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Putting Water to Work – Urban Water Utilities in Regional New South Wales and Victoria[#]

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Abstract: In recent times the relative economic efficiency of urban water utilities has been neglected as policymakers sought to secure urban water supplies. This paper is an effort to measure the efficiency consequences of a number of recent urban water policy initiatives. Data Envelopment Analysis (DEA) is employed in order to measure the relative technical efficiency of urban water utilities in regional New South Wales (NSW) and Victoria. We show that the almost universal policy of water restrictions is likely to reduce relative efficiency and the typically larger utilities located in Victoria are characterised by a higher degree of managerial efficiency. A number of implications for urban water policy are advanced.

Keywords: Water Policy; Urban Water Utilities; Relative Efficiency.

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Introduction

Urban Australia had largely avoided the direct consequences of both intense irrigated agriculture and drought up until the turn of the 21st century. However, a combination of changed weather patterns and population growth (Young *et al.* 2006; NWC 2006) delivered water shortages of varying degrees to almost every capital city in Australia by the beginning of 2007. The ‘drought’ visiting the cities has seen unparalleled interest in solutions to the so-called ‘water crisis’ (Crase and Dollery 2006). Water restrictions, bold engineering schemes such as recycling and desalination plants, and arguments regarding the moral attributes of a green suburban lawn have each been hallmarks of the debate at various stages (see, for instance, Brennan *et al.* 2007; Grafton and Kompas 2007; Watson 2007). The catchphrase ‘every drop counts’ seems now to be known everywhere and by everyone.

Urban water policy hasn’t always been such a frenzied arena. The earliest attempts at reform were relatively dull affairs aimed at blunting the effects of monopoly industry structures (see CoAG 1994). Although the current state of urban water storages can justify to some extent this change in emphasis, turning a blind-eye to the relative operational efficiency of what are still in essence local monopolies may result in unintended, and expensive, consequences. Efforts to ‘secure’ urban water supplies via engineering feats may well prove successful, yet will undoubtedly prove expensive to build, operate and maintain. Ironically, the addition to urban water supplies as a consequence may lead to a lowering in the price paid for water by consumers should pricing tribunals maintain their enthusiasm for marginal cost pricing principles.

The intense focus on safeguarding and husbanding urban water supplies may also allow relatively inefficient institutional arrangements to continue unchallenged, hidden in the fog of efforts to ‘make every drop count’. While the primary responsibility of policy makers is no doubt to ensure sufficient water resources exist to supply urban populations, the secondary aim of government to deliver welfare enhancing policy should not be forgotten. This paper seeks to fill this particular gap in the analysis of urban water in Australia.

In this study we examine 52 water utilities from regional New South Wales (NSW) and Victoria in order to measure relative technical efficiency and productivity over a four year period, 2000 to 2004. We also measure the determinants of relative efficiency with respect to a number of exogenous variables, including governance arrangements, network characteristics and the consequence of recent urban water policy instruments.

The paper proceeds as follows. Section 2 provides some background from contemporary urban water policy in Australia in an effort to establish the need for an investigation of relative efficiency in urban water. Section 3 outlines the econometric technique to be employed and is followed in section 4 by a brief review of applications of relative efficiency measurement in the water and wastewater sectors. Section 5 outlines the data and methodology considerations, while the results of the various models are presented in section 6. The paper concludes with some policy implications in section 7.

Contemporary Urban Water Policy in Australia

Water policy in Australia has largely focused on the troubling complexities of irrigated agriculture. This shouldn’t surprise, since approximately 60 per cent of ‘harvestable’ water is consumed in that sector. However, each of the two most recent water policy landmarks, the 1994 ‘Water Resources Policy’ (WRP) (CoAG 1994) and the 2004 National Water Initiative (NWI) (CoAG 2004) attempted reform in the urban water sector. Each bears the hallmarks of their era.

In 1994, COAG set itself the task of reforming a wide range of so-called ‘Government Business Enterprises’ as part of an ambitious microeconomic reform agenda known as ‘National Competition Policy’. In essence, utilities owned by governments were to take on corporate structures and face the harsh reality of market determined prices, or at least approximates of them. Water and wastewater utilities were to ‘recover costs’ through prices and governments would reform institutional structures in order to allow GBE’s to operate as though they were in the business of maximising profits for the shareholder. Yet, since the utilities were essentially still monopolies, independent price regulators would scrutinise their activities to ensure services were provided in accordance with the principles of economic efficiency.

The state government in Victoria, under the inspirational leadership of Jeff Kennett, took the intent of NCP to heart. As part of a wider effort to reform local government, the urban water sector was consolidated from around 130 local government water utilities to just 18 urban water authorities, now owned by the state government, but governed by Ministerial appointed, skills based boards. Two over-riding principles were to drive reform: pay for use pricing and significant cuts in operating costs (Sadler 1998).

The response in NSW was sluggish in comparison. Although due deference was paid to the efficiency principles outlined in both the NCP and WRP, wholesale structural reform was not forthcoming. In particular, water and wastewater services remained with local government, and the number of utilities remained stagnant. As a result, implementation of full cost recovery and volumetric pricing was far from uniform, as indicated by the efforts of the NSW government department responsible for oversight of the sector to encourage some of the smaller utilities to implement these reforms as late as 2004.

The NWI was in essence an attempt to correct many of the failings with respect to reform of rural water policy from the well intentioned WRP (Byrnes *et al.* 2006), however urban water reform was briefly addressed. Perhaps reflecting a degree of completion of the 1994 objectives, much of the focus turned to the role of water utilities as guardians of the resource, a function not mentioned in the WRP. While ‘efficiency’ was manifest in cost cutting and reformed pricing structures in 1994, in the NWI the term became synonymous with the now well worn slogan, ‘making every drop count’. Integrated Water Cycle Management[1] and Water Sensitive Urban Design[2] were to be implemented in a vague and somewhat counterintuitive[3] partnership of urban water utilities and state and federal policy makers.

The ‘performance’ of utilities was addressed through a commitment to develop nationally consistent performance reports. The states agreed to develop a nationally consistent framework for the benchmarking of pricing and service quality for metropolitan, non-metropolitan and rural water delivery agencies. In practice, this has resulted in slight changes to the existing performance reports in an attempt to bring uniformity to the definitions of the performance measures, to enable comparisons among the states. The National Water Commission (NWC) released the first nationwide performance benchmarking reports in May 2007 (NWC 2007a; 2007b).

Utilities were segregated according to size (measured by the number of connected properties a utility serves). Those utilities in the large category (so-called ‘Major Urban Utilities’) had in excess of 50,000 connected properties, while utilities with between 10,000 and 50,000 connected properties were in the small size category (Non-Major Urban Utilities). The next report, due for release in May 2008, will combine the two, since the small utilities will be required to report accurately on the same criteria that applied to large utilities in 2007.

[1] The focus of IWCM is on creating a loop within the existing water supply, sewerage and stormwater network, with the aim of making optimal use of treated water.

[2] The aim of WSUD is to neutralise the effect of new urban development of the ‘water balance’.

[3] Urban water utilities must one of the few ‘businesses’ to actively discourage sales of the product they sell!

It is interesting to note that those utilities with fewer than 10,000 connected properties will not be subject to the stringent reporting requirements determined by the NWC. As ACIL Tasman (2005, 31) note ‘Australia’s urban water industry comprises approximately 300 utilities. Approximately 70 per cent of Australia’s population are serviced by 26 utilities, while the 200 smallest utilities collectively services only three million customers’. The implication of this is that utilities with fewer than 10,000 connections exist primarily in order to provide essential services and should not be subject to scrutiny with respect to the efficiency of their operations. However, of the water utilities in NSW, only around 25 per cent will be classified as ‘Non-Major’. This serves to highlight the benefit of this paper to the water policy debate in Australia, since it constitutes the first detailed study of the economic efficiency of the majority of NSW water utilities soon to disappear from the radar of future performance audits by the NWC.

A second failing of the National Performance reporting framework is that it relies on partial performance indicators, expressed in absolute terms[4]. Comparing the ‘performance’ of utilities is limited by this, since one utility may be the benchmark on one indicator and middle of the table on another. One of the aims of this paper is to calculate the relative efficiency (or performance) of water utilities. The following section outlines the econometric technique to be employed.

Econometric Technique

DEA as a Measure of Relative Performance

Attempts at relative performance measurement generally fall into two broad categories; Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). In the first, the parameters of a given functional form are estimated with the aim of measuring relative firm efficiency with reference to the estimated frontier. The term stochastic points to an allowance for both

[4] The intent of the NWC is to express in relative terms in future reports (NWC 2007a), but precisely what form ‘relative’ will take is unknown.

technical (as opposed to allocative) inefficiency (deterministic) and matters outside the control of a firm (non-deterministic) (Coelli *et al.* 2005).

Alternatively, DEA makes no assumptions regarding the parameters of the production frontier, preferring to make use of mathematical programming to determine the frontier as a function of the dataset itself. A hull is constructed around the data, and this is assumed to be the efficient frontier (Zhu 2003). Firms can produce within and on the frontier, but not beyond it. In the parlance of production economics, the frontier is said to represent the feasible set of production points and equates to the observed 'best-practice' benchmark against which firms within the industry are judged.

DEA was adopted for this study since SFA would require the imposition of a number of assumptions regarding the shape of the production frontier. These assumptions could not be formulated with a sufficient degree of confidence in the current circumstances since there is a paucity of existing research with respect to the Australian water sector to guide the choice of specification, and this is particularly so at a regional level. Notwithstanding the advantages of using DEA, a choice of this form carries costs. DEA is an entirely deterministic model, necessitating additional econometric steps if one wishes to account for stochastic and exogenous influences. Furthermore, incorporating the extraneous information into the DEA specification is not a particularly flexible process, requiring a number of *a priori* assumptions to be imposed upon the direction in which factors influence relative efficiency (Coelli *et al.* 2005).

DEA calculations generally result in three interconnected measures of relative efficiency. The first is 'overall' efficiency, which can be decomposed into 'pure' efficiency and 'scale' efficiency. Assume data are obtained relating to inputs K and outputs M for a sample of N firms. For the ith firm these can be represented by the column vectors x_i and y_i, respectively. The dataset consists of the input vector KxN = X and output vector MxN = Y. The following model seeks to minimise input consumption while leaving output constant.

$$\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
&\text{s.t.} \\
&-y_i + Y\lambda \geq 0, \\
&\theta x_i - X\lambda \geq 0, \\
&\lambda \geq 0.
\end{aligned} \tag{1}$$

The minimisation task is achieved by θ while λ is a Nx1 vector of constants that locates points on the frontier. Overall technical (in)efficiency is given by scores obtained in θ, relative to λ. Note that θ is the objective function, and operates only with respect to inputs. The linear programming problem must be solved N times, once for each firm in the sample.

Thus far it has been assumed that a given increase in inputs will result in an equi-proportionate increase in output, implying constant returns to scale. However, countless empirical studies have shown that certain industries benefit or suffer from variable returns to scale. To assume an industry operates under constant returns to scale, when in fact some relative efficiency could be gained through variation in scale, gives rise to the concept of scale inefficiency. DEA can be extended to allow for the calculation of 'pure' technical efficiency devoid of scale effects through the addition of a convexity constraint, $\mathrm{N}1'\lambda = 1$, to provide:

$$\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
&\text{s.t.} \\
&-y_i + Y\lambda \geq 0, \\
&\theta x_i - X\lambda \geq 0, \\
&\mathrm{N}1'\lambda = 1, \\
&\lambda \geq 0.
\end{aligned} \tag{2}$$

where $\mathrm{N}1'$ is an Nx1 vector of ones.

The constraint allows a relatively tighter envelopment frontier that is more convex than that obtained under the assumption of constant returns to scale. As a result, the efficiency scores obtained for the firms under the variable returns to scale model will be greater than or equal to those measured in the constant returns case. Measures of relative scale inefficiency are obtained by taking the ratio of overall to pure efficiency.

Using DEA to Measure Productivity

Relative efficiency scores can be easily manipulated in order to measure productivity, provided panel data are acquired (Coelli *et al.* 2005). The Malmquist Productivity Index[5] is a technique well suited to the task of analysing productivity changes in industries with multiple outputs and/or inputs. If DEA scores are calculated for a firm i, in two periods s and t, an input-oriented Malmquist TFP change index can be calculated. Taking period t as the reference point, the index can be expressed as:

$$
\begin{aligned}
&M_i^t\left(\mathrm{y}_s,\mathrm{x}_s,\mathrm{y}_t,\mathrm{x}_t\right)=\frac{d_i^t\left(\mathrm{y}_t,\mathrm{x}_t\right)}{d_i^t\left(\mathrm{y}_s,\mathrm{x}_s\right)}\\
&\text{where}\\
&M_i^t=\text{the Malmquist index}\\
&\mathrm{y}_s=\text{output in period } s\\
&\mathrm{x}_s=\text{input in period } s\\
&\mathrm{y}_t=\text{output in period } t\\
&\mathrm{x}_t=\text{input in period } t\\
&d_i^t=\text{the distance function}
\end{aligned}
\tag{3}
$$

where $d_i^t\left(\mathrm{y}_t,\mathrm{x}_t\right)$ represents the distance function from period t observation relative to the period t technology, and $d_i^t\left(\mathrm{y}_s,\mathrm{x}_s\right)$ is the distance function from period s observation relative to period t technology, allowing measurement of productivity change from period t to s. A value of $M_i>1$ indicates an increase in productivity, and a value of $M_i<1$ is interpreted as a decline in productivity between the periods.

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[5] The Malmquist TFP Index was first introduced by Caves *et al.* (1982a; 1982b). The reference to 'Malmquist' results from the exploitation of so-called 'Malmquist distance functions' to measure productivity change relative to a given technology. In this context, the term 'technology' alludes to the best-practice production frontier at a chosen point in time (Coelli *et al.* 2005).

Since change can be measured with respect to technology in period t or s, it is customary to take the geometric mean of these two indices, as follows:

$$M_i\left(\mathrm{y}_s,\mathrm{x}_s,\mathrm{y}_t,\mathrm{x}_t\right)=\left[\frac{d_i^s(\mathrm{y}_t,\mathrm{x}_t)}{d_i^s(\mathrm{y}_s,\mathrm{x}_s)}\,\mathrm{x}\,\frac{d_i^t(\mathrm{y}_t,\mathrm{x}_t)}{d_i^t(\mathrm{y}_s,\mathrm{x}_s)}\right]^{\frac{1}{2}} \qquad (4)$$

Equation 4 can be expressed alternatively as:

$$M_i\left(\mathrm{y}_s,\mathrm{x}_s,\mathrm{y}_t,\mathrm{x}_t\right)=\frac{d_i^t(\mathrm{y}_t,\mathrm{x}_t)}{d_i^s(\mathrm{y}_s,\mathrm{x}_s)}\left[\frac{d_i^s(\mathrm{y}_t,\mathrm{x}_t)}{d_i^t(\mathrm{y}_t,\mathrm{x}_t)}\,\mathrm{x}\,\frac{d_i^s(\mathrm{y}_s,\mathrm{x}_s)}{d_i^t(\mathrm{y}_s,\mathrm{x}_s)}\right]^{\frac{1}{2}} \qquad (5)$$

The first term outside the bracket is the ratio of DEA efficiency scores calculated in periods t and s and represents change in overall efficiency. The term inside the brackets is the geometric mean of the shift in technology (or the efficient frontier) between the periods t and s, and is often termed technology change in the literature.

The construction of equation 5 suggests that, in the absence of any shift in the technology between the periods, changes in TFP are due entirely to relative efficiency changes. Likewise, given an assumption of zero change in relative efficiency between the periods in question, changes observed in TFP are entirely a result of shifts in the technology.

Given the four distance functions in equation 5 four linear programming problems must be calculated in order to measure TFP for a firm, and by definition, its constituent parts. They are:

$$\begin{aligned}
&d_i^t\left(\mathrm{y}_t,\mathrm{x}_t\right)=\min_{\theta,\lambda}\theta,\\
&\mathrm{st}\ \text{-}\mathrm{y}_{it}+\mathrm{Y}_t\lambda\geq 0,\\
&\theta\mathrm{x}_{it}-\mathrm{X}_t\lambda\geq 0,\\
&\lambda\geq 0,
\end{aligned} \qquad (6)$$

$$\begin{aligned}
&d_i^s\left(\mathrm{y}_s,\mathrm{x}_s\right)=\min_{\theta,\lambda}\theta,\\
&\mathrm{st}\ \text{-}\mathrm{y}_{is}+\mathrm{Y}_s\lambda\geq 0,\\
&\theta\mathrm{x}_{is}-\mathrm{X}_s\lambda\geq 0,\\
&\lambda\geq 0,
\end{aligned} \qquad (7)$$

$$
\begin{aligned}
& d_i^t\left(\mathrm{y}_s, \mathrm{x}_s\right)=\min_{\theta, \lambda} \theta, \\
& \text{st } -\mathrm{y}_{is}+\mathrm{Y}_t \lambda \geq 0, \\
& \theta \mathrm{x}_{is}-\mathrm{X}_t \lambda \geq 0, \\
& \lambda \geq 0,
\end{aligned} \tag{8}
$$

and

$$
\begin{aligned}
& d_i^s\left(\mathrm{y}_t, \mathrm{x}_t\right)=\min_{\theta, \lambda} \theta, \\
& \text{st } -\mathrm{y}_{it}+\mathrm{Y}_s \lambda \geq 0, \\
& \theta \mathrm{x}_{it}-\mathrm{X}_s \lambda \geq 0, \\
& \lambda \geq 0.
\end{aligned} \tag{9}
$$

The four linear programming problems are to be solved for each firm in the sample.

Literature Review

One of the most enduring themes in the literature on water and wastewater relative efficiency has been the testing of hypotheses regarding the existence of public versus private ownership effects. As a result, the majority of the literature is not of direct relevance to this research. As outlined in Table 1, it could hardly be claimed that a consensus was reached on the question. An excellent synopsis of the studies summarised in Table 1 can be found in Coelli and Walding (2005).

Nevertheless, three studies are of particular relevance to this study: Aubert and Reynaud (2005), Woodbury and Dollery (2004) and Coelli and Walding (2005).

Table 1: Relative Efficiency Studies of the Water and Wastewater Sector

Author	Data	Method	Results
Anwandter and Ozuna (2002)	110 water and sewerage utilities - 1995	DEA	Regulatory reform must introduce competitive pressures and reduce information asymmetries to be effective
Aubert and Reynaud (2005)	211 water utilities – 1998-2000	SFA	Regulatory regime is important to efficiency
Bhattacharyya, Harris, Narayanan and Raffiee	31 private and 190 public - 1992	SFA	Public firms not disadvantaged in terms of efficiency

(1995b)			
Bhattacharyya, Harris, Narayanan and Raffiee (1995a)	26 rural water utilities - 1992	SFA	Private firms are most efficient, of government utilities, municipality owned are most efficient on average
Bottasso and Conti (2003)	Unbalanced panel of 28 to 21 firms - 1995-2001	SFA	Limited economies of scale; average cost inefficiency has steadily decreased over time
Byrnes (1991)	49 private and 105 public - 1976	SFA	Models that measure ownership effects must first account for selectivity bias to yield accurate results
Byrnes, Groskopf and Hayes (1986)	59 private and 68 public firms - 1976	DEA	No significant difference in inefficiency as a result of ownership
Coelli and Walding (2005)	18 water utilities – 1996-2003	DEA	In order for regulators to make use of efficiency estimates, data quality must improve
Cubbin and Tzanidakis (1998)	29 water firms from the regulated water industry – 1993-1995	DEA and COLS (cost function)	Each method returns substantially different efficiency measures
Estache and Kouassi (2002)	21 water utilities – 1995-97	SFA	Relatively low efficiency explained by pervasive corruption and poor governance arrangements
Estache and Rossi (2002)	50 water companies - 1995	SFA	Efficiency unaffected by ownership structure
Faria, Souza and Moreira (2005)	13 private and 148 public - 2002	SFA	Neither location of ownership significantly influenced efficiency
Fox and Hofler (1986)	20 private and 156 public - 1981	SFA	Equal technical inefficiency however private utilities had significantly higher allocation inefficiency
Garcia-Sanchez (2006)	24 water utilities - 1999	DEA	Ownership not a significant influence on efficiency
Lambert, Dichev and Raffiee (1993)	33 private and 238 public - 1989	DEA	Public firms have greater technical and allocative efficiency
Lynk (1993)	10 public water utilities – 1980-88; 22 private water utilities – 1985-88	SFA	Scope economies; Private firms appeared less efficient than public firms
Tupper and Resende (2004)	20 water sewerage companies - 1996-2000	DEA	Exogenous variables had significant influence on efficiency
Woodbury and Dollery (2004)	73 water supply authorities – 1998-2000	DEA	scope for general improvement in the performance of regional water utilities

Aubert and Reynaud (2005) investigated the role of regulatory oversight on the relative efficiency of water utilities in Wisconsin, USA. In sum, the authors found that regulatory regimes and the relative efficiency of water utilities were significantly related. Regimes that required extensive information gathering by regulators resulted in higher levels of efficiency, while those with less information demands tended to be associated with less efficient utilities.

The findings of efficiency gains as a result of so-called 'hard' (as opposed to soft) regulation have important implications for the regulation of water and wastewater utilities in NSW and Victoria. As outlined in section 2, water authorities in Victoria are subject to regulatory oversight by an independent economic regulator while water utilities in NSW are subject to so-called 'soft' regulation. The findings of Aubert and Reynaud (2005) suggest that the benefits of 'hard' regulation may well compensate for the additional cost of regulation. Whether this is the case in the current context is a matter for empirical investigation.

In the Australian context, there appear to be only two published studies. Woodbury and Dollery (2004) represented the first attempt at analysing the efficiency of water and wastewater providers in regional NSW. In addition, they made a significant contribution to the literature through the construction of water quality indices. Overall the results of their study suggested scope for general improvement in the performance of regional water utilities in NSW.

Coelli and Walding (2005) studied the 18 largest urban water providers in Australia. Although this mainly involved an examination of urban water utilities in the Australian capital cities, a number of the utilities were located in regional Victoria. In essence their study was designed to aid policy makers when considering price-cap regulation problems. By examining the technical efficiency and productivity of the utilities, Coelli and Walding hoped to 'provide comprehensive performance information to help regulatory authorities set (so-called) CPI-X price paths that encourage efficient performance' (2005, 2). They found that the mean technical efficiency (TE) score of the utilities was 0.904, implying that the average firm could have reduced input consumption by 9.6 per cent without reducing output. In terms of Total Factor Productivity (TFP) growth, the authors found that the average annual TFP change over the seven-year period (1995-96 to 2002-03) was a 1.2 per cent decline per year. This was attributed primarily to the implementation of demand management policies during the sample period resulting in reduced output, which, when combined with a renewed focus on water quality, resulted in a proportionate increase in input use. However, the major conclusion from this study was that data of much more robust quality would be required before regulatory bodies could rely upon results from efficiency studies such as this, at least as far as it relates to the setting of prices.

It seems reasonably clear from this brief review of the extant literature that there is a paucity of relative efficiency studies relating to water and wastewater utilities in Australia, despite 15 years of reform in the sector and overwhelming public interest in water matters.

Methodology and Data

The dataset analysed in this study consists of 14 Victorian[6] and 38 NSW[7] water utilities over the period July 2000 to June 2004[8]. Utilities servicing fewer than 3,000 connections were excluded, to ensure Victorian utilities were compared against NSW utilities of a comparable size. This yielded a balanced panel of 52 observations over four years, generating 208 observations in total.

Although data relating to both labour and fixed capital were available, the input measure, Total Operating Cost, has been intentionally restricted to include only expenses related to the current operation of the water business, such as maintenance of the network, treatment, wages and salaries, administration and energy consumption. Labour was excluded as an input for a number of reasons. First, the measure of labour in Victoria was aggregated across the water and wastewater businesses, while in NSW it was disaggregated. This disparity presented the unenviable task of determining how to disaggregate the Victorian labour data. Second, the data series relating to Victorian labour measures began only in 2003. Third, consultations

[6] The largest Victorian regional urban water authority, Barwon Water, was excluded since it was twice the size of the next largest utility.

[7] A number of NSW utilities were excluded due to data limitations.

[8] The data are from financial years. Henceforth, 2001 refers to July 2000 – June 2001; 2002 relates to July 2001 – June 2002 and so on.

with representatives from the urban water sector in Victoria revealed that management decisions to vary the labour force were not closely related to the quantity of total water supplied (C. Heiner, pers. comm., 27 April 2007).

Fixed capital was also excluded on a mixture of theoretical and pragmatic grounds. Turning first to theoretical considerations, a number of scholars have previously noted that the infrastructure related to the provision of water services is a sunk cost, since it is difficult to conceive putting it to an alternative use (Sheil 2000). If this is so, it calls into question the inclusion of various measures of fixed capital in a DEA model since management are unlikely to seek to minimise this input. Furthermore, while additions to capital through time are likely, the opposite is not. A decline in total water produced is rarely followed by the decommissioning of water mains or the dismantling of pumping and treating infrastructure. Of potentially more relevance to the estimation of relative technical efficiency are current capital expenses incurred as a result of renewals activities, which is captured under operating costs. A number of existing empirical studies excluded a measure of fixed capital (see, for instance, Coelli and Walding 2005; Garcia and Thomas 2001; Bhattacharyya *et al.* 1994).

Justification on pragmatic grounds relates to the historically poor measurement of the value of infrastructure in NSW local government[9], made painfully clear by an independent inquiry into the financial sustainability of NSW local government, the so-called Allan report (2006). Considering the widespread lack of confidence in fixed infrastructure values, it was prudent to exclude this variable rather than attempt to adjust for the errors in the results. With respect to separate measures of energy and materials consumption, while the NSW data disaggregate operating costs into various classes, including administration, energy and materials, the Victorian data do not. Consequently, it was not possible to include separate input variables for materials and energy.

[9] For a review of the problem in Australian local government data of this kind see Dollery *et al.* (2006).

In order to aid comparison between years, and utilities in each state, the variable was inflated to reflect 2004 nominal values, by applying the headline consumer price index for Melbourne. The use of this less than ideal inflation factor was made necessary by data relating to Victorian water utilities being inflated prior to publication, whereas data for NSW utilities were published in nominal terms.

The two outputs modelled are (1) Total Potable Water Supplied and (2) Complaints per 1,000 connections. The constituent parts that form Total Potable Water Supplied were similar across both states, with the exception that Victorian utilities included environmental flows, whereas those in NSW did not. However, only three of the 14 Victorian utilities recorded environmental flows during the period, and they accounted for a very small portion of the total. Output quality was measured by the number of customer complaints made per 1,000 connections. This was essentially due to this data being almost universally reported, a characteristic not shared by more direct measures of quality.

It was necessary to transform the complaints variable since it was to enter the model as an output. Maximising complaints is clearly not an objective of utility managers, and the data were modified such that maximising the vector was akin to minimising *actual* complaints. Zhu (2003, 106-7) suggested an approach to transform ‘undesirable’ outputs for use in DEA models, which was followed here. All data relating to utilities in NSW was sourced from the Department of Energy, Utilities and Sustainability (2005) and VicWater (2005) was the source for data relating to Victorian utilities.

Table 2 reports descriptive statistics for each variable in each of the four years.

Table 2: Descriptive Statistics of Inputs and Outputs

Year	Description	Mean	Standard Deviation
2001	Total Operating Cost	4,561,622	4,052,699
	Complaints Index	131	26
	Total Potable Water	9,147	10,582
2002	Total Operating Cost	4,789,358	4,224,969
	Complaints Index	89	24
	Total Potable Water	9,699	13,304
2003	Total Operating Cost	5,288,760	4,765,318
	Complaints Index	121	19
	Total Potable Water	9,650	13,062
2004	Total Operating Cost	5,455,686	4,932,479
	Complaints Index	96	22
	Total Potable Water	9,062	12,545
52 utilities, of which:	Large (3,000 – 10,000 connections) = 21 Very Large (> 10,000 connections) = 31		

Two telling patterns emerge from an analysis of Table 2. First, average total operating costs increased during the period, despite the variable having been adjusted for inflation. Although not reported here, costs increased relatively more in NSW. Second, average total potable water supplied increased initially from 2001 to 2002, levelling out through 2003, before falling slightly below 2001 levels in 2004. Combined, this suggests a sharp increase in per unit operating costs over the period.

As mentioned in section 1, an attempt is made in this paper to analyse the determinants of relative efficiency. This is achieved through the specification of a Tobit regression model in which the DEA scores generated from the evaluation of equations 1 and 2 are regressed against a set of explanatory variables. Table 3 outlines the suite of variables thought to influence relative efficiency, and the *a priori* expectations. They are grouped under the four broad themes contained in Table 3.

Table 3: Variables Thought to Influence Relative Efficiency

Variable	Code	Definition	*a priori* expectation
		Scope, scale and density	
Residential consumption	z_2	Proportion of Total Potable Water consumed by residential consumers	–
Water Losses	z_3	Percentage of Total Potable Water attributed to 'Water Losses'	+
Production Density	z_4	Total Potable Water (KL)/number of connections	+
Customer density	z_6	Number of properties per km of water main	~
Large utility	N/A	Utility had between 3,001 and 10,000 connections	–
Very large utility	z_9	Utility had > 10,000 connections	–
		Treatment, pumping and infrastructure expenses	
Groundwater	z_{10}	> 50 per cent of water sourced from groundwater	+
Reticulator	z_{11}	Primary function of utility was to reticulate treated water supplied from bulk supplier	+
Unfiltered supply	z_{12}	> 50 per cent of water supplied was not subject to filtration process	+
Dams	z_{13}	Utility was responsible for maintenance of at least one bulk water storage (typically a dam)	–
		Climate	
Temperature	z_{14}	Average of mean monthly maximum temperature during November to March (inclusive)	+
Rain days	z_{15}	Total number of days where rainfall was recorded between November and March (inclusive)	–
Rainfall	z_{16}	Total rainfall recorded between November and March (inclusive)	–
Rainfall intensity	z_{17}	Aggregate rainfall (mms) during November to March (inclusive)/ aggregate number of days with rain during November to March	–
		Institutional	
RUWA	z_{18}	Utility was a Regional Urban Water Authority, located in Vic.	~
		Period	
2002	z_{19}	Year specific dummy variable: 2002	–
2003	z_{20}	Year specific dummy variable: 2003	–
2004	z_{21}	Year specific dummy variable: 2004	–

Note: All data was sourced from DEUS (2005) for NSW utilities and VicWater (2005) for Victorian utilities, with the exception of 'climate' variables. Data under that heading was supplied by the Bureau of Meteorology on request.

Returns to Scale, Economies of Scope and Economies of Density

An influential paper by Garcia and Thomas (2001) found evidence of economies of scope, scale, production density and customer density in water networks. Production density was defined as the demand per customer, with network size and the number of customers held constant. Customer density was defined as the number of customers, having held the size of the network and production density constant. The influence of each is modelled by the inclusion of (z_4) and (z_6) respectively. Our *a priori* expectations are guided by evidence from Garcia and Thomas (2001) and Mizutani and Urakami (2001).

Scope was narrowly defined by Garcia and Thomas (2001) as the production of both desirable (consumed by the customer) and 'undesirable' water. A variable measuring network loss as a percentage of total water delivered (z_3) is included and our *a priori* is guided by Garcia and Thomas's (2001) finding that scope economies exist in water networks. Finally, a dummy variable (z_7) to reflect size is included to capture scale related effects.

A variable was included to record the proportion of Total Potable Water consumed by residential consumers (z_2) in order to measure any relationship that may exist. Our *a priori* is equivocal, since a number of countervailing factors exist. Benefits arise from billing and servicing one large customer versus numerous smaller customers, the fact that industrial consumers are typically not subject to restrictions on water use, and a more predictable pattern of use by industrial customers, implying less variation in utility costs related to meeting peaks in demand. Alternatively, non-residential consumers (the majority of which are presumably industrial) may require water supplied at a higher quality or pressure, introducing relatively higher costs.

It is important to note a number of caveats regarding the quality of the underlying data used to construct the abovementioned variables. First, data pertaining to the kilometres of water mains were available in Victoria only from 2003 onwards. Accordingly, it was assumed that network size did not decline between 2001 and 2004 and therefore the values available for 2003 acted as substitutes for the missing data relating to 2001 and 2002.

The number of connections to the network is generally not well reported, particularly in NSW (DEUS 2005). This stems from utilities being more interested in the number of assessments (essentially a measure of the number of customers billed) since this drives revenue. Finally, the proportion of water 'lost' was found to be generally under-reported in NSW (DEUS 2005). As a result a default value of 10 per cent of total potable water supplied was imposed by the data collecting agency for a number of utilities.

Treatment, Pumping and Infrastructure Expenses

Urban water supply systems are complex, and are distinguished to a considerable extent by the characteristics of the area they are designed to service (Jones and French 1999). Clearly, whether a water utility is in a location characterised by favourable external conditions is largely beyond the control of managers. Thus, the following variables were incorporated to take into account the possible influence of each variable.

When used as a source of raw water, groundwater (z_{10}) typically requires vertical pumping from the given aquifer, generally leading to higher energy expenses; however, a characteristic of groundwater is its relative physical and biological purity due to the natural purification that takes place as the water seeps through the soil. The only treatment usually required is for hardness and salinity (Jones and French 1999, 131). This typically leads to relatively lower treatment expenses than those required for surface water. Furthermore, the multiple contaminants and impurities in surface water typically require a multi-step treatment process, which can substantially increase treatment expenses. Moreover, confined aquifers sometimes have the distinct advantage of flowing to the surface under natural pressure, negating considerable pumping expenses. Utilities that rely on groundwater as a source are generally able to avoid these costs. A further benefit of groundwater is that, providing the size of the aquifer and its recharge rate have been carefully estimated and consumption of the source is conservative, the resource can be considered more reliable, unlike surface water[10].

On balance of these considerations, therefore, it might have been expected that this variable (z_{10}) would have a positive coefficient. Furthermore, some evidence in the literature points toward benefits in terms of relative technical efficiency for those utilities reliant on groundwater (see, for instance, Bhattacharyya *et al.* 1995a; Woodbury and Dollery 2004).

Utilities are typically responsible for at least the treatment and reticulation of the potable water they supply, although a small number (all located in NSW) are responsible only for the reticulation of treated water. Generally, a positive coefficient was expected on this variable (z_{11}), due to the avoidance of treatment expenses; however, it was equally likely that treatment costs would be partially recovered by the bulk water supplier. Furthermore, reticulation could still result in considerable operating expense due to unfavourable topography or low network density.

Certain water utilities have access to raw water supplies of such quality that filtration is not required. As filtration is a considerable contributor to treatment expenses, this variable (z_{12}) was expected to have a positive coefficient.

Utilities that are responsible for the maintenance and operation of a dam or dams or other significant headworks infrastructure may incur significantly higher operating costs than those not saddled with this burden, although such costs may also attend bulk water charges. Nevertheless, on balance a dummy variable (z_{13}) was included to account for the impact on relative efficiency; a negative coefficient was expected.

[10] These are non-trivial caveats, a fact to which water managers in Australia are becoming painfully aware.

Climatic Effects

The vagaries of climate impact upon the quantity of water produced more intensely during the so-called irrigation season, covering the months November through to March (C.Heiner, pers. comm., 27 April 2007). This relates mainly to the tendency for residents to irrigate lawns and fill pools during those months, rather than in winter. The climate-related data employed in this analysis were therefore restricted to the irrigation period for each year. Two dimensions are important in this context: temperature and rainfall.

A variable was included to measure average maximum temperature (z_{14}) so that the effect of generally hotter conditions on relative efficiency was taken into account. These conditions might be expected to appear through increased per capita consumption, particularly by residential consumers, as they water lawns more often to replenish water lost through higher rates of evapotranspiration. A positive coefficient is expected.

In an effort to introduce some measure of rainfall intensity, (z_{17}), a variable to measure the average rainfall *per rainday* was included. The variable obviously provided only a crude approximation since it gave no indication of whether a combination of both heavy and light rainfall events occurred on the one day, or whether one day with extreme rainfall was followed by several days of lower rainfall. As a result, it was not immediately apparent whether a significant relationship would be found to exist between rainfall intensity (z_{17}) and relative technical efficiency. Given the uncertain *a priori* expectations surrounding this variable, the two constituent elements of the rainfall intensity ratio (total number of raindays (z_{15}) and total rainfall during the period (z_{16})) were to be retained should the rainfall intensity variable prove insignificant.

Institutional Effects

The dummy variable to identify Victorian utilities (z_{18}) was included to measure any difference in relative technical efficiency for Victorian utilities as a group when compared with utilities in NSW. This variable (z_{18}) was included in order to examine this question after having controlled for the other important variables, like relative size and access to groundwater, for instance.

Other Effects

The purpose of including dummy variables to represent different time periods is to ensure that changes in relative efficiency *partially* attributable to productivity change are not erroneously reflected in other variables included in the model. Given the increase in the average cost of supplying a megalitre of potable water during the period, a generally negative coefficient was expected on each of the time related dummy variables.

Multicollinearity tests revealed that apart from the obvious relation between rainfall and rainfall intensity, no evidence of serious multicollinearity was evident.

Results

Technical Efficiency Results

Equations 1 and 2 were solved for each utility for each of the four years in the sample. It is important to note that direct comparisons between years are without theoretical basis, since efficiency scores are relative to the best performing utilities in each year. Descriptive statistics are reported in Table 4 below.

Table 4: Descriptive Statistics of DEA Scores

	Overall Technical Efficiency			Pure Technical Efficiency			Scale Technical Efficiency		
				2001					
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.482	0.491	0.458	0.555	0.537	0.603	0.878	0.909	0.794
Median	0.433	0.433	0.428	0.477	0.477	0.559	0.887	0.905	0.823
St.Dev.	0.190	0.198	0.165	0.220	0.198	0.263	0.092	0.061	0.109
				2002					
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.459	0.462	0.450	0.495	0.495	0.497	0.934	0.934	0.936
Median	0.413	0.401	0.435	0.431	0.430	0.436	0.989	0.985	0.992
St.Dev.	0.216	0.209	0.234	0.226	0.209	0.268	0.117	0.104	0.147

				2003					
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.461	0.471	0.433	0.503	0.503	0.504	0.931	0.938	0.910
Median	0.387	0.387	0.399	0.440	0.445	0.414	0.981	0.970	0.993
St.Dev.	0.216	0.216	0.211	0.239	0.223	0.278	0.113	0.083	0.167
				2004					
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.456	0.466	0.427	0.517	0.513	0.527	0.902	0.911	0.877
Median	0.424	0.424	0.407	0.460	0.460	0.426	0.950	0.949	0.974
St.Dev.	0.217	0.213	0.225	0.253	0.225	0.315	0.128	0.102	0.177

In terms of both overall and pure technical efficiency the results suggest that the ‘average’ utility could have reduced input consumption by around 50 per cent while holding output constant, relative to the benchmark water authorities. The benchmark utilities in terms of overall efficiency were generally Corowa, Forbes and Gunnedah in NSW, and Gipplsand in Victoria. In terms of pure technical efficiency Corowa, Gunnedah and Gippsland formed the frontier in all four years, while Forbes and Lower Murray were benchmarks in three of the four years. It is interesting to note that only Gippsland is from the ‘Very Large’ size category.

With respect to scale efficiency, the results suggest a relatively high degree of scale efficiency. Once again, Corowa, Forbes and Gippsland were the benchmark utilities over the period. In all three measures of relative efficiency there is little evidence to suggest that an advantage is held by utilities in either state.

Table 5: Productivity of Utilities

	Total Factor Productivity	**Efficiency Change**	**Technical Change**
Ave All Utilities: 2001–2004	0.905 (–10%)	0.969 (–3.1%)	0.933 (–6.9%)
Ave NSW Utilities: 2001–2004	0.901 (–10.4%)	0.975 (–2.6%)	0.924 (–7.9%)
Ave Vic Utilities: 2001–2004	0.916 (–8.8%)	0.955 (–4.6%)	0.958 (–4.3%)
Ave All Utilities: 2002	0.867 (–14.3%)	0.927 (–7.6%)	0.935 (–6.7%)
Ave All Utilities: 2003	0.995 (–0.5%)	1.003 (0.3%)	0.992 (–0.8%)
Ave All Utilities: 2004	0.859 (–15.2%)	0.98 (–2.0%)	0.877 (–13.1%)

Table 5 reports the results of our calculations of TFP, and its constituent parts, efficiency change and technical change. The TFP of this group of utilities fell by an average of 10 per cent each year through the period. Utilities in the two states had slightly different TFPs, although this would appear to be of little economic significance. A more striking result was the decline in both efficiency change and technical change. While the productive capacity of the industry declined over the period, the overall technical efficiency in the sector also fell. However, just under 70 per cent of the decline in TFP was attributable to declines in the productive capacity of the sector.

Explaining Technical Efficiency Results

Three separate Tobit regression equations were estimated in order to investigate the determinants of overall, pure technical and scale efficiency. Using a technique known as 'testing down' (Kennedy 2003), the suite of explanatory variables statistically related to each of the measures of relative efficiency were determined. In order to test the joint significance of each final model, a Wald test was conducted with the null hypothesis of joint insignificance of the variables. The results are reported in Table 6.

Table 6: Explaining Technical Efficiency Measures

Variable	*Description*	*Overall*		*Pure technical*		*Scale*	
		Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
α	Constant	0.1549	0.070	0.2024	0.029	0.8704	0.000
z_2	Residential consumption	0.0020	0.026	0.0024	0.015	-	-
z_4	Production density	0.0005	0.000	0.0005	0.000	-	-
z_9	Very large utility	–0.0483	0.011	–0.0611	0.003	0.0386	0.014
z_{10}	Groundwater	0.1236	0.005	0.1184	0.006	-	-
z_{11}	Reticulator	–0.0640	0.005	–0.1009	0.000	-	-
z_{12}	Unfiltered supply	–0.0684	0.005	–0.1071	0.001	-	-
z_{13}	Dams	–0.0625	0.007	–0.0940	0.000	-	-
z_{18}	RUWA	0.0541	0.035	0.1303	0.000	–0.0574	0.010
z_{19}	2002	-	-	-	-	0.0561	0.006
z_{20}	2003	-	-	-	-	0.0526	0.008
z_{21}	2004	-	-	-	-	0.0238	0.258
e	Error term	0.137	0.000	0.158	0.000	0.110	0.000
R-squared		0.576	N/A	0.553	N/A	0.090	N/A
Adjusted R-squared		0.557	N/A	0.533	N/A	0.063	N/A

Log likelihood	118.404	N/A	89.115	N/A	163.778	N/A
			Wald tests			
F-statistic	448.091	0.000	407.063	0.000	16.891	0.000
Chi-square	4032.819	0.000	3663.564	0.000	101.345	0.000

The percentage of water consumed by residential customers was found to be significant for both overall and pure technical efficiency. However, the coefficient was positive; the opposite to the *a priori* expectation for this variable. A possible explanation for this is that those utilities supplying a relatively large proportion of their water to industrial customers may be required to invest relatively more heavily in water treatment in order to meet the standards required by industrial customers. However, it is important to note the indirect nature of this argument. It would seem the proposition is worthy of further investigation in later studies, since the consequences of relative efficiency may well be of significance.

There was evidence for returns to production density for both overall and pure efficiency; however, the economic significance of this variable was questionable. As an example, based on the results of this study, a large urban water utility would experience a decline in relative efficiency of two and a half per cent from a cut in per connection consumption of 50 kilolitres per year. Given average water consumption for a non major urban water utility was 263 kilolitres a year in 2005-06 (NWC 2007b), this represents a 19 per cent decline in consumption. Nevertheless, cumulative reductions in per connection consumption are likely to result in a decline in relative efficiency.

Somewhat unexpectedly, the dummy variable to identify very large utilities (>10,000 connections) returned a negative coefficient for overall and pure technical efficiency. This implied decreasing returns to scale in water provision, assuming relative efficiency scores were reasonable proxies for average cost. However, the group of authorities in the largest size category were operating at a scale relatively closer to the minimum efficient scale, indicated by the positive co-efficient in the scale efficiency model. Victorian utilities are more likely than those in NSW to be relatively more scale inefficient.

The negative coefficient with respect to overall and technical efficiency appears to contradict the substantial evidence in the literature for increasing returns to scale in the urban water sector (see Garcia and Thomas 2001); however, given that the model is not a direct test of the shape and slope of the long-run average cost curve for the industry, it would be heroic in the extreme to conclude that this result disproves the body of evidence alluded to above.

An alternative explanation may be the relatively higher regulatory burden imposed on the largest utilities by regulators. This might take the form of implied expectations that services delivered by these water providers will be of an exceptional standard, or that far more rigorous reporting requirements are imposed. Thus, the relative inefficiency may be found in the administrative aspects of the utilities operations, rather than the physical relationship between inputs and outputs. In other words, the result may simply reflect additional costs incurred as a result of regulatory impost, rather than defiance of the well established law of increasing returns to scale in large network industries (Friedman 2002).

The dummy variable reflecting reliance on groundwater as a source of raw water supply was found to be positive and statistically significant for both overall and technical efficiency. Furthermore, the magnitude of the coefficient suggests *economic* significance. This result is particularly relevant because it suggests the benefits of sourcing raw water supplies from groundwater are relatively large.

Reticulators were found to be less relatively efficient on average for both overall and pure technical efficiency, as were utilities responsible for maintenance of a dam or headworks. While the result for dams was expected, the positive sign for reticulators may reflect the cost of purchasing ‘regulated’ raw water.

Utilities reliant on water not requiring filtration were found to be less efficient on average. Why this is the case is a matter for further study. No correlated defining characteristic is apparent. For example, some of the utilities are located in relatively high population growth areas on the coast (Coffs Harbour and North Coast Water), while others are located inland, in areas experiencing relative population decline (Mudgee, Grampians and Central Highlands).

Victorian utilities were found to be on average five per cent more efficient in terms of overall efficiency, and 13 per cent more efficient by pure technical efficiency, after having controlled for all other variables included in the model. Consequently, it can be concluded that RUWAs are relatively more efficient than their similarly-sized NSW counterparts, a conclusion not reached in the first stage DEA analysis. This suggests that the managers of Victorian utilities may have had grounds to complain that the first stage DEA model did not adequately reflect the operating environment or other exogenous influences.

Concluding Remarks and Policy Implications

The significance of this paper can be argued along four main fronts. First, this study represents the first analysis of the economic efficiency of regional urban water and wastewater utilities in NSW and Victoria. Second, to the author's knowledge, this is the first analysis of the contribution differing institutional structure makes to relative (in)efficiency and productivity in the Australian water context. Combined, these two aspects of the study represent genuine contributions to the literature. Furthermore, in the context of the newly established national performance reporting arrangements for water utilities, the research establishes a benchmark against which future analysis of urban water utilities can be measured.

We note five main policy implications from the results presented in section 6.

Water Conservation Policies Reduce Efficiency

The results that indicate there are efficiency advantages from higher levels of production density in water networks are powerful in terms of informing current water policy. They suggest that policies designed to reduce per capita consumption of water within a given network, such as water restrictions, are likely to have a negative impact on the relative technical efficiency of water utilities. It has already been established elsewhere that water restrictions result in welfare losses for consumers of water (Brennan *et al.* 2007). This study indicates that the policy also has an efficiency aspect. Thus, there are now multiple reasons to suggest that rationing potable water via regulation is a policy with multiple costs attached. It follows that the purported benefits of rationing potable water by regulation should be compared with the costs outlined by Brennan *et al.* (2007) and the present study.

Groundwater is a Source of Efficiency in Regional NSW

This analysis found an economically and statistically significant link between the relative efficiency of water utilities and access to groundwater. The policy implications of the result are limited, since they merely confirm the existence of such a relationship, rather than explaining why that link exists. However, it seems a matter of some importance to further investigate this relationship with a view to determining why relative technical efficiency has been found to be higher in those utilities with access to groundwater. For instance, it might be hypothesised that the protection of groundwater from pollutants provided by the barrier between the surface and the groundwater aquifer may result in reduced costs from the avoidance of some of the treatment related expenses faced by those utilities reliant on surface water. Alternatively, the existence of groundwater may be correlated with another exogenous factor that has not been included in this model. Regardless, activities that prevent LWUs from accessing groundwater have been shown by this research to have well established costs attached in the form of foregone efficiency. It follows that current efforts to better understand the nature of groundwater systems (see, for instance, NWC 2007a) are, as a result of this finding, even more valuable.

Higher Proportion of Industrial Consumers Reduces Efficiency

An unexpected finding from this study was the negative correlation between higher proportions of water supplied to industrial users and relative efficiency. While it is clearly not sensible to suggest water utilities limit the proportion of water supplied to industrial consumers in order to improve relative efficiency, the result should be considered by regulators and policy makers when considering the relative performance of urban water utilities in regional locations. This also points to the need for councils and state governments to re-evaluate the net benefits of attracting industry to their jurisdiction and the form and quantity of incentives offered to attract their patronage.

Drought and/or Water Restrictions Impact Water Utilities Equally

A further policy implication from this study relates to the role of institutional or regulatory structure in managing the effects of drought. It seems clear from the results relating to the productivity of the water sectors in regional NSW and Victoria that the ability of managers to cope with the consequences of the drought is not related to the state in which the utility is located. Consequently, threats to the security of urban water supply are not likely to be ameliorated through the pursuit of a 'basin-wide' approach to urban water management. In other words, the benefits of a plan such as that proposed by the federal government to take control of rural water management in the Murray–Darling Basin, replicated in the urban water context, appear to have little support from the empirical results presented here.

Large NSW Utilities may benefit from 'Hard' Regulation and Separation from Local Government

Water utilities in Victoria were found to be 13 per cent more pure efficient when compared to utilities in NSW of a similar size. Why this was so cannot be deduced from this study. However, it could be hypothesised to have been a consequence of a number of related factors. First, the composition of the boards of Victorian utilities was a function of relative expertise, rather than boards being required to provide proportional representation to the local government area each served. Local government water utility managers are likely to have an engineering background, while strategic decisions made by the Victorian utility boards are less likely to be framed within an engineering paradigm, perhaps thus leading to a lower propensity to 'gold-plate' infrastructure. Second, management expertise may be relatively more attracted to Victorian utilities due to the prospect of reporting to a board, rather than the general manager of a council and gaining Kudos at the State level rather than within local government. In other words, the relatively more corporate structure may attract professionals comfortable in that environment. The implication of this assumption is that the relatively more skilled employees are attracted and retained by Victorian utilities, and less so by NSW councils.

However, an interesting trade-off appears to be present. While the generally bigger utilities in Victoria are able to attract water management expertise, giving rise to technical efficiencies, set against this is the loss of scale efficiency, insomuch as the results suggest that Victorian utilities exceed 'optimal' size. Third, the proximity of the relevant elected officials (i.e. councillors) in NSW may have resulted in some diversion of attention or resources to projects that did not constitute an efficient use of resources.

These results suggest a possible policy response. A relatively cost-free option might be incorporated, such as reforming governance arrangements. In NSW, water utilities of sufficient size (for example, more than 10,000 connections) could be brought within the regulatory gamut of the IPART (the independent economic regulator in NSW). Separation of ownership may also be considered. Utilities with more than 10,000 connections could be required to separate from local government, following adequate compensation from the state government, to form state government statutory authorities. To mimic the Victorian structure, each authority could be governed by a board, based on relevant expertise, rather than council representation. The board would be responsible to the relevant state government minister, via a license that established the conditions by which the authority would be permitted to operate. However, the transaction costs incurred would need to be carefully estimated, since the benefits associated with reform of this type are unlikely to be overwhelming based on this result.

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