

Assessing of the impact recycling. A comparison on the change in productivity and eco-productivity of municipal waste services: A case study for Chile.

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The collection of municipal solid waste (MSW) is a public service that impacts the environment and public health. The generation of MSW has increased significantly in the last decade. Therefore, international institutions such as the United Nations and the European Union promote the recycling and reuse of MSW and be part of the 2030 Sustainable Development Goals (Llanquileo-Melgarejo et al., 2021). This increase in the volume of MSW has marked consequences from an environmental point of view and an economic point of view. For this reason, several studies have evaluated the performance of European municipalities in the provision of MSW services. However, in South America, there are no previous studies related to evaluating the change in productivity and/or eco-productivity of municipalities in the collection and treatment of their MSW, which is the main objective of this work. On the other hand, economic efficiency and productivity indicators have traditionally been used to support decision-making processes (Molinos-Senante et al., 2014). These indicators provide information on how the product-input relationships differ between decision-making units (DMU) or over time (Yu et al., 2008). As a concept, productivity is defined as the relationship between the results obtained and the resources used in their production over time. Unlike the change in productivity, the concept of eco-productivity integrates inputs, desirable outputs and environmental variables (Molinos-Senante et al., 2014). Regarding this topic, the literature is minimal, and only (Simoes et al., 2012) and Pérez-López et al. (2018) evaluated the change in the productivity of municipalities in the provision of MSW services using the Malmquist Productivity Index (MPI). However, this index has two significant drawbacks: i) it is necessary to choose between an entry orientation or an exit orientation (Williams et al., 2011) and; ii) MPI relates the efficiency change (ECH) and the technical change (TCH) (the two drivers of productivity change) through multiplication (Cook et al., 2010). To overcome these disadvantages, there is an alternative indicator, the Luenberger Productivity Indicator (LPI), which has been shown to have significant advantages over the MPI: i) the LPI relates ECH and TCH through summation; ii) can simultaneously focus on increasing outputs and decreasing inputs (Boussemart et al., 2003) showed that the MPI overestimates the change in productivity, unlike the LPI, concluding that the LPI is higher than the MPI. Focusing on eco-productivity change, i.e., the dynamic performance of MSW providers including environmental variables, the literature review showed no previous studies evaluating the change in eco-productivity of municipalities in the provision of waste services. In other words, there are no previous studies that evaluate the change in productivity by simultaneously integrating unsorted waste as undesirable output and recyclable waste as desirable outputs. To evaluate the impact of recycling on the performance of MSW providers, this study calculates and compares estimates of productivity change and eco-productivity change. In doing so, the LPI was used to estimate productivity change

scores, while the Malmquist-Luenberger Productivity Index (MLPI) (Chung et al., 1997) was calculated to measure eco-productivity change. The empirical application focused on a sample of 313 Chilean municipalities evaluated (out of 345 in total) that provide MSW services during the 2015-2019 period. The results of Table 1 illustrate that considering recycled and non-recycled waste (Eco-productivity Change), the MPLI had a more significant increase between the years 2018-2019 considering only unclassified waste. On the other hand, in the change in efficiency between the years 2016-2017, they obtained a decrease, this being 0.993, and for the change in productivity for the years 2017-2018, a score was obtained 0.949, while its highest value was 1.055 among the years 2018 and 2019 for MLECH and for MLTCH 1.137 in the same period, this means that the municipalities increased their efficiency taking into account recycling. Finally, when considering the technological change for productivity 6.711 and Eco-productivity 6.529, its increase is reflected between 2018-2019, related to the improvement of public policies regarding recycling and separation of waste from origin.

Recent Publications

1. Llanquileo-Melgarejo, P., Molinos-Senante, M. (2021). Evaluation of economies of scale in eco-efficiency of municipal waste management: an empirical approach for Chile. *Environ Sci Pollut Res* 28, 28337-28348.
2. Llanquileo-Melgarejo, P., Molinos-Senante, M., Romano, G., and Carosi, L. (2021). Evaluation of the Impact of Separative Collection and Recycling of Municipal Solid Waste on Performance: An Empirical Application for Chile. *Sustainability*, 13 (4), 2022.
3. Molinos-Senante, M. and Maziotis, A. (2021). The Cost of Reducing Municipal Unsorted Solid Waste: Evidence from Municipalities in Chile. *Sustainability*, 13 (12), 6607.
4. Romano, G., Molinos-Senante, M. (2020). Factors affecting eco-efficiency of municipal waste services in Tuscan municipalities: An empirical investigation of different management models. *Waste Manag.* 105, 384-394.
5. Simoes, P., Cruz, N.F., Marques, R.C., (2012). The performance of private partners in the waste sector. *J. Clean. Prod.* 29-30, 214-221.

Biography

Paula is a PhD(c) In Engineering Sciences, Civil Engineering area in the Department of Hydraulic and Environmental Engineering of the Pontificia Universidad Católica de Chile. She is a Chemical Engineer, and her beginnings as a professional were in the agricultural, cosmetic and renewable energy industries, participating in production and management processes. Her objective when entering the Doctorate program was to provide solutions applicable to industry and academia. Her research and work interests include waste management, circular economy, evaluation of technical-economic projects of an environmental nature, renewable energies, chemical processes. Moreover, she has presented her research on Waste Management at conferences in Chile, Germany, Greece, Italy, Spain. She and she maintains a constant collaboration with from different countries researchers. She is active as a peer reviewer for related environmental journals and wants to continue contributing where needed, constantly applying science to the real problems we are currently experiencing worldwide.