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Fuzzy AHP-TOPSIS approaches to prioritizing solutions for reverse logistics barriers

Pornwasin Sirisawat*, Tossapol Kiatcharoenpol

Department of Industrial Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Chalongkrung Road, Ladkrabang, Bangkok 10520, Thailand

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ABSTRACT

Due to an increasing demand for green products and also pressures from customers and other players along the supply chain, which now pay more attention to environmental awareness and sustainable management, many companies especially in the electronics industry have begun to realize the importance of applying green supply chain management concepts into their activities; reverse logistics (RL) practice is one of the important strategies to provide efficient resource utilization and minimize waste from end of life (EOL) products by following legislation and green concepts. But recently reverse logistics practices are faced with some barriers which make the implementation of reverse logistics difficult and unsuccessful. To increase efficiency in reverse logistics adaptation of the electronics industry, companies need to understand and consider the priorities of both barriers and solutions for developing policies and strategies to overcome these barriers. Therefore, this study focused on the classification of reverse logistics barriers and ranking of both barriers and solutions of reverse logistics implementation in the electronics industry. This paper proposes a methodology based on fuzzy analytical hierarchy process (Fuzzy AHP) and fuzzy technique for order performance by similarity to ideal solution (Fuzzy TOPSIS) in which fuzzy AHP is applied to get the weights of each barrier by using pairwise comparison, and fuzzy TOPSIS is applied for the final ranking of the solutions of reverse logistics implementation. The case of Thailand's electronics industry is used in the proposed method. To illustrate the robustness of the method, sensitivity analysis is used in this study.

1. Introduction

Over the last decade environmental issues have become an important issue in various industries including the electronics industry due to an increase in environmental awareness, enforced legislation, industrial ecology and corporate citizenship (Prakash & Barua, 2015). The policy and decision makers have to consider environmental issues in each activity of their organization along their supply chain (Kannan, Jabbour, & Jabbour, 2014). Many companies have applied reverse logistics (RL) concept to their policies and strategies for sustainability development which focused on the reduction of waste and created value from return of used products (Sirisawat, Kiatcharoenpol, Choomrit, & Wangphanich, 2016). Rogers and Tibben-Lembke (1998), explained that RL is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. RL focuses on maximizing value from the returned item or minimizing the total RL cost from the backward flow of materials (Kannan, Pokharel, & Kumar, 2009).

According to law and legislation, it forced producers to take care of their End of Life (EOL) products and the Waste Electrical and Electronic Equipment (WEEE) directive (directive 2002/96/EC) enforced electronics manufacturers to efficiently manage the return and proper disposal of packaging or used products (Govindan, Soleimani, & Kannan, 2015; Nikolaou, Evangelinos, & Allan, 2013). Even though the RL concept is widely used in many companies, it still has a lots of barriers that make RL practices difficult and unsuccessful. Each barrier cannot be solved at the same time and might require different solutions or treatment (Prakash & Barua, 2015; Sharma, Panda, Mahapatra, & Sahu, 2011). Hence, priority and ranking of barriers and solutions is needed to solve such barriers.

Previous research has studied and introduced some barriers, drivers and also solutions for RL practices in many countries (Abdulrahman, Gunasekaran, & Subramanian, 2014; Govindan, Kaliyan, Kannan, & Haq, 2014; Prakash & Barua, 2015; Rahman & Subramanian, 2012; Ravi & Shankar, 2005; Sharma et al., 2011; Zaabi, Dhaheri, & Diabat, 2013). However, the study of barriers and solutions in Thailand's

* Corresponding author.
E-mail address: sirisawat.p@gmail.com (P. Sirisawat).

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Table 1
RL practices barriers with criteria and sub-criteria.

Criteria	Criteria code	Sub-criteria	References
Management barriers	MB1	Lack of commitment by top management	Ravi and Shankar (2005), Mathiyazhagan et al. (2013), Prakash and Barua (2015), Sharma et al. (2011), Jindal and Sangwan (2011), Wiel et al. (2012), Zaabi et al. (2013), PWC (2008), Abdullah et al. (2011), Govindan et al. (2014), Abdulrahman et al. (2014), Yacob (2012), and Rogers and Tibben-Lembke (2001)
	MB2	Lack of strategic planning for ensuring RL practices	
	MB3	Lack of awareness and understanding in RL adaptation	
	MB4	Lack of specific goals for environment and waste management	
	MB5	Lack of policies for RL practices	
Organization barriers	OB1	Lack of proper organizational structure & support for RL practices	Prakash and Barua (2015), Luthra, Kumar, Kumar, and Haleem (2011), Yacob (2012), Jindal and Sangwan (2011), Wiel et al. (2012), Zaabi et al. (2013), Abdullah et al. (2011), Sharma et al. (2011), Rogers and Tibben-Lembke (2001), Govindan et al. (2014), and Pumpinyo and Nitivattananon (2014)
	OB2	Lack of training & education about RL	
	OB3	Lack of organization personnel resources	
Product barriers	PB1	Uncertain quality and quantity of return products from point of consumption	Ravi and Shankar (2005), Prakash and Barua (2015), Sharma et al. (2011), Jindal and Sangwan (2011), Abdullah et al. (2011), Yacob (2012), Rahman and Subramanian (2012), and Govindan et al. (2014)
	PB2	Less economic value recovered	
	PB3	Risk of storage of hazardous materials	
Legal barriers	LB1	Lack of enforced laws, legislation and directives for EoL products	Prakash and Barua (2015), Rogers and Tibben-Lembke (2001), Jindal and Sangwan (2011), Zaabi et al. (2013), Abdulrahman et al. (2014), Rahman and Subramanian (2012), Sharma et al. (2011), Luthra et al. (2011), Mathiyazhagan et al. (2013), Govindan et al. (2014), Pumpinyo and Nitivattananon (2014), and Sirisawat and Kiatcharoenpol (2016)
	LB2	Lack of government supportive policies on RL practices	
	LB3	Loopholes in Thai laws and regulations on waste management	
Technological barriers	TB1	Lack of information and technological systems for RL practices	Ravi and Shankar (2005), Prakash and Barua (2015), Sharma et al. (2011), Jindal and Sangwan (2011), Luthra et al. (2011), Zaabi et al. (2013), Mathiyazhagan et al. (2013), Pumpinyo and Nitivattananon (2014), and Govindan et al. (2014)
	TB2	Lack of available technological infrastructure to adopt RL practices	
	TB3	Lack of technical expertise to support RL practices	
	TB4	Lack of flexibility to change from traditional system to new system	
Infrastructural barriers	IB1	Lack of infrastructure facility to support RL implementation	Prakash and Barua (2015), Abdulrahman et al. (2014), Yacob (2012), Pumpinyo and Nitivattananon (2014), and Jindal and Sangwan (2011)
	IB2	Lack of efficient and effective systems to monitor returns and recalls	
	IB3	Increase of unstandardized waste management area	
Financial barriers	FB1	Financial constraints	Ravi and Shankar (2005), Sharma et al. (2011), Rogers and Tibben-Lembke (2001), Luthra et al. (2011), Wiel et al. (2012), Mathiyazhagan et al. (2013), Govindan et al. (2014), Abdulrahman et al. (2014), Yacob (2012), Pumpinyo and Nitivattananon (2014), Rahman and Subramanian (2012), Prakash and Barua (2015), Jindal and Sangwan (2011), and Zaabi et al. (2013)
	FB2	High investments and less return-on-investments	
	FB3	Expenditure in collection and storage of used products	
	FB4	Cost of environmentally friendly packaging	
	FB5	Cost of nonhazardous and hazardous waste disposal	
Involvement and support barriers	ISB1	Lack of coordination and collaboration with 3rd party logistics (3PL) providers	Ravi and Shankar (2005), Prakash and Barua (2015), Sharma et al. (2011), PWC (2008), Govindan et al. (2014), Abdulrahman et al. (2014), Yacob (2012), Rahman and Subramanian (2012), Jindal and Sangwan (2011), and Mathiyazhagan et al. (2013)
	ISB2	Lack of support of supply chain partners	
	ISB3	Lack of public focus on environmental issues	

electronics industry remains unstudied.

This research focuses on the identification of barriers in Thailand's electronics industry and ranks solutions to solve its barriers. Electronics companies or other related Thai industries could use the results from the ranking of solutions to solve RL practices barriers and also develop efficient and appropriate policies and strategies for their companies to improve competitiveness. A hybrid of decision making methods was used for prioritizing and ranking of solutions. And fuzzy approach was used to manage the vagueness and uncertainty of the human options in which human judgment in decision making has often been unclear and difficult to estimate with exact numerical values (Patil & Kant, 2014). Therefore this study proposed the hybrid fuzzy Analytical hierarchy process (Fuzzy AHP) and fuzzy technique for order performance by similarity to ideal solution (Fuzzy TOPSIS) method to prioritize and rank solutions of RL practices. Fuzzy AHP was used to determine the preference weights and Fuzzy TOPSIS was used to ranking solutions. The empirical case of Thailand's electronics industry is used for the proposed methods. The remainder of this paper is organized as follows: Section 2 is reviews of the literature on barriers and solutions of RL practices. Section 3 presents the fuzzy AHP and fuzzy TOPSIS method. Section 4 illustrates an approach for ranking solutions of RL practices. The results and discussion of the case study are shown in Section 5. Finally, a conclusion is given in Section 6.

2. Literature review

2.1. Reverse logistics practices

Electronics manufacturers of Thailand have faced some barriers from reverse logistics practices making the implementation of reverse logistics practices unsuccessful and inefficient. Many organizations have a lots of barriers such as lack of government support, lack of knowledge in reverse logistics practices, lack of research and development for new technology, some manufacturers still do not understand