The Significance of Reverse Logistics to Plastic Solid Waste Recycling in Developing Economies

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Abstract

Plastic solid waste (PSW) recycling can lead to sustainable resource utilization and reverse logistics is a concept that can enable the recovery of this waste type in the supply-chain. In developing economies, informal waste recovery is predominant and in need of recycling and reverse logistics systems to enable sustainable recoveries. The paper analyses studies that have focused on recycling and reverse logistics (RLs) as a way to determine the significance of this relationship to sustainable resource utilization and waste management. The study has identified a number of merits in implementing reverse logistics systems and these can benefit the developing economies. Nevertheless, most of the studies analyzed have been conducted in developed economies were plastic waste recycling and reverse logistics are in existence. The study identified no studies on reverse logistics and plastic recycling in Africa and therefore recommended that more research is needed on this topic to enable plastic manufacturing companies and waste managers make sustainable decisions and systems.

Keywords

Plastics, Reverse Logistics, Recycling, Sustainability

1. Introduction

Plastic materials have captured the manufacturing industry because of their favorable properties. These properties have enabled the production of many products out of plastic materials. However, the manufactured plastic products continue to increase the amount of waste generated and there is need for proper management and disposal of this waste type (Ferri et al., 2015). The continuous use of plastic materials in the packaging industry has resulted in more virgin resources been used and solutions to prevent the diminution of the virgin resources is needed. Production and usage of numerous million tons of plastics as packaging materials happens every year (Blanco, 2014; Papong et al., 2014.). Approximately 50% of manufactured plastic products are utilized for single disposable applications (Hopewell et al 2009). As such, there is a rapid increase in the amount of plastic solid wastes (PSWs) produced as most plastic products' life is short.

RL is an engineering management concept which has been used in the recovery of end-of-use or end-of –life plastic products by manufacturing companies. It is described as a means of assisting firms perform, resulting in the recovery of materials that were once generated as waste while helping in the reduction of societal and environmental impacts (Santos et al, 2014; Chaves et al., 2014). Increased public awareness on environmental preservation combined with waste opposing ideas and raw materials scarcity are among the factors for RL systems development (Fehr et al, 2010). These developments are planned as environmental concerns and economic motives. As a result, a lot of firms have been encouraged to explore on the product recovery and take backs as a way forward to sustainable management of waste.

RL and waste management relationship activities on waste focus on recycle, reuse and proper disposal in the reverse distribution channels (Kinobe et al, 2015). Due to this, recycling is one of the options considered sustainable for managing plastic solid waste. It is considered one of the best options in the waste management hierarchy. Recycling is defined as a means of waste material retention in the process line as a way of process costs reduction and new possibilities open ups (Veiga, 2013; Chaves et al, 2024; Braga Junior and Rizzo, 2010). As a result of the ability to recapture value in discarded products by bringing them back to the production line, reverse logistics involving recycling offers important opportunities to companies to lower costs along the supply-chain and improve profitability and visibility (Frota-Neto et al, 2008; Chiou et al, 2012). However, in developing economies, majority of waste is recovered by the informal waste sector which lack proper recovery and management tools and as such the amount of waste recovered is little. A number of studies have affirmed that, in developing economies, informal waste recovery is predominant (Scheinberg et al, 2011; Ezeah et al., 2013; Gutberlet, 2010; Medina 2007; Coelho, 2011). As a result of such predominance and non-existence of reverse logistic systems for most recyclable wastes, the wastes recovered by the informal waste sector are usually not sustainable.

This study analyses research that has focused on reverse logistics and recycling. Recycling refers to the separation and collection of plastic wastes from the generators to the plastic converters or manufacturers. Reverse logistics is considered the concept or tool used in returning these end-of-life or end –of –use plastic products from the generators to the convertors. The purpose of the analysis is to determine if there is need for studies on reverse logistics of plastic solid wastes (PSWs) in developing economies such as Africa.

Review of literature on RL and recycling is the first section of the paper. The results and discussion follows and finally the conclusion.

2. Literature Review

Application of reverse logistics has become an important aspect to sustainably manage natural resources and one of the options of achieving this, is by recycling. Zhou and Wang (2008) highlighted that, the first known definition of RL referred to the function of logistics in regards to materials recycling. A number of studies are related with RL. Nevertheless, this study concentrates on recycling in RL systems and attention is paid to plastic wastes. Therefore, the perspective on the review of literature is in regard to RL and recycling.

2.1 Recycling

Due to the continuous usage and extraction of natural resources, the availability of a lot of the natural resources is at risk (Borvczko et al., 2014). As a result of this sustainability challenge, it is necessary to implement the existing sustainable waste management options such as recycling in order to preserve our natural resources. Instead of concentrating on waste disposal methods, waste should be considered as the next new resource (Huysman et al., 2015). Recycling is an option capable of considering waste as resources. Materials of economic value are diverted from waste flows therefore reduction in waste quantities collected and disposed (Troschinetze and Minelic, 2009; Matter et al 2013). Further it brings once discarded or thrown out materials into the production cycle thus saving natural resources and energy (Dias and Braga Junior, 2016).

Despite the application of recycling as a resource recovery option as well as a waste management option, in most developing economies, there is still need for the development and application of effective and efficient recycling systems in order to fully tap and benefit from its advantages. There is need to balance the economic growth and resource consumption by way of utilizing resources more efficiently (BIO-SEC=SERE, 2012).

2.2 Reverse Logistics

Carter and Ellran (1998) define RL by highlighting recycling as a means to which companies can become environmentally efficient. This is affirmed by Rogers and Tibben-Lembke (2001) as they acknowledge that environmental impacts of the supply-chain are reduced by activities in the supply-chain. Reverse logistics accords companies the ability to recapture value in discarded products by bringing them back to the production line and with the aspect of recycling, opportunities to improve profitability and visibility and cost reduction across the supply-chain are presented (Chiou et al, 2012; Frota-Neto et al , 2008).

Manufacturers in developing economies should seriously consider the application of RLs for their valuable end-of-life plastic products. However, in most developing economies, reverse logistics chains comprise of a vast number of the informal sector (Kinobe et al (2015). These RL chains are usually not organized and rely on recyclables collected from waste delivery trucks and temporary garbage dumpsites (Matter et al., 2012). As a result of this, wastes that could have qualified for recycling usually end up at the dumpsite or never recovered. Despite the fact that RL is considered substandard and with less value addition in developing economies due to less gains accrued

(Fleischmann et al., 2001). The fact is that, RL has economic and environmental benefits if sustainably implemented for example source segregation encouragement to ease grading and sorting (Kinobe et al., 2015).

2.3 Reverse Logistics and Recycling

In developed countries, several studies have been conducted to determine the best ways manufacturing companies can recapture back the plastic waste and use it as input material in their manufacturing processes. Baaran (2012) conducted a research on factors that make manufacturing companies desire to recycle. The study aimed to find relationships between options for recycling and some manufacturing companies' characteristics. Results revealed that some characteristics expected to develop relationships with treatments options were not supported while others were supported in the two analyses. Coelho et al (2010) analyzed in an integrated way, best alternatives for improving the recycling system through examination of the life cycle of PET bottles in Brazil. The results revealed the need for post consumer structuring of the reverse chain while engaging government and the industrial sector using the production chain of PET bottles. Zhang and Wen (2014) analyzed the worldwide current collection and recycling practices of PET bottles from the perspective of PET recycling rate, consumption and methods for recycling collection. The results showed that, 90% collection of post consumer PET bottles was performed by the informal sectors; in which small factories reprocess PET bottles while they are not designed with equipments for pollution control. The studies by Baaran (2012), Coelho (2010) and Zhang and Wen (2014) have addressed the need to recycle waste. Baaran (2012) study indicates the needs to identify factors that can make manufacturing companies desire to recycle while Coelho (2010) and Zhang and Wen (2014) have addressed the need to develop reverse logistics chains for PET recycling.
The table below gives a summary of studies on reverse logistics and recycling. The purpose of the summary is to identify the research type previously carried out, methodology adapted and to identify the research gap.

Table 1: Summary of some studies on Reverse Logistics and Recycling

Source	Type of Study	Waste Type	Method Used
Bing et al (2014)	A decision support tool for analyzing the effects of household plastics collection, treatment and separation systems was designed while the logistics network was examined.	Household plastic waste	Scenario study approach (mixed integer linear programming)
Coelho et al (2010)	Best alternatives of improving the recycling system were examined in an integrated manner using life cycle for PET bottles in Brazil.	PET Bottles	Review
Dias and Braga Junior., (2016)	RLs practices performed by the retailer were examined and in each department, amounts of waste generated were measured.	Retail waste (plastics and cardboards)	Wuppertal method,
Fehr et al (2014)	To close the balance of tipping into RLs, the objective of shifting opportunities was pursued.	Household waste	Qualitative , Quantitative
Ferri et al (2015)	To solve the challenges of waste management, a RLs network was proposed.	Reverse logistics in MSWM	generic mathematical modeling
Kinobe et al (2015)	Examined the redistribution, reprocessing, collection and final market for wastes into a reverse supply-chain network.	MSW Reverse logistics at a landfill	Qualitative and Quantitative
Zhang et al (2011)	An inexact RLs model for MSWM systems was proposed.	MSW	Model development
Siliva and Neto (2011)	Feasibility of introducing RLs in the plastics industry was examined in Brazil	Plastic waste	Quantitative
Matar et al (2013)	Introduced a model for use in the reuse-recycling or production of plastic beverage bottles.	PET Plastic Bottles	Model development
Pati et al.(2008)	In the recycling industry of waste paper, a multi-objective goal programming was investigated for the design of a RLs network	Waste Paper	Mulit-objective goal programming
Yu et al (2015)	To Manage the RLs of MSW a multi-objective linear programming was developed	MSW	Multi linear programming
Zarei et al (2010)	An integrated forward and RLs system for used vehicles recycled was designed using mathematical model	Used Vehicles	Mathematical model

Dat et al (2012)	A WEEE RLs network was designed using single objective cost-minimization model	WEEE	Cost minimization model
Alumur et al (2012)	A RLs system for remanufacturing, recycling, inspection and collection of used products was investigated using multi-period mixed integer programming.	Used products	Mixed integer programming
Demirel et al. (2008)	A single objective mixed integer linear programming was proposed for minimizing RLs operation costs of a used vehicles network	Used Vehicles	Mixed integer linear programming

3. Results and Discussion

The main observations from the review and analysis of the studies indicate that; the studies above have looked at the implementation of reverse logistics in MSW, household waste, used vehicles and WEEE wastes. The studies above have applied mathematical modeling and programming methodologies in the design of the RLs network. Further most of these studies have designed the RLs to either maximize profits or minimize costs of recovery (Demirel et al., 2008; Alumur et al., 2012; Dat et al., 2012; Zarei et al., 2010; Yu et al., 2015; Pati et al., 2008). Few studies have investigated reverse logistics and plastic recycling in developing countries (Matar et al, 2013; Coelho et al, 2011). However, the application of such studies in developing economies of Africa is little. Kinobe et al (2015) looked at the application of reverse logistics at a landfill and attention was paid to MSW. Further, only few of the studies presented in table 1, have assessed reverse logistics and recycling from an industry perspective. It is cardinal to note that, Coelho et al (2011) indicated the need for engaging government and the industrial sector in the structuring of reverse chains for post-consumer products through public policies as a way of supporting cleaner technologies for production chains for PET bottles. This broad conclusion is significant for the development of reverse logistics systems in developing economies of Africa as it provides a foundation. It is necessary that sustainable ways of recovering plastic wastes are implemented in developing economies in order to alleviate the current waste challenges been faced as well as cater for resource utilization.
Despite the study by Ferri et al (2015) focusing on model development for MSW, the study has proposed a reverse logistics network that incorporates legal, environmental, economic and social factors. This proposition is significant for manufacturing industries as well as waste management during the development of RL systems for plastic wastes. Even though the proposition can be complex, the need to incorporate sustainability dimensions in recovery programs is significant.
With much of the waste been recovered by the informal sector in developing economies, the reviewed work has provided insight on the need for designing proper RL systems in order to tap into the benefits of recycling. However, in order to achieve sustainability in the arena of RL and recycling, most research activities and technological innovation as well as market creation for recycled products is needed (Siliva and Neto, 2011). Further a number of benefits such as reduction of environmental impacts and economic costs as well as job creation are some of the advantages of implementing reverse logistics.

4. Research Gap

There is serious need for studies on reverse logistics and recycling in developing economies such as Africa. Future research should focus on development of reverse logistics systems for recycling plastic solid wastes. Future RLs systems should focus on integration of the relevant stakeholders in the recovery and recycling of plastic solid waste. Focus should be paid on the application of the factors that influence stakeholders' participation in recovery programs as parameters.

5. Conclusion

Generation of plastic solid wastes is occurring at a rapid rate. In developing economies where a number of economic developments and rapid urbanization is happening, it is likely that the percentage of PSW will increase in the coming years. In order to over the challenges of managing plastic wastes, sustainable means of resolving the problem are either reusing it or recycling. The study has highlighted the significance of developing sustainable systems for managing waste through recycling.

The study has shown that most of the reviewed studies on reverse logistics have designed networks for RLs using mathematical programming for the purpose of maximizing returns or minimizing costs. However, in developing economies, few studies have been conducted on RLs in the plastic industry and therefore the study has identified the way forward for future researchers.
The benefits of reverse logistics systems and recycling can proof sustainable and provide a number of solutions to the challenges of managing waste faced in developing economies. Incorporating RLs in the manufacturing and waste management sector can reduce disposal capacity at the landfills, lessen emissions from dumpsites, reduce expenditures on collection and energy utilization, reduce litter and provide more jobs to the people involved in the recoveries. The research has also shown that more studies on reverse logistics and recycling systems are needed in developing economies of Africa.
However, it is important that waste managers and manufacturers understand that the implementation of such systems is not easy. An understanding of the needed outcomes from the system is necessary before the actual implementation. It is vital to identify the needed players in the recovery programs in order to optimize the recovery of the PSW. In developing economies, where most of the waste is recovered by the informal sector, it is necessary to consider the incorporation of the informal waste sector in the recycling and reverse logistics systems to enable sustainable recoveries.

Acknowledgements

Special thanks to the University of Johannesburg for the financial support.

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