University of New England

School of Economics

Efficiency Measurement in Australian Local Government: The Case of NSW Municipal Water Services

by

Kim Woodbury and Brian Dollery

No. 2003-13

Working Paper Series in Economics

ISSN 1442 2980

http://www.une.edu.au/febl/EconStud/wps.htm

Copyright © 2003 by UNE. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided this copyright notice appears on all such copies. ISBN 1 86389 862 X

Efficiency Measurement in Australian Local Government: The Case of NSW Municipal Water Services

Kim Woodbury and Brian Dollery**

Abstract

Australian local government has experienced a series of reforms directed at increasing economic efficiency. An important element in the reform program has been the development of a number of partial indicators of local government service delivery in the states and territories. This paper attempts to augment this literature on performance measurement in Australian local government by using Data Envelopment Analysis (DEA) with holistic indices of allocative and technical efficiency in NSW municipal water services. It also seeks to incorporate qualitative indicators into efficiency measures. "Best-practice " councils are identified and the underlying causes of municipal water service efficiency are analysed.

Key Words: data envelopment analysis, efficiency measurement, local government, water services

** Kim Woodbury of Tamworth City Council. Brian Dollery is Professor of Economics at the School of Economics, University of New England and Yokohama National University. Contact information: School of Economics, University of New England, Armidale, NSW 2351, Australia. Email: bdollery@metz.une.edu.au;

INTRODUCTION

A comprehensive and ongoing program of reform has become a dominant characteristic of Australian local government in recent years. A key feature of this reform program has been the systematic development performance indicators to assist in determining the impact of various reform policies as well as benchmarking municipal services. In the absence of contestable markets, and the information and incentives provided by these markets, performance indicators, and especially measures of comparative performance, have been perceived as a method by which the effectiveness of local government service provision can be gauged.

Australian local government performance measurement is at present in its formative stages and a number of problems require resolution (Dollery and Wallis, 2001). For example, the vast majority of Australian work has focused on the calculation of partial performance measures, which typically involve single input/single output indices (WSAA, 1999; ARMCANZ, 2000; AWA, 2000), with only a few studies examining total factor productivity (SCNPMGTE, 1992; ACT Auditor General, 1995). Similarly, previous studies employing Data Envelopment Analysis (DEA) have concentrated exclusively on quantitative magnitudes of output (Worthington and Dollery, 2000), without any assessment of qualitative criteria. Accordingly, the present paper seeks to extend this literature by developing holistic performance measures that incorporate the qualitative dimension of local government service delivery.

Municipal water services in NSW provide an excellent milieu for the empirical analysis of Australian local government performance for several reasons. Firstly, vast resources are deployed and the sector is thus important from the perspective of public policy. For instance, water services, including wastewater, constitute a considerable proportion of municipal activity in NSW and had a combined turnover of $569 million in 1998/99 (DLWC 2000: Table 5). This represents around 12 per cent of the total outlays for councils, which is almost equal to each of the other two major municipal activities - roads ($0654 million) or recreation and culture ($654 million) (NOLG 1999: 194). Secondly, recent regulatory developments in the water industry, in addition to stricter environmental controls through licences operated by the NSW EPA, have made this an active arena for service provision over the latter half of the 1990s. Finally, state water authorities and water industry bodies have recently emphasised the development of appropriate performance measures in the water industry. Data consistency, quality and completeness have thus been reinforced. Moreover, data collected from councils in water provision is more detailed than for other municipal services. For example, the DLWC has introduced extra information through special schedules as part of the DLG annual submission from councils. In addition to the costs and the number of properties receiving the service, representing the standard level of detail reported on other council services, these schedules now quantify various aspects of water quality, complaints, environmental transgressions, licence breaches and levels of service. Nevertheless, data consistency, quality and completeness, while generally better than for other council services, are still far from satisfactory.

The paper itself is divided into six main sections. Section 2 provides a brief synopsis of the salient features of the NSW water services sector and the reasons why it has been selected for detailed analysis. Section 3 focuses on methodological considerations, especially the question of qualitative variables; every effort has been made to render this discussion accessible to the non-specialist reader. Section 4 examines data problems while section 5 discusses the selection of outputs and inputs. The results of the estimation procedures are considered in section 6. The paper ends with some brief concluding comments in section 7, with special emphasis on the practical ramifications of our findings for Australian water utilities.

INSTITUTIONAL BACKGROUND

Water service provision in NSW has a number of significant characteristics. Firstly, municipal water services are provided under the Water Act (1912), the Water Supply Authorities Act (1987), the Local Government (Water Services) Regulation (1999), and the Local Government Act (1993). The Local Government Act (1993) specifically stipulates that water services should be independent of other council functions, requires the establishment of individual water funds, and prohibits any cross subsidisation between these funds.

Local government has been obliged to institute activity-based costing to comply with the competitive neutrality principle of National Competition Policy, which requires the proportionate attribution of overheads between the different functions performed. This seeks to force full disclosure of the costs of services and to ensure that all water provision expenditure is separately assigned. The regulatory framework attempts to encourage management decisions that optimise outcomes for each financially distinct municipal service, including water provision, rather than to optimise outcomes for "whole of local government" functions as a single entity. Secondly, water services have different inputs and outputs from other council functions and employ different technologies. Water schemes typically consist of a water source (dam, river or bore), treatment works (coagulation and filtration treatment), pumping stations, reservoirs, and pressurised reticulation systems (pipework) to the consumer. Water services use entirely different infrastructure from other council services, including wastewater provision, and can thus be validly assessed in isolation.

Determining performance in water provision requires information on both the effectiveness and efficiency of the service. The Steering Committee for the Review of Commonwealth/State Service Provision (SCRCSSP, 2001, p. 10) has argued that "overall outcomes", "access and equity", "appropriateness" and "quality" should be included in any assessment of local government services. Nevertheless, any analysis of local government water services will be constrained by the availability of the data, the quality of data, the assumptions employed, and the extent to which councils face divergent operating environments. In the present case two significant constraints were present. Firstly, suitable measures for access and equity were not available and thus could not be incorporated into the analysis. Secondly, factors such as the conservation of water for other economic and environmental reasons (like salinity) may affect the appropriateness of some of the quantitative output measures.

METHODOLOGICAL CONSIDERATIONS

The calculation of productivity measurement for services where there are multiple inputs and outputs is much more difficult than for single input, single output services. This is particularly the case where price data for the inputs and/or outputs is not available. This situation applies to many publicly provided services, including local government water services. The methodology employed in this paper provides one solution to determining efficiency and total factor productivity (TFP) using DEA, which allows for service quality measures to be incorporated into the conceptual model.

DEA is often used as a quantitative technique to measure the relative efficiency (or productivity) of organizations in the same industry. It is typically the preferred measure of relative efficiency for complex organizations in complex environments because it readily lends itself to the analysis of multiple output organizations, especially where binding constraints affect the behaviour of the organizations in question. In essence, DEA combines all the input and output information on the firm into a single measure of productive efficiency that lies between zero (i.e. a completely inefficient firm) and unity (i.e. a completely efficient firm). DEA is thus an application of linear programming that can be used to measure the relative efficiency of organizations with the same goals and objectives.

Both public sector regulators and managers are interested in various aspects of the economic efficiency of given enterprises. Economic efficiency has various dimensions, including allocative efficiency, productive efficiency, dynamic efficiency, scale efficiency and scope efficiency. Allocative efficiency refers to the efficient distribution of productive resources among alternative uses so as to produce the optimal mix of output. By contrast, technical or productive efficiency refers to the use of resources in the technologically most efficient manner in order to obtain the maximum possible output(s) from a given set of inputs. When productive efficiency is determined in monetary terms, then it is sometimes refereed to as cost efficiency Dynamic or intertemporal efficiency refers to the economically efficient use of resources through time and thus embraces both allocative and productive efficiency. Scale efficiencies and scope efficiencies focus on the manner in which organizational size affects the costs of service delivery. Thus as the scale of operations increases, an organization can experience decreasing, constant or increasing average costs of production; economies of scale refer to situations where larger output reduces unit costs. On the other hand, scope economies deal with the impact of organizational size on the whole range of services produced by the organization. Economies of scope refer to the economies achieved by a firm that is large enough to engage efficiently multi-output production; producing many goods together allows each to be produced at a lower average cost.

The empirical measurement of allocative, cost, productive and scale efficiencies involves the estimation of production frontiers. DEA effectively estimates the frontier by finding a set of linear estimates that bound (or envelop) the observed data. Measuring productive and scale efficiencies using DEA requires data on output and input quantities whereas measuring allocative and cost efficiencies also needs data on input prices.

Outputs measures used in previous DEA studies of local government services have used only quantitative measures, and often non-discretional quantitative output measures like the number of books lent at libraries, the number of residents receiving garbage collection, the quantity of development applications processed, and so forth. However, service quality measures have not to our knowledge been incorporated into DEA when assessing the efficiency of Australian local government services. Worthington and Dollery (2000) provide a detailed and easily accessible discussion of the use of DEA and other frontier techniques for the measurement of economic efficiency in local government, including Australian local government.

In the area of water services, in common with many other public services, the total value of a service cannot be adequately assessed in terms of quantitative outputs alone. For instance, the physical and chemical quality of the water supplied (water quality) and disruptions to supply (reliability) are important qualitative attributes of the final product.

In order to remedy this unsatisfactory situation, service quality measures have been incorporated into a DEA using two procedures. In the first place, we have converted a number of raw quality measures into index numbers for water quality and service quality. Together with the quantitative measures, these were used as outputs in the DEA. Secondly, a quantity measure (namely, the quantity of water consumed) was adjusted using the quality index numbers, which was then used as an output in the DEA.

This paper has adopted a new method of including include service quality measures in the analysis that consists of a three-stage process: Conversion of service quality measures into indices, which together with quantitative measures, were used as outputs for the analysis; the calculation of efficiency scores using DEA; and then comparing non-discretional environmental variables with the DEA results by employing Tobit regression techniques to help account for differences in observed efficiencies.

DATA CONSIDERATIONS

The question of appropriate data was complicated by various practical considerations. Firstly, each council in NSW compiles aggregate data as part of its annual reporting requirements to the state government. This includes financial information, business characteristics, fees and charges, and operating costs for various services, including water services.

Secondly, the NSW Department of Local Government (DLG) (2001) then collates much of this aggregate data from the 177 councils across NSW to produce state-wide tables and a printed annual document (such as Comparative Information on NSW Local Government Councils - 2001). Key performance information is reproduced in the following areas: financial and corporate; library; domestic waste management; wastewater services; water supply services; planning and regulation; environmental management and health services; recreation and leisure services; community services; total staff numbers; and total operating expenditure. In water services only the average water account and water operating costs per connection are included. In addition, council profile data such as population, area, population density, population growth, aboriginal population and non-English- speaking population is adduced from the Australian Bureau of Statistics and individual council documents.

Thirdly, more detailed state-wide data is available in the areas of water and wastewater services from the Department of Land and Water Conservation (DLWC) which collates information provided by the 126 NSW water authorities, consisting of councils and the two metropolitan water authorities (Sydney Water and Hunter Water). Information going back to 1995/96 is now documented each year (see, for instance, Performance Comparison - 1999/2000 NSW Water Supply and Sewerage). Earlier data is also available, but it is not as comprehensive as the later data and its quality is not quite as good.

Fourthly, the Australian Water Association (AWA) has gathered data from 67 water authorities across the country serving between 10,000 and 50,000 assessments {Performance Monitoring Report - 1998/99). Much of the information duplicates the DLWC data, and it does not cover all NSW councils, although some additional data is presented.

Of these four sources the most detailed and comprehensive for NSW councils was the DLWC data. Further investigation of unpublished information from this Department revealed additional useful information on the disaggregation of input costs and input factors. Data quality and completeness have improved in recent years, and for this reason only data from 1995/96 was considered further for this study.

The relevant information available from the above sources is outlined in Table 1. From Table 1 it is clear that there are a number of possible variables that could be considered for the DEA, or for analysis of DEA results using Tobit regression analysis.

TABLE 1

Summary of Relevant Available Data for NSW Water and Wastewater Utilities from 1995/96 to 1999/2000

Category	Indicator / Variable	Service Applicable	Years Coverage	No. of Councils with Data
Business Characteristics	Population Served	Both		120
	Properties Serviced	Both		115-121
	Assessments	Both		115-121
	Total Annual Consumption	Water		84-119
	Consumption by sector	Water		48-56
	Total Annual Collection	Wastewater		91-119
	Total Annual Treatment	Wastewater		89-123
	Trade Waste Quantity	Wastewater		19
	Properties per km of Main	Both		118-120
Levels of Service	Compliance with Drinking Water Guidelines	Water		62-113
	Average Customer Outage	Both		46-85
	Service Complaints	Both		29-112
	Water Quality Complaints	Water		61-104
	EPA Licence Compliance	Wastewater		85-103
	Confirmed Sewer Chokes	Wastewater		106-120
	Sewerage Overflows	Wastewater		77-95
	Odours	Wastewater		106-120
Costs	Total Operating Costs	Both		112-121
	Management Costs	Both		105-119
	Treatment Costs	Both		111-115
	Pumping Costs	Both		111-115
	Maintenance Costs	Both		111-115
	Operational Costs	Both		111-115
	Energy Costs	Both		111-115
	Chemical Costs	Both		111-115
Asset Value	Asset Replacement Cost	Both		118

Source: DLWC 2001 and additional data supplied confidentially, DLG 2001

Water services are shaped by several factors, including the population served, quantities to be transported and treated, quality standards, age and type of infrastructure, raw water quality, amount of rainfall, topography, soil types, population density, seasonal population variations and the amount of industrial activity.

The first three of these factors are outputs and, while not at the discretion of management, were selected for use in the DEA. The remaining factors listed impact on the services in the following ways: The age of the infrastructure influences the amount of maintenance required to provide continued supply of the service: The type of infrastructure represents the technology used and thus the production function faced by the council; Raw water quality determines how much treatment is required to meet the drinking water guidelines; Rainfall effects the raw water quality and so the amount of treatment required; Topography influences pumping costs and ease of construction works; The corrosiveness of the soil affects the life of pipework and thus maintenance necessary to keep the system serviceable; Population density determines the average amount of pipe required to service each property; Seasonal variations in populations may require larger capacity infrastructure to meet standards all year round; and finally, the amount of industrial activity can influence the average quantity of water consumed. Where relevant data has been available these factors have been compared to the DEA outputs using Tobit regression to determine what is the nature of the influence. It is evident from the Table 1 that the completeness of data set varies significantly across the range of partial performance indicators. The number of councils capable of analysis depended upon having complete data sets for all of the relevant inputs and outputs. There was a trade-off between maximising the number of councils with adequate data for the DEA and being able to incorporate a sufficient number of appropriate input and outputs. Of the 177 councils in NSW, some 114 provide water services, including the two metropolitan water authorities (Sydney Water and Hunter Water), most primarily non-metropolitan councils. 73 water supply authorities are analysed in this paper, with 33 having incomplete data and 8 not supplying a full range of services (bulk water suppliers or reticulators only). Sydney Water and Hunter Water, the two biggest water authorities in NSW by far, were eliminated from the analysis having not provided a sufficient breakdown of their costs. Whilst it would have been advantageous to have included them, the magnitude of the difference in size compared all other water authorities in NSW and to each other may also have been problematic for the DEA.

SELECTION OF OUTPUTS AND INPUTS

The selection of the variables used defines the conceptual model adopted for the assessment of performance in this study. The analysis used the following variables: Quantitative outputs; water quality as an output; service reliability as an output; operating costs as inputs; capital as an input; and a number of environmental variables for regression with the calculated efficiencies.

All outputs were obtained from data contained in Tables 5 to 12 of the 1999/2000 NSW Water Supply and Sewerage Performance Comparisons (DLWC, 2001). Though the data seems to improve over time, the incompleteness of data for earlier years has restricted either the number of councils or number of years that can be considered in the analysis. The outputs used in the analysis consisted of:

Quantitative Outputs (1 & 3 year analyses)

Output 1: number of assessments (services to properties);

Output 2: annual water consumption.

Service Quality Outputs (1 year analysis)

Output 1: Water Quality Index;

Output 2: Water Service Index (reliability). The service quality indices were each complied from a number of service quality measures:

Water Quality Index: Compliance with chemical and physical requirements; and compliance with microbiological requirements. Water Service Index: Water quality complaints; service complaints; and average customer outage.

The data available for the service measure were less complete than for the quantitative outputs, so averages over the last 3 years were used. This meant that averages (by arithmetic means) were calculated at times using one or two year's data.

There are three issues to be considered in relation to these indices:

Firstly, the weights for each measure making up the indices are not known. This could be assessed through surveys of consumers as to their relative preferences in relation to the measures. However, resource availability did not permit this. Equal weights for all measures making up each index were therefore adopted.

Secondly, the service quality indicators need to be converted to indices with similar scales and direction. The raw indicators which make up the two "quality indices" were already presented in index form with a range from 0 to 100 (100 being the best quality) and so were used in that configuration. The raw indicators which make up the two "service indices", however, were required to be each converted to matching indices. To do this the raw figures were converted so that the worst council score used in the analysis was assigned 50 for each index. Average scores for each of the indices ranged from 86 to 98.

Thirdly, a number of techniques can be used to calculate the aggregate indices. In order to compare the impacts and assess the suitability of using different methods, the following options were used to obtain these aggregate indices: Arithmetic mean of the indicator indices; geometric mean of the indicator indices; multiplication of the indicator indices (adjusted back to a scale from 0 to 100); and minimum of the indicator indices. It may be expected that the latter two of these methods to obtain aggregate indices will be more punitive against councils with lower service quality indicators.

Two procedures were employed to incorporate service quality indices into the DEA. Firstly, the aggregate indices were, together with the quantitative measures, used as separate outputs in the DEA. Secondly, quantity measures - namely the quantity of water consumed - were quality- adjusted using the aggregate indices, which was then used as an output in the DEA. The two indices were aggregated further into one index ("water quality and service index") consistent with the different methods used to determine the aggregate indices as detailed above. This index was then multiplied by the quantity of water consumed. The multiplication of quantity of water by a quality index is similar to the index number approach adopted by Saal and Parker (2000).

Input data was obtained from more detailed spreadsheets provided by DLWC. Since this data existed only for the year 1999/2000 more general data (DLWC, 2001, Tables 5 to 12) was used in the 3 year DEA, which calculates TFP.

Inputs (1 year analysis)

Input 1: Management costs;

Input 2: Maintenance and operation costs;

Input 3: Energy and chemical costs;

Input 4: Capital replacement costs;

Inputs (3 year analysis)

Input 1: Management costs;

Input 2: Maintenance, operation, energy and chemical costs;

The management, energy and chemical and capital replacement costs were taken directly from the DLWC data sets. The maintenance and operation costs were calculated by subtracting these three costs from the total operating costs. The maintenance and operation costs therefore represents all other operating costs not covered, and included treatment, pumping and reticulation main maintenance, but excluded the electricity and chemicals used.

Some previous studies have used the total length of mains as a measure of capital (ACT Auditor General 2000). The use of the estimated capital replacement costs provides better coverage of all capital infrastructure since it includes dams, treatment works, pump stations and reservoirs as well as the reticulation system. On the other hand, the length of mains is easier to measure and less prone to inaccuracies from variations in estimating current construction rates. For this reason the DLWC provides guidelines and suggested construction rates to aid councils in the capitalisation of their water assets.

A detailed break-up of input costs for the 1997/97 and 1998/99 years was not readily available. Service quality indicators also had to be averaged over the 3 years for the one-year analysis due to data incompleteness. This meant that a smaller number of input and output variables could be used for the 3 year DEA (ie. Malmquist TFP calculation) as indicated above.

Some adjustment also had to be made to the data. Firstly, all input costs were deflated to 1996/97 prices using the Construction Industry Producer Price Indices (ABS, 2001). Using different deflators was not possible since each of the input costs include a mixture of labour, plant and materials, and other suitable deflators were only employed for the year 1998/99. Secondly, there were some inconsistencies in the disaggregation of costs between data sets, which involved the minor adjustment of input costs for two councils. Since in some cases inputs costs or quantitative outputs were missing for one year, interpolation and assignment of a cost equivalent to the same deflated cost (or output amount) as the following year was undertaken.

One limitation of this conceptual model derives from the fact that water consumption is treated as an output. If a council thus successfully implements a demand management program to conserve water by reducing water consumption, then productive efficiency may fall under our model due to under-utilisation of infrastructure.

The data compared against the DEA results using Tobit regression were: Population to account for variations in average size of households and businesses; properties per kilometre of main as an indicator of population density; location (coastal or not) to account for differences in community acceptance of effects on the environment, and/or large seasonal variations in population; rainfall as an indicator of lower water consumption; percentage of residential assessment to account for variations in the residential and industrial/commercial mix; whether water is filtered or unfiltered (water only) as one indicator of the level for treatment required; and whether groundwater is used (water only) as another indicator of the level for treatment required. All data was sourced from the DLWC except for rainfall figures that were taken from the Bureau of Meteorology (3 September, 2001) for the three-year period 1999 to 2001. The Tobit models were calculated using the SHAZAM computer program with truncation set at one.

DISCUSSION OF RESULTS

A number of techniques were used to calculate the aggregate "quality index" and "services index" and the "water quality and service index" for the one-year analysis. This produced six alternative models that are described below:

Alternative A: Quantitative outputs only used (no service quality measures employed);

Alternative B: Quantitative outputs augmented with the two indices as separate outputs (calculated using arithmetic mean of the indicator indices);

Alternative C: Quantitative output(s) multiplied by the quality index (which was obtained from using the arithmetic mean of the quality indicators), thus leading to quality adjusted output levels;

Alternative D: Quantitative output(s) multiplied by the quality index (which was obtained from using the geometric mean of the quality indicators);

Alternative E: Quantitative output(s) multiplied by the quality index derived as a product of the quality indicators; and Alternative F: Quantitative output(s) multiplied by the quality index defined as the minimum value of the quality indicators.

These alternative models were used consistently in the one-year DEA computations. It was anticipated that Alternatives E and F would be more punitive against lower service quality indicators than Alternatives C and D.

Technical Efficiency, Scale Efficiency and Peers in Water Services The efficiencies of water services provided by the 73 councils considered were calculated for the year 1999/2000 using the multi-stage option of the DEAP computer program. A summary of the technical and scale efficiencies for the six alternative models is contained in Table 2 below.

TABLE 2

Efficiencies in NSW Council Water Services in 1999/2000

Alternative Model Specification						
Minimum technical efficiency (crs)	0.354	0.391	0.356	0.357	0.362	0.368
Unweighted average technical efficiency (crs)	0.737	0.758	0.735	0.735	0.730	0.734
Weighted average technical efficiency by Assessments (crs)	0.780	0.783	0.780	0.780	0.780	0.781
Weighted average technical efficiency by water consumed (crs)	0.776	0.779	0.775	0.775	0.773	0.774
No. of fully efficient councils (crs)	15	16	15	15	15	15

(crs)	N/A	3.5	0.6	0.7	1.9	1.5
Spearman's rank coefficient when compared to Alternative A (crs)	1.000	0.926	0.998	0.998	0.975	0.992
Minimum technical efficiency (vrs)	0.383	0.408	0.385	0.386	0.387	0.394
Unweighted average technical efficiency (vrs)	0.798	0.862	0.796	0.796	0.793	0.797
Weighted average technical efficiency by Assessments (vrs)	0.884	0.930	0.885	0.885	0.890	0.888
Weighted average technical efficiency by water consumed (vrs)	0.877	0.929	0.878	0.878	0.882	0.881
No. of fully efficient councils (vrs)	23	37	22	22	22	22
Spearman's rank coefficient (vrs)	1.000	0.791	0.998	0.998	0.958	0.989
Minimum scale efficiency	0.582	0.479	0.598	0.599	0.646	0.621
Average scale efficiency	0.925	0.888	0.925	0.925	0.922	0.923
No. of scale efficient councils	16	18	15	15	15	15
No. of peers (including default peers)	22	25	21	21	20	20

The average technical efficiencies for the councils analysed were 0.737 and 0.798 for constant returns to scale (CRS) and variable return to scale (VRS) respectively using Alternative A. This marginally changes to 0.735 and 0.796 using Alternative C. The average scale efficiency was 0.925 for both Alternatives A and C. This means there is scope for improvements in efficiency in local government water services of 26.5, of which 6.1 is due scale inefficiencies and 20.4 is due to purely technical inefficiencies (using the Alternative C model). Average efficiencies weighted by the number of assessments and volume of water consumed is also provided in Table 2. Increases in average CRS and VRS efficiency when scores were weighted by assessments and volumes show that, on average, larger municipalities were more efficient.

The average efficiency figures give an overall indication of the current position for the whole 73 councils used in the analysis and therefore the potential for councils in general to improve their efficiency. The distributions of the efficiencies on the basis of number of councils using Alternative C are shown in Figures 1, 2 and 3. Alternative C has been employed where general results from the conceptual model are discussed. Alternative C is used since it is the most conservative approach to undertaken to incorporate quality.

FIGURE 1

Distribution of Technical Efficiencies (CRS) in NSW Council Water Services in 1999/2000 using Alternative C Model

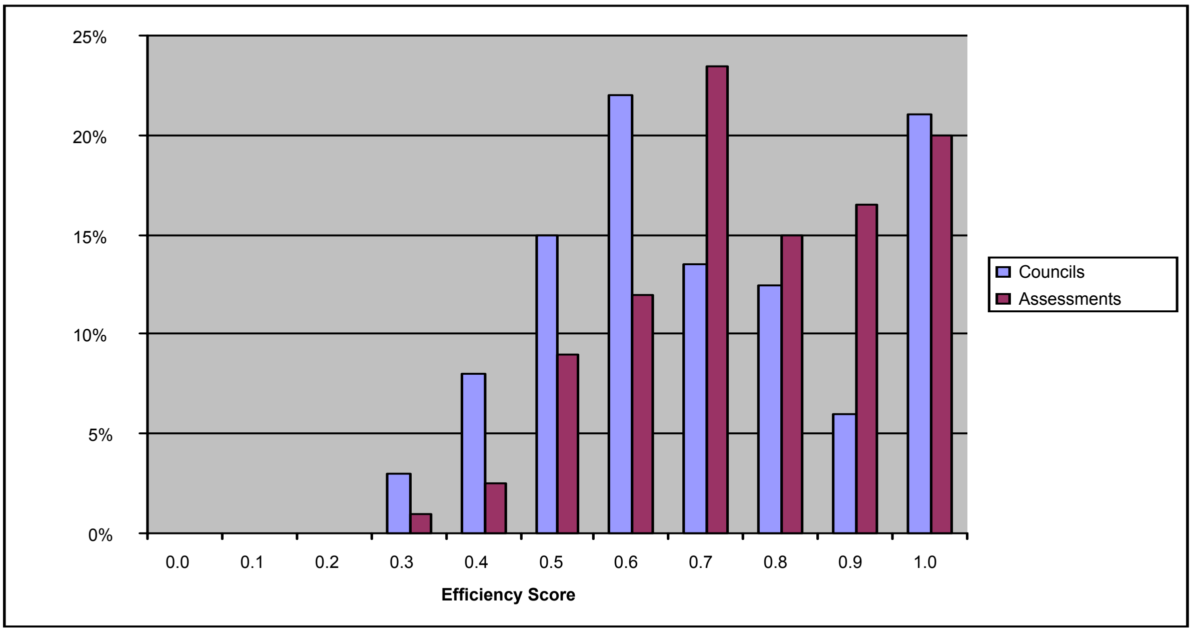


FIGURE 2

Distribution of Technical Efficiencies (VRS) in NSW Council Water Services in 1999/2000 using Alternative c Model

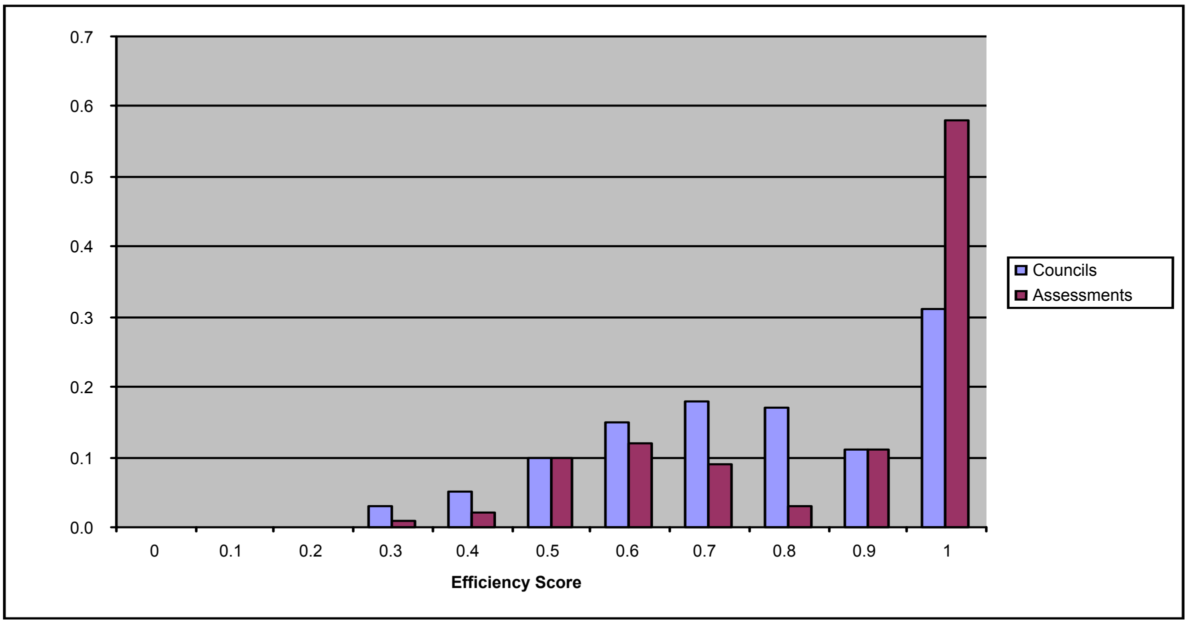
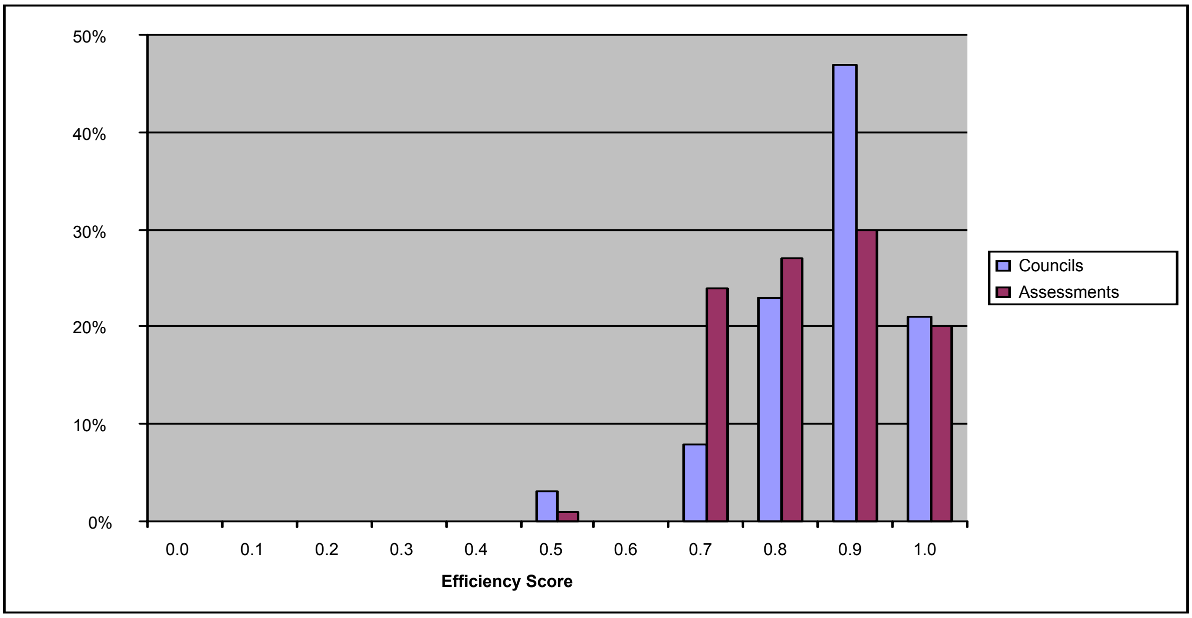


FIGURE 3

Distribution of Scale Efficiencies in NSW Council Water Services in 1999/2000 using Alternative C Model



As well as providing the distribution by the number of councils (unweighted), a weighted distribution by the number of assessments is also provided. This second distribution is therefore weighted towards councils with larger populations (assessments). In Figure 1 the distribution of technical efficiencies under constant returns to scale weighted by assessments shows higher scores were generally observed for larger councils by comparing it to the unweighted distribution. This is consistent with the differences in weighted and unweighted average efficiencies given in Table 2.

Another way to summarise the efficiency result is to give the average scores for councils of similar size as shown in Figure 4 below.

FIGURE 4

Average Technical Efficiencies by Council Size (number of assessments) in NSW Water Services in 1999/2000 using Alternative C Model

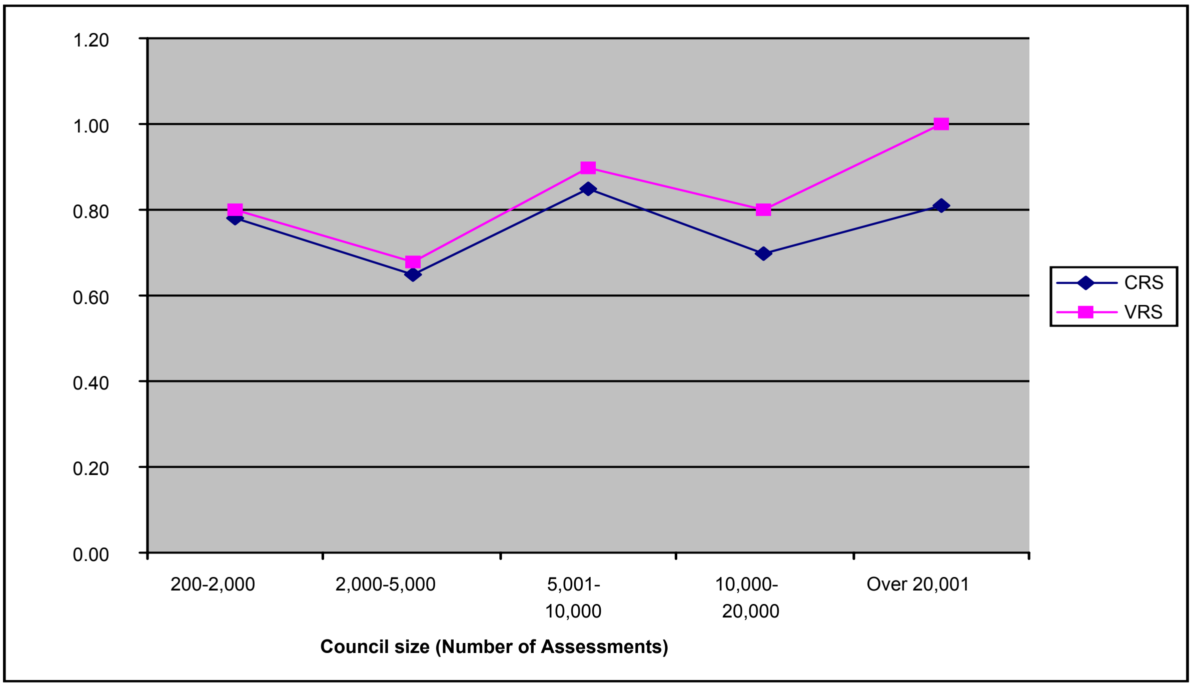


Figure 4 also indicated the general trend of larger councils having higher efficiencies under both CRS and VRS. Another feature of the DBA results is that a large number of councils face decreasing returns to scale. This is highlighted in Table 3 below.

TABLE 3

Number of Councils by Returns to Scale in NSW Council Water Services in J 999/2 000

Alternative Model Specification	Alternative A	Alternative C	Alternative E
Constant returns to Scale	15	14	15
Increasing returns to Scale	24	24	25
Decreasing returns to Scale	34	35	33
Total Number of Councils	73	73	73

The average technical efficiencies for the councils analysed were 0.737 and 0.798 for constant returns to scale (CRS) and variable return to scale (VRS) respectively using Alternative A. This marginally changes to 0.735 and 0.796 using Alternative C. The average scale efficiency was 0.925 for both Alternatives A and C. This means there is scope for improvements in efficiency in local government water services of 26.5, of which 6.1 is due scale inefficiencies and 20.4 is due to purely technical inefficiencies (using the Alternative C model). Average efficiencies weighted by the number of assessments and volume of water consumed is also provided in Table 2. Increases in average CRS and VRS efficiency when scores were weighted by assessments and volumes show that, on average, larger municipalities were more efficient. The average efficiency figures give an overall indication of the current position for the whole 73 councils used in the analysis and therefore the potential for councils in general to improve their efficiency. The distributions of the efficiencies on the basis of number of councils using Alternative C are shown in Figures 1, 2 and 3. Alternative C has been employed where general results from the conceptual model are discussed. Alternative C is used since it is the most conservative approach to undertaken to incorporate quality.

FIGURE 1

Distribution of Technical Efficiencies (CRS) in NSW Council Water Services in 1999/2000 using Alternative C Model

The large number of councils facing decreasing returns to scale suggests that for many municipalities the technologies currently used need to be upgraded, particularly if those councils which face decreasing returns to scale experience large growth rates in population or industrial activity. On the other hand, it may suggest that some treatment works are too large, and the construction of more, smaller plants may be advantageous when major upgrades take place. The similarity in total numbers of constant, increasing and decreasing returns to scale between the alternative models reflects the high stability between alternative models for individual council results.

Because of the method of developing the possible production frontier, DEA may calculate input slacks for firms where the frontier runs parallel to an axis. An input slack for a particular input implies some reduction in that input can be achieved without affecting the quantity of output produced. As indicated in Table 4, there were a relatively large number of input slacks calculated by the DEA. In particular, a large number of municipalities had slacks for management costs and energy and chemicals. The energy and chemical costs may be explained by the natural variation in raw water quality, which may require different amounts of treatment to meet the drinking water guidelines. The number of slacks in management costs requires further investigation.

TABLE 4

Input Slacks in NSW Council Water Services in 1999/2000

Input Slacks	Input Cost	Management	Operational & Maintenance	Energy & Chemicals	Plant Replacement
Alternative A	Count	23	15	25	5
	Mean	$11,942	$21,077	$13,103	$ 276,000
	Max	$195,936	$361,053	$134,170	$9,178,000
Alternative C	Count	24	15	28	
	Mean	$12,585	$21,989	$12,419	$274,000
	Max	$193,489	$364,427	$118,888	$9,605,000
Alternative E	Count	24	15	28	
	Mean	$14,294	$27,129	$11,318	$260,000
	Max	$187,993	$363,759	$118,666	$10,009,000
Average Input Cost		$444,622	$587,099	$154,102	$39,987,000

of the three alternative models indicated in Table 4. For Energy and Chemicals costs, however, there were differences. Tweed had the largest input slack in Alternative A, and Cowra in Alternatives C and E. The effect of the addition of quality variables into the analysis on Energy and Chemical costs is highlighted by examining those two councils. While Cowra's slacks for this input was around $118,000 for each alternative, Tweed's slack dropped from $134,170 in Alternative A to $69,161 and $2,997 for

Alternatives C and E respectively. Since both Tweed and Cowra had high service quality indicators, this suggests that the frontier changed significantly between the alternative models near the zone where Tweed lay, but was relatively constant near Cowra.

The large figures for Plant Replacement costs do not reflect additional importance to this input, but only that the plant replacement costs for the whole schemes are much larger the operating costs. This input represents a relative rental on capital and is not problematical for the DEA calculation.

Comparing the Alternative Methods for Incorporating Service Quality

From the individual council technical efficiency figures it was evident that Alternative B does not in general penalise poor performance. This is because the indices used are scale neutral, while all other outputs and inputs are scale dependent. Looking at the relative efficiencies of the smaller councils highlights this problem. From inspection of the detailed service quality data, many of the smaller councils have lower service quality indices. In most instances higher technical efficiency scores are noted for Alternative B results, compared to Alternative A, for these smaller councils providing lower service quality, which appears counter intuitive. For this reason Alternative B is considered an unsatisfactory technique to incorporate service quality indicators into DEA and is therefore excluded from further comparisons.

Only modest differences in individual and average technical efficiency scores occur between Alternatives A and C (maximum individual variation for CRS of 10 for Brewarrina with the next highest being 3.3 for Yarrowlumla, the absolute average difference for all councils was 0.6 for CRS, and the Spearman's rank coefficient was 0.998 for CRS). The most punitive alternative. Alternative E, gave a 32.5 and 11.6 variation in technical efficiency (CRS) for Brewarrina and Yarrowlumla respectively.

The absolute average difference between Alternatives A and E was 1.9, and the Spearman's rank coefficient was 0.975 for CRS. This indicates high stability between the DEA models with and without quality measures included.

This surprising result may be explained in at least four ways. Firstly, it suggests that the DEA may assign a small weighting to the quantity of water consumption measure (and adjusted measures) compared to the other output (the number of assessments). The second explanation is that there are too many inputs and/or outputs that creates too many peers and inflates the efficiencies so that there is little difference between alternate methods. Thirdly, the result may indicate that similar councils have comparable service quality indices: That is, there is only modest relative change between the council and its peers (the relevant part of the frontier) when comparing the different alternatives. Fourthly, the quality index scales or method of averaging indices may need to be more punitive than even the Alternative E model.

Taking three individual councils used in the analysis having low service quality indices (Brewarrina, Pristine Waters and Bombala), we find different relative circumstances from the DEA results. The technical efficiencies for these councils under CRS are shown in Table 5 below. While Pristine Waters has low service quality indices it is calculated as fully efficient for both CRS and VRS for all of the alternative models. It is a peer for a large number of councils (26 using Alternative C). This means that even taking into account the quality service adjustments in each model for Pristine Waters and other similar councils, it was still on the frontier. Brewarrina, on the other hand, has a CRS technical efficiency of 0.935 and 0.850 for Alternatives A and C respectively. Brewarrina's is its own peer for Alternative A, but has major contributing peers for Alternative C, Culcain (40) which has mid-level service quality indices, Nundle (33) and Hay (25) which have very high service quality indices, Bombala is somewhere between these two cases since CRS technical efficiency drops slightly from 0.626 to 0.622 using Alternative C compared to Alternative A. Bombala's major contributing peer is Culcain (78 and 81 respectively), which has mid-level service quality indices.

TABLE 5

Technical Efficiencies in Selected NSW Councils having Zow Service Quality Indices (CRS), 1999/2000

Alternative Model Specificatio n	A	C	D	E	F
Pristine Waters	1.000	1.000	1.000	1.000	1.000
Brewarrina	0.935	0.850	0.838	0.631	0.753
Bombala	0.626	0.622	0.622	0.622	0.622

Table 5 also gives an indication of how punitive each of the alternative methods of incorporating service quality measures is for individual councils. The Spearman's rank coefficients and absolute average differences in CRS technical efficiencies compared to Alternative A for the 73 councils are also given in Table 2. These indicate that using the geometric and arithmetic means generate similar results. Alternatives E and F are methods designed to be more punitive but, as in the specific case of these three councils, the relative change in the adjusted outputs amounts compared to a council's peers is most critical in determining the extent of the impacts of service quality measures in the analysis. These three smaller councils all have less than 2000 assessments. To highlight further the characteristics of the analysis and efficiency scores, the seven largest councils are examined below in Table 6.

TABLE 6

Efficiencies in NSW Councils Providing Water Services and having more than 20,000Assessments in 1999/2000 using Alternative C Model

Measure	Assessments	CRS	VRS	SE	RS	Main Peers
Coffs Habour	21,200	0.831	0.958	0.868	drs	Richmond 60

Gosford	63,200	0.914	1.000	0.914	drs	Self
Hastings	24,900	0.734	1.000	0.734	drs	Self
Mid Coast	33,200	0.838	1.000	0.838	drs	Self
Riverina	25,500	0.706	1.000	0.706	drs	Self
Shoalhaven	45,200	1.000	1.000	1.000	drs	Self
Tweed	25,800	0.768	0.976	0.787	drs	Richmond 46%

All of the councils above, with 20,000 assessments or more, face decreasing returns to scale. The high VRS technical efficiencies with lower CRS technical efficiencies indicate that the scale of operation for the technologies used is the major source of inefficiency for these large councils. Richmond Valley (6,450 assessments) has the major peer weighting for Coffs Harbour and Tweed, although both Gosford and Shoalhaven are have minor peer weightings for these two councils.

Peers and Special Councils

Table 2 shows the number of peers for each alternative model. All peers lie on the variable returns to scale frontier and are therefore VRS technically efficient. These peers are thus are examples of "best practice" for similar councils to benchmark. Excluding the Alternative B model that was previously discarded, the number of peers ranges from 20 to 22 councils. Of these, four are peers by default using the Alternative C model (Balranald, Lower Clarence, Tamworth and Tumbarumba): That is, they are peers for themselves but no other council. Being a peer by default indicates that different input/output mixes apply to the council compared to all others.

There are 4 councils that are peers of more than 20 other councils: They are described in Table 7. It should be noted that they are small to medium-sized councils; many of the larger municipalities were technical efficient under VRS as seen in Table 6. There was no larger council that was a peer for 20 or more local governments.

MidCoast Water had the highest number of the larger utilities. These five councils may thus considered efficient councils, which should be used for other councils to benchmark against as they look to improve their performance.

TABLE 7

Special Councils/or NSW Water Suppliers - Peers for Many Other Councils in 1999/2000 using Alternative C Model

Council	Number of Councils	Size (Number of Assessments)
Culcairn	28	520
Richmond Valley	26	6,450
Nambucca	25	5,670
Wakool	23	1,170
MidCoast	II	30,200

Explaining Efficiency Scores in Water Services

To help explain trends in overall council inefficiencies, Tobit regression analysis was carried out to ascertain if there is any relationship between the calculated individual council technical efficiencies and various potentially influencing factors for which data is available. Table 8 summarises the calculated coefficients of correlation.

TABLE 8

Regression Analysis of CRS and VRS Technical Efficiency in NSW Council Water Services/or

1999/2000

Population	-0.22E-0.5	-1.48	-0.036	0.15E-05	0.75	0.019
Properties per km of main	0.37E-02	1.29	0.112	-0.13E-03	-0.41E-01	-0.003
Location (coastal)	0.14	1.18	0.029	0.74E-01	0.57	0.012
Rainfall	0.55E-04	1.25	0.154	0.57E-04	1.14	0.126
% Residential	0.52E-02	0.72	0.551	0.12E-01	1.60	1.069
Unfiltered	-0.36E-	-0.46	-0.005	-0.21E-01	-0.24	-0.002

Water	01					
Groundwater	0.22	2.17	0.018	0.28	2.33	0.018
Constant	0.61E-01	0.95E-01		-0.48	-0.68	
Squared Correlation between Observed and Expected Values	0.204			0.268		

Only the variable for Groundwater had T-ratios greater than 1.96, the figure required at the 5 level of significance. However, this variable had low elasticities (0.018 for both CRS and VRS), indicating that it had little influence on efficiency scores.

The squared correlation between observed and expected values of 0.20 and 0.27 shows that factors other than the seven variables used in the regression analysis must primarily account for the variations in efficiencies calculated by the DEA. These factors could include topography, soil re-activity and management performance. Unfortunately, time constraints precluded further investigations into these and other possible factors. Efficiency Change, Technical Change and Total Factor Productivity Change in Water Services Using the same computer program (DEAP) with the Malmquist option, efficiency and productivity changes were calculated over a 3 year time period (1997/98 to 1999/2000) for the same 73 councils. A summary of the efficiency and productivity changes is contained in Table 9 below.

TABLE 9

Total Factor Productivity in NSW Council Water Services from 1997/98 to 1999/2000

Malmquist Index - Summary of All Councils	**Year 2**	**Year 3**	**Mean**
Efficiency change	0.963	0.999	0.981
Technology change	1.057	0.987	1.022
Total factor productivity (unweighted)	1.018	0.987	1.002
Weighted TFP by assessments	-	-	1.011

Weighted TFP by quantity of water consumed	-	-	1.012

Over the 3 years TFP increased slightly (0.2) which was made up of a 2.2 increase due to changes in technology and a 2.1 decrease in efficiency (rounding-off error of 0.1). This suggests that staff may have taken time adapting to new technologies (eg. where new treatment plants were commissioned). A longer time period would have been preferred. However, the number of councils with complete data sets would have been reduced further. Weighting individual council TFP figures by assessments and the quantity of water consumed increased the average growth to 1.1 per cent and 1.2 per cent respectively. This indicates that larger councils had higher TFP growth on average than smaller councils in water services. The weighted figures provide a better representation of TFP growth in water services provided by local government across the state.

The weighted productivity growth indicated for water services provided by NSW councils in Table 9 over the two-year period (1.1 and 1.2 per cent per annum) is consistent with that from other comparable studies. SCNPMGTE (1992) report on Melbourne Water found that for the period 1984/85 to 1990/91, TFP increased by 0.9 percent per year. IPART (1999) estimated that the average annual TFP growth for the whole electricity, gas and water sector was 2.9 per cent from 1974/75 to 1994/95. Saal and Parker (2000) calculate 0.8 per cent growth in TFP in England and Wales combined water and wastewater services during the period 1995 to 1999. These three studies employed aggregate numbers in the calculation of TFP. This method implicitly includes a weighting by size when estimating TFP for more than one firm.

For many local governments in the sample, service quality data was not available for each of the three years. This excluded the TFP analysis from taking into account changing quality measures in this study. More complete data will enable the quality factors to be included in the calculation of future TFP.

Comparison of DEA Results with Partial Performance Measures Currently Used

To assess the suitability of using partial performance measures to represent performance for the water services provided by councils in NSW, a comparison was undertaken comparing the technical efficiencies under CRS and VRS from the DEA (using Alternative C) with three main partial performance indicators currently in use. The three partial measures used were: Average operating costs per assessment; average operating costs per quantity of water consumed (or wastewater treated); and average operating costs per length of main.

Higher DEA efficiency scores indicate better performance. To ensure the partial indicators similarly gave higher scores for greater accomplishment, the reciprocals of the partial measures were used.

The comparisons were done in two ways. Firstly, Spearman's rank coefficients were calculated comparing each of the five measures using those 73 councils previously analysed. Secondly, municipalities were ranked by their performance scores, employing each of the measures. The calculated spearman's rank coefficients are given in Table 10.

TABLE 10

Comparison of Partial Measures and Calculated Technical Efficiencies using Spearman's Rank Coefficients for NSW Council Water and Wastewater Services in 1999/2000

Water– Spearman's Rank Coefficients	**Op costs/ assess**	**Op cots/vol**	**Op costs/ main**	**TE (CRS)**	**TE (VRS)**
Operating costs per assessment	1.00	0.47	0.43	0.48	0.49
Operating	–	1.00	0.26	0.66	0.64

costs per volume					
Operating costs per length of main	–	–	1.00	0.25	0.25

Table 10 shows that no partial performance measure could produce similar rankings to either the CRS or VRS technical efficiencies in water services. Operating costs per volume of water consumed was the partial performance indicator with the highest Spearman's rank coefficient when compared to both CRS (0.66) and VRS (0.64) technical efficiencies.

To garner some indication of the individual changes in rank, councils were listed by rank for water services. The ranks of three individual cases (Dubbo, Snowy River and Tamworth) are considered in Table 11 below.

TABLE 11

Comparison of Partial Measures and Calculated Technical for Selected Councils – Water Services in 1999/2000

Water– Spearman's Rank Coefficients	Op costs/ assess	Op cots/vol	Op costs/ main	TE (CRS)	TE (VRS)
Dubbo	46	38	65	60	56
Snowy River	24	59	17	45	55
Tamworth	26	15	48	33	20

From Table 11 it is evident that the ranks vary considerably for different partial performance indicators. This raises the issue of which performance measure, or combination of measures, should be used to represent overall efficiency. Some significant variations between partial and the technical efficiencies are also shown. This seems to demonstrate that a weighted average of a number of partial performance indicators cannot adequately account for the pure technical efficiency of a council.

These comparisons serve to illustrate the limitations of using partial performance indicators as performance measures and highlight the additional dimension of scale efficiency when using the DEA method.

CONCLUDING REMARKS

Six alternative models were used to compare different ways of incorporating service quality measures into the DEA. The use of indicators for separate DEA outputs was unsatisfactory since their scale neutrality was inconsistent with the other outputs and inputs. The adjustment of quantitative outputs by multiplication with aggregate service quality indices provided a superior methodology. Averaging of service quality indicators when compiling the aggregate indices was found, not surprisingly, to be less punitive than either multiplication of the indices or adopting the minimum index number. However, the differences between the more and less punitive alternative models were less than expected (as indicated by the Spearman's rank coefficients and absolute average differences). This could be explained inter alia by the relative differences of municipal service quality measures and their relation to the different production frontiers. Evaluation of individual council results revealed that there were, in general, only minor variations between a local government's service quality indices and that for its peers. The council sample group used in this paper may also have contributed to this result; municipalities that did not provide complete quality data sets may have had lower levels of service quality. More complete data will enable this question to be explored in the future.

The methods utilised in this paper provide a potentially useful means of analysing the various factors affecting efficiency and productivity change in NSW local government water services. Several water authorities were identified as special cases: namely Culcairn, Richmond Valley, Nambucca, Wakool, and MidCoast. These utilities are peers for many other local governments and so should be critical in the next phase of the performance improvement process, detailed benchmarking between councils.

Our results suggest that there is scope for general improvements in the 1999/2000 performance in NSW local government water services of 26.5, with scale inefficiencies accounting for 6.1 and purely technical inefficiencies 20.4. Previous performance measures for NSW councils in water services only enabled comparisons against the "average council" or the ranking of councils based on one or more partial performance indicator. A comparison of the ranking of councils obtained from this study, using DEA and employing three commonly used partial performance indicators of efficiency, was undertaken for water services. This generated Spearman's rank coefficients ranging between 0.25 and 0.66 when comparing the partial performance measures against the holistic technical efficiency scores for constant and variable returns to scale. These figures indicate significant differences in results and demonstrate that caution should be exercised when using a partial performance measure in isolation as an indicator of efficiency. The inclusion of service quality measures into the DEA generally produced only modest differences in technical efficiency scores compared to a model without quality outputs, for the sample councils analysed. There were, however, larger variations for a small number of councils, with a maximum individual efficiency variation of 10 and 32 for Brewarrina water services using the least and most punitive models respectively. Detailed investigation of individual cases suggests that the generally modest changes indicated that often there was only slight relative change between a council and its peers (on the relevant part of the production frontier) when comparing models with and without quality. That is, it was observed that, in general, "similar- type" councils had similar service quality indices. While more punitive models against poor quality gave larger variations, this was less than expected.

TFP over the 3 years from 1997/98 to 1999/2000 increased only slightly by 0.2 for water supply. This figure changed to 1.1 when weighted by the number of assessments. The weighted results are consistent with other studies on TFP previously undertaken in the water industry (SCNPMGTE, 1992; Saal and Parker, 2000).

A number of measurement issues were identified in the paper. The non-availability and incomplete data for some municipalities reduced the number of councils that could be used in the analysis and prevented the incorporation of service quality measures into TFP calculations. Data quality appeared reasonable but was problematic for some municipalities. Since the measurement of partial indicators is still being developed, data completeness and quality should continue to improve. Better and separate measures for rental of capital stock and labour costs would further improve future studies in this area. Moreover, capital upgrades and reconstruction costs should be separated from maintenance and operational costs.

Future studies could refine the models used in this study and, in particular, the conversion of service quality indicators to quality indices. This could be done by undertaking community surveys to help determine what emphasis (or weighting) consumers place on each of the service quality indicators used in this paper.

On the methodology side, there is scope for future research on the treatment of quality aspects within the DEA framework. A possible alternative would have been to include some quality indicators in the form of the number of faults or outages or complaints. Such quality data could have been treated as "bad outputs" along with the conventional "good outputs".

The DEA method provides a fresh approach and gives different insights to the partial indicator methodology currently used in Australian local government benchmarking. Up to this point, partial performance indicators have been the main method of comparing council performance by the NSW7 Department of Local Government, Department of Land and Water and other water industry organisations. Overall comparisons have proved difficult using this method where multiple inputs and outputs are present. DEA enables s an assessment of technical and scale efficiency as well as efficiency changes over time by way of TFP indices.

NOTE

[1] The views expressed in this paper do not necessarily reflect the views of the Tamworth City Council.

REFERENCES

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). ***Performance Comparisons 1988/89 to 1998/99: Water Supply and Sewerage Services,*** Australian Water Association, Canberra.

Australian Capital Territory (ACT) Auditor General (1995). ***ACTEW Benchmarked,*** Report No. 7, AGPS, Canberra.

Australian Water Association (AWA) (2001). ***Performance Monitoring Report 1999-2000: Australian Non-major Urban Water Utilities,*** Australian Water Association, Canberra.

Australian Water Association (AWA) (2000). ***Performance Monitoring Report 1998-1999: Australian Non- major Urban Water Utilities,*** Australian Water Association, Canberra.

Dollery, B. E. and Wallis, J. L. (2001). ***The Political Economy of Local Government***, Edward Elgar, Cheltenham.

National Office of Local Government (NOLG) (2001). ***1999/2000 Report on the Operation of Local Government (Financial Assistance) Act 1995,*** (Local Government National Report, AGPS, Canberra.

National Office of Local Government (NOLG) (1999). ***1998/1999 Report on the Operation of Local Government (Financial Assistance) Act 1995,*** Local Government National Report, AGP, Canberra.

New South Wales Department of Land and Water Conservation (DLWC) (2001). ***Performance Comparisons: NSW Water Supply and Sewerage 1999/2000,*** New South Wales Department of Land and Water Conservation, Sydney.

New South Wales Department of Land and Water Conservation (DLWC) (2000). ***Performance Comparisons: NSW Water Supply and Sewerage 1998/99,*** New South *Wales* Department of Land and Water Conservation, Sydney.

New South Wales Department of Local Government (NSWDLG) (2001). ***Comparative Information on NSW Local Government Councils 1998/99,*** NSW Department of Local Government, Sydney.

New South Wales Department of Local Government (NSWDLG) (1999). ***Comparative Information on NSW Local Government Councils 1997/98,*** NSW Department of Local Government, Sydney.

Saal, D. and Parker, D. (2000). ***Productivity and Price Performance in Privatised Water and Sewerage Companies of England and Wales,*** Office of Water Services, London.

Steering Committee on National Performance Monitoring of Government Trading Enterprises (SCNPMGTE) (1992) ***Measuring the Total Productivity of Government Trading Enterprises.*** AGPS, Canberra.

Steering Committee for the Review of Commonwealth/State Service Provision (SCRSSP) (2001). ***Report on Government Services 2000,*** Auslnfo, Canberra.

Steering Committee for the Review of Commonwealth/State Service Provision (SCRSSP) (1998). Data Envelopment Analysis: A Technique for Measuring Efficiency of Government Sen'ice Delivery, Industry Commission, Melbourne.

Water Services Association of Australia (WSAA) (1999). ***The Australian Water Industry: WA Facts '99,*** Water Services Association of Australia, Canberra.

Worthington. A. C. & Dollery, B. E. (2000). ***'An Empirical Survey of Frontier Efficiency Measurement Techniques in Local Government',*** Local Government Studies 26, pp. 23-52.