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An Examination of the 'Skills Shortage' in Australian Local Government: The Case of Wastewater Service Provision in Regional New South Wales and Victoria

Joel Byrnes*, Lin Crase, Brian Dollery* and Renato Villano***
**School of Business, Economics and Public Policy & Centre for Local Government, UNE and*
***School of Business, La Trobe University*

Abstract: A recent policy issue in Australian local government has centred on a so-called 'skills shortage' in the sector, particularly in regional jurisdictions. In this paper, we examine the role of divergent governance structures in order to measure the impact of unique managerial factors upon relative efficiency in wastewater service delivery. We find that larger utilities, governed by skills based boards, are relatively more technically efficient than those operating as a business unit of local government. We argue that this is partly explained by the ability of those utilities to attract and retain relatively more skilled staff. A number of policy recommendations are advanced.

Keywords: Water Policy; urban wastewater utilities; relative efficiency.

Centre for Local Government, School of Business, Economics and Public Policy, University of New England, Armidale NSW 2351. Phone: + 61 2 6773 2500, Fax: + 61 2 6773 3596. Email: bdollery@une.edu.au

Introduction

Several recent inquiries into Australian local government have claimed that a general degree of managerial incompetence, especially in asset management, coupled with conflict-riddled elected councils and concomitant policy deadlock can partly explain the perilous state in which the sector now finds itself (see, for instance, Allan (2006) and Dollery *et al.* (2007)). It follows that reform of local council governance arrangements to better reflect corporate-style managerial structures may represent a partial solution to these problems in contemporary Australian local government. First, the highly-skilled managers may be more willing to consider a career in local government if common managerial techniques applied in both the public and private sectors. Second, less scope for ongoing political interference by elected councillors in the management of local public service delivery may provide some comfort to those more accustomed with profit maximisation goals. This begs the question as to the role of governance arrangements in the relative efficiency of public sector enterprises. If a corporate-style structure can be shown to lead to greater efficiency, then wholesale reform of local government service delivery arrangements may be warranted.

It is against this background that the key research questions of this paper are cast. We examine the relationship between institutional structure and the economic efficiency of urban wastewater utilities in regional New South Wales (NSW) and Victoria after having controlled for a number of exogenous factors. As we shall see in the following section, a period of reform in the governance of local government service provision in the state of Victoria presents an ideal framework in which to test our hypothesis through comparison of the relative efficiency of utilities in each state.

The paper proceeds as follows. In Section 2 some structural features of the urban wastewater sector are considered as background to the empirical investigation. Section 3 outlines the econometric technique to be employed in measuring relative efficiency, while section 4 serves to highlight the paucity of academic studies that have investigated relative efficiency in the industry. Methodological and data considerations are discussed in section 5, followed by a presentation of the results of this study in section 6. Implications for policy and concluding remarks are offered in section 7.

The Structure of Urban Wastewater Provision in Regional Australia

For the vast majority of the last century, the provision of urban wastewater services in both NSW and Victoria was a function of local government or alternatively water boards established by neighbouring councils. This continues to be the case in NSW, where water and wastewater services provided outside of the state capital (Sydney) and two satellite regions (the Central Coast and Hunter districts) are largely the responsibility of councils. In Victoria, widespread microeconomic reform throughout the early 1990s by the (then) Kennett state government resulted in responsibility for water and wastewater provision being transferred to regional boards, appointed by and responsible to the state government. Eighteen regional districts were established (Smith 2004); a substantial rationalisation of the sector which at one point had no less than 400 bodies with some role to play in the regulatory framework (World Bank 2004). The standard argument based on the benefits arising from scale economies and a more business-like structure was advanced as justification for the reform (Vince 1997).

In one sense it might be argued that this represents the main point of difference between the institutional structure of urban water and wastewater provision in the two states. While a series of local government amalgamations have since taken place in NSW (Dollery *et al.* 2006), reducing the number of councils with water and wastewater responsibilities, the number of utilities providing those services in NSW is still around five times greater than that in Victoria. Perhaps of most significance, the regional water authorities in Victoria are directly regulated by an independent competition watchdog (the Essential Services Commission), while councils in NSW are indirectly monitored by a state government department (Department of Water and Energy). Furthermore, while the executive of Victorian utilities is focused on running a water and wastewater business, the managers of NSW utilities can potentially be distracted by the broader concerns of local government operations and, of course, local politics.

The policy catalyst for the wide-ranging reforms in Victoria was a nation-wide focus on microeconomic reform arising from the so-called ‘National Competition Policy’ (Sadler 1998). A substantial portion of the reform agenda focused on the activities of Government Business Enterprises, and in particular, on increasing their economic efficiency. Urban water utilities were regulated as local monopolies in need of oversight in order to curb excess.

A separate but parallel programme of reform was underway in the water policy arena, known as the Water Resources Policy (WRP), formulated by the Council of Australian Governments[1] (CoAG). Urban water issues appeared somewhat belatedly, and the intent of the WRP was to be consistent with NCP reforms in that arena. By 2004, a re-statement of the WRP was announced – the National Water Initiative (NWI). Rural water reform was the main aim of this policy. However, a relatively small section addressed urban water reform, and in particular, the performance of urban water and wastewater utilities.

Among other things, 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 implementation, this has resulted in slight changes to a number of existing performance reports with the aim of bringing 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; 2007 b).

[1] COAG comprises the Prime Minister of Australia, the Premiers of the six Australian states, the Chief Ministers of the two territories and a representative of the third tier in the Australian federation, local government.

Utilities were segregated according to size (measured by the number of connected properties a utility serves). Those utilities servicing in excess of 50,000 connections were deemed 'Major Urban Utilities', while utilities responsible for between 10,000 and 50,000 connected properties were classified as 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.

A failing of the National Performance reporting framework is that it relies on partial performance indicators, expressed in absolute terms[2]. A number of authors have established the limits of this approach (see Dollery *et al.* 2006 for a summary), since one utility may be the benchmark on one indicator and exhibit only modest performance on another indicator. In this paper we calculate the *relative* efficiency (or performance) of wastewater utilities using a technique that accommodates multiple performance indicators. The following section outlines the econometric technique that was employed.

Econometric Technique

DEA as a Measure of Relative Performance

Attempts at relative performance (or efficiency) 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 production frontier. The term stochastic points to an allowance for both technical (as opposed to allocative) inefficiency (deterministic) and matters outside the control of a firm (non-deterministic) (Coelli *et al.* 2005).

[2] 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.

Alternatively, DEA makes no assumptions regarding the parameters of the production frontier, utilising 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 and given the paucity of research to guide specification, it was considered prudent to employ DEA. Notwithstanding the advantages of 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.

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

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.

Literature Review

There is a paucity of relative economic efficiency studies with respect to the activities of urban wastewater utilities. Indeed, the present study would appear to be the first to examine urban wastewater utilities in Victoria, and therefore represents a genuine and timely contribution to the literature. Given the dearth of empirical evidence, we are guided by research on urban water utility efficiency, an excellent synopsis of which can be found in Coelli and Walding (2005) and for the sake of brevity is not repeated here. Unfortunately, most studies have been in the context of the benefits and costs of public and private ownership of utilities, and as a result are not of direct relevance in this context. Furthermore, a clear pattern of evidence regarding the benefits of each has failed to emerge. However, of the extant literature three studies are worthy of closer examination: Aubert and Reynaud (2005), Woodbury and Dollery (2004) and Coelli and Walding (2005).

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 a significant relationship between the degree of regulatory oversight and the relative efficiency of water utilities. Those utilities required to provide extensive information to regulators were found to have higher levels of relative efficiency. Since Victorian wastewater utilities are subject to a more stringent form of economic regulation than those in NSW, the findings of efficiency gains from so-called ‘hard’ (as opposed to soft) regulation have important implications for the regulation of wastewater utilities in NSW and Victoria. The suggestion that there are efficiency gains attached to ‘hard’ regulation seems a matter well suited to empirical investigation in the current context.

There appear to be only two published studies of relative efficiency in the Australian water and wastewater sectors. Woodbury and Dollery (2004) investigated the relative efficiency of water and wastewater providers in regional NSW, finding that there was scope for general improvement in the performance of the utilities in question, indicated by an average DEA score of around 0.7 for the sample.

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. They found that the mean technical efficiency score of the utilities was 0.904, implying that the average utility could have reduced input consumption by 9.6 per cent without reducing output. However, the major conclusion was that data of much more robust quality would be required before regulatory bodies could rely upon results from efficiency studies such as theirs, at least as far as it relates to the setting of prices.

From this brief review of the extant literature it seems reasonably clear that there is a need for greater scrutiny of the efficiency of wastewater utilities in Australia. This is somewhat surprising since, as was briefly alluded to in section 2, the sector has undergone 15 years of reform.

Methodology and Data

The dataset analysed in this study consists of 14 Victorian[3] and 42 NSW[4] wastewater utilities over the period July 2000 to June 2004[5]. 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 56 observations over four years, generating 224 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 wastewater 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

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

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

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

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 with representatives from the urban wastewater sector in Victoria revealed that management decisions to vary the labour force were not closely related to the quantity of total wastewater treated (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 and wastewater 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 wastewater treated is rarely followed by the decommissioning of wastewater 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.

Justification on pragmatic grounds relates to the historically poor measurement of the value of infrastructure in NSW local government[6], 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 judged 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

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

not. Consequently, it was not possible to include separate input variables for materials and energy.

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 wastewater utilities being inflated prior to publication, whereas data for NSW utilities were published in nominal terms.

The two outputs modelled are (1) Total Wastewater Treated and (2) Complaints per 1,000 connections. The constituent parts that form Total Wastewater Treated were similar across both states. 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 1 reports descriptive statistics for each variable in each of the four years.

Table 1: Descriptive statistics of inputs and outputs

Year	Description	Mean	Standard Deviation
2001	Total Operating Cost	3,738,612	3,501,319
	Complaints Index	135	28
	Total Wastewater Treated	4,556	5,270
2002	Total Operating Cost	4,017,957	3,761,066
	Complaints Index	134	28
	Total Wastewater Treated	4,504	5,039
2003	Total Operating Cost	4,218,759	3,937,731
	Complaints Index	76	26
	Total Wastewater Treated	4,402	4,737
2004	Total Operating Cost	4,255,662	3,838,192
	Complaints Index	93	28
	Total Wastewater Treated	4,444	4,989
56 utilities, of which:	Large (3,000 – 10,000 connections) = 28 Very Large (> 10,000 connections) = 28		

Two telling patterns emerge from an analysis of the data in Table 1. First, average total operating costs increased during the period, despite the variable having been adjusted for inflation. Second, average total wastewater treated fell between 2001 and 2004. Combined, this suggests a sharp increase in per unit operating costs over the period.

As mentioned earlier, we specify 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 in an attempt to explain the determinants of relative efficiency. Table 2 outlines the suite of variables thought to influence relative efficiency, and our *a priori* expectations. They are grouped under the four broad themes contained in Table 2.

Table 2: Variables thought to influence relative efficiency

Variable	Code	Description	*a priori* expectation
		Returns to Scale, Economies of Customer and Production Density	
Residential Connections	z_1	Proportion of connections classified as residential	–
Production Density	z_2	Kl of wastewater treated per connection	+
Customer Density	z_3	Number of connections per km of main	+
Very large utility	z_4	Utility serviced more than 10,001 connections	–
		Treatment and pumping expenses	
Tertiary treatment	z_5	Dummy to reflect majority of wastewater treated to a tertiary standard	–
Land discharge	z_6	Dummy variable to indicate discharge of treated effluent to land	–
Ocean discharge	z_7	Dummy variable to indicate discharge of treated effluent to an ocean outfall	+
River discharge	z_8	Dummy variable to indicate discharge of treated effluent to a river	–
Sewer main chokes and breaks	z_9	Number of chokes and main breaks per 100km of main	~
		Period	
2002	z_{10}	Year specific dummy variable: 2002	–
2003	z_{11}	Year specific dummy variable: 2003	–
2004	z_{12}	Year specific dummy variable: 2004	–
		Institutional effects	
Victorian Utility	z_{13}	Dummy variable to identify utilities located in Victoria	+

Source: 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 Customer and Production Density

Although Victorian utilities recorded the proportion of sewage collected from residential customers, data limitations particular to NSW utilities forced the use of residential *connections* (z_1) to the sewerage network. While it would have been preferable to include the actual quantity of tradewaste passing through the treatment plant, the proxy was expected to detect the presence of any significant relationship between relative operational efficiency and a substantial proportion of tradewaste. There was a reluctance to expect a particular sign, since the extent to which tradewaste must be treated at the treatment plant tends to vary with the particular type of industry and the level to which the waste is treated prior to being released into the sewerage network (VicWater 2005). It is also influenced by the licensing requirements imposed by the environmental regulator. That is, not all wastewater needs to be treated to the same extent before being returned to the environment.

Lloyd (1993, 69) conveyed the additional burden felt by wastewater authorities from treating tradewaste by invoking an example from the now defunct Shepparton Water Board:

> Although the Board services a population of approximately 33,000, it estimates that the water and wastewater requirements of major food processing industries within its boundaries are such that it actually services the equivalent residential population of 650,000 or 20 times the actual population.

Although it is now common practice for wastewater utilities to levy a tradewaste charge, and for specialised connections to the sewerage network to be made at the expense of the industrial customer, disproportionate tradewaste might still be expected to result in lower relative efficiency.

In this paper, following Garcia and Thomas (2001), we define production density (z_2) as the total wastewater treated per customer, with network size and the number of customers held constant, while customer density (z_3) is defined as the number of customers, having held the size of the network and production density constant. Our *a priori* expectations with relation to both are uncertain since Mays and Tung (1992) found that there are decreasing returns in the network (arising from increased customer density), yet considerable returns to scale at the treatment plant (as a result of increased production density).

A dummy variable was included to reflect utility size (z_4). Although the specification of the variable returns to scale DEA model should have taken into account scale effects, dummy variables were included to control for the uncertainty associated with the measure of scale employed – the quantity of wastewater treated – rather than a physical measure of network size. This variable may also measure the effect of any increase in regulatory burden imposed on larger utilities. Of course, in analysing the results from the constant returns to scale DEA model, this dummy variable will likely be of crucial importance.

Treatment and Pumping Expenses

The major expense arising from operating a wastewater system is that relating to treatment. Accordingly, a range of variables was included to account for differences in the extent to which utilities are required to treat wastewater. The degree to which sewage is treated depends in part on where the resulting effluent is to be discharged. For instance, a utility that discharges effluent into a river that is both of considerable environmental value and is the source of raw water for a town downstream is required to 'produce' effluent of a quality close to that of the receiving environment. In contrast, effluent that is to be discharged from an ocean outfall might only require rudimentary treatment.

A dummy variable (z_5) was included for those utilities that treat to the highest standard (tertiary treatment), while dummy variables to account for varying discharge points (land (z_6), ocean (z_7) and river (z_8)) were included. Since some utilities discharge to multiple points, some were assigned dummies for more than one discharge location. It is generally expected that those utilities treating to a tertiary standard will incur greater costs, resulting in a lower relative efficiency score. Consequently, it was expected that those discharging to the ocean would have the lowest treatment expenses, resulting in a positive coefficient, and those discharging to land and river would have higher treatment costs, resulting in negative signs for these variables. However, the magnitude of the coefficient was expected to be higher for those discharging to rivers.

Breaks and chokes in sewer mains are a driver of operation expenses since they must be repaired quickly to minimise spills of raw sewage (Jones and French 1999). To account for this expense, a variable (z_9) was included that measures the number of breaks and chokes per 100km of sewerage main. It was included because the majority of breaks and chokes are arguably beyond the direct control of managers. Such incidents usually increase during times of drought as soils shift and put pressure on pipes, and as a result of storm events which cause sewer chokes following the ingress of stormwater. Thus, a degree of uncertainty surrounds the expected sign on this coefficient.

Climatic Effects

Variables to reflect rainfall were not included due to data limitations. Ideally, a variable would have been included to measure large intense rainfall events, since these tend to result in much higher quantities of stormwater being diverted to treatment plants. This rise is as a result of ingress and illegal connections to the sewerage network. Unfortunately the data were not available, and so climate variables were excluded from this analysis.

Period

The purpose of including dummy variables to represent different time periods (z_{10}, z_{11} and z_{12}) 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.

Institutional Effects

A dummy variable to identify Victorian utilities (z_{13}) was included to determine whether, as a group, Victorian wastewater providers were more or less relatively efficient than those in NSW after having controlled for the group of factors contained in Table 3. Since this represents the primary motivation for this research, we formed no a priori expectations.

Multicollinearity tests revealed no evidence of serious multicollinearity between the explanatory variables.

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 3 below.

Table 3: 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	0.487	0.483	0.501	0.569	0.526	0.698	0.879	0.918	0.760
Median	0.459	0.459	0.463	0.516	0.491	0.680	0.947	0.966	0.742
St.Dev.	0.159	0.170	0.119	0.201	0.172	0.227	0.136	0.093	0.172
					2002				
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.535	0.520	0.580	0.607	0.544	0.796	0.904	0.955	0.752
Median	0.511	0.489	0.560	0.546	0.498	0.823	0.959	0.995	0.800
St.Dev.	0.158	0.167	0.116	0.204	0.168	0.184	0.124	0.059	0.143
					2003				
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.527	0.515	0.563	0.664	0.610	0.828	0.808	0.846	0.694
Median	0.507	0.491	0.541	0.633	0.546	0.842	0.808	0.854	0.723

St.Dev.	0.167	0.184	0.095	0.209	0.194	0.162	0.142	0.133	0.103
					2004				
Statistic	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*	*All*	*NSW*	*Vic*
Mean	0.557	0.542	0.602	0.629	0.579	0.777	0.902	0.936	0.801
Median	0.535	0.509	0.549	0.581	0.559	0.767	0.961	0.966	0.850
St.Dev.	0.179	0.186	0.146	0.206	0.187	0.190	0.137	0.095	0.185

The results suggest there was considerable scope for relatively more efficient use of inputs. In the year in which average overall technical efficiency for utilities in both states was at its highest (2004), the 'average' utility could have reduced input use by 44.3 per cent while leaving output unchanged. Only one utility (Gunnedah in NSW) was the benchmark in all four years in terms of overall efficiency, although Orange (also in NSW) appeared on the frontier twice. In terms of pure technical efficiency, Gunnedah was joined by the Victorian utilities Gippsland, Lower Murray and Westernport in forming the frontier in all 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, although utilities in NSW have a considerable advantage in this respect. Once again Gunnedah was the only benchmark utility in all four years.

It is interesting to note that there is a consistent pattern of higher relative overall technical efficiency for Victorian utilities from 2002 onward. This finding suggests that Victorian wastewater utilities, as a group, were at an advantage during the period. Of particular note, Victorian utilities were substantially more efficient in terms of relative pure technical efficiency, however this was offset by relative scale inefficiency. This result suggests the benefits of the governance arrangements in place throughout Victoria were muted by inefficiencies derived from excessive size.

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 4.

Table 4: Explaining technical efficiency measures

Variable	*Description*	*Overall*		*Pure technical*		*Scale*	
		Coeff.	**Prob.**	**Coeff.**	**Prob.**	**Coeff.**	**Prob.**
α	Constant	–0.8377	0.004	–0.7418	0.030	0.7164	0.000
z_1	Residential connections	0.0125	0.000	0.0141	0.000	N/A	N/A
z_2	Production density	0.0007	0.000	0.0004	0.027	0.0004	0.001
z_5	Tertiary treatment	–0.0766	0.000	–0.1097	0.000	N/A	N/A
z_6	Land discharge	N/A	N/A	–0.0576	0.039	0.0319	0.045
z_7	Ocean discharge	–0.0531	0.042	–0.0548	0.084	N/A	N/A
z_8	River discharge	N/A	N/A	–0.0865	0.012	0.1103	0.000
z_{10}	2002	0.0519	0.064	N/A	N/A	0.0263	0.148
z_{11}	2003	0.0532	0.070	0.0811	0.005	–0.0637	0.004
z_{12}	2004	0.0846	0.004	0.0488	0.089	0.0294	0.157
z_{13}	RUWA	0.0726	0.000	0.2204	0.000	–0.1465	0.000
e	Error term	0.153	0.000	0.173	0.000	0.106	0.000
R-squared		0.165	N/A	0.306	N/A	0.438	N/A
Adjusted R-squared		0.130	N/A	0.273	N/A	0.417	N/A
Log likelihood		102.023	N/A	75.153	N/A	185.908	N/A
			Wald tests				
F-statistic		407.658	0.000	304.232	0.000	2618.706	0.000
Chi-square		3668.918	0.000	3042.315	0.000	20949.64	0.000

The results suggest that a higher proportion of residential connections is associated with higher overall and pure technical efficiency, suggesting industrial connections to the sewer network may entail relatively higher input use. The positive coefficient on the variable for production density for all three measures of relative efficiency implies some costs to utilities as a result of policies to reduce per capita indoor water consumption. However, the respective magnitudes call into question the economic significance of the results.

The results relating to the treatment and discharge variables are mixed. The sign and magnitude of the tertiary treatment co-efficient were expected. In contrast, however, the negative sign for ocean discharge is perplexing, since treatment of wastewater for disposal by this method is typically rudimentary. It may be that factors relating to the coastal location of these utilities are being captured. In a similar vein, the positive coefficient for both land and river discharge in terms of scale efficiency may reflect certain characteristics of utilities situated inland.

The result of most interest, however, relates to the dummy variable identifying Victorian utilities. Noting that the dummy variable for size was found to be insignificant in this specification, Victorian utilities were, on average, 22 per cent more purely technically efficient. With respect to relative scale efficiency, Victorian utilities were found as a group to be, on average, 14 per cent less scale efficient than their counterparts in NSW. This is confirmed by the seven per cent advantage held by Victorian utilities in terms of overall technical efficiency. This group of results has significant policy implications and we address these in the following section.

Concluding Remarks and Policy Implications

The significance of this paper can be argued along two main fronts. First, this study represents the first analysis of the economic efficiency of regional urban wastewater utilities in NSW and Victoria. Second, to the best of our knowledge, this is the first analysis of the contribution differing governance structures make to relative (in) efficiency in the Australian water context. In combination, 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 and wastewater utilities in Australia, the research establishes a benchmark against which future analysis of urban wastewater utilities can be measured. We noted two main policy implications from the results presented in section 6.

An unexpected finding from this study was the positive correlation between higher proportions of wastewater connections to residential customers and relative efficiency. While it is clearly not sensible to suggest utilities limit the proportion of wastewater treated from industrial customers in order to improve relative efficiency, the result should be considered by regulators and policy makers when considering the relative performance of urban wastewater 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.

The most important finding in the context of this paper relates to the disparity in relative efficiency scores between wastewater utilities in NSW and Victoria. Wastewater utilities in Victoria were found to be 22 per cent more pure technically 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 during the period was a function of relative expertise, rather than a proportional representation of the local government area each utility served. It might be argued that this contributed to a higher degree of managerial competence due to the tendency for local government water utility managers in NSW to have an engineering background. On the other hand, strategic decisions made by the Victorian utility boards are less likely to be framed within an engineering paradigm, given the diversity of backgrounds of board members, diluting the propensity to ‘gold-plate’ infrastructure. Second, skilled managers 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 dealing with a broader set of stakeholders, rather than simply 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 relatively more skilled employees are attracted and retained by Victorian utilities, and less so by NSW councils. The relatively poor results for NSW utilities may also suggest that the proximity of elected officials (i.e. councillors) may have resulted in some diversion of attention or resources to projects that did not constitute an efficient use of resources.

However, an interesting trade-off appears to be present. While the generally bigger utilities in Victoria appear able to attract better 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. This finding adds weight to the argument that ‘bigger is not better’ in local public service delivery (see Dollery *et al.* 2007), with the obvious caveat that this result is confined to wastewater services.

These results provide support for the argument that governance arrangements are important in delivering relative efficiency gains in public service provision. More specifically, policy makers in NSW may consider reform of wastewater provision in NSW. For example, utilities with more than 10,000 connections could be required to separate from local government, following adequate compensation from the state government, to form statutory authorities owned by the state government. 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, through a license that established the conditions by which the authority would be permitted to operate.

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