Efficiency in South African water utilities: a comparison of estimates from DEA, SFA and StoNED

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Climate change has brought renewed and increasing attention to the productivity and efficiency of the water sector. This has stimulated interest, which has manifested itself in the increased application of statistical tools to measure the productivity and efficiency of water utilities. Policymakers in developed countries are already making use of statistical analyses of water systems for determining productivity and efficiency. For efficiency analysis to be useful to policymakers, the various approaches used should produce estimates that are consistent in identifying the best and worst firms, as well as overall rankings of firms in terms of their efficiency levels. Generally, data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are the most common frontier analysis techniques used to measure the productivity and efficiency of water utilities. DEA places less emphasis on the shape of the frontier and is credited for its axiomatic properties that can accommodate a multiplicity of inputs and outputs, as well as its ability to consider returns to scale. On the other hand, SFA decomposes deviations from the frontier into random noise and inefficiency terms. These tools are not direct competitors, but complement each other, due to their respective advantages. In the recent years, a new efficiency analysis technique, the stochastic non-parametric envelopment of data (StoNED) emerged in the literature. StoNED combines the axiomatic, non-parametric, piecewise linear DEA-style frontier with a stochastic SFA-style treatment of inefficiency and noise. Thus, it is more robust to both model misspecification and noise.

In this study we compare efficiency scores from DEA, SFA, and StoNED, using the South African water sector as a case study. More precisely, the study investigates the consistency of efficiency scores obtained from these three efficiency analysis techniques in the context of a water sector from a developing country. We estimate cost efficiency based on cross-sectional data from 102 South African water utilities in the period 2013/14. Thus, the study extends existing studies that compare frontier analysis methods by introducing a robust semi-non-parametric methodological tool. This methodological cross-checking process using three methodological tools provides more robust, reliable and useful information and diagnostics for regulatory analysis and policymakers. This is an innovative approach, and to the best of our knowledge this is one of few such studies – and, the first cross-checking process using three methods – to be applied to the water sector. Furthermore, this is the first application of the StoNED approach to the water sector. The results suggest that the StoNED method (based on the methods of moments estimator) outperforms SFA and DEA. However, based on the pseudo-likelihood estimator, SFA outperformed StoNED. Overall, the results suggest moderate consistency across the three methods. Based on the findings, we conclude that our study presents a robust approach to efficiency analysis in water utilities.

Keywords: water utilities, StoNED, DEA, SFA, frontier efficiency.