

Measuring the performance of water service providers in urban India: implications for managing water utilities

Shreekant Gupta

Email: sgupta@niua.org

Surender Kumar

Email: skumar@teri.res.in

Gopal K. Sarangi

Email: gopalkrishna.sarangi@gmail.com



National Institute of Urban Affairs

Core 4B, India Habitat Centre, Lodhi Road

New Delhi 110003

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Shreekant Gupta^{*}, Surender Kumar^{} and Gopal K. Sarangi^{***}**

Abstract

This study assesses the efficiency of urban water supply system in select 27 Indian cities for the year 2004-05. It applies data envelopment analysis (DEA) as an analytical tool for measuring technical efficiency. Cities are categorised into two groups (e.g. Municipal Corporations and Government, and Municipal Corporations and parastatals) according to the management structures of their water utilities. The results exhibit that though the average overall average technical efficiency scorings between these two groups are not significantly different, but the decomposition of this total efficiency indicates that the utilities that are managed by Municipalities in collaboration with parastatals are relatively scale efficient in comparison to the other group. Moreover, the results also have implications for urban domestic water pricing. We find that most of the water utilities are operating under decreasing returns to scale (DRS) implying that water should be priced at marginal cost of supply.

^{*} Director, National Institute of Urban Affairs, India Habitat Centre, Lodhi Road, New Delhi 110003, India

^{**} Associate Professor, TERI University, India Habitat Centre, Lodhi Road, New Delhi 110003, India

^{***} Research Scholar, TERI University, India Habitat Centre, Lodhi Road, New Delhi 110003, India

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Shreekant Gupta^{*}, Surender Kumar^{} and Gopal K. Sarangi^{***}**

I. Introduction

Provision of adequate water supply to a growing urban population is a daunting task worldwide (Schuringa, 2006, Nallathiga, 2006). This assumes greater significance in the context of India due to its implications for economic growth, productivity, and poverty reduction (Mathur and Thakur, 2003). It is estimated that by 2025, 50 percent of Indians will reside in urban areas (India Assessment, 2002). Given this growth of urban population coupled with increasing usage of water due to increasing incomes, and declining water quality because of groundwater contamination and surface water pollution, water problems will definitely aggravate in almost all urban conurbations in India. Recognizing the importance of the water sector, the emphasis should be on improving performance through reforming the management institutions, policies, and planning systems (World Bank, 2002). Therefore, it reasons, to look at the existing structure and functions of urban water supply system and to examine the level of performance of water utilities in India.

Water supply system in urban India suffers from a number of problems. There exists serious mismanagement in water supply system in urban India (Singhal and Johri, 2002; Kundu and Thakur, 2006). This mismanagement is reflected in the presence of weak institutions, low resource mobilization capacity, poor information dissemination system, deplorable service quality condition, low coverage, inadequate and ill designed supply system, insufficient treatment capacity, unstructured distribution system etc. It is apprehended that these concerns are going to intensify due to rising water demand with the rising pace of urbanization coupled with snags in the supply front. All these developments call for using the approach of performance measurement of urban local bodies to examine their existing strengths and weaknesses and to improve their capacity in the front where they are weak to deliver the services efficiently.

The need for performance measurement of cities is well documented (Ammons, 1996, Osborne and Gaebler, 1993, Wood, 1998). Performance measurement can be defined as an approach to determine how effectively and efficiently an urban local body delivers the required service. It examines both the quantitative and qualitative aspects of an agencies functioning. Moreover it establishes a connection between policy options and their outcomes. The use of this technique is not new in water utilities. Many countries have adopted this technique to improve the performance of their utilities. The rationale behind measuring performance stems from the fact

^{*}Director, National Institute of Urban Affairs, India Habitat Centre, Lodhi Road, New Delhi 110003, India

^{**}Associate Professor, TERI University, India Habitat Centre, Lodhi Road, New Delhi 110003, India

^{***}Research Scholar, TERI University, India Habitat Centre, Lodhi Road, New Delhi 110003, India

that it can play as an effective instrument of incentive mechanism to improve the performance of the sector. Usually two different categories of performance benchmarking techniques are employed by the scholars to measure the efficiency of water utilities. One is the average analysis or simple ratio measures, or sometimes called as the partial productivity index and the other one which takes into account all the inputs used and outputs produced by the utilities is called total factor productivity measures. The total factor productivity measures are based on either regression analysis (RA) or Data envelopment analysis (DEA) technique.

Despite the existing inefficiency concerns in the urban water supply situation in India, to our surprise there is a dearth of literature in examining this aspect with the use of techniques like RA and DEA. Going by the existing literature, we are unable to find any study done so far by applying these techniques. Some partial productivity measurement methods have been used to examine the issue of (in)efficiency (Singhal and Johri, 2002; WSP, 2006). Singhal and Johri (2002) in their paper point out the existing deficiencies in the water supply management system in urban India and suggest the use of performance management indicators to improve the deteriorating water management system.

WSP (2006) develops some performance indicators using ratio methods to measure the efficiency of water supply systems in some select urban localities. Performance data was collected for 13 utilities covering 23 cities and towns across India. The indicators chosen were investment, financial, billing and collection, quality, costs and staffing, network, metering, unaccounted for water (UFW), production/consumption, coverage etc. A detailed analysis was carried out within the sample to elicit the performance levels among cities. Further, overall sample average was also compared with international benchmarks. WSP (2006), in a similar fashion to the other study (e.g., Singhal and Johri (2002)), applies ratio methods to evaluate the cities in terms of their ability to supply water. From methodological point of view it can be argued that the use of ratio methods is incapable to reflect the true picture of performance of the utilities.

The present study will be the first of its kind in using the concept of total factor productivity to estimate the technical efficiency in providing water services in 27 cities in India. For analytical purposes, the study uses the output-oriented DEA approach to estimate the relative efficiency of 27 cities in the provision of water services in urban India for the year 2004-05. Given the existing distortions in the availability of cost data, it reasons to employ the technique of DEA, which is less demanding on cost information. Further, use of the technique of regression requires a prior knowledge of the functional form, whereas DEA does not require such kind of assumptions regarding the specifications of production technology.

The rest of the paper is organised as follows. Section II describes the existing urban water supply situation and the inherent problems associated with it. Section III reviews some select literature analyzing the efficiency of the water sector. The focus here is to review literature analyzing the effect of ownership on performance on a comparative basis. Section IV elaborates the methodology adopted and the estimation technique followed. Section V describes the data. Section VI spells out the results derived from the study and the last section concludes the paper.

II. Some stylised facts of urban water supply in India

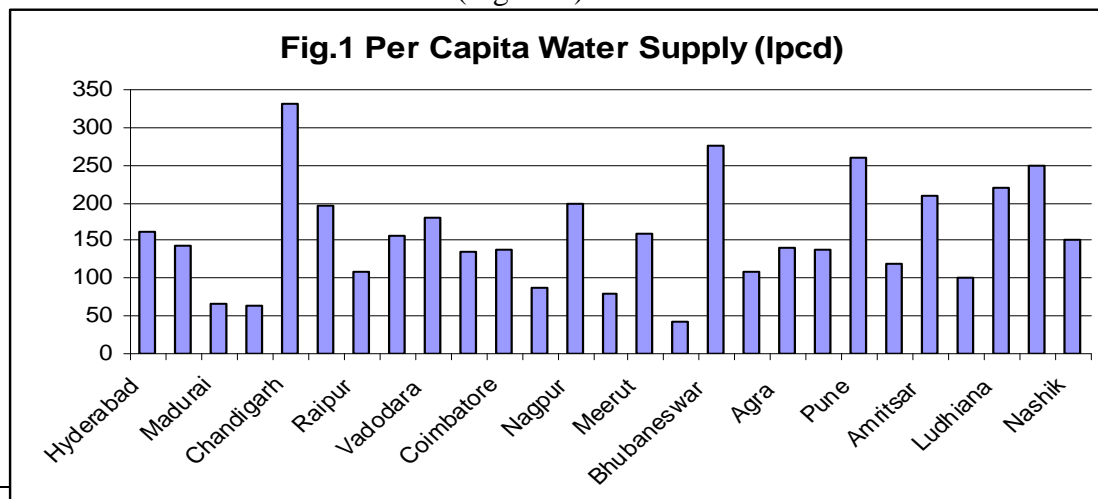
The responsibility of supplying water in urban India vests with State governments. While the Central Government formulates overall policy for the development of the water sector in urban areas, State Governments lay down detailed policies and set up institutions for the proper management and development of water systems in these areas.

The institutional setting for providing water in urban areas varies from state to state. State level Public Health Engineering Departments (PHEDs), specialised statewide water supply and sewerage boards (WSSBs), specialised city-level WSSBs, and Municipal Corporations (MCs) and urban local bodies, are the leading providers of water in urban India. Apart from these, some other bodies such as various Ministries and Departments, financial institutions, external support agencies, NGOs, and private sector's also play direct and indirect roles in water supply.

A brief description is given here on the existing situation on some leading indicators of the water supply system on a comparative basis for some select cities¹. Figures are collected for a cross section of 27 Indian cities for different variables. The principal data source for our study is the different volumes of City Development Plans (CDPs) available online on the website of the Ministry of Urban Development, Government of India. These CDPs give information on various dimensions of water supply system in different urban units of India. The comparison is done for the variables such as litres per capita per day (lpcd) of water supply, water connections per thousand population, per capita revenue expenditures, hours of water supply, percentage of population served, etc.

Litres per capita per day of water supply

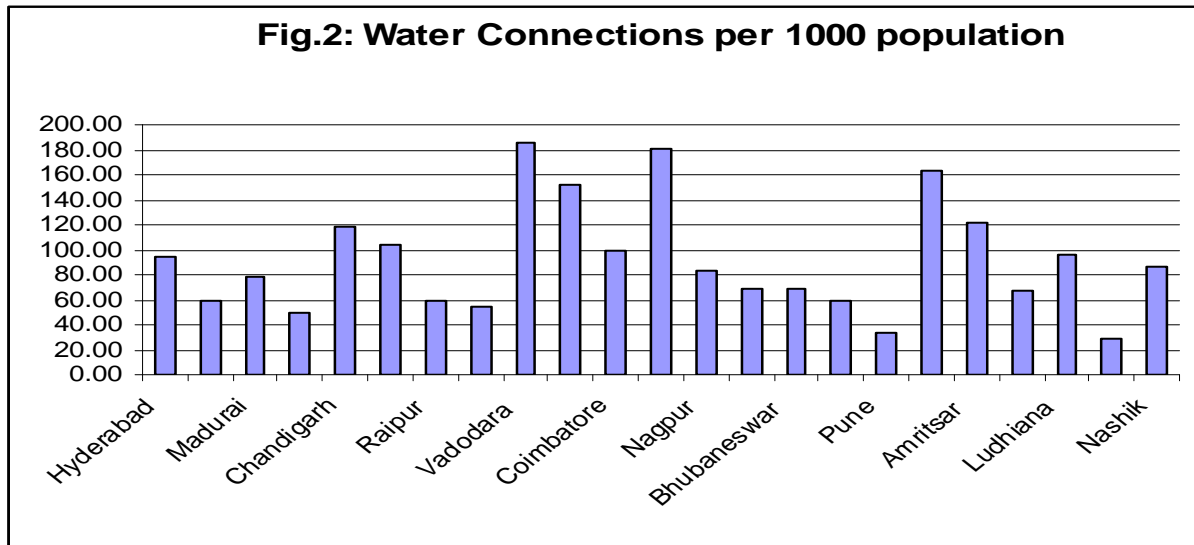
This gives an idea of the quantum of water available. The National Drinking Water Mission (NDWM) in the late 1980's fixed 140 lpcd as the norm. Around half of the cities attain this norm. Average lpcd of water supply is lowest in Guwahati (41.23 lpcd) and highest in Chandigarh (about 8 times that of Guwahati). Although the average for our sample is 156 lpcd, there is wide variation across cities (Figure 1).



¹ The selection of cities from the 63 cities covered by the JN National Urban Renewal Mission was constrained by availability of data.

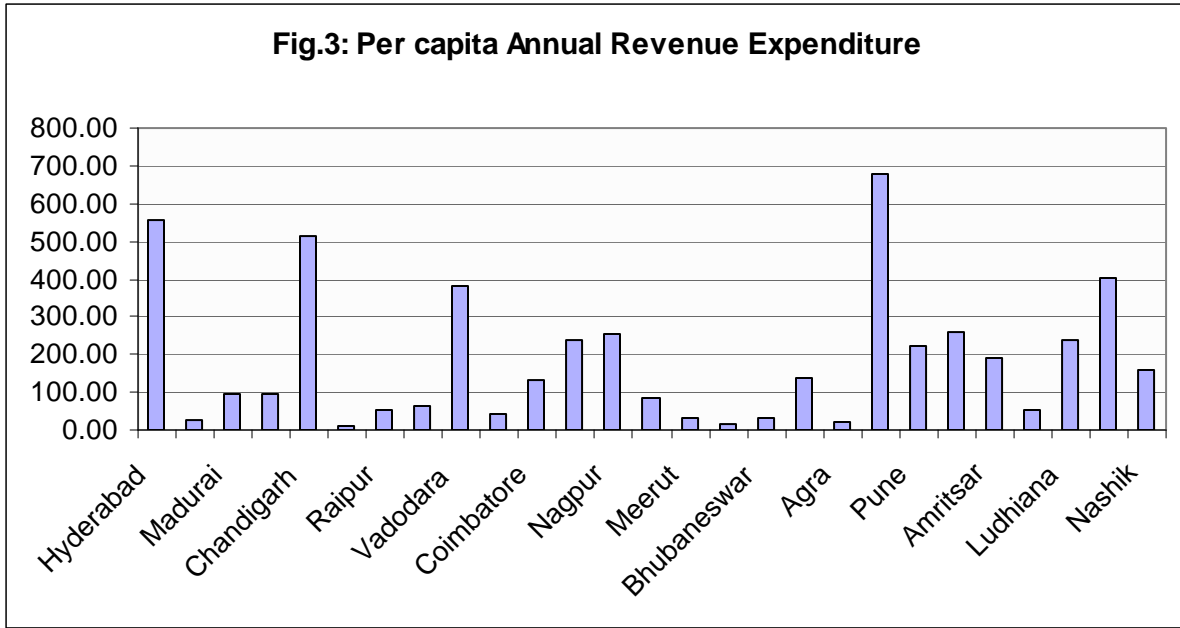
Water connections

A comparative assessment of the data for 23 cities for water connections shows that the connection per 1000 people is highest in Vadodara i.e. 185.4 and lowest in Greater Mumbai i.e. 29.35. There is also large variation among cities in this front. It is also a debatable issue whether the water connection figures does qualify to say that water is available to the people. It might be possible that connections are there but water may not be available physically.



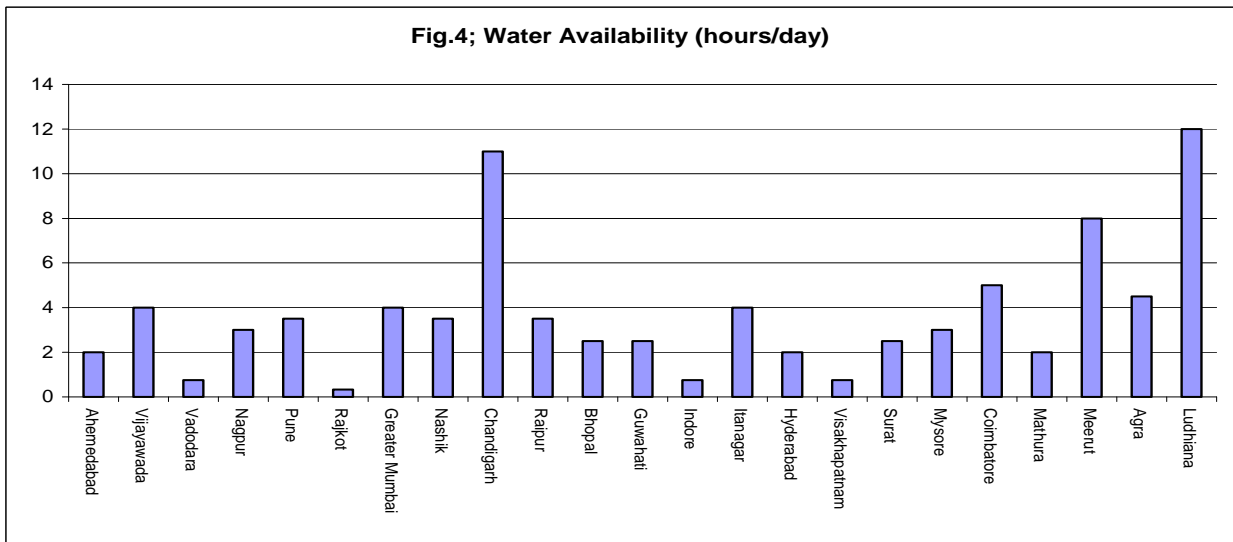
Annual per capita revenue expenditure

The revenue expenditures comprise expenditures made for operation and maintenance (O and M) of the utilities, establishment costs, debt servicing etc. Annual per capita revenue expenditure is calculated by dividing the figures of revenue expenditure with the total population of the city. An analysis of 27 cities exhibits that the annual per capita revenue expenditure is highest in the Itanagar i.e. Rs 677 followed by Hyderabad (Rs 556.58) and Chandigarh (Rs 511.47), and lowest in Surat (Rs 11.60) followed by about Rs. 13 and Rs 20 for Guwahati and Agra. The mean annual per capita revenue expenditure is Rs 185.



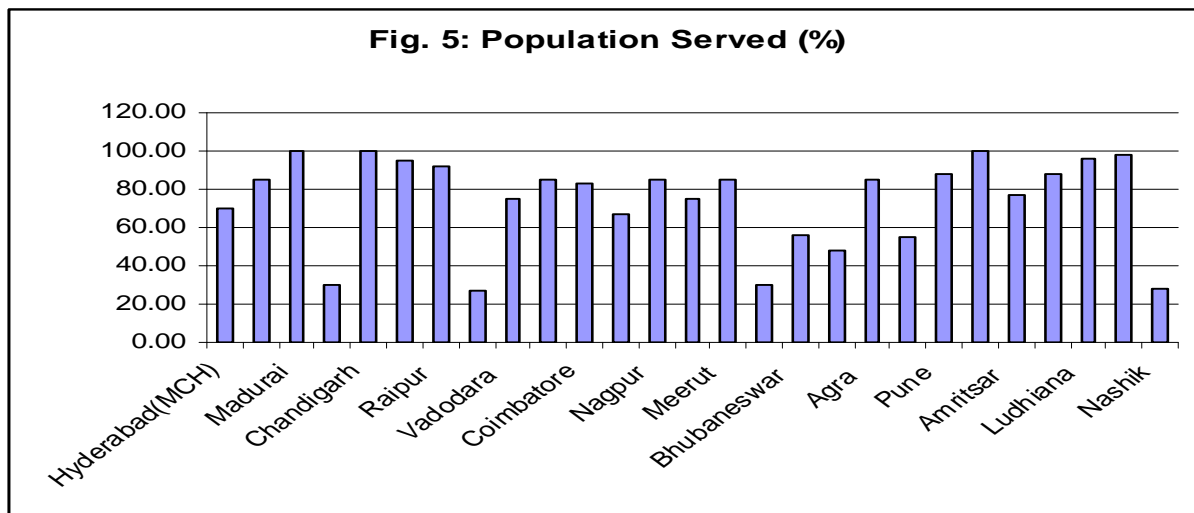
Water availability (hours/day)

It can be defined as the number of continuous hours per day for which water supply is available from the public system. In term of hours of water supply, among the 23 urban localities, Ludhiana fares well and rank as the highest in supplying water followed by Chandigarh. On the other hand, water supply in the cities like Rajkot, Vishakapatnam, Indore and Vadodara are very poor ranging between 30 minutes to 45 minutes per day. The average hour of water supply among cities is 3.7 hours. If we compare these figures with the figures of some cities of the Asian countries, we find that almost all Indian cities analysed here perform very badly. For example, cities like Singapore, Hong Kong, Seoul, and Kuala Lumpur have 24x7 water supply.



Percentage of population served

This measure indicates the proportion of the population in the service area that receives water from the system. Taking the total population figure of the city and the population served by the



water supply system for 27 cities, it is found that almost 100 percent of populations are served by the water supply system in Chandigarh, Madurai, Rajkot, and Greater Mumbai whereas cities like Vijayawada, Visakhapatnam, Nashik and Guwahati, it varies between 20 to 40 percent. It must be cautioned here that, while examining the suitability of this indicator as a measure of the effectiveness of the water supply system, one must keep in mind that the dramatic growth of population in almost all the urban localities distorts the ratio significantly.

The above description of some select cities illustrates the physical dimensions of the water supply situation in urban India. Apart from these concerns, there exist serious problems of governance in water supply system in urban localities in India in terms of lack of transparency and accountability in the functioning, resulting in poor level of performance (WSP, 2006). The unhealthy water supply problem in urban India is because of poor cost recovery, tariffs not reflective of cost of service, inappropriately targeted and ill-defined subsidies, and inadequate investments (World Bank, 1999). A brief account is given here on some dimensions of the existing problems in the provision of water in urban India.

Unviable pricing policy: Poor pricing policy fails to provide the required incentives to improve the system both technically as well as institutionally (Mathur and Thakur, 2003). Present prices don't cover even half of the operation and maintenance (O&M) costs in case of urban water and the continuation of subsidies does not have any rationale as it is not benefiting the targeted poor (Reddy and Mahendra Dev, 2006). Rather, these subsidies encourage inefficiency in water use and bring threats for its sustainable supply (TERI, 1995). Thus, the revenue generated from user

charges falls short of the expenditure made for it. As a consequence of which assets deteriorate and puts question mark on the financial sustainability of the services. Further, the financial sustainability is hindered by the existence of low level of financial management and accounting system, high capital and O&M costs, overstaffing and very high level of non-revenue water, existence of high level of subsidies and single entry cash-based accounting system having insufficient information to make the system transparent.

Managerial inefficiency: It is argued that the deficiency in the availability of water in urban areas is due to the existence of weak managerial capacity (Kundu and Thakur, 2006). The spectrum of skills and expertise that requires undertaking the managerial problems in urban areas are clearly lacking in most of the urban local bodies in India (NIUA, 1998). The management structure is not unified, reflecting lack of coherence in the decision making process.

Poor institutional set-up: The institutional set up of the water and sanitation sector of urban India is characterised by the non-existence of effective regulator, lack of controls and co-ordination between the concerned agencies. Existence of multiple institutions and lack of co-ordination among them results in ambiguous and unclear responsibilities (Singhal and Johri, 2002).

Simply listing down the problems of urban water supply in India is not enough. The need of the hour is to find an appropriate solution which is Pareto improving. To find such a solution with the existing resource constraint, first it becomes necessary to measure the extent of inefficiency, i.e., how much service quality can be improved by making better use of the existing inputs. It is also a hard fact that all the utilities are not equally inefficient; some may be more inefficient in comparison to their peers. We also know that in India, different bodies, such as PHED of State Governments, Municipal Corporations and parastatals² manage the urban water supply. Therefore, the present study first tries to measure the extent of technical inefficiency of urban water supply bodies of selected cities and then try to relate to the performance of these bodies to their management structure.

III. Analytical review of recent literature

We briefly discuss some recent applied studies analysing efficiency of urban water supply in various countries using regression analysis, DEA, and stochastic frontier analysis (SFA). The emphasis here is to give an account of the analytical and methodological part of the literature. It does not include any study from India; as to our knowledge so far no study has been attempted in this direction to analyze the efficiency of this sector with the use of these techniques.

The debate on ownership and its linkage with efficiency in water sector originated with the seminal paper by Crain and Zardkoohi (1978). They assessed the relative efficiency of public versus private water utilities in the United States with the use of a log linear cost function derived from a generalised Cobb-Douglas production function. For the estimation of the cost function, labour and capital were taken as two input variables and a dummy was incorporated to examine the effects of ownership on the efficiency of the sector. The paper concludes that

² Parastatal bodies are part of the government with some degree of functional autonomy, e.g., the Delhi Jal Board (DJB).

publicly owned utilities had higher costs and lower labour output elasticity in comparison to their private counterparts. Though this paper initiated the debate of measuring the comparative efficiency of public versus private ownership, it is not without criticism. The assumption of homogeneous output appears to be inappropriate and non-inclusion of opportunity cost of capital sounds illogical in a sector like water where capital costs constitute significant portion of the total cost. Similarly, Bruggink, (1982) carried out an analysis of measuring the relative efficiency of the public versus private ownership in water utilities and concludes that private operators are relatively better to others. However, based on a variation of the Chow test, he finds that ownership does not have any significant effect on the structure of the cost or underlying production functions.

Feigenbaum and Teeples (1983) critiques Crain and Zardkoochi (1978) and Bruggink, (1982) on methodological grounds. They approached the problem from a different perspective with the use of a hedonic cost function technique. They conclude that there is a little difference in the performance levels between the private operators and public operators. But non-inclusion of capital costs in Feigenbaum and Teeples (1983) study was also criticised (Coelli and Walding, 2005). A further development to this debate was added by the Teeples and Glyer (1987). Using the water utilities data of California, the authors analysed the earlier studies made by Crain and Zardkoochi (1978), Bruggink (1982) and Feigenbaum and Teeples (1983) on a comparative basis. They came out with the view that the differing results in these earlier studies were due to the existing model restrictions implicit in the all of the studies.

Byrnes et al. (1986) attempted to assess the relative efficiency of private versus public ownership in water utilities with the use of linear programming technique of DEA. They specified the production model with single output variable, volume of water delivered and seven input variables: ground water, surface water, purchased water, part time labour, full time labour, length of pipe line and storage capacity. The authors find that there is not much difference in the technical efficiency scores of private versus public firms.

Lambert and Dichev (1993) also carried out a comparative assessment of the performance of private versus public water utilities. DEA technique was used to calculate the efficiency scores for 238 public and 32 private firms. The data were taken from American Water Works Association (AWWA). The study concludes that the major source of inefficiency is the technical inefficiency. There exists little difference between performance of private and public firms.

Estache and Kouassi, (2002) attempted to figure out the determinants of efficiency levels achieved by 21 African water utilities. The results show that corruption is negatively linked to efficiency while governance is positively associated with efficiency. Analysing the effects of privatization, they found that, the privatization does have an impact on the performance of the water utilities. This is in contrasts to the study carried out by the Estache and Rossi (2002) for Asia, where they concluded that there is no significant difference between the private and public operators.

Kirkpatrick et al. (2006) also addresses the issue of ownership and its effect on performance of the sector. This study examines the effects of privatization on the performance of the sector using data of African water utilities. Both the SFA and DEA techniques are used for the analysis. The

result shows that there is not much difference in the performance between the privately owned utilities and publicly owned utilities.

From the review of above cited studies, it can be summarised that there is no clear-cut evidence as to which type of ownership is superior over the other. The results are mixed in nature. In some cases differing results are because of differing methods used. Therefore great caution must be taken while deciding a particular method for a particular situation. The present study extends the literature on efficiency and ownership of water utilities by measuring the technical efficiency of Indian water utilities. Although the Indian urban water supply system is not fully privatised, the utilities face differing levels of autonomy in management.

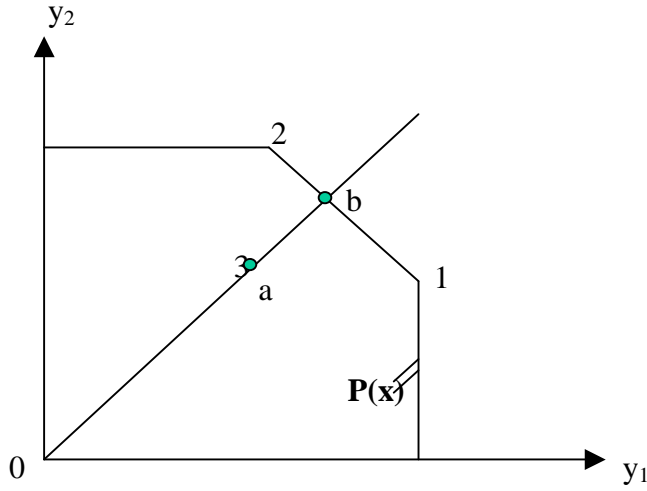
IV. Methodology and estimation

The previous section explains the various techniques such as ordinary least square (OLS), SFA and DEA used in analyzing the efficiency of water industry in various countries. Though the OLS technique is easy to use and simple to interpret, it suffers from the problem of specifying the functional form for the production technology and unable to provide information on frontier performance. SFA though able to solve the latter problem by specifying a composed error term, splitting the error into two different parts as data noise term and error due to the inefficiency, it also suffers from the problem of specifying the functional form and requires specification about the distributional patterns of its composed error terms.

This study uses the output oriented DEA technique which neither requires specification of the error term nor the distributional form of the error term. Although the major disadvantage of this approach is that it does not accommodate the effects of data noise, while OLS and SFA does so. DEA basically erects a production frontier consists of most relatively technically efficient municipalities in the sample. This process generates the technical efficiency measures for each unit in the sample by comparing observed values (the particular data point) to optimal values (the best performing value) of outputs and inputs. The score of unity represent the best performing unit in the sample, and the score more than that implies that the unit or the service is not performing as well as its efficient peers. A rather interesting implication of DEA score is that, it also says that the how much more output could have been produced, if the given service could somehow emulate the production process of the efficient one, i.e., which is operating at the frontier of the production technology. The basic model of DEA can be briefly stated as follows.

Output oriented measures of technical efficiency tell us how much more a water utility can produce from a given amount of resources. This can be illustrated with Figure 6. Suppose there are three water utilities producing two outputs, y_1 and y_2 (lpcd and population served) and each using one input (revenue expenditure). Further assume that first two utilities are benchmark utilities; they are on the boundary or best practice frontier of the technology. Utility 3 employs the same quantities of the inputs as used by utilities 1 and 2, but produces less of both of the outputs, is in the interior of the output set, and obviously not as efficient (productive) as utilities 1 and 2. If we measure the deviation of utility 3 from the best practice frontier in a radial way, its relative technical efficiency is given by ob/oa , which can also be thought of as a ratio of maximum potential output (at b) to observed (actual) output (at a). This measure is referred to as the Farrell output-oriented measure of technical efficiency.

Figure 6



More formally it can be defined as follows: Technology of water utility can be specified either by production, cost or profit functions. The output distance function generalises the production technology of a multi-output utility. Assume that water utility employs a vector of inputs $x = (x_1, \dots, x_N) \in R_+^N$ such as revenue and water storage capacity (as a proxy for capital stock), etc. to produce a vector of outputs $y = (y_1, \dots, y_M) \in R_+^M$ such as lpcd, population served, etc, and then define the production technology of the water utility as

$$T = \{(x, y) : x \text{ can produce } y\} \quad (1)$$

and the output distance function is defined as,

$$D_o(x, y) = \inf[\{x, y/\theta\} \in T] \quad (2)$$

Equation (2) characterizes the output possibility set by the maximum equi-proportional expansion of all outputs consistent with the technology set (1). Output distance function is non-decreasing, positively linearly homogeneous and convex in outputs and decreasing in inputs. The output distance function takes a value, which is less than or equal to one if the output vector is an element of the feasible production set. Furthermore, the distance function will take a value of unity if output vector is located on the outer boundary of the production possibility set.

In computing the distance functions, we choose the DEA (or activity analysis) methodology among competing alternatives, so as to take advantage of the fact that the distance functions are reciprocals of Farrell efficiency measures. The DEA involves the use of linear programming methods to construct a piecewise linear envelopment frontier over the data points such that all observed points lie on or below the frontier. Thus, the technical efficiency for each firm is computed like this

$$\begin{aligned}
& (D_y(x^0, y^k))^{-1} = \max \theta \\
& st \\
& \sum_{k=1}^K z_k y_m^k \geq \theta y_m^0 \quad m = 1, \dots, M \\
& \sum_{k=1}^K z_k x_n^k \leq x_n^0 \quad n = 1, \dots, N \\
& z_k \geq 0 \quad k = 1, \dots, K
\end{aligned} \tag{3}$$

where M is the number of outputs produced, N is the number of inputs employed, and K is the number of water utilities. (z_1, \dots, z_k) are variables, which show the intensity with which each utility is used in order to construct the frontier of the production possibilities set. In the formulation of equation (3), by restricting $z_k \geq 0$, we imposed the condition of constant returns to scale (CRS). In the DEA, we can impose various kinds of returns to scale on reference technology by changing the restrictions on intensity variables. For example if $\sum_{k=1}^K z_k \leq 1$, then the technology satisfies the non-increasing returns to scale (NRS) and if the sum of intensity variable is restricted to exactly equal to one, we can model variable returns to scale (VRS) which allows increasing, constant and decreasing returns to scale.

Technical inefficiency under CRS is the product of scale inefficiency and pure technical inefficiency. A water utility is operating under the condition of optimal returns to scale if the output oriented technical efficiency of a water utility is equal under CRS and VRS scenarios, otherwise it is scale inefficient. Deviations from scale efficiency are essentially deviations from CRS and therefore can be due to operating at a point of increasing or decreasing returns to scale. If the technical efficiency under CRS is not equal to the efficiency under VRS but the efficiency score under VRS and NRS are equal then the utility is operating under decreasing returns to scale (DRS). Finally, if the efficiency score are equal under CRS and NRS but less than VRS then the utility is operating in the range of increasing returns to scale (IRS) (Grosskopf, 1986; Kumar, 2006).

V. Description of data

The present study has taken 27 cities into consideration for the analysis. Although till date more than 40 CDP's are available online, but the unavailability of the required information restricted us to end up in analyzing the efficiency only for 27 cities. The cities which are analysed in the present study are: Agra, Ahmedabad, Amritsar, Bhopal, Bhubaneswar, Chandigarh, Coimbatore, Guwahati, Hyderabad, Indore, Itanagar, Ludhiana, Mathura, Meerut, Mumbai, Madurai, Mysore, Nagpur, Nanded, Nashik, Pune, Raipur, Rajkot, Surat, Vadodara, Vijayawada, and Visakhapatnam. The selection of inputs and outputs for the estimation of technical efficiency is based on the availability of data as well on the knowledge gained from the literature survey. The variables chosen for the present analysis are as follows: revenue expenditure (rupees/year), water

production capacity, and water served³. The first two variables are treated as inputs and total water served is used as output. Table 1 provides descriptive statistics for the variables used in measuring performance and the cause of variation in performance.

Table 1: Descriptive statistics

Variable	Unit	Mean	Standard Deviation	Max	Min
Revenue Expenditure	Million Rupees	451.8	199	5160.09	10.8
Water Production Capacity	Million Litres	407.5	618	3100.00	10
lpcd of Water Supply	Litres	156	70	332.00	41.23
Population Served	Percentage	77	22	100.00	27.00
Total Water Supplied	Million Litres	353	596.6	3158.53	6.40
Per Capita Revenue Expenditure	Rupees	184.64	181	676.65	11.60
Storage Capacity	Million Litres	157	204	782.00	3.00

Some clarifications need to be made with regard to the data used in the model. The revenue expenditures generally constitute recurring expenditures made on establishments, repairs and maintenance, debt servicing, etc. It is also imperative to mention that some other variables could have better served as input variable indicators, but unavailability of data does not allow us to include those relevant variables. On a similar ground, our analysis is limited in focusing only on single (total water served) output variable. Therefore, we analyze the model using the data on single output, total water served by a water utility as a function of revenue expenditures and water production capacity.

We feel it merits mentioning here few points on the existing data inaccuracies and inconsistencies. The available data are not standardised across CDPs. For example, somewhere the units of water available are mentioned in MLD (Million Liters per Day), whereas in other CDPs it is in MGD (Million Gallons per Day) units. Further high degree of aggregation also handicapped us to restrict our analysis only at an aggregated level. For example, for cities like Raipur and Coimbatore, the variable on revenue expenditure and all its sub-components are available but this is not the case for other cities like Ahmedabad and Madurai.

VI. Results

Using the data set for 27 cities, output oriented technical efficiency scorings are generated and are presented in Table 2. Recall that we are using output oriented measure of technical efficiency, therefore the efficiency scores greater than one implies that the utility has potential to increase its output for the given level of inputs. The efficiency estimates reveal that two cities,

³ Water served is defined as lpcd multiplied by the population of the city.

namely, Agra and Surat are operating at the frontier. These cities are also operating at the optimal scale of operation. In both of these cities the per capita revenue expenditure is lowest one (in Surat about Rs 12 and in Agra about Rs 20) and the lpcd is higher than the average. On the other hand, Mathura, Bhopal, Visakhapatnam, Nashik and Itanagar are the worst performing cities. These cities have the potential to increase the quantity of water supplied by three to eight times. For example Itanagar has highest per capita revenue expenditure and lpcd is just 137 liters. Similarly, Bhopal spent around the national average of per capita revenue expenditure but delivers only 88 liters of water on lpcd basis. The other cities have the potential to increase the desired output by some percentage to three times. The regression results in Table 4 also confirm that there is inverse relationship between per capita revenue expenditure and technical efficiency and positive association between technical efficiency and lpcd.

Table 2: Output-oriented technical efficiency of urban water providers in India

Group	City	Scale Efficiency	Pure Technical Efficiency	Technical Efficiency at CRS
Municipal Corporations and Government	Bhubaneswar	1.074	1.080	1.160
	Chandigarh	1.471	1.020	1.500
	Raipur	1.025	1.600	1.640
	Greater Mumbai	2.020	1.000	2.020
	Rajkot	1.146	1.780	2.040
	Nagpur	1.750	1.200	2.100
	Pune	2.140	1.000	2.140
	Ahmedabad	2.150	1.000	2.150
	Vadodara	1.510	1.470	2.220
	Vijayawada	1.455	1.560	2.270
	Indore	1.660	1.530	2.540
	Guwahati	2.930	1.000	2.930
	Itanagar	3.210	1.000	3.210
	Nashik	1.769	1.860	3.290
	Bhopal	1.419	2.650	3.760
Average	1.69	1.32	2.23	
Municipal Corporations and Parastatals	Surat	1.000	1.000	1.000
	Agra	1.000	1.000	1.000
	Meerut	1.187	1.230	1.460
	Amritsar	1.252	1.270	1.590
	Nanded	1.073	1.920	2.060
	Coimbatore	1.210	1.810	2.190
	Ludhiana	1.779	1.310	2.330
	Mysore	1.044	2.280	2.380
	Madurai	1.016	2.480	2.520
	Hyderabad	1.849	1.460	2.700
	Visakhapatnam	1.324	2.990	3.960
	Mathura	1.047	7.680	8.040
Average	1.20	1.82	2.20	
Overall Average		1.43	1.55	2.21

The overall average figures of scale inefficiency reveal that the utilities are not utilizing their resources optimally. We find that Itanagar, Guwahati, Pune and Ahmedabad are most scale

inefficient water utilities. These water utilities can improve their performance by changing the level of their operation.

Recall that technical efficiency is decomposed into scale efficiency and pure technical efficiency. Table 3 reveals the operating scale of different water utilities. The scale efficiency results indicate that only two of the utilities are operating at the optimal scale and seven cities are operating under increasing returns to scale. But all the remaining cities, i.e., eighteen water utilities are operating under DRS. These results have implication for urban domestic water pricing. Generally, in the public utility pricing literature it is assumed that the utilities are operating under IRS and the marginal cost-pricing rule that ensures economic efficiency is not applied since the full cost is not recovered. These results support the idea that to get efficiency in the operation of water utilities the water should be priced according to the marginal cost of supply of the water.⁴

Table 3: Returns to Scale observed at various water utilities

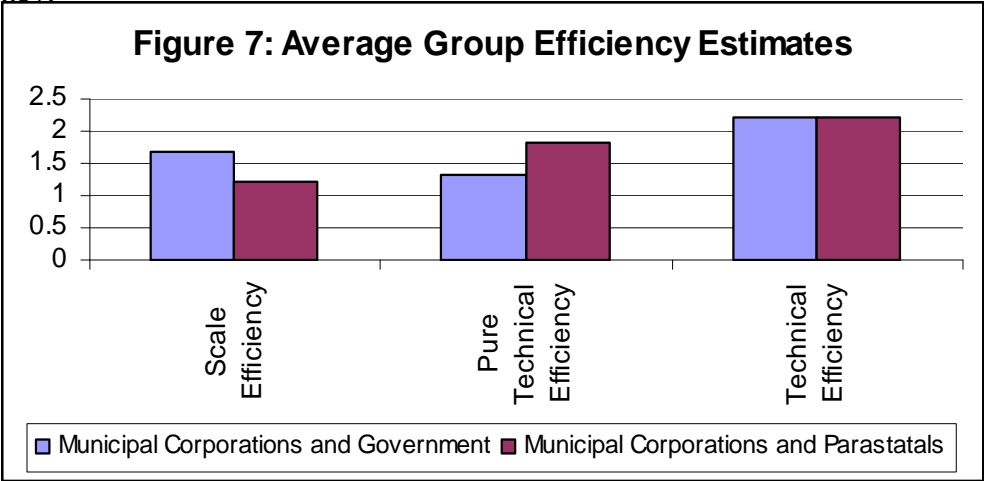
Returns to Scale	Name of the City
Constant Returns to Scale (Optimal Returns to Scale)	Surat and Agra
Increasing Returns to Scale	Raipur, Madurai, Mathura, Bhubaneswar, Nanded, Guwahati and Itanagar
Decreasing Returns to Scale	Chandigarh, Nagpur, Ahmedabad, Coimbatore, Vadodara, Vijayawada, Mysore, Hyderabad, Nashik, Bhopal, Visakhapatnam, Meerut, Amritsar, Greater Mumbai, Rajkot, Pune, Ludhiana, Indore

To explain the differential in efficiency scores we classify the utilities according to their management structure. Although the public owns all the water utilities in India but they are managed by different agencies. Categorizing water utilities into different groups according to their management structure is not so easy as there is no clear-cut division of responsibilities among the agencies involved in supplying water under the existing arrangements. In the utilities managed by Municipal Corporations, the municipal authorities themselves are responsible for managing all the activities of planning, designing, construction, implementation, maintenance, operation and management of water supply system. Similarly, the utilities, which are managed by Municipal Corporations and the Government agencies (e.g. PHED), both the authorities, undertake all the activities with varying degrees of responsibility. In some cases, PHED does the capital work, the remaining task is undertaken by Municipal Corporations (e.g. Raipur), in others PHED is assigned to carry out most of the activities leaving very little to be done by the municipal authorities (e.g. Bhopal and Indore). While in others, PHED is the leading agency to manage the water supply system in the city (e.g., Itanagar). In some others, there is some functional autonomy in the management of water utilities, i.e. parastatal bodies manage the utilities (e.g., Hyderabad, Agra). In other cities water supply is the responsibility of both parastatal and Municipal Corporations or are managed by all the three, i.e., PHED, Municipal Corporations and parastatal bodies.

⁴ Whittington (2003) also observes that many South Asian cities are facing the situation of decreasing returns to scale in operation as they have to incur high costs to bring additional water into cities.

Following this description, we split up the utilities into two groups as Municipal Corporations and the Government in one group and Municipal Corporations and parastatals as another. We have done it with the conviction that as both Municipal Corporations and State Government agencies are different layers of the Government, it logically justifies putting them in one group. While making grouping of the water utilities, we assumed that there exists some degree of functional autonomy with the group entitled as Municipal Corporations and parastatals. Therefore, we feel it is quite reasonable to put them into a separate category.

Figure 7 shows the performance of water utilities according to their management structures. The efficiency scores reveal that the water utilities run by the combination of Municipal Corporations and parastatal bodies are performing not better than the other group in terms of overall technical efficiency.



The decomposition of technical efficiency results reveal that though the group consisting the utilities that are managed by Municipal Corporations in association of parastatals is not different in terms of overall technical efficiency, but they have relatively better performance in terms of scale efficiency to the other group (Figure 7). The results presented in tables 2 and 3 also indicate that the scale efficiency is clearly linked to the management of the utility although in both the groups utilities are operating under DRS and IRS. In the group consisting of Municipal Corporations and Government there are four utilities and in the other group there are three utilities that are operating under IRS. *Per se*, the utilities operating under IRS are small cities in comparison to other cities, and the variation in efficiency scores warrants more analysis.

The issue of the type of ownerships and its implications for the performance of water utilities has been in debate with the publication of the seminal paper by the Crain and Zardkoochi (1978). Though the results are of mixed in nature, very often the techniques used for analyzing the efficiency are being questioned for its appropriateness and suitability. It must be mentioned here that though the pure form of privatization is yet to see the light of the day as a separate institution to provide water in urban India, it can be assumed that there exists some degree of private managerial discipline, in the group categorized as Municipal Corporations and parastatals. Taking this as granted, our results, in some extent, corroborates with the results reached by the Crain and Zardokhi, Bruggink (1982) Estache and Kouassi (2002) that private operators are relatively better in comparison to their public counterparts.

One other issue of concern is to determine the factors underlying the changes in the various measures of efficiency. We expect that specific attributes of an individual utility contribute to its performance. Therefore, to further aid an understanding of the results discussed above and to test the hypothesis whether functional autonomy in management of utilities has affected the various measures of efficiency, we regress various measures of efficiency on utility specific variables such as its management, water storage capacity etc. Tobit regression is often used with censored data and is suitable for analysis of efficiency scores. In the first equation the technical efficiency scores, in the second equation scale efficiency scores and in the third equation pure technical efficiency scores were taken as dependent variables. To examine the relationship between different measures of efficiency and their determinants, we included the dummy variable for management, i.e., one for the utilities that are somehow managed by the parastatal bodies and zero for the others, per capita per day water supplied (lpcd), per capita revenue expenditure, and water storage capacity of the utility.

Table 4 provides the parameter estimates of the regressions for the efficiency indexes. The regression results show that three efficiency indexes are significantly affected by most of the independent variables. We find that the lpcd and per capita revenue expenditure variables affect the efficiency indexes negatively and positively respectively as expected in all the three regressions. It is expected that the utilities that are providing higher lpcd and incur less per capita revenue expenditure be expected to be more efficient. The water storage capacity of the utilities increases the performance of water utilities, though the coefficient of water storage is not statistically significant for scale efficiency.

The signs of management variable represented by the dummy variable are of particular interest and require some discussion. We find that the management variable is not statistically significant for all the three indexes. The management of water utilities linked to functional autonomy leads to increase in scale efficiency. But we find that the functional autonomy in management is not linked to technical efficiency of the utilities. Here it should be noted that most of the small cities such as Itanagar and Guwahati are managed by the Municipal Corporations and Government, although the utilities are efficient in terms of pure technical efficiency, but they are not fully utilizing the economies of scale, i.e., they are facing downward sloping average and marginal costs curves. These cities are the case of pure natural monopoly where the water cannot be priced according to the principle of marginal cost pricing since a firm with economies of scale cannot recover its costs with marginal cost pricing.⁵

⁵ In the single product case: “a firm producing a single homogeneous product is a natural monopoly when it is less costly to produce any level of output of this product within a single firm than with two or more firms” (Joskow, 2005). This definition corresponds to the property of subadditivity of the cost function (Sharkey, 1982), which (in the single product case) is equivalent to economies of scale. Consequently, in the single product case, economies of scale are a sufficient but not necessary condition for natural monopoly (Joskow, 2005).

Table 4: Factors Determining Technical and Scale Efficiency of Water Utilities

Dependent Variables →	Technical Efficiency		Pure Technical Efficiency		Scale Efficiency	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	17.866*	3.922	18.602*	5.211	6.370*	3.885
Dummy for management	0.020	0.030	0.196	0.375	-0.822*	-4.046
Log (lpcd)	-1.735**	-2.357	-1.283**	-2.392	-0.516**	-2.011
Log (per capita revenue expenditure)	0.515**	1.936	0.779*	2.903	0.211**	2.151
Log (Storage capacity)	-0.668*	-3.577	-1.222*	-5.918	-0.062	-0.875
Adj. R ²	0.315		0.05		0.272	
Log likelihood	-39.71		-32.11		-19.36	

Note: *, **, *** indicate that the variable is statistically significant at 1%, 5% and 10% level of significance.

VII. Conclusions

The productivity of water utilities has been an important policy issue for a long time. This has assumed greater significance in the current context of reforms in the structure and functions of the utilities. This paper contributes to that debate by analyzing the impact of management on efficiency.

The results indicate that the utilities, which are run by Municipal Corporations and parastatals perform relatively better in comparison to the group combined by Municipal Corporations and Government. Taking the variable of total water served as an indicator of the operating performance, we find that the utilities run by Municipal Corporations and parastatals are relatively scale efficient in comparison to the group combined by Municipal Corporations and Government. Further, the regression analysis shows that the scale efficiency is clearly linked to the management of the utility. Our results also have implications for the pricing of water. The offshoot of our analysis suggests that as most of cities (e.g. eighteen out of twenty seven) are operating under decreasing returns to scale, marginal cost pricing principles can be followed. This is in contrast to the common pricing practice of utilities having the character of natural monopoly.

Therefore it can be concluded from our analysis that though it is difficult to make a clear cut segmentation of the institutions into private and public, nevertheless assuming a certain degree of functional autonomy element that inherently exist in the parastatal bodies, our study affirms that functional autonomy may have the potential to improve water services in developing countries like India.

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