital, since the possibility of substitution between opex and capex can distort estimates of productivity changes with respect to either one of these inputs. Hence, in this section we present estimates not just of the partial productivity factor (PFP) for opex, but also the PFP for capital and the total factor productivity (TFP).

3.2 Data used

As outlined in section 2.3, for this task we relied on data provided by Seqwater. We did not use the NPR dataset for this task because it did not provide any disaggregated detail on opex, there were considerable gaps in the data, and some of the data seemed less reliable than the data provided by Seqwater.

To calculate the PFP and TFP indices, we need both the physical quantities of inputs used, and the expenditures on those inputs.[8] For some of the inputs we did not have the physical quantities of the inputs or the quantity data seemed unreliable (for example, for some of the chemicals used). For each of those inputs, we proxied the quantity of the input by the deflated series of expenditures for the input. The cost deflators we used for this purpose were chosen to be consistent with the QCA's approach and Seqwater's cost escalation approach.

Seqwater was unable to provide us with data for FY2020 within the timeframes available to prepare this report. We chose not to supplement the data provided by Seqwater with FY2020 NPR data for Seqwater since the results would be sensitive to differences between methodologies for constructing the two datasets. Furthermore, due to our reservations about the reliability of the NPR data for Seqwater in historical years, we considered that it would be imprudent to use the FY2020 NPR data for Seqwater. As a consequence, we relied only on the data provided to us by Seqwater data up to and including FY2019.

3.3 Measures of inputs and outputs used

Outputs

We requested and were provided with information on a number of outputs produced by Seqwater. In addition to the total volume of urban water supplied we considered the volume of irrigation water supplied, water quality measures, and water security measures. The data for the volume of

8 The expenditures are needed to calculate the expenditure shares of the different inputs, which are used as weights in the Törnqvist index formula.

irrigation water was not closely correlated with opex, hence we excluded it from out consideration. We also excluded the water quality measures on the basis that they typically took only a few distinct values, and they were not considered to be major cost drivers. Water security measures, such as storage levels, were considered to be more reflective of drought conditions rather than a driver of costs. Hence, we selected the total volume of urban water supplied as the most relevant output for our analysis. This is also one of the main cost drivers typically considered in the analysis of water distribution productivity. The use of a single output variable also reduces the complexity of calculating the productivity indices, since it circumvents the need to derive output weights required when combining several output variables into a single measure of output.

Operating expenditures

We requested and were provided with detailed expenditure information for Seqwater. We combined the opex expenditures into seven categories, with expenditure information covering the period from FY2014 to FY2019. These are shown in the first seven rows of **Table 1**

Table 1: Inputs used in the analysis

Input category	Measure of input used in analysis
Electricity	Electricity: actual quantities (MWHr)
Chemicals	Chemicals: cost deflated using Brisbane CPI
Sludge disposal	Sludge disposal: actual quantities (Tonnes)
Maintenance	Maintenance: cost deflated using Brisbane CPI
Labour	Labour: actual quantities (FTEs)
Contractors	Contractors: cost deflated using 56% QLD WPI, 44% Brisbane CPI
Other	Other: cost deflated using Brisbane CPI
Capital costs (for TFP and capital cost PFP)	Capital costs: cost deflated using Brisbane CPI

Source: Frontier Economics

Note: The cost deflators were chosen to be consistent with QCA's approach and Seqwater's cost escalation approach

The calculation of the PFP and TFP indices requires data on the physical quantities used in each input category. For several of the inputs we did not have data on the physical quantities or the data seemed unreliable. For those inputs we used the deflated expenditures for that category as a proxy for the quantity of input.

The cost deflators we used for each input are shown in the second column of **Table 1**. We deflated chemicals, maintenance and other costs using the Brisbane CPI.[9] This is consistent with the approach used in the 2018 Decision.[10,11] Contractor expenses are deflated using a weighted

9 ABS 6401.0, series A2325816R.

10 QCA, 2018 Final Report, p. 15.

11 QCA, 2018 Final Report, p. 54.

combination of the Queensland wage price index[12] and the Brisbane CPI as proposed by Seqwater for the 2018 review and accepted by the QCA.[13]

Capital input

In principle, the capital input used in productivity analysis should reflect the flow of capital used in production, analogous to the hours of labour used or the quantity of chemicals, rather than the stock of assets. When the stock of assets is used as the capital input, there is an implicit assumption that the flow of capital stock used in production is proportional to the stock of capital.

In this study, we have used the 'user cost of capital' approach to measure capital inputs. The traditional approach to calculating the annual user cost of capital is to take the sum of the nominal return on capital and nominal depreciation, and subtract capital gains. We adopted an ex ante approach to this task, whereby the returns on and of capital for FY2014 through FY2018 were taken from the 2015 Decision,[14] and the return on and of capital for FY2019 were taken from the 2018 Decision.[15] In the 2015 Final Report, the inflationary gain in the RAB was deducted from the figures for the return on capital. In the 2018 Final Report, an indexation amount for inflation was reported separately; we subtracted this from the return on capital.

To obtain a time series of the user cost of capital in constant dollar terms for the capital input into production, we deflated the user cost of capital values using the Brisbane CPI.

Taking an ex ante approach means that we are using the QCA's assessment of the anticipated efficient user cost of capital over the regulatory period. This is consistent with our aim of estimating the shift in the efficient frontier rather than a combination of frontier shift and catch-up.

Figure 6 below shows the inputs used in our analysis over time. The chart shows that opex inputs decreased through to FY2017, thereafter increasing and returning to FY2014 levels in FY2019. The reduction to FY2015 was driven by reductions in maintenance, contractors and the 'other materials/inputs' category; the increase between FY2017 and FY2018 was driven by growth in labour, contractors and the 'other materials/inputs' category.

Capital input, as measured by the user cost of capital, increased steadily over the period, with the exception of an abnormally high user cost of capital in FY2015. This was driven by a low inflation forecast for FY2015 at the time the QCA made its determination. This meant that a relatively modest amount of expected inflation was subtracted by the QCA from the allowed return on assets for FY2015.

A comparison between the output index and the total input index suggests that, overall, inputs increased in line with the output, measured by the total volume of urban water supplied. However, the capital input grew considerably faster than output, while opex declined slightly over the period. This suggests that over the sample period there may have been substitution away from opex towards capital.

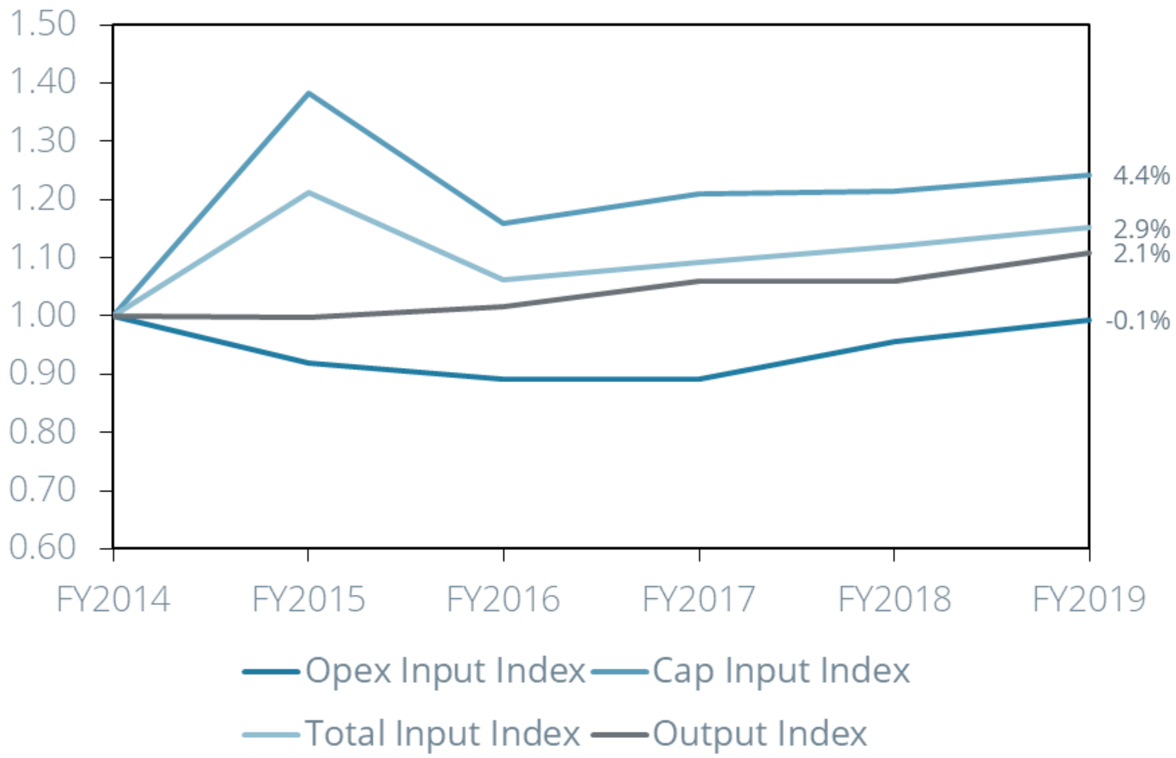
12 ABS 6345.02a, series A85021977A.

13 PWC, Cost escalation factors – Final report, July 2017, p. 23.

14 QCA, 2015 Final Report, Table 26.

15 QCA, 2018 Final Report, Table 57.

Figure 6: Inputs and outputs over time when the user cost of capital is used as the capital input



Source: Frontier Economics analysis of data supplied by Seqwater

3.4 Results from PFP and TFP models

The technical Appendix to this report explains how we construct the PFP and TFP indices.

The results from the PFP and TFP analysis are shown in **Figure 7**. The Figure shows that opex productivity (represented by the opex PFP index) increased between FY2014 and FY2017, after which it declined slightly between FY2017 and FY2018, and has remained flat between FY2018 and FY2019. In its 2018 review the QCA reported that:[16]

> *KPMG noted that actual expenditure has been consistently below that recommended by the QCA in the 2015 review, lending support to the contention that Seqwater has achieved efficiencies over the regulatory period*

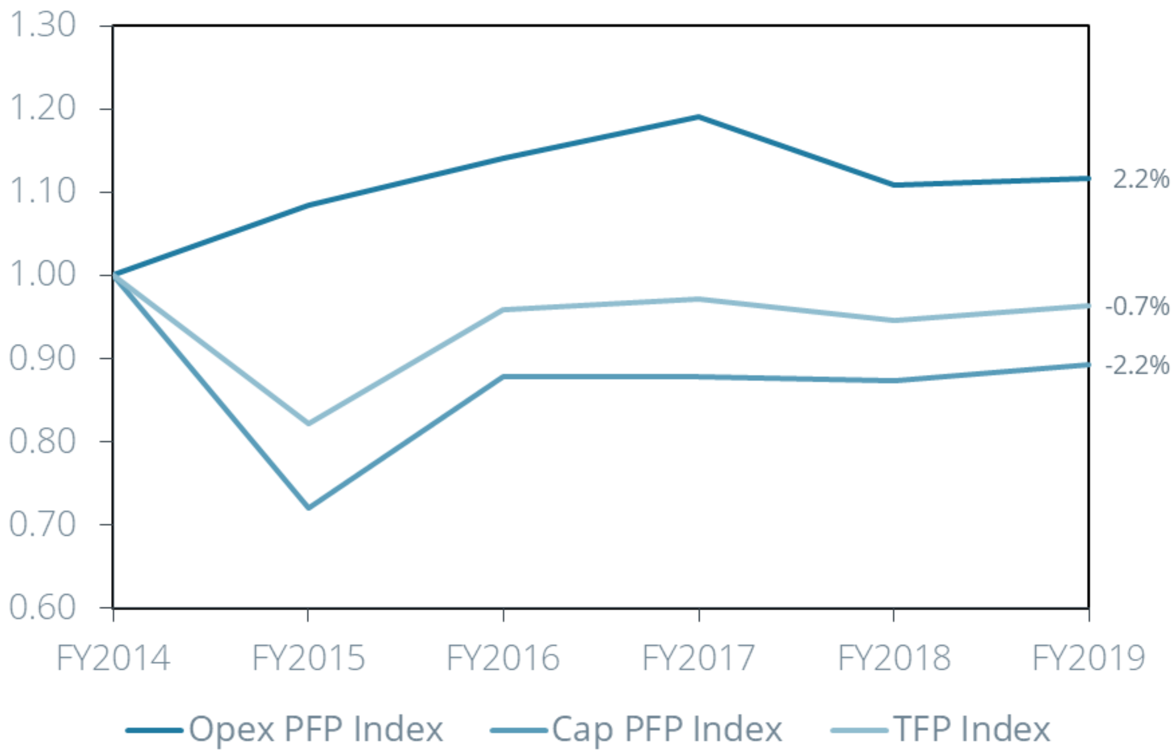
Figure 7 suggests that these efficiencies were achieved as a result of catch-up to the frontier in the years up to 2017. Catch-up in efficiency cannot be sustained over the longer period. Once a business has caught up with the frontier, future efficiency gains can only be expected to occur as a result of frontier shift.

16 QCA (2018), *Seqwater Bulk Water Price Review 2018–21*, p.21.

It is likely that the changes in opex productivity that we observe after 2017 are due to frontier shift rather than catch-up. One can expect future changes in productivity to be similar to the changes after 2017 rather than those up to 2017.

Figure 7 shows that over the whole period from 2014 to 2019, opex productivity increased at an annual rate of 2.2%. However, this estimate of productivity growth is very sensitive to the years used to calculate the growth rate. While opex productivity exhibits high growth over 2014-2016, the annual growth rates in opex productivity from 2016 or 2017 onwards, when catch-up in efficiency might be assumed to have been achieved, are negative. The growth rates in opex productivity over the different periods are summarised in **Table 2**.

Figure 7: PFP and TFP indices over time



Source: Frontier Economics analysis of data supplied by Seqwater

Table 2: Estimated annual growth rates in PFPs and TFP over different time periods

Period	Annual growth in opex PFP	Annual growth in capital PFP	Annual growth in TFP
2014 - 2019	+2.2%	-2.2%	-0.7%
2014 - 2017	+6.0%	-4.3%	-1.0%
2017 - 2019	-3.2%	+0.9%	-0.4%

Source: Frontier Economics analysis of data provided by Seqwater

The chart also shows that there was a considerable fall in capital productivity between 2014 and 2015 of over 20%, with a partial rebound the following year, after which the capital PFP has remained almost flat. The growth rates in capital productivity over the different periods are summarised above in **Table 2**.

It is possible that the gain in opex productivity in the earlier years was due to substitution between opex and capital expenditure. The ACCC notes that:[17]

> *For cost-benchmarking applications, it is important to ensure that there are no artificial incentives that create cost inefficiency through. . . substitution of capital expenditure for operating expenditure.*

Such substitution of non-capital inputs for capital inputs is likely to have improved the overall efficiency of the firm. However, the improvement in productivity may be overstated if one were to focus only on the change in productivity of the non-capital investments. For example, the firm may have invested in new technology that results in a reduction in its labour force (and, therefore, its opex). This would manifest as (a potentially large) increase in the opex PFP, but a reduction in the capital PFP—since the firm has substituted some non-capital inputs for additional capital inputs. The net effect of this substitution may be that, overall, the firm has become somewhat more productive. However, focussing exclusively on the opex PFP may create the false impression that the overall productivity of the firm has increased very substantially.

To reduce the risk of drawing erroneous conclusions of this nature, it is desirable to consider not only partial productivity measures, but also the firm's total factor productivity. The TFP index in **Figure 7** shows that the TFP index, like the capital PFP index, decreased between 2014 and 2015, with a rebound the following year. The changes in the TFP index are similar to those of the capital PFP, but the swings are less severe due to the impact of the rise in the opex PFP between 2014 and 2017.

Over the whole period from 2014 to 2019, TFP changed by -0.7% p.a. As shown **Table 2**, the average annual growth rate in TFP from 2017 onwards (i.e., the period after significant catch-up in efficiency appears to have been achieved by Seqwater) is -0.4% per year.

3.5 Conclusion

We found that over the period 2014 to 2019, the average annual growth in Seqwater's partial and total productivity measures are:

- +2.2% p.a. for the opex PFP;
- -2.2% p.a. for the capital PFP; and
- -0.7% p.a. for TFP.

However, it seems likely that the growth in Seqwater's opex PFP over some of this period may be attributable to catch-up efficiency rather than frontier shift alone. Indeed, in its 2018 final decision

[17] ACCC (2012), *Benchmarking Opex and Capex in Energy Networks,* ACCC/AER Working Paper Series, Working Paper no.6, p.21.

for Seqwater, the QCA noted that Seqwater had made significant and consistent efficiency improvements in opex over the previous regulatory period.

Catch-up efficiencies cannot be realised indefinitely. Once a firm has caught up to the efficient frontier, future efficiencies can only be realised through frontier shift. Seqwater's opex PFP shows a significant increase between 2014 and 2017. It is likely that the changes in opex productivity that we observe after 2017 are due to frontier shift rather than catch-up. To investigate this possibility we estimated the same three productivity measures over the period 2017 to 2019.[18]

Our analysis shows that over the period 2017 to 2019, Seqwater's partial and total productivity measures are:

- -3.2% p.a. for the opex PFP;
- +0.9% p.a. for the capital PFP; and
- -0.4% p.a. for TFP.

One can expect future changes in productivity to be similar to the changes after 2017 rather than those up to 2017.

We have computed a TFP measure for Seqwater as well as opex and capital PFPs. It is well-recognised in the literature, and by economic regulators, that firms may substitute efficiently between capital and non-capital inputs to production. Movements in a firm's opex PFP may (in part) reflect such substitution choices. For instance, a firm may elect to undertake more maintenance work to extend the life of its assets and avoid expensive asset replacement. This would result in a reduction in the firm's opex PFP and an improvement in the firm's capital PFP (all else remaining equal). The opposite may also be true. A firm may favour capital expenditure solutions over opex solutions (e.g., the investment in new technology to free up labour), and such choices may also be efficient. In such circumstances, the firm's opex PFP would increase, and its capex PFP would decline (all else remaining equal). The overall productivity of the firm's production choices can be seen by examining changes in its TFP over time.

We therefore recommend that the QCA have regard to TFP results when determining an appropriate productivity growth rate for Seqwater to avoid the estimates of the productivity growth rate being confounded or distorted by such input substitution choices. Seqwater's average historical productivity growth rate, measured using a TFP index, ranges between -0.7% p.a. and -0.4% p.a., depending on the historical period considered.

18 See **Table 2**.

4 Estimating the productivity rate for bulk water supply using NPR data

4.1 Introduction

We also investigated whether an appropriate productivity growth rate for Seqwater could be estimated using the opex productivity growth rate for each of the five bulk water supply utilities included in the NPR database – Seqwater, Melbourne Water, WaterNSW, SA Water, and Water Corporation (Perth).[19] Our aim was to obtain a range of opex productivity growth rates across businesses in the bulk water supply industry to inform our assessment of what productivity growth rate might be reasonable to expect Seqwater to achieve over the upcoming regulatory period. The success of this approach depends, of course, to a large extent on the quality of data available for this task. Hence, we first discuss the limitations of the NPR dataset with respect to the bulk water supply businesses.

4.2 Limitations of the NPR data

As noted previously, there are substantial deficiencies in the NPR database. There are gaps for key variables, for example operating costs of WaterNSW. We observed that in some years, operating costs for water supply[20] were not reported, yet operating costs per ML of water supplied was reported, which enabled the derivation of operating cost for that year.[21]

We also sought to remove the desalination costs of Melbourne Water that were submitted as a component of the operating cost in the NPR database from FY2013 onwards, as the delivery of desalination services is unrelated to the regulated bulk water services delivered by Seqwater. It is our understanding that these costs were not only operating costs associated with the desalination plants, but included a substantial amount of lease payments. After receiving advice from Melbourne Water, we removed these payments by subtracting the amounts reported in Melbourne Water's published annual accounts. The desalination volumes were not included in the water supply volume measure used for Melbourne Water.

While we use Seqwater supplied data for Seqwater for this task,[22] we also present results using NPR data for Seqwater, to illustrate the impact of using NPR data on any findings.

4.3 Measures of inputs and outputs used

As in section 3, we used the volume of water supplied as the sole output measure for bulk water utilities. To obtain the volume of water supplied we took the maximum of three measures:

19 We did not calculate the TFP growth rates for this investigation because of data limitations.

20 NPR dataset variable IF11.

21 For example, if we observe operating cost per ML, revenue per ML and revenue, we can infer the operating cost indirectly.

22 We use Seqwater data from FY2014 through to FY2019 as we were unable to obtain FY2020 data within the timeframes available to prepare this report.

- The sum of surface water, ground water and desalination volumes;
- Total volume of urban water supplied (W11); and
- Volume of potable water produced for supply into the urban water system (W11.3).

As disaggregated cost information is not available in the NPR database, we used the water supply operating cost as the sole input measure.[23] Nominal operating cost was deflated using an equally weighted combination of the appropriate capital city wage price index and consumer price index.[24]

We also observed several anomalies with the NPR data:

- No desalination volumes were reported for Water Corporation (Perth) in FY2014, though it is our understanding that desalination volumes were being produced during FY2014.
- WaterNSW reported a large (85%) increase in operating cost between FY2015 and FY2019, though operating cost per ML declined considerably.
- Seqwater reported implausibly low operating costs in FY2016.

As the NPR data for Seqwater, in particular the operating cost information, are unreliable, we used the Seqwater supplied data rather than data sourced from the NPR database for Seqwater. However, for the other four bulk water suppliers we currently had no viable alternative to the NPR database. Therefore, the results presented below use NPR data for Melbourne Water, WaterNSW, SA Water, and Water Corporation (Perth).

As the NPR database does not contain data on the user cost of capital, we are unable to repeat the TFP analysis applied to Seqwater in section 3 using NPR data. While the NPR dataset does contain information on written down asset values, this is not in our opinion an ideal measure of capital cost.

4.4 Results from opex PFP indices

As noted in the previous section, to calculate the opex PFP indices for the five bulk water supply businesses, we used opex as the input measure and the volume of water supplied as the output measure. While it would have been desirable to use more disaggregated measures of inputs and/or outputs, that approach was not feasible due to the limitations of the NPR dataset.

Figure 8 and **Figure 9** show the input and output indices for each of the five bulk water supply businesses over time. Note in **Figure 8** that, for WaterNSW, opex data were only available for 2014, 2015, 2019 and 2020, and that there was a very material increase in real opex of almost 80% between 2015 and FY2019, from $99 million to $180 million (real $2014). This increase was anomalous, with a substantial decrease in FY2020 to $99 million (real $2014).

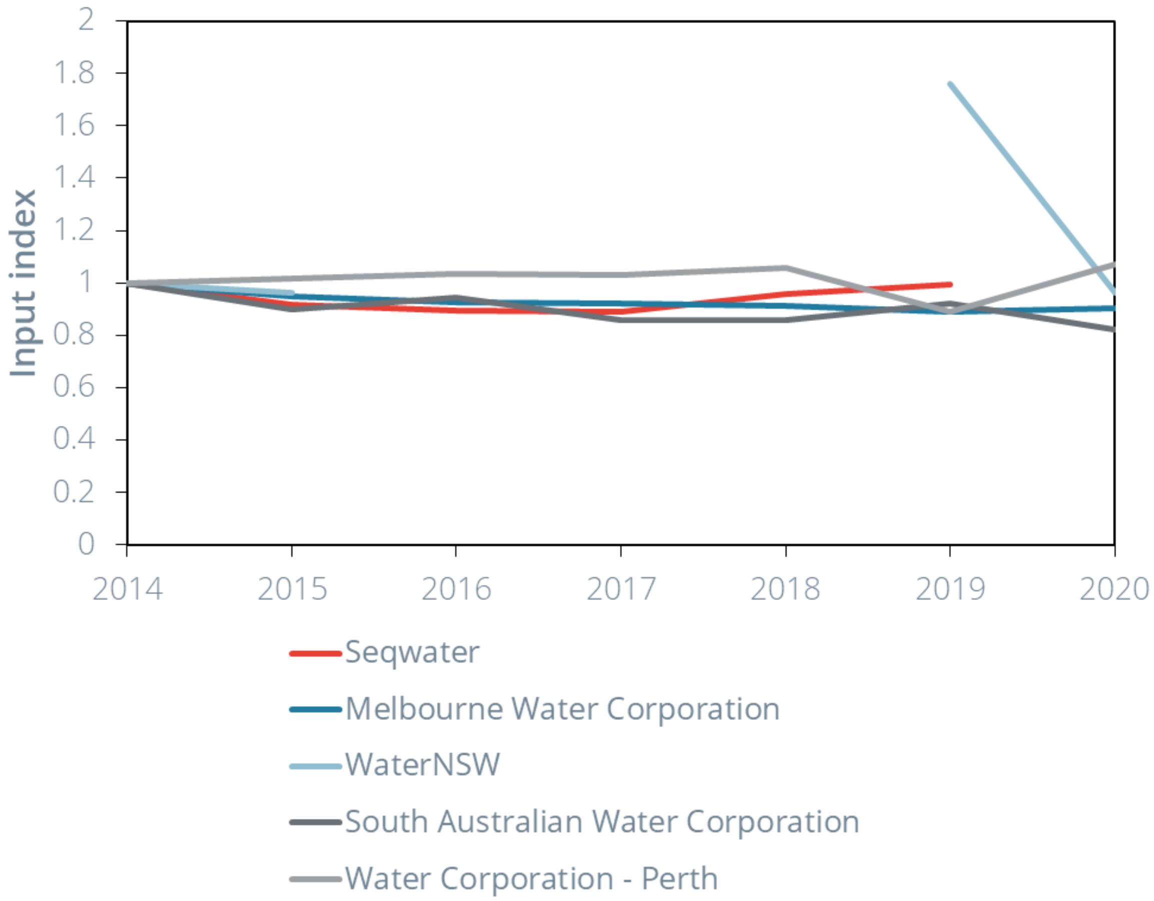
Real opex for SA Water, on the other hand, decreased substantially over the period, falling by 18% from $368 million to $302 million (real $2014).

The trends in opex over the sample period for the other three businesses fall between these two extremes.

23 This includes water distribution expenses for SA Water and Water Corporation – Perth.

24 We follow the approach of Economic Insights' 2017 Victorian urban water utility benchmarking report for the Essential Services Commission of using a simple (equal-weighed) average of wage and consumer price indices.

Figure 8: Opex input indices for bulk water supply businesses



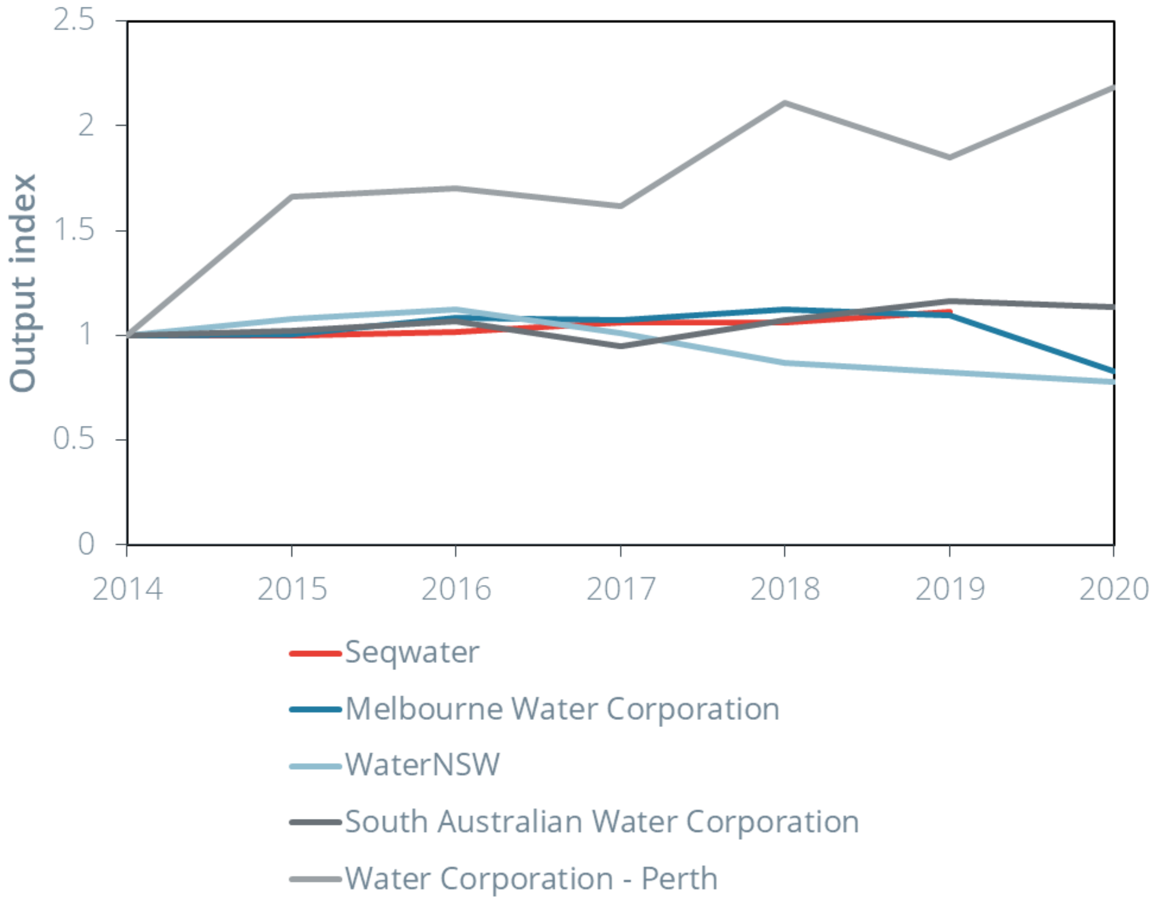
Source: Frontier Economics analysis of NPR data and data supplied by businesses

The output indices in **Figure 9** show slightly increasing trends for Seqwater, Melbourne Water and SA Water over the period. For WaterNSW, output increased moderately between 2014 and 2016, and then decreased quite sharply over the following years.

Output for Water Corporation (Perth) is affected by a change in reporting practices. In 2014, water produced by desalination was not included as part of the output volume for that year, whereas in subsequent years it was included. In view of this, we have calculated two opex productivity growth rates for Water Corporation (Perth), one for the whole sample period and the other for the period from 2015 to 2020. We also note that in 2018 there was a large increase in storage levels, which likely explains the large increase in output in the last two years.

For the other three businesses, output increased slightly between 2014 and 2020 with relatively little volatility from year to year.

Figure 9: Output indices for bulk water supply businesses

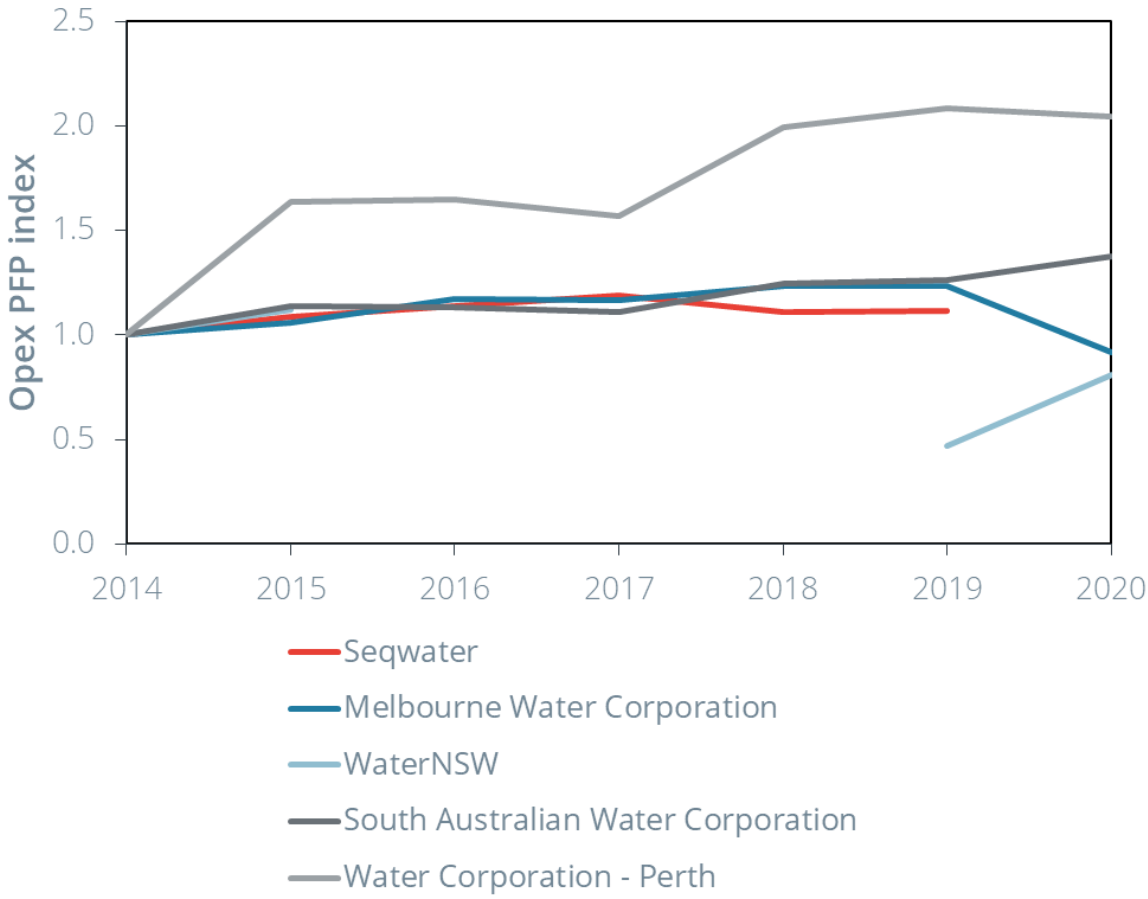


Source: Frontier Economics analysis of NPR data and data supplied by businesses

Combining the input and output indices results in the opex PFP indices shown in **Figure 10** and summarised in **Table 3**. The estimated productivity growth rates vary widely between businesses. The largest estimated productivity growth rate is for Water Corporation (Perth) over the whole sample at 12.63% p.a. If data for 2014 are excluded, because of the change in the way desalination volumes are accounted for, the productivity growth rate for Water Corporation (Perth) reduces to 4.54% p.a.

SA Water also has a very high productivity growth rate at 5.49% p.a. At the other extreme, both WaterNSW and Melbourne Water had negative productivity growth rates of -3.42% p.a. and -1.45% p.a. respectively. Such large positive and negative annual productivity growth rates are unrealistic and fall well outside estimates found in other studies.

Figure 10: Opex PFP for bulk water supply businesses



Source: Frontier Economics analysis of NPR data and data supplied by businesses

Table 3: Estimated productivity growth rates for bulk water supply businesses

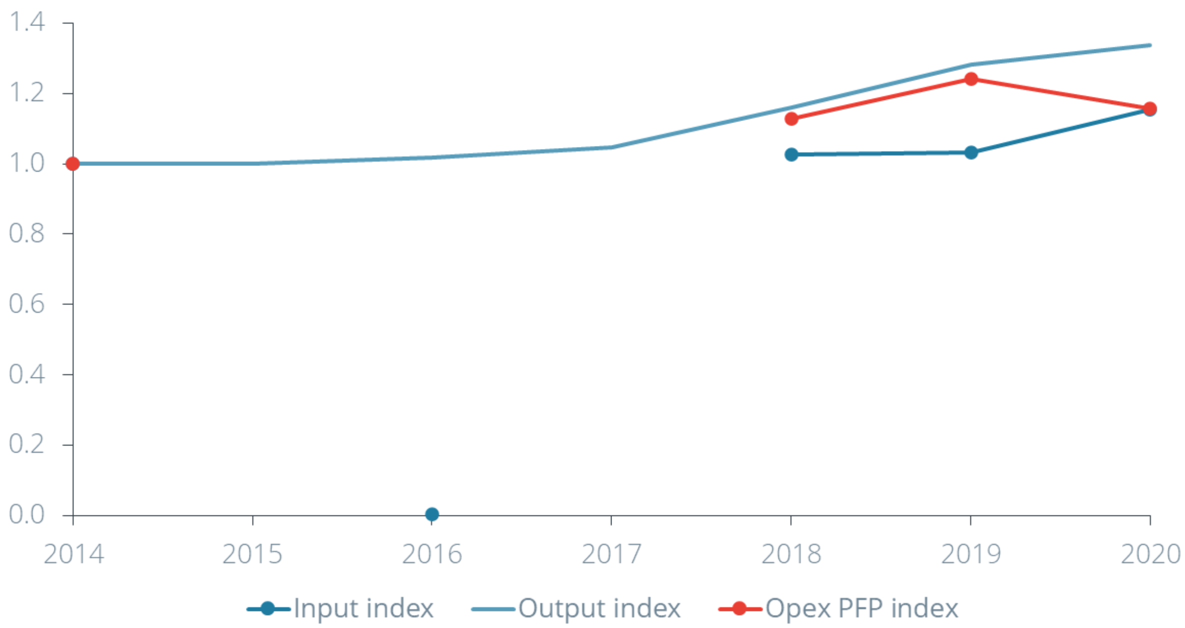
Bulk water supplier	2014-2020	2015-2020
Seqwater	2.23%	
Melbourne Water	-1.45%	
WaterNSW	-3.42%	
SA Water	5.49%	
Water Corporation (Perth)	12.63%	4.54%

Source: Frontier Economics analysis of NPR data and data supplied by businesses

Note: For Water Corp (Perth), volumes in 2014 excluded desal volumes while they were included in subsequent years. Hence we have included an extra column that shows the result for Water Corp (Perth) when 2014 is excluded from the analysis. As expected, that results in a much lower productivity growth rate. For Seqwater, the growth rate is the growth rate over the 2014-2019 period.

If one were to use the NPR data for Seqwater, the results obtained would differ from those presented in **Figure 8** through **Figure 10**. The indices, shown in **Figure 11**, indicate growth in opex PFP of 2.47% p.a. between FY2014 and FY2020, compared to 2.23% p.a. in **Table 3** (albeit for a different time period). The difference in these results is largely due to errors in the NPR data as discussed in section 4.2, such as the implausible figure of $821,190 for Seqwater's real opex reported in the NPR dataset for FY2016, leading to a value close to zero for the opex input index for that year, and a correspondingly very high value of over 300 for the opex PFP (not shown on the chart).

Figure 11: Indices using NPR data for Seqwater



Source: Frontier Economics analysis of NPR data

Note: The opex PFP index for FY2016 is over 300 and is not shown on the chart

4.5 Conclusion

The likely explanation for the unrealistic productivity growth rates in opex PFP for the bulk water supply businesses are shortcomings in the NPR data. In view of this, we recommend that Seqwater not rely on these estimates of productivity growth rates (derived using NPR data) for other bulk water providers in its regulatory submission. However, it may be possible to obtain more reliable estimates of the productivity growth rates for the other businesses if data could be sourced directly from the other businesses. Such an extensive data collection exercise was not feasible within the scope of this study.

5 Productivity growth rate estimates for water distribution businesses

5.1 Introduction

Given the difficulties in deriving reliable estimates of the historical productivity rates of bulk water businesses (as discussed in the previous section), in this section we seek to estimate the productivity growth rate in a closely-related industry. A relevant industry for which data is available is the urban water distribution industry. In this section we discuss the approach and present the results of our analysis for the urban water distribution industry. The dataset used for this analysis is the data on urban water utilities in the NPR dataset. This dataset is described in more detail in section 5.3.

5.2 Estimation approach used

In choosing an estimation approach for estimating the productivity growth rate for urban water distribution utilities, we considered the properties of the different approaches discussed in section 2. Using the average or COLS cost function approaches would ignore, possibly substantial, inefficiencies for some of the businesses, which could distort the estimation of the productivity growth rate. On the other hand, as discussed in section 2.4, use of DEA to estimate the productivity growth rate would present technical problems.

SFA does not suffer from these issues. It makes an allowance for inefficiency. And a time trend is included to capture the shift in the frontier over time. We also note that it is one of the approaches suggested by KPMG in its advice for the 2018 price review, and it was used by Economic Insights to estimate the productivity growth rate for the Victorian urban water distribution businesses in a study commissioned by the ESC in 2017.[25]

In view of the above considerations, we decided that the most appropriate approach for the task at hand is the SFA approach. A description of the SFA approach is provided in section 2.2. We used the Stata statistical software package to estimate the SFA models.

5.3 Description of data used in the analysis

The NPR database provides data for 85 water utilities for the period 2002-03 through to 2019-20. While some of these businesses are, at least in part, bulk water utilities, the vast majority are urban water distribution utilities. After removing pure play bulk water utilities and sewerage only utilities, the NPR database provides data on the activities of 76 water distribution utilities.[26]

We noted in earlier sections that the NPR data for the bulk supply businesses exhibits substantial shortcomings in terms of data quality. In our opinion this precluded the use of this dataset to obtain reliable estimates of productivity growth for bulk water suppliers. While there are also

[25] Economic Insights (2017), *Victorian Urban Water Utility Benchmarking*, Report prepared for the Essential Services Commission.

[26] This includes SA Water and Water Corporation – Perth.

shortcomings associated with the quality of data for the water distribution businesses, these data issues do not seem as severe as for the bulk water supply businesses. Moreover, using a much larger sample mitigates the problem to some extent when using the SFA model, since the SFA model allows for random errors. This allows data errors to be considered as statistical noise that contributes to the imprecision of estimates but does not invalidate the estimates of the model parameters.[27]

With the larger number of utilities in the urban water distribution sample, statistical techniques such as SFA become feasible, whereas using such techniques on the bulk water supply sample consisting of only five utilities would produces very unreliable results.

5.4 Measures of inputs and outputs used

Following the approach used by Economics Insights in its 2017 for the ESC, we treat real opex as the dependent variable (i.e., the input) in the SFA model. To obtain real opex, we deflated the nominal operating costs in the NPR dataset using an equally weighted combination of the CPI and the EGWWS WPI, in line with the approach used by Economic Insights.[28]

We considered three output variables for the analysis:

- Water supplied;[29]
- Number of connections; and
- Mains length.

5.5 Results from SFA models

The NPR database allocates the businesses into categories based on the number of connections:

- Small – 10,000 to 20,000 connected properties;
- Medium – 20,000 to 50,000 connected properties;
- Large – 50,000 to 100,000 connected properties; and
- Major – more than 100,000 connected properties.

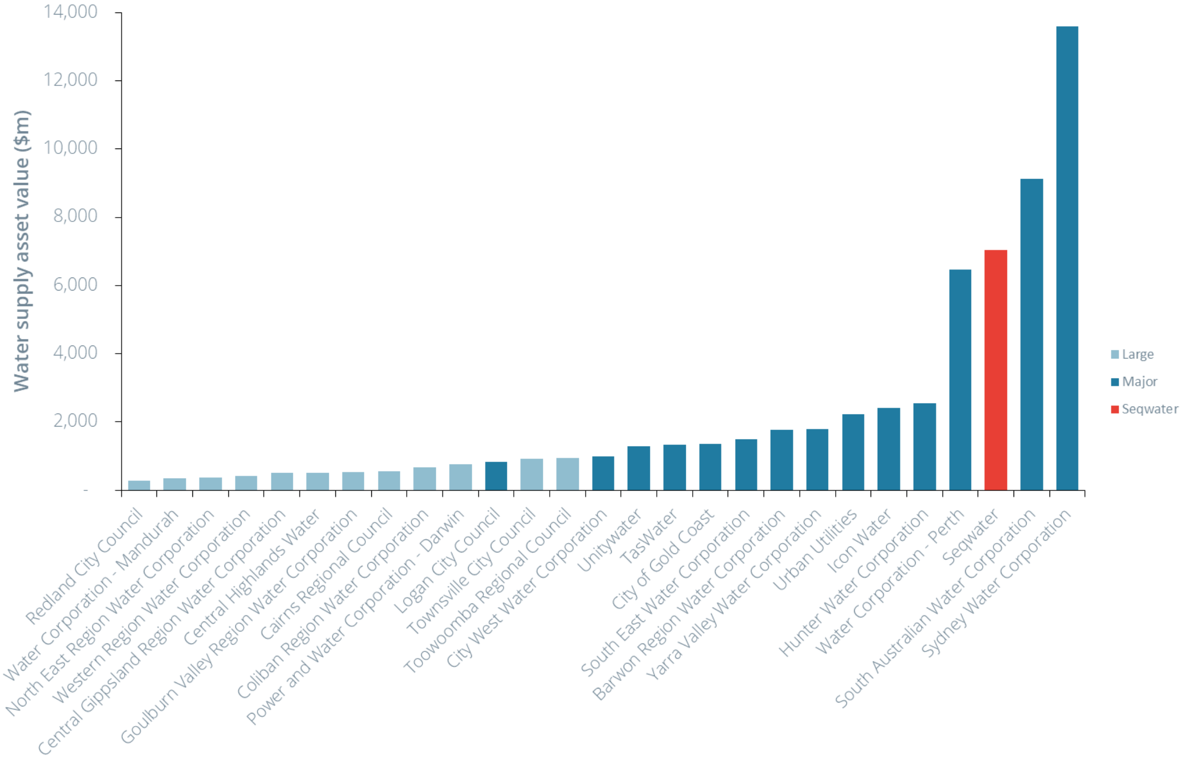
When estimating SFA models for different combinations of size categories for the urban water distributors, we found that the estimates for the productivity growth rate (frontier shift) were sensitive to the size category. This could, in part, be due to scale economies. To find a suitable subsample to use as a benchmark for Seqwater, we compared Seqwater's size to the size of the urban water distributors. However, since Seqwater is a bulk water business rather than a distributor, the number of connections is not an appropriate measure for comparing the size of Seqwater with the urban water distributors. Instead, we have compared Seqwater with the distributors on the basis of asset value and revenue. These comparisons are shown in **Figure 12** and **Figure 13**.

27 This holds if the data errors are in the dependent variable (opex in the present case). If there were sizable errors in the data for other variables used in the model, we would have a so-called errors-in-variables issue, which would result in statistically inconsistent estimates.

28 Economic Insights (2017), *op cit.*

29 NPR variable W11: Total urban water supplied (ML). Data from the 2018 dataset is appended to the 2020 dataset.

Figure 12: Seqwater's asset value compared to urban water distributors



Source: Frontier Economics analysis of NPR data

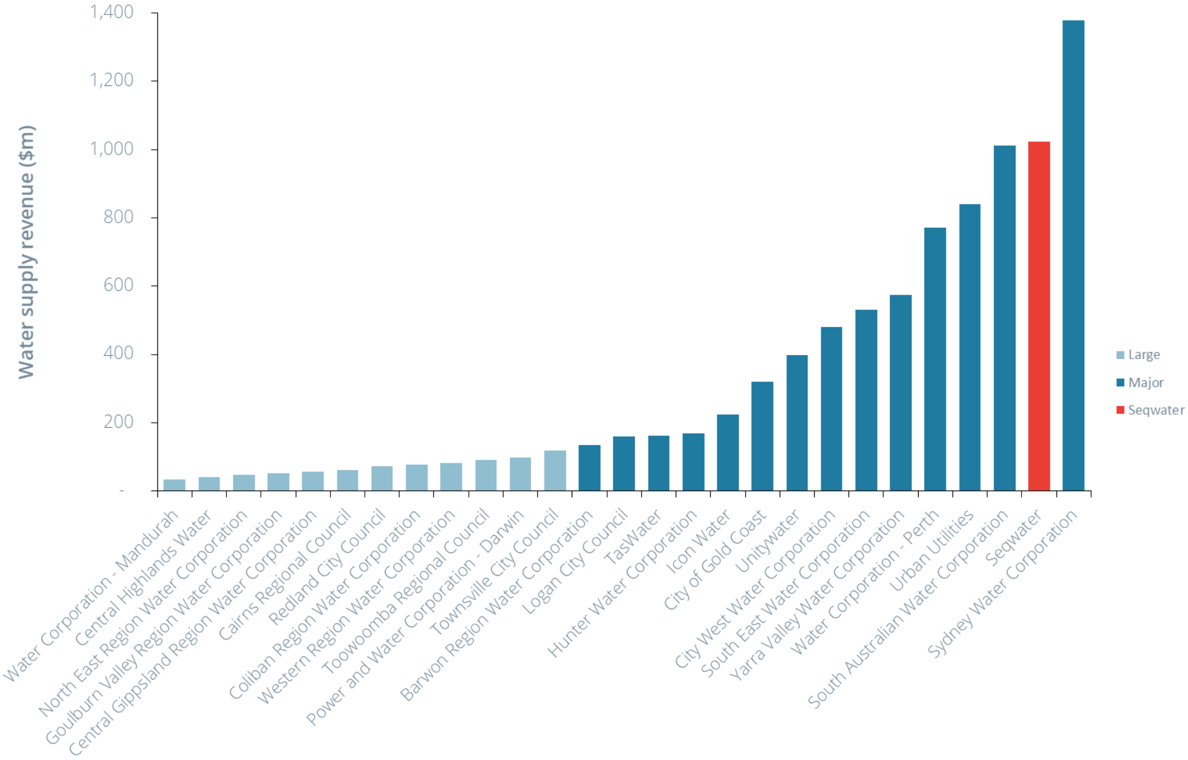
It is clear from these charts that, in terms of these measures of scale, Seqwater is comparable in size to a 'major' water distributor. In view of this, we consider that it is appropriate to focus on SFA estimates of the productivity growth rate for the water distributors in the 'major' urban water distributors. However, this category is fairly small, consisting of just 15 utilities. Hence, we also undertook an SFA analysis for the expanded sample consisting of the 'major' plus 'large' urban water distributors, consisting of 27 utilities in total.

The estimation was carried out in two stages. First an SFA model was fitted using all the data for a given subsample. We then removed any 'outlier' utilities and re-estimated the model. The criterion chosen for identifying an outlier utility was whether one or more of its residuals was at least 0.25 in absolute terms, implying that in one or more years the utility's real opex was at least 25% higher or lower than was predicted by the model.[30]

After removing outlier utilities, the sample sizes of the samples used in the SFA estimations were 122 for the 'major' sample, and 187 for the 'major' plus 'large' sample.

30 The prediction includes the predicted technical efficiency of the utility.

Figure 13: Seqwater's revenue compared to urban water distributors



Source: Frontier Economics analysis of NPR data

The preferred outputs selected for inclusion in the final model specification were selected via an iterative process. Starting with a constant and a time trend, we successively added output variables to the model if that improved the fit of the model to the data, as assessed by a commonly used statistical criterion known as the Bayesian Information Criterion (BIC).[31]

This selection procedure led to a specification in which the only output driver of opex in the model is the number of customer connections for the combined 'large' and 'major' sample, and the number of customer connections and water supplied for the 'major' only sample. However, we also present results for a second model specification in which all three output variables – number of connections, water supplied and mains length – are included in the model. In all specifications, the dependent variable in the model is real opex, and opex as well as the output variables are specified in logarithms.

31 We also carried out a selection procedure in the reverse direction, starting with all output variables in the model and successively removing variables if they were insignificant or had the wrong sign. This yielded the same specifications as the forward approach.

Table 4: Estimated productivity growth rates for urban water distributors using SFA

	Estimated productivity growth rate		
Sample	**Connections only**	**Connections and water supply**	**All drivers of opex**
Major only		-2.2% p.a.	-2.4% p.a.
Large & major	-1.9% p.a.		-1.9% p.a.

Source: Frontier Economics analysis of NPR data for the period 2008-09 to 2019-20

Table 4 presents the estimates of the productivity growth rates produced by the four different SFA models discussed above (two different samples and different specifications for each sample). The Table shows that, over the period 2008-09 to 2019-20, the estimated productivity growth rate for urban water distribution businesses of similar scale to Seqwater was negative for all four models, with the estimates ranging from a 2.4% p.a. decline in productivity to a 1.9% p.a. decline in productivity. The two models estimated using only the 'major' utilities sample indicate a decline in productivity of 2.2% p.a. and 2.4% p.a. respectively. The estimates of the rate of productivity change are statistically significantly different from zero.

5.6 Conclusion

We have applied SFA to estimate the historical average productivity growth rate of urban water distribution businesses of similar scale to Seqwater using NPR data up to 2019-20. Our analysis indicates that, over the period 2008-09 to 2019-20, the productivity growth rate in these businesses was negative with estimates of the change in productivity ranging between -2.4% p.a. and -1.9% p.a., depending on the sample used and the model specification.

6 Regulatory precedent

6.1 Introduction

When setting the opex productivity growth rate allowance for Seqwater in its 2018 decision, the QCA (and its adviser, KPMG) gave consideration to the productivity growth rate determined by other regulators in Australia. We have therefore also considered the opex productivity growth rates set in a selection of recent regulatory decisions that relate to water businesses. **Table 5** below presents the regulatory decisions we considered and the productivity growth rate determined in those decisions.

Table 5: Regulatory decisions considered

Decision	Reference	Productivity growth rate
ERA – Water Corporation (2017)	The efficient costs and tariffs of the Water Corporation, Aqwest and Busselton Water, Final Report	0.75% p.a.
ESC - South Gippsland Water (2020)	South Gippsland Water final decision	1.0% p.a.
ESC - Western Water (2020)	Western Water draft decision	2.0% p.a.
ESCOSA - SA Water (2020)	SA Water Regulatory Determination 2020, Final Determination: Statement of Reasons	0.5% p.a.
ICRC - Icon Water (2018)	Regulated water and sewerage services prices 2018-23, Final Report	1.75% p.a.
IPART – Sydney Water (2020)	Review of prices for Sydney Water, Final Report	0.8% p.a.
IPART - WaterNSW (2020)	Review of prices for Water NSW Greater Sydney, Final Report	0.8% p.a.
OTTER - TasWater (2018)	2018 Water and sewerage price determination investigation final report	1.50% p.a.
QCA - GAWB (2020)	Gladstone Area Water Board price monitoring 2020–25 Part A: Overview, Final Report	1.0% p.a.
QCA - Sun Water (2020)	Rural irrigation price review 2020-24, Part B: Sunwater, Final Report	0.2% p.a.

Source: Various regulatory decisions. Note: Whilst not stated explicitly in all decisions, we understand that the productivity growth rates in the decisions reported in this Table are compound rather than static rates.

6.2 Interpretation of recent regulatory precedent

Table 5 above indicates that the opex productivity growth rates adopted in recent regulatory decisions range from 0.2% p.a. (the QCA decision for Sun Water) to 2.0% (the ESC decision for Western Water). However, for the reasons we explain below, the relevance of a number of these decisions should be viewed with some caution.

6.2.1 Productivity growth rates set by the ESC

During the QCA price review for the Gladstone Area Water Board (GAWB), the QCA's adviser, KPMG, recommended that the QCA apply a productivity growth rate of 1.8% p.a. to GAWB. KPMG derived that recommended productivity growth rate by reference to the average productivity growth rates proposed by Victorian water businesses in the 2018 PREMO price reviews.

However, in the final GAWB decision, the QCA adopted a more conservative productivity growth rate of 1.0%, and in doing so stated the following:[32]

> *We note the basis for KPMG's recommended efficiency factor. However, we are mindful that comparisons with efficiency factors applied in other specific contexts should be made cautiously. For example, some of the larger adjustments by the Victorian water businesses in the 2018 PREMO review may have been proposed in the context of growing retail demand forecasts, which is different to the demand for bulk water faced by GAWB in 2020–25 (Chapter 8). Consequently, we adopted a more conservative approach and applied GAWB's proposed efficiency target of 1 per cent...*

We agree with the QCA that caution is warranted when considering the relevance to bulk water suppliers of productivity growth rates proposed by retail water businesses (and accepted by the ESC) in Victoria.

Furthermore, we note that the PREMO regulatory framework applied by the ESC differs in some important respects from the framework applied by the QCA. Specifically, under the PREMO framework, Victorian businesses that offer (and deliver successfully) high efficiency improvements are rewarded with a return on equity allowance that exceeds the standard allowance. That is, the water businesses regulated by the ESC are rewarded, through the allowed rate of return, for pursuing and delivering ambitious efficiency improvements. It is very possible that the efficiency improvements targeted by water businesses under a PREMO framework reflect a combination of catch-up efficiency and frontier shift efficiency. This may be particularly true in the early regulatory periods under the PREMO framework, when there may be significant scope for catch-up efficiencies to be realised. As we have noted earlier in this report, the QCA ought to reflect only frontier shift (rather than catch-up efficiency) when setting the opex productivity growth rate for Seqwater. To the extent that the productivity growth rates proposed by Victorian water businesses conflate catch-up and frontier shift efficiencies, those productivity growth rates would overstate the productivity growth rate that may be relevant to Seqwater.

32 QCA, *Gladstone Area Water Board price monitoring 2020–25 Part A: Overview, Final Report*, May 2020, p. 45.

For these reasons, in our view the QCA should exclude from consideration any productivity growth rates set by the ESC that exceed 1.0%. This is because, as the ESC has noted, a productivity growth rate of 1.0% "is the minimum required for a 'Standard' PREMO rating."[33] This would result in the highest productivity growth rate reported in **Table 5**, 2.0%, being excluded from consideration.

6.2.2 Productivity growth rate set by ICRC

The second highest productivity growth rate reported in **Table 5** is the productivity growth rate of 1.75% p.a. set by ICRC in 2018 when determining Icon Water's regulated charges. Icon Water proposed an annual opex productivity growth rate of 1.75%. This proposed productivity growth rate was reviewed and recommended by the ICRC's adviser, Calibre.[34] The ICRC adopted Calibre's recommendations, thereby accepting Icon Water's proposed productivity growth rate of 1.75%.[35]

When describing its proposed productivity growth rate, Icon Water explained the following:[36]

> *Icon Water also included an efficiency factor in the base step trend derivation of controllable opex for water and sewerage. An annual efficiency factor of 1.75 per cent has been estimated. This is based on various business restructures in the current regulatory period that are expected to yield cost savings during the 2018–23 regulatory period (section 3.2.1). It is also consistent with the NSW Independent Pricing & Regulatory Tribunal's recent decision on catch-up efficiency savings (IPART 2016).*

That is, Icon Water noted that the basis for the productivity growth rate it proposed was various business restructures, and noted that the proposed savings were consistent with catch-up efficiency saving targets adopted by IPART.

Elsewhere in its proposal to the ICRC, Icon Water explained that these restructures comprised the following:[37]

- Major restructure undertaken in the Finance Group;
- Major restructure undertaken in the Project Delivery Group. The new structure is focused on improving project management capability and the creation of a Program Management Office which has standardised systems and processes to ensure greater certainty of delivery;
- A review of the Safety and Business Solutions (SBS) Group to ensure Icon Water has the most effective and efficient structure to deliver services that meet the changing needs of the business, particularly in the critical areas of safety and corporate services. This resulted in an

33 ESC, South Gippsland Water final decision, 10 June 2020, p. 12.

34 Calibre, Calbre, Review of Icon Water's Capital and Operating Expenditure for Water and Sewerage Services, Final Report, 11 July 2018, p. 58.

35 ICRC, Regulated water and sewerage services prices 2018–23, Final Report 1, May 2018, p. 55.

36 Icon Water, Regulatory proposal to ICRC, Attachment 7 – Operating expenditure, 30 June 2017, p. 22.

37 Icon Water, Regulatory proposal to ICRC, Attachment 7 – Operating expenditure, 30 June 2017, pp. 9-10.

amalgamation of the SBS and Governance Groups to form a combined Business Services Group.

- A shift from a product-based split of water and sewerage functions in the areas of asset management, network planning and operations, to an approach that merged the water and sewerage asset management groups and reassigned corporate functions. The new operating model necessitated further organisational restructuring to ensure Icon Water has the most effective and efficient structure in place to support the changes.

In other words, the source of the savings proposed by Icon Water appears to be (at least in part) due to some major business transformations, akin to catch-up activity, which produced ongoing efficiency benefits during the regulatory period. The productivity gains proposed by Icon Water do not appear to relate solely to incremental frontier shift efficiency gains.

6.2.3 Productivity growth rate set by OTTER

The third highest productivity growth rate reported in **Table 5** is the productivity growth rate of 1.50% p.a. set by OTTER in 2018 when determining TasWater's regulated charges. OTTER explained that its decision to impose a productivity growth rate of 1.50% on TasWater in that determination was informed by two considerations:

- Advice from its consultant, Arup, on the scope for TasWater to make significant productivity improvements; and
- A survey of the productivity growth rates that had been applied by regulators in recent decisions.

Arup provided advice to the OTTER that suggested that there was scope to make significant labour productivity improvements through major upgrades to asset management systems, investment in integrating treatment plants and updating technology:[38]

> *While additional savings on salary costs should be possible, of primary concern for the PSP3 period will be a need and expectation from its customers and stakeholders for a significant lift in measured staff productivity. This should be achievable as the benefits of the integrated asset management systems, and a capex project focus of integrating treatment plants and updating technology provide the opportunity for staff to be redeployed to undertake other roles to speed the capex and maintenance programs, leading to much improved compliance to technical standards and regulatory requirements.*

Arup went on to explain that TasWater owned a "significantly larger number of water and sewerage treatment plants and other water assets" than its mainland peers, and that this had been driven by legacy ownership structures. In addition, a legacy focus on small service areas had "limited access to economies of scale and scope to the detriment of planning and delivery efficiency, and

38 Arup, Review of Tasmanian Water and Sewerage Corporation's Operating and Capital Expenditure, Final Report, p. 10.

hence arguably a large negative impact on productivity."[39] Arup advised OTTER that rationalisation of assets, processes and operational activities would lead to greater efficiency gains.

Arup's advice raises two important considerations:

- Firstly, much of the required efficiency gains that Arup identified would seem to relate more to catch-up efficiency rather than frontier shift (e.g., the need to rationalise assets and change legacy processes to come in line with TasWater's "mainland peers"). This would suggest that only some of the productivity growth rate of 1.50% p.a. applied by OTTER related to frontier shift.
- Secondly, whilst Seqwater (like TasWater) was formed through a process of aggregating several small providers, there is no evidence that Seqwater faces the same need to realise catch-up efficiencies, or is otherwise in a similar position to TasWater. For instance, in its 2018 decision for Seqwater, the QCA did not make any adjustments to Seqwater's base year opex to remove any inefficiencies.[40] Nor did the QCA's adviser, KPMG, find any evidence of inefficiency in Seqwater's base year opex, or a need for efficiency gains to catch up to peer firms.

The second piece of evidence that OTTER relied on when determining a productivity growth rate of 1.50% for TasWater was a survey of the productivity growth rates that other water sector regulators had adopted in recent determinations. The regulatory precedents that OTTER considered were in fact those identified by KPMG when advising the QCA on Seqwater's costs for the 2018-21 regulatory period. A summary of those regulatory decisions is reproduced in **Table 6** below.

Table 6: Regulatory precedent on the productivity growth rate considered by OTTER

Sydney Water	**2017**	**2018**	**2019**	**2020**
Continuing efficiency	0.3%	0.5%	0.8%	1.0%
Catch up efficiency	0.5%	0.8%	2.0%	2.0%
SA Water	**2016-17**	**2018-18**	**2018-19**	**2019-20**
Continuing efficiency	1.0%	1.0%	1.5%	1.5%
Victorian Urban Water	**2013-14**	**2014-15**	**2015-16**	**2016-17**
Continuing efficiency	1.0%	1.0%	1.0%	1.0%
Water Corporation	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Continuing efficiency	2.5%	2.5%	2.5%	2.5%

Icon Water	**2016-17**	**2017-18**	**2018-19**	**2019-20**	**2020-21**	**2021-22**	**2022-23**
Continuing efficiency	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%	1.75%

Source: OTTER, 2018 Water and sewerage price determination investigation – Final Report, Figure 7.3

We note that more recent regulatory determinations for some of the businesses referred to in the Table above have adopted lower productivity growth rates than those that were available to the ICRC when it made its decision in 2018. For instance, as **Table 5** shows:

[39] Arup, Review of Tasmanian Water and Sewerage Corporation's Operating and Capital Expenditure, Final Report, p. 10.

[40] QCA, Seqwater bulk water price review 2018-21, Final report, March 2018, p. 22.

- In 2020, IPART adopted a continuing efficiency productivity growth rate of 0.8% p.a., and no catch-up efficiency rate, for Sydney Water. By contrast, the average continuing efficiency rate plus catch-up rate reported for Sydney Water over the years 2016-17 to 2019-20, in **Table 6**, is approximately 1.97% p.a.; and
- In 2020, ESCOSA adopted a continuing efficiency productivity growth rate of 0.5% p.a. for SA Water. By contrast, the average continuing efficiency productivity reported for SA Water over the years 2016-17 to 2019-20, in **Table 6**, is approximately 1.25% p.a.

Furthermore, we note that the productivity growth rate of 2.5% p.a. attributed to the Water Corporation by KPMG in **Table 6** is misleadingly high. In its 2017 determination for the Water Corporation, the ERA determined an efficiency target that reduced real base operating expenditure *per connection* by 2.5% p.a. This is the figure that KPMG appears to have reported in **Table 6**. However, as the ERA explained in its 2017 final decision, this efficiency target per connection translates into a productivity growth rate of 0.75% p.a. when applied to the Water Corporation's aggregate opex:[41]

> *... the ERA applies a 2.5 per cent per annum efficiency target, on a per connection basis. The ERA's efficiency target translates to approximately a 0.75 per cent per annum efficiency target applied to aggregate operating expenditure.*

Hence, KPMG (and the ICRC) should have considered the much lower figure of 0.75%, rather than the productivity growth rate of 2.5% reported in **Table 6** (as we have done in **Table 5**).

Finally, as explained in section 6.2.2, the productivity growth rate of 1.75% applied by the ICRC to Icon Water is likely to represent a mixture of catch-up efficiency and frontier shift. Therefore, that figure likely overstates the estimate of frontier shift relevant to the 'trend' component when applying the base-step-trend approach.

6.3 Conclusions

The opex productivity growth rates adopted in recent regulatory decisions range from 0.2% p.a. to 2.0%. However, as we have explained in this section, the highest of the productivity growth rates applied by regulators in recent decisions are unlikely to be relevant when considering the appropriate productivity growth rate to apply to Seqwater. This is because:

- A number of regulatory decisions appear to conflate catch-up efficiency and frontier shift when determining the productivity growth rate. However, under the QCA's framework, the productivity growth rate applied in the trend component of the base-step-trend approach should only reflect frontier-shift efficiency. Incorporating a measure of catch-up efficiency in the trend component and assessing the base year level of opex for efficiency (as is typically done when applying the base-step-trend approach) would effectively double-count catch-up efficiency, thereby producing an opex allowance that would be below the efficient level.

41 ERA, Inquiry into the efficient costs and tariffs of the Water Corporation, Aqwest and Busselton Water, Final Report, 10 November 2017, pp. 36-37.

- As the QCA itself has noted recently, relatively high productivity targets proposed by Victorian water businesses in the 2018 PREMO review may have been proposed in the context of growing retail demand forecasts, which may be different to the demand for bulk water in Queensland.
- The PREMO framework rewards water businesses for setting and then delivering against ambitious productivity targets with a higher-than-standard return on equity allowance. This is a fundamental difference from the QCA framework, and may explain the relatively high productivity growth rates proposed by some Victorian water businesses in recent determinations.
- Some regulatory decisions (e.g., OTTER's 2018 decision for TasWater) determined the productivity growth rate by reference to previous regulatory decisions, which have been superseded and replaced by lower productivity growth rates.
- The productivity growth rates applied by some regulators have been reported incorrectly by advisers to the QCA. By way of example, KPMG advised the QCA in 2018 that the ERA had applied a productivity growth rate of 2.5% p.a. to the Water Corporation. This represents a misunderstanding on KPMG's part. In fact, the ERA has clarified that the productivity growth rate it applied to the Water Corporation is approximately 0.75% p.a. across aggregate opex.

Taking the factors above into account, in our view, recent regulatory determinations would support a productivity growth rate (reflecting frontier shift) that is more in the range of 0.2% p.a. to 1.0% p.a.

7 Overall estimate of productivity

In this report, we have:

- Estimated Seqwater's historical productivity growth rate using TFP analysis;
- Estimated the historical productivity growth rate of Australian water distribution businesses of similar scale to Seqwater, using SFA; and
- Investigated recent, relevant regulatory precedent on the productivity growth rates adopted by regulators in Australia in order to reflect frontier shift efficiency.

The estimates of the productivity growth rate using these different methods are summarised in **Table 7**.

Table 7: Summary of evidence

Approach	Conclusion on productivity growth rate
TFP estimates of Seqwater's historical productivity rate	-0.7% p.a. to -0.4% p.a.
SFA estimates of historical productivity growth rate of Australian water distribution businesses of comparable scale to Seqwater	-2.4% p.a. to -1.9% p.a..
Recent regulatory precedent	+0.2% p.a. to +1.0% p.a.

Source: Frontier Economics

Given this evidence, we consider that it would be reasonable for the QCA to apply an annual cumulative productivity growth rate (reflecting frontier shift efficiency) of no higher than +0.2% p.a.

We note that this rate would be consistent with the productivity growth rate applied by the QCA to:

- Seqwater when setting its bulk water charges over the 2018-21 regulatory period; and
- Seqwater and Sun Water when setting prices relating to the supply of water for rural irrigation services.

A Calculation of partial and total factor productivity indices

Measuring productivity

Productivity is measured by taking the ratio of the quantity of outputs produced divided by the quantity of inputs used to produce those outputs. That is:

$$(1)\ Productivity = \frac{Quantity\ of\ outputs}{Quantity\ of\ inputs}.$$

Therefore, productivity will increase when less inputs are used to produce a given level of output, or alternatively, when the quantity of output increases for a given level of inputs. Similarly, productivity will decline if more inputs are required to produce a given level of output, or alternatively, if for a given level of inputs the quantity of output declines. It is important to note expression (1) refers to the 'quantity' of outputs and the 'quantity' of inputs. Sometimes the quantities are not known, but the revenue for an output, or the cost of an input are known. In those cases, the dollar amounts are sometimes used as proxies for the quantities; but it is then important to ensure that these proxies for the quantities are measured in constant dollar terms, i.e., deflated using an appropriate index.

Productivity measures can be turned into an index by choosing a base period and expressing all the values for the productivity measure relative to the value in the base period. For example, assume that the productivity values calculated using formula (1) for the years 2018, 2019 and 2020 are 500, 450 and 600 respectively, and we choose 2018 as the base year. The productivity index for the 3 years would then be 1, 0.9 and 1.2 (that is 500/500, 450/500 and 600/500).

Partial and total productivity measures

If the quantity of outputs in the formula (1) is a measure of all the outputs produced by the business or industry, and the quantity of inputs is a measure of all the inputs used to produce those outputs, then a productivity index is referred to as a total factor productivity (TFP) index. If, however, the measure of the inputs does not capture all the inputs used in production, then the index is referred as a partial factor productivity (PFP) index. Similarly, the measure of outputs does not capture all the outputs.

Commonly used PFP indices are the opex PFP index and the capital PFP index. These PFP indices still have a measure of total output in the numerator of expression (1), but in the denominator they only have a measure of the opex used to produce those outputs (opex PFP), or of the capital used to produce those outputs (capital PFP).

Combining outputs and inputs

In order to calculate a productivity index, it is usually necessary to combine a number of different types of outputs into a single output measure, and to combine a number of different inputs into a single input measure. For example, a single measure to capture different components of opex may have to combine the hours of labour used in production, the amount of energy used and the amounts of various materials used. This usually involves taking a weighted combination of the different components included in the aggregated measure.

The approach most widely used in productivity studies to combine different inputs into a single input measure, or to combine different outputs into a single output measure is the Törnqvist indexing procedure. We have used this approach in this study. This procedure focuses on the change in the aggregate measure of outputs produced between two periods (or between two businesses), and the change in the aggregate measure of inputs used.

Suppose we want to combine several inputs into a single input measure. The Törnqvist approach first calculates the percentage change between the periods in the quantity of each input. It then takes a weighted average of these percentage changes. That is then interpreted as the percentage change in the aggregate measure of inputs between the periods.

The percentage change in input quantities is calculated using logarithms (for small percentage changes, the change in the log of the quantities is virtually identical to the percentage change). The weights used to combine the percentage changes for the different inputs are based on the contribution that each input makes to the combined cost. The cost share of each input to the combined cost is averaged across the two periods under consideration, and those average cost shares are used as the weights when combining the percentage changes in the quantities of inputs between the two periods.

Box 1 presents the algebraic formula for calculating the change in the aggregate input measure between periods $\boldsymbol{s}$ and $\boldsymbol{t}$. The input quantities are denoted by $\boldsymbol{X}$, and different inputs are indicated by the subscript $\boldsymbol{j}$. Hence, $\boldsymbol{X_{js}}$ denotes the quantity of input $\boldsymbol{j}$ used in period $\boldsymbol{s}$, and $\boldsymbol{X_{jt}}$ denotes the quantity of input $\boldsymbol{j}$ used in period $\boldsymbol{t}$. The cost shares of input $\boldsymbol{j}$ in periods $\boldsymbol{s}$ and $\boldsymbol{t}$ are denoted by $\boldsymbol{C_{js}}$ and $\boldsymbol{C_{jt}}$. The weight attached to input $\boldsymbol{j}$ is the average cost share across the two periods $\frac{(\boldsymbol{C_{js}}+\boldsymbol{C_{js}})}{2}$, and the percentage change is represented by $\log\left(\frac{\boldsymbol{X_{jt}}}{\boldsymbol{X_{js}}}\right)$. The Σ sign in the box indicates summation across the different inputs.

Box 1: Törnqvist formula for change in aggregate input measure between periods *s* and *t*

$$Change\ in\ inputs = \log\left(\frac{Inputs_t}{Inputs_s}\right) = \sum_j \frac{(\boldsymbol{C_{jt}} + \boldsymbol{C_{js}})}{2} \times \log\left(\frac{\boldsymbol{X_{jt}}}{\boldsymbol{X_{js}}}\right)$$

Source: Frontier Economics

We can write a similar expression for the aggregate change in outputs between periods $\boldsymbol{s}$ and $\boldsymbol{t}$. The output quantities are denoted by $\boldsymbol{Y}$, and different outputs are indicated by the subscript $\boldsymbol{i}$. The revenue shares in periods $\boldsymbol{s}$ and $\boldsymbol{t}$ are denoted by $\boldsymbol{R_{is}}$ and $\boldsymbol{R_{it}}$. Box 2 presents the algebraic formula for calculating the change in the aggregate output measure between periods $\boldsymbol{s}$ and $\boldsymbol{t}$.

Box 2: Törnqvist formula for change in aggregate output measure between periods *s* and *t*

$$Change\ in\ outputs = \log\left(\frac{Outputs_t}{Outputs_s}\right) = \sum_i \frac{(\boldsymbol{R_{it}} + \boldsymbol{R_{is}})}{2} \times \log\left(\frac{\boldsymbol{Y_{it}}}{\boldsymbol{Y_{is}}}\right)$$

Source: Frontier Economics

Productivity index

The change in the productivity index between periods s and t is obtained by subtracting the change in the inputs from the change in the outputs:

(2) $$Change\ in\ productivity\ index = \log\left(\frac{TFP_t}{TFP_s}\right)$$
$$= Change\ in\ outputs - Change\ in\ inputs$$
$$= \log\left(\frac{Outputs_t}{Outputs_s}\right) - \log\left(\frac{Inputs_t}{Inputs_s}\right)$$

If the change in the aggregate output measure between the two periods is greater than the change in the aggregate input measure then the change in the productivity index will be positive, indicating that productivity has increased between the two periods. Conversely, if the change in the aggregate output measure between the two periods is less than the change in the aggregate input measure, then the change in the productivity index will be negative, indicating that productivity has decreased. between the two periods.[42]

Starting with a base year when the productivity index is set to 1, we can evaluate expression (2) over a number of consecutive years and construct a TFP index.[43] The same approach can be used to construct PFP indices.

42 Multiplying any of the changes in the above formulas by 100 turns them into percentage changes.

43 One would need to take the antilog of the change in the index in (2). This is the ratio of the productivity index between year t and s. Using this ratio, one can build up the index by applying it in successive years, starting with the base year.

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