



13th International Conference on Industrial
Engineering and Industrial Management

XXIII Congreso de Ingeniería de Organización

A large, abstract concrete sculpture with a central archway, set against a blue sky and green ground. The sculpture is made of dark, weathered concrete blocks. The archway is the central focus, and the overall shape is reminiscent of a stylized letter 'C' or a bridge structure.

**Organizational
Engineering
in Industry 4.0**

BOOK OF ABSTRACTS

Gijón, 11th-12th July 2019

Book of Abstracts

**“13th International Conference on
Industrial Engineering and
Industrial Management” and
“XXIII Congreso de Ingeniería de
Organización (CIO2019)”**

Book of Abstracts

**“13th International Conference on
Industrial Engineering and Industrial
Management” and “XXIII Congreso de
Ingeniería de Organización
(CIO2019)”**

COORDINADORES

DAVID DE LA FUENTE GARCÍA

RAÚL PINO DIEZ

PAOLO PRIORE

FCO. JAVIER PUENTE GARCÍA

ALBERTO GÓMEZ GÓMEZ

JOSÉ PARREÑO FERNANDEZ

ISABEL FERNÁNDEZ QUESADA

NAZARIO GARCÍA FERNÁNDEZ

RAFAEL ROSILLO CAMBLOR

BORJA PONTE BLANCO

© 2019 Universidad de Oviedo
© Los autores

Servicio de Publicaciones de la Universidad de Oviedo
Campus de Humanidades. Edificio de Servicios. 33011 Oviedo (Asturias)
Tel. 985 10 95 03 Fax 985 10 95 07
[http: www.uniovi.es/publicaciones](http://www.uniovi.es/publicaciones)
servipub@uniovi.es

I.S.B.N.: 978-84-17445-38-6
DL AS 1875-2019

Imprime: Servicio de Publicaciones. Universidad de Oviedo

Todos los derechos reservados. De conformidad con lo dispuesto en la legislación vigente, podrán ser castigados con penas de multa y privación de libertad quienes reproduzcan o plagien, en todo o en parte, una obra literaria, artística o científica, fijada en cualquier tipo y soporte, sin la preceptiva autorización.

Environmental Performance of an e-waste Recycling Program in Colombia: An Agent-Based Simulation Approach

Velásquez-Rodríguez OF⁸⁴, Moreno-Mantilla CE, Bula G

Keywords: Environmental performance, agent-based model, e-waste, reverse logistics.

1 Introduction

Reverse logistics has been frequently studied in the context of the implementation of e-waste collection and recycling programs intended to mitigate the environmental impact of electric and electronic equipment. However, given the importance of customers' willingness to participate for success of this type of programs, this has been a neglected aspect in the extant literature. For this reason, the present work develops and tests an agent based simulation model that empirically explores consumers' behavior and allows measuring the environmental performance of a refrigerator post-consumption waste management program in Colombia.

2 Objectives

The objective of this paper is to analyze how the behavior of final consumers, related to the decision of what to do with their electrical and electronic equipment at the end of its useful life, impacts the environmental performance of recycling programs for this kind of products.

3 Methods

In order to achieve the above objective, a simulation agent based model is proposed. Simulation combines the clarity and generality of mathematical models with more realistic models and statistical analysis (Größler and Schieritz, 2005).

This model is grounded on "Red Verde" post-consumer refrigerator management program in Colombia. The characterization of the agents in our model and the relationships among agents were made based on a case study of the reverse logistics system of Red Verde (Rojas Chaparro, 2018) and in a web survey applied to

⁸⁴Oscar Fabián Velásquez Rodríguez (e-mail: ofvelasquezr@unal.edu.co)
Facultad de Ingeniería, Universidad Nacional de Colombia.

375 households in Bogotá, Colombia, to study the intention to either return an end-of-life refrigerator to the Red Verde program.

4 Results

The results of the model show that for the final consumers the strategies of return the refrigerators to “Red Verde” and delivering them to the informal recyclers have the same convenience from the environmental point of view. Additionally, it can be observed that the option to return the refrigerators to the post-consumption management program has initially better environmental performance in comparison to delivery to informal recyclers. This is mainly due to CO₂ emissions avoided by carrying out an adequate treatment of the dangerous substances. However, due to the adoption of isobutene technology the performance of these two strategies (i.e., return to Red Verde and deliver to informal recyclers) tend to converge. Finally, it was shown that life extension strategies such as reuse have a negative environmental impact due to the CO₂ emissions generated due to the loss of energy efficiency.

5 Conclusion

Based on the results of the model, a contagious effect of environmental concern can be established, which is reflected in the growth of the percentage of refrigerators delivered to Red Verde over time. However, the returned refrigerators do not exceed 31% of the total. This suggests that it is necessary to introduce mechanisms for achieving effective sustainability communication and incentive behavior change (O’Rourke, 2014), such as sharing information (Olorunniwo and Li, 2010) or using ICTs (Jayaraman, Ross and Agarwal, 2008) and thus promote the delivery of refrigerators to Red Verde. Additionally, we see the need to extend the agent-based model for the inclusion of logistics costs, with emphasis in the evaluation of possible trade-offs between environmental and economic performance.

References

- Größler, A. and Schieritz, N. (2005) ‘Of Stocks, Flows, Agents and Rules - “Strategic” Simulations in Supply Chain Research’, in Kotzab, H. et al. (eds) *Research Methodologies in Supply Chain Management*. Heidelberg: Physica-Verlag, pp. 445–460.
- Jayaraman, V., Ross, A. and Agarwal, A. (2008) ‘Role of information technology and collaboration in reverse logistics supply chains’, *International Journal of Logistics Research and Applications*, 11(6), pp. 409–425. doi: 10.1080/13675560701694499.
- O’Rourke, D. (2014) ‘The science of sustainable supply chains’, *Science*, 344(6188), pp. 1124–1127. doi: 10.1126/science.1248526.
- Olorunniwo, F. O. and Li, X. (2010) ‘Information sharing and collaboration practices in reverse logistics’, *Supply Chain Management: An International Journal*. Emerald Group Publishing Limited, 15(6), pp. 454–462. doi: 10.1108/13598541011080437.