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Assessing the sustainability of water companies: A synthetic indicator approach

María Molinos-Senante[a,b,c,*], Rui Cunha Marques[d], Fátima Pérez[e], Trinidad Gómez[e], Ramón Sala-Garrido[f], Rafael Caballero[e]

[a] Departamento de Ingeniería Hidráulica y Ambiental, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, Santiago, Chile
[b] Escuela de Arquitectura e Instituto de Estudios Urbanos, Pontificia Universidad Católica de Chile, El Comendador 1916, Santiago, Chile
[c] Centro de Desarrollo Urbano Sustentable CONICYT/FONDAP/15110020, Av. Vicuña Mackenna 4860, Santiago, Chile
[d] Center for Urban and Regional Systems (CESUR), CERIS, IST, University of Lisbon, Av. Rovisco Pais, Lisbon, Portugal
[e] Departamento de Economía Aplicada (Matemáticas), Universidad de Málaga, Campus El Ejido, Málaga 29071, Spain
[f] Departamento de Matemáticas para la Economía y la Empresa, Universidad de Valencia, Campus dels Tarongers, Valencia 46022, Spain

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ABSTRACT

Performance indicators (PIs) are essential in the benchmarking process used to rate and rank water companies. However, a set of individual PIs does not provide a holistic assessment of company performance from multiple perspectives. A multidimensional evaluation of the performance of water companies can be achieved by aggregating the PIs into a synthetic indicator. Although the concept of sustainability involves economic, environmental and social criteria, most of the previous studies have not considered these three dimensions simultaneously. This paper discusses a process of indicator aggregation using two approaches based on multi-criteria decision analysis to evaluate and compare the sustainability of water companies from a holistic perspective. A synthetic indicator embracing economic, environmental and social PIs was computed for a sample of 154 Portuguese water companies. Both methods yielded similar rankings of water company sustainability. The techniques and results presented in this paper may be utilized as a means of improving the benchmarking process in regulated water industries, as well as providing valuable contributions to decision-makers on the most efficient steps for improving the sustainability of urban water services.

1. Introduction

The benchmarking process in the water industry is currently a topic of international importance. In many countries, such as England and Wales, the Netherlands, Portugal and Chile, the water industry exists as a monopoly or within very restricted power centers. In this context, benchmarking assumes a strategic importance for governments and regulators to create incentives for efficiency and innovation. Without these centralized controls, there is a greater risk that water supply operators would take significant advantage of users by abusing their power within the market place (Marques et al., 2011; Molinos-Senante et al., 2015). Hence, for regulatory purposes, benchmarking is essential to control and supervise the quality of service and/or to establish appropriate tariffs and fair market prices (Marques, 2006). The use of benchmarking is normally based on performance indicators (PIs) which allow for the development of competition by comparison (yardstick competition). One approach to yardstick competition is sunshine regulation which involves a public display of performance data of regulated firms (water companies in our case study), thereby fostering information transparency and allowing consumers/users to make unencumbered comparisons of suppliers. This system encourages the poor-performing water utilities to improve the quality of service they provide since various stakeholders are likely to apply pressure to improve below-average performance (Marques et al., 2011).

In the context of regulated water industry, water utilities must provide regular reports on several PIs to the regulator and/or government. These PIs capture management, environmental, financial and, more recently, social data with respect to water operations (Palme and Tillman, 2008). The PI system consists of numerous elements, making them difficult to use by citizens and water

* Corresponding author at: Departamento de Ingeniería Hidráulica y Ambiental, Pontificia Universidad Católica de Chile, Av. Vicuña Mackenna 4860, Santiago, Chile. Tel.: +56 223544219.
E-mail addresses: mmolinos@uc.cl (M. Molinos-Senante), rui.marques@ist.utl.pt (R.C. Marques), f.perez@uma.es (F. Pérez), trinidad@uma.es (T. Gómez), ramon.sala@uv.es (R. Sala-Garrido), rafael.caballero@uma.es (R. Caballero).

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regulators for sunshine regulation purposes. One of the difficulties in interpreting PIs is that they are not all the same in terms of importance and this inequality leads to misunderstanding as to the trade-offs among them. That is, high performance on one indicator does not necessarily compensate for low performance on another. A major limitation of evaluating performance based on a set of PIs, therefore, is that it does not provide a holistic view. Using this approach, the output of the assessment process is not a measure of general performance, and it is therefore very difficult to rank water companies based on their general performance (Duarte et al., 2009). One way of bypassing this limitation is to aggregate the PIs, converting them into a synthetic indicator which provides a multidimensional assessment of the performance of water companies. Aggregating individual indices using Multi-Criteria Decision Analysis (MCDA) is a common technique to construct synthetic indices for sustainability evaluation. MCDA has been used to evaluate the sustainability of a wide range of activities, services and/or processes (e.g., Giannetti et al., 2009; Voces et al., 2012; Molinos-Senante et al., 2014).

At the same time, consideration of sustainable development has become an increasingly important factor for the regulation and governance of the water industry (Cashman and Lewis, 2007). While there is an increasing recognition of the need to improve the sustainability of urban water systems, previous studies suggest a lack of consensus on the appropriate criteria to assess water companies' performance with regard to sustainability (e.g., Foxon et al., 2002; Sahely et al., 2005; Palme and Tillman, 2009; Rojas-Torres et al., 2014). This is due, in part, to the lack of a clear definition of a sustainable water company. Nevertheless, for this study we adopted the traditional vision of sustainability which separates the concept of sustainability into three dimensions: environmental, economic and social (WCED, 1987; Singh et al., 2012).

The majority of published studies on urban water supply have focused on assessing the sustainability of physical and engineering aspects of water supply systems, in particular the water distribution networks (e.g. Hamouda et al., 2009; Tabesh and Saber, 2012; Marques et al., 2015; Aydin et al., 2014), leading to sustainability indices based primarily on technical criteria such as reliability, resiliency and vulnerability. Studies have also evaluated sustainability from an environmental perspective using life cycle assessment (Lundie et al., 2010; Schulz et al., 2012). The economic sustainability of water distribution systems have been evaluated using both a life cycle costing approach (Schulz et al., 2012) or minimizing overall system costs (Ahn and Kang, 2014). There is, however, a lack of information in the published literature that focuses on the sustainability of water companies themselves. Based on our review, only four papers (Klostermann and Cramer, 2007; Duarte et al., 2009; Singh et al., 2010; Marques et al., 2015) describe the application of empirical data to evaluate the sustainability of a sample of water companies; only two of them used MCDA (Duarte et al., 2009; Marques et al., 2015). While Klostermann and Cramer (2007) compared the sustainability of two Dutch water companies using several PIs, the lack of an integrated evaluation process relative to the selected companies makes the PIs difficult to utilize on a broader scale by key decision makers. Singh et al. (2010) evaluated the sustainability of 18 Indian water companies using six sustainability parameters. To accomplish this, they aggregated technical efficiency and scaled efficiency scores computed by data envelopment analysis methodology. Duarte et al. (2009) proposed a synthetic index of service quality to evaluate the general performance of water companies, where the index is calculated as a weighted linear combination of the normalized scores of each performance indicator. The initial indicators are grouped so as to reflect protection of the water usersí interest, as well as sustainability of the utility and environment. These factors do not correspond to the traditional dimensions of sustainability (economic, social and environmental). From a methodological point of view, the normalization process was based on "fuzzy" data sets and the opinion of a panel of experts by using the analytic hierarchy process (AHP). Although the AHP has several advantages, there are downsides as well. First, the number of required pairwise comparisons may become very large, making the AHP a lengthy and potentially cumbersome task. Second, distinguishing among preferences using Saaty's scale may prove difficult for the decision maker. Saaty's scale consists of 1–9 ratios, each indicating how many times one element is more important or dominant over another element with respect to the criterion to which they are compared (Saaty, 2008). Third, since the results of the AHP are dependent on the participants who perform the pairwise comparisons, those results will always be subject to human error and a certain level of subjectivity that varies from person to person (Molinos-Senante et al., 2014). Finally, the study by Marques et al. (2015) evaluated the sustainability of water supply systems through the Macbeth method, adopting the water utility of Lisbon, Portugal as a case study. Therefore, in order to weight the coefficients as required by the AHP, stakeholders are asked to pass judgment on the difference in attractiveness between two criteria at a time using a semantic scale having seven categories. The performance measures are usually qualitative judgements which are further quantified proportionally on a 0–100 scale (Bana e Costa and Vansnick, 1994). In addition to employing the MCDA methodology, these researchers adopted two additional dimensions of sustainability, consisting of assets and governance, which were employed along with the previously indicated metrics of environment, social and economic dimensions.

The goal of the study described here is to contribute to an improvement in the sustainability assessment system of water companies. In doing so, an initial set of sustainability indicators is aggregated into a synthetic indicator based on two novel methodologies, specifically the distance-principal component (DPC) and the global programming synthetic indicator (GPSI), yielding a general measure of sustainability for each water company. Since DPC follows a statistical approach while GPSI in based on a non-statistical technique, the final metric provides insight into differences in ranking of water companies when the two different approaches are applied in concert. Information provided in this paper provides a means for the assessment of the reliability of the DPC and NGPSI approaches and contributes to the standardization of the two methods.

Although there have been a significant number of empirical studies recently completed that assess water company performance, none of them focus on developing a composite indicator which provides a holistic performance perspective. The current study, therefore, is a pioneering and novel approach in the framework of water company performance through its integration of multiple indicators into a single and synthetic metric. This synthetic indicator facilitates interpretation of the PIs and allows water companies to be ranked by sustainability, thus improving benchmarking and allowing both societal users and water managers to make critical decisions based on quantitative data and, if needed, implement corrective measures to improve the sustainability of water urban services over time.

Following this Introduction, the paper is divided into four additional sections. Section 2 describes the methodologies applied. Sections 3 and 4 illustrate the case study and then provide results and discussion, respectively. Finally, conclusions are presented in Section 5.

2. Methodology

Previous studies have illustrated the multiple methodological approaches for constructing synthetic or composite indicators