A FRONTIER APPROACH TO INTEGRATE QUALITY PARAMETERS IN BENCHMARKING ANALYSIS OF WATER SUPPLY UTILITIES

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ABSTRACT

Although agenda of Water supply in sufficient quantity and standard quality is highlighted in India from last few years. But Yet Performance assessment and Efficiency evaluation of water supply services not in practice. However the analysis is confined to the realm of researchers and policy makers. The present paper spells inclusion of quality parameter in assessment of utilities through frontier approach, the Stochastic Frontier Analysis (SFA), and integrates this with water quality as a Model output. This paper also discusses the SFA methodology in details for possible application to assess urban water supply services in India.

Keyword: Benchmarking, Efficiency Evaluation, Performance Assessment, Stochastic Frontier Analysis, Water Supply Services, Water Quality Index.

I INTRODUCTION

SFA is widely adopted benchmarking tool, first choice of many econometricians to assess performance and efficiency evaluation in various sectors like coal, Petroleum, Irrigation, Banking, water sector and so on. Although in India few studies has been done to assess the performance of water supply sector by the use of SFA. SFA is a parametric and mathematical approach for estimating relative efficiencies of any firm. In developed countries use of SFA was successfully employed by econometricians in water supply sector. Following [1], [2], [3], [4], [5], [6], [7], [8], [9]., [10], and [11] successfully employed SFA technique in Water supply sector.

Globally SFA technique was successfully employed by [12] for Africa, [13] for Asia,[14] for France, [15] for Itali, [16] for Japan, [5] for Peru, [10] for Sloveniya, [17] for UK, [18] for Madhya Pradesh, India.

Because of the monopoly of the public utilities in India, there should be a systematic approach to assess the performance of these public utilities to know the right way through which utility can achieve its maximum output/profit goals. SFA based efficiency evaluation studies have been very rare in developing countries, primarily because of lack of an appropriate database on the performances of water supply services, and also because the water supplies are yet to take on the form of an industry that would need management on business lines to improve operational efficiencies and to effect savings.

The present work focuses on evolving a SFA-based framework for benchmarking urban water supply services with water quality parameters included in the model as an output variable.

II SFA METHODOLOGY

The Stochastic frontier production function was independently proposed by [19], and [20]. The original specification involved a production function specified for cross-sectional data which had an error term which had two components, one to account for random effects and another to account for technical inefficiency.

Cobb-Douglas Stochastic Frontier model for cross sectional data is given by the formula:

$$\ln q_i = \beta_0 + \beta_1 \ln X_i + V_i - U_i \text{--(I)}$$

- Where V_i-U_i is known as a composed error term and this is the beauty of stochastic frontier model also known as the residual for decision making unit (DMU).
- V_i = random variables which are assumed to be independently identically distributed (i.i.d.) $N(0,\sigma_v^2)$ and independent on U_i
- U_i = Non-negative random variable, typically assumed to be exponential, half normal or truncated normal, associated with technical inefficiency in production of utility such that for a given technology and levels of inputs, the observed output falls short of its potential output.

Equation (I) can be written as:

$$q_i = \exp(\beta_0 + \beta_1 \ln X_i) * \exp(V_i) * \exp(-U_i) \text{ ------------------(II)}$$

Where,

$\exp(\beta_0 + \beta_1 \ln X_i)$ = Deterministic component

$\exp(V_i)$=Noise

$\exp(-U_i)$ =Inefficiency

Estimation of stochastic frontier is computationally facilitated by the use the parameterization proposed by [21].

$$\Sigma\sigma_s^2 = \sigma_u^2 + \sigma_v^2 \text{ and } \gamma = \sigma_u^2/\sigma_s^2$$

Remember, however, that parameter 'γ' is not equal to the ratio of the variance of technical inefficiency effects to the total residual variance. Estimation of the parameters of the stochastic frontier was accomplished by maximum likelihood. The firm-specific distance function (technical efficiency), represented by the random variable $\exp(-U_i)$, is not directly observable. [22] proposed the conditional expectation of U_i, conditioned on the realized value of the composed error term $\varepsilon_i$as an estimator of U_i. Jondrow et al. (1982) have demonstrated the conditional distribution of U_i given ε_i is that of an $N(\mu_i, \sigma^2)$ random variable truncated at zero with $\mu_i = \sigma_u^2\varepsilon / \sigma^2$

- The distance between observed and maximum possible output for given inputs (output efficiency)
- The distance between observed and minimum possible input for given outputs (input efficiency)

The unknown parameters are replaced by their ML estimates. One estimator of the sample mean of technical efficiency is the arithmetic average of these predictors for the individual technical efficiencies. A firm can lie on or within the frontier, and the distance between actual output and the frontier output represents technical inefficiency. Measure of technical efficiency is the ratio of observed output to the corresponding stochastic frontier output.

Starting values used were OLS parameter estimates of the production function. Maximum Likelihood estimator (ML estimator) was found to be significantly better than the COLS estimator when the contribution of the technical inefficiency effects to the total variance term is large [23].

III DETAILS OF QUALITY AND PERFORMANCE INDICATORS FOR SFA

For quality assessment of services quality parameter known as a water quality indices can be successfully included in SFA. Previous studies include water quality parameter like number of working treatment plant, water quality as environmental variables in parametric approach. Table 3.1 represents a set of indicators required for SFA.

Table 3.1. Data requirements of the water supply services for performance indicators with respect to its definitions & data specifications

S. No.	Indicators	Definition	Data specifications
1	Average daily clear water production (MLD)	Average volume of water produced daily to fulfill the requirement of the city	Output
2	No. of employees	Number of employees working in a municipality	Input
3	Capital (length of the piped network in Km)	In the absence of Capital cost of municipality length of the piped network of water supply services taken as a proxy variable.	Input
4	Installed capacity of water treatment plant	Total capacity of water filtration and treatment plant	Input
5	Density of customers (population served / coverage area by service)	Density of customers defined as a ratio of population served by the municipality to the coverage area by services.	Input/Environmental Variables
6	Non- revenue water (loss) (%)	Non- revenue water or define as a loss	Dummy variables/Environmental variables
7	Number of connections	Number of connections supplied by the municipality	Quality variable/output variable
8	Operating expenditure (Rs. in Lakhs)	Total expenditure on electricity, maintenance, chemicals etc.	Output
9	Price of labor (Avg. annual wages, Rs. in lakhs)	Total expenditure on staff salary	Input
10	Prize of Electricity (Rs. in lakhs)	Total expenditure on electricity	Input
11	Area of service	Area covered by the services	Environmental variables
12	Water quality Index	A single value represent the water quality on the basis of one or other quality parameters which translates the list of constituents and their concentrations present in a sample.	Environmental variables

3.1 The water quality index

The last of the variables, the water quality index (WQI) is a multi-parameter number that integrates various parameters representing water quality. Developed by National Sanitation Foundation, USA in 1970, the WQI included nine water quality parameters. These 9 water quality parameters are Dissolved oxygen, Fecal coliform, PH,

BOD_5, temperature difference, total phosphate, Nitrate, Turbidity and total solids. WQI may be however, adopted with some modifications as needed by the municipal authorities.

United Nations Environment Programme [24], suggests a number of WQIs. These include:

1. Drinking Water Quality Index (DWQI)
    a. all parameters regardless of WHO designation
2. Source Water Quality Index (SWQI)
    a. health and microbial criteria only
    b. arsenic, boron, cadmium, chromium, copper, fluoride, lead, manganese, mercury, nitrate, nitrite, faecal coliforms
3. Acceptability Water Quality Index (AWQI)
    a. acceptability criteria only
    b. ammonia, chloride, iron, pH, sodium, sulphate, zinc

IV CONCLUSION

In order to improve the efficiencies of water supply services, it is necessary that their performances be evaluated over time, and competition be generated for inculcating a culture of efficient delivery of these services. Hence, as a matter of policy, there is a need to collect data regularly, and on preselected and predefined parameters to ensure consistency. It is suggested that parametric approach like SFA is best suited for efficiency measurement in India where some environmental factors affect utilities performance. The biggest benefit/beauty of SFA is having a capacity of inclusion of Noise in parametric form.

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