“Decision framework for risk analysis in product recovery systems”

Dr. Jitender Madaan (jmadaaniitd@gmail.com), Divya Choudhary and Parikshit Charan Department of Management Studies, Indian Institute of Technology, Delhi, India Indian Institute of Management, Raipur, India**

ABSTRACT

Organizations are incorporating the Product Recovery System (PRS) in their business practices not only because of legislative pressure but, also to sustain in the competitive market. Product returns are sizeable assets for any organization and managing them in an effective and cost-efficient manner can lead to the development of sustainable economies. However, PRS is a multifaceted process and along with many advantages, also brings along various uncertainties and complexities into the system. However, a considerable amount of research has been done in the area of risk management in conventional supply chain; literature explicitly focusing on the issue of risk control in PRS is surprisingly sparse. To address this gap in literature, study proposes a product recovery system risk management framework for managing the recovery channel risks. The decision framework illustrates the role of risk management in PRS and sets the significant foundation for future research in this direction The research has practical implications for the organizations involved in product recovery or planning to implement recovery operations. It can assist the organizations in controlling the recovery channel risks and can guide the managers to incorporate risk management practices in PRS.

Keywords: Product Recovery System (PRS), Risk Management, Product Recovery System Risk Management Framework.

Introduction

Presently, exploitation of virgin resources is increasing rapidly worldwide, as a result of escalating population and requirements of people. Accordingly, for the sustainable development of society, it is becoming essential to address the issue of “Environmental Degradation”. According to Keong (2008), virgin resources of about 240,000 tons can be saved, if all customers across the globe return just one used mobile device. It is equivalent to reducing the greenhouse gases to the same level as in removing 4 million vehicles from the road. Moreover, the volume of products being returned by the customers is increasing rapidly and is estimated to be about $100 billion value per year, which is about 6 percent of the sales (Stock 2001). In a developing country such as India, an estimated 146,000 tons of e-waste is generated each year with a growth of 10 percent every year (Agrawal et al. 2014). A risk is being posed due to the hazardous elements present in e-wastes, especially in countries with limited environmental regulations (Hula et al. 2003). Additionally, extended producer responsibility and legislative regulations are obligating enterprises to take responsibility for returned products. Consequently, to impede the exploitation of natural resources and to manage the returns properly, enterprises are opting for "*Sustainable practices*" and "*Product Reco very System (PRS)* " is an obvious solution. PRS constitute the backflow of products from customers to manufacturers for recapturing value from returns through recovery options such as reuse, recycle, resale, remanufacture etc. A body of knowledge has been developed around the recovery system field, especially during the last decade and it has obtained recognition both as a research field and as a practice (Rogers and Tibben-Lembke 1999).

In conventional supply chain perspective, a set of processes are carried out according to customer demands to transmit products from suppliers through manufacturers, distributors and retailers to the final customers. However, many products move beyond the conventional supply chain horizon, leading to additional business transactions such as used products are sold on secondary markets; obsolete products are refurbished to meet latest market standards again; failed components are repaired to serve as spare parts; unsold stock is salvaged; reusable packaging is returned and refilled; used products are recycled into raw materials again. The set of processes which can incorporate these product flows beyond the conventional supply chain scheme is known as Product Recovery System (PRS). In other words, recovery system can be defined as an extension of conventional supply chain to handle End-of-life, End-of-use, obsolete and warranty returns (Choudhary and Madaan 2013). However, some of the definitions related to PRS present in literature are given below in Table 1.

Table 1- Definitions related to Product Recovery System

Author(s) (Year)	Description
Thierry et al. (1995)	Product recovery management encompasses the management of all used and discarded products, components, and materials that fall under the responsibility of a manufacturing company.
Fleischmann et al. (1997)	The process of planning, implementing, and controlling the efficient, effective inbound flow and storage of secondary goods and related information opposite to the traditional supply chain direction for the purpose of recovering value or proper disposal.
Rogers and Tibben–Lembke (1999)	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.
Guide and Van wassenhove, (2002)	A series of activities necessary to remove dead stock or used products from a customer for the purpose of recycling, remanufacturing, and re-using the product.
Prahinski and Kocabasoglu (2006)	The process of retrieving the product from the end consumer for the purposes of capturing value or proper disposal. Activities include transportation, warehousing, distribution and inventory management.
Srivastava (2008)	The process of planning, implementing and controlling the efficient, effective inbound flow, inspection and disposition of returned product and related information for the purpose of recovering value.

The recovery operations encompassed by PRS are as follows (Guide and Van Wassenhove 2002):

1. Product Acquisition- It includes product acquirement from the customers.
2. Reverse Logistics – It refers to recovering products from customers for value reclamation or for proper discarding. It involves gate-keeping, transportation, warehousing, and inventory management.
3. Inspection and disposition – In this process all the returned products are examined for their quality, and to identify a suitable recovery strategy for each of them.
4. Reconditioning – In this step, the value is reclaimed from the returned products through a suitable recovery operation, such as repair, cannibalization, remanufacturing and recycling etc.
5. Distribution and sales **–** developing secondary markets for reclaimed products.

The complete representation of PRS considering all the explained recovery operations is as depicted in Figure 1.

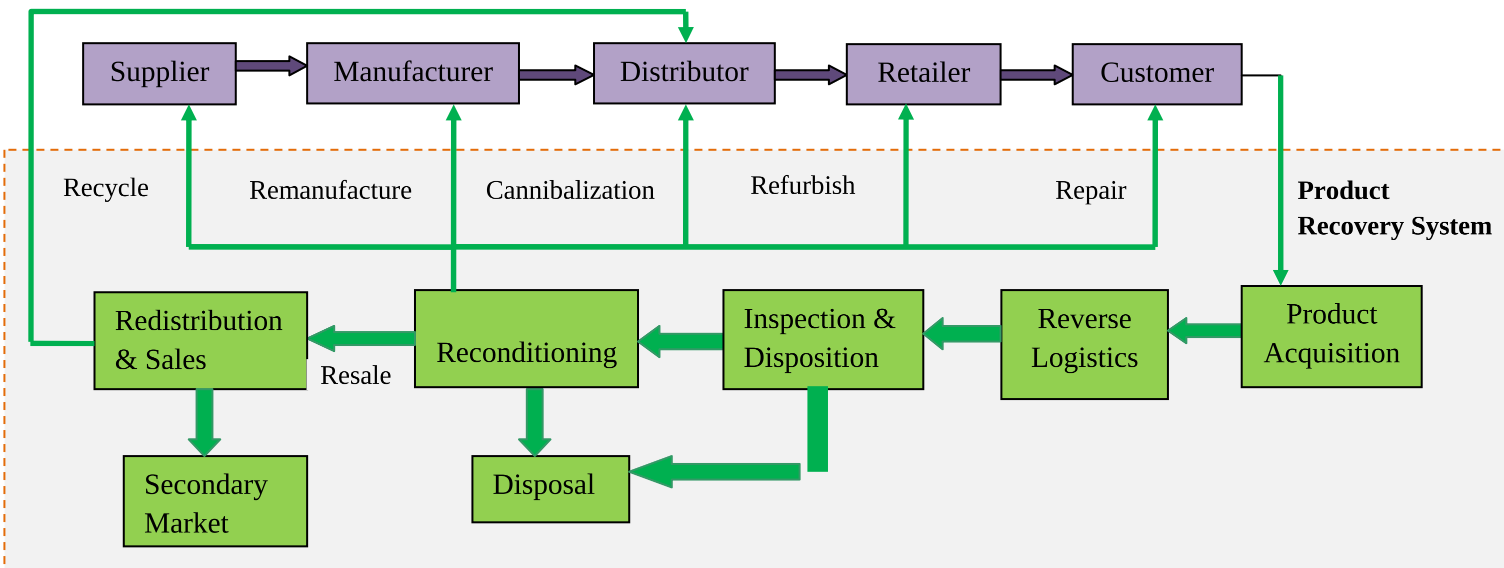

Figure 1- Product Recovery System

Concerns about environmental issues, sustainable development, and legal regulations have made organizations responsive to product recovery operations (Srivastava and Srivastava 2006). Additionally, the scope of PRS is far greater than just fulfilling the legislative obligations since it provides economical benefits from the returns and expands the competitive abilities of the organization (Mangla et al. 2013). It also assists in the building of recovery strategies that can enhance consumer relations and increase product sales (Prahinski and Kocabasogl 2006). Despite these benefits, PRS and its strategic value are often ignored by the organizations (Autry et al 2001). Some of the reasons for this reluctance towards recovery system implementation are: preoccupation with core business, Lack of awareness, intricacies in End-of-life recovery option selection for handling the returns, ambiguities and difficulties in collection and transportation of returns; uncertainties associated with the cost involved and revenue; government regulations etc (Choudhary et al. 2014). Product recovery is a multifaceted process and along with many advantages, also brings along a number of risks and uncertainties in the business practices (Bai and Sarkis 2013). Accordingly, it is required to focus on the management of uncertainties and risks present in recovery system for reducing the negative implications of the occurrence of certain associated disruptions.

However, a considerable amount of research has been done in the area of risk management in conventional supply chain (Bradley 2014, Ghadge et al. 2013); literature explicitly focusing on the issue of risk control in PRS is virtually nonexistent (Janse et al. 2010). Although, previous studies have focused on the benefits, enablers and barriers of recovery system (Rahmanan and Subramanian, 2012, Abdulrahman et. al 2014), there exists a gap in literature regarding risk analysis in PRS. The study attempts to address this gap building upon the research in conventional supply chain and risk management. The paper initially identifies the risks existing in return system and then proposes decision framework for PRS risk management. The framework illustrates the incorporation of risk management practices in the product recovery system at all the phases for the management of associated risks and to improve the recovery performance. The research has practical implications for the organizations involved in product recovery or planning to implement recovery operations. It can assist the organizations in controlling the recovery channel risks and can guide the managers to incorporate risk management practices in PRS. In the next section, literature review is discussed and various associated risks are identified. The risk management framework is proposed in the following section.

Literature Review

Rogers and Tibben-Lembke (1999) suggested that organizations can increase their efficiency through systematic incorporation of recovery operations in their existing systems. Accordingly, these recovery operations that accommodate value reclamation of End-of-Life, End-of-Use, obsolete and warranty returns together constitute the product recovery system. PRS is a value recovering process in which value of end-of life, used, defected, and obsolete products is reclaimed with the help of various product recovery operations (Wadhwa et al. 2009). Initially, PRS was mainly considered as a method of recapturing the value of product returns through recycling only. Nevertheless, scope of PRS has evolved with time for several reasons, which are as follows: amount of returns in some industries have increased up to 50% of sales; Secondary market opportunities are increasing leading to revenue generation; legislative regulations are enforcing the organizations to take the responsibility of returns; consumer awareness; and lastly, due to the increasing cost of landfill facilities (Prahinski and Kocabasoglu 2006). Additionally, efficient management of product recovery operations results in enhanced customer relationships, conservation of virgin resources and an estimated reduction of about 10% in total annual logistics costs (Skinner et al. 2008). Product recovery system manages the returns in a more effective and cost-efficient way leading to the sustainable development of the organizations in a sound manner (Madaan et al. 2012). Moreover, recovery of returns has become a primary managerial focus from a cost view point and the impending influence on consumer loyalty. In a survey, it was found that 92 percent of customers are willing to shop again if the return policies are convenient, whereas, 82 percent of customers are not willing to shop again in case of inconvenient return policies (Skinner et al. 2008). So, in order to retain customers in today's highly competitive market, organizations are required to strategically manage their PRS.

The flow of returned products represents a sizeable asset for many organizations, but much of that asset value is lost in the reverse channel. Managers focus primarily on the forward supply chain for new products and are often unaware of the magnitude of these losses and causes of their occurrence (Guide et al. 2006). It has been estimated that as a product moves through the product recovery system, more than 45% of its asset value is lost in the process (Blackburn et al. 2004). This loss can be even higher for the short life cycle products such as laptops etc., which can lose value in excess of 1% per week. One of the major reasons for this tremendous loss of asset is the product's decrease in value with time (Guide et al. 2006, Gobbi 2011). This elapsed time in value recovery is the result of various uncertainties and risks associated with PRS. The uncertainties are related to quality, time, amount and diversity of returns; estimation of operation and cost related parameters for reverse logistics networks; decisions about resolution for product returns and costs of co-ordination along the return system etc. (Srivastava 2008, Fleischmann 1997, Rogers and Tibbn-Lembke 1999). Accordingly, it is required to focus and develop risk management aspects in PRS for improving its efficiency and achieving the desired results.

A substantial amount of previous research has focused on various PRS issues such as environmental aspects (Stock 2001); network design (Srivastava 2008); third party reverse logistics provider (Meade and Sarkis 2002); profitability (Tan and Kumar 2006); optimal EOL alternative selection (Wadhwa et al. 2009) etc. However, the issue of risk management in PRS is immature and still needs to be explored. To address this gap in literature, the study attempts to develop a risk management framework to optimize the risk exposure of product recovery system. The process of risk management usually begins with a study to identify the potential risks that a project could generate or to which it could be exposed (Gandhi et.al 2012). Further, as reverse channel is an extended part of conventional supply chain, there are chances for overlap of risks among the two. Also, an improvement in PRS performance can enhance the efficiency of forward value chain. Accordingly, structuring upon the literature of supply chain risks and product recovery and discussions with the experts, some of the PRS risks have been identified as presented in Table 2.

Table 2- Risks in Product Recovery System

Risk Categories	Risk Events	Description
Returns Collection Risk	Collection point risk	Risk associated with the location of collection points i.e. weather they are accessible to all range of customers willing to return products.
	Gate keeping Risk	Risk associated with the erroneous screening of return products and allowing the undesired returns to enter the product return system.
	Product Returns Forecast Risk	Risk due the inability to predict the time and amount of return products.
	Transportation Risk	Risks associated with the transportation of the returned goods, such as delays due to bad weather, traffic density and breakdown, damage of return products during transportation, and accidents.
	Return Handling Risk	Risk related to the safety of workers while handling toxic returns and chances of damage during inventory storage in warehouses.
	Information Risk	Uncertainty regarding access to accurate information about the return products such as

Inspection and Disposition Risks		constituents, harmful effects if any, list of component parts etc. required for their reprocessing.
	Marginal Value of Time Risk	Risk due to the inability to process the returned products within the desired time which can in turn lead to deterioration of residual value of returns.
	Decision Making Risk	Risk associated with the selection of appropriate processing technique such as recycling, reuse, cannibalization, disposal etc. for recapturing the value of return products.
	Facility Risk	Risk due to the breakdown of machine, electricity or water failure causing a delay in recovery operations or leading to unavailability of plants, warehouses and official buildings.
Reprocessing Risks	Lower Recovery Rate Risk	Risk of lower-than-expected recovery from the return products which can affect the plant's effective production capacity.
	Quality of Reprocessed Output Risk	Quality related issues of remanufactured, repaired, secondary products and products manufactured from recycled raw material.
	Disassembly Complicatedness Risk	Uncertainty about the disassembly sequence of the return leading to wastage of time and sometimes inability to disable the product due to the complexity involved.
	Sustainable Regulations and Compliance Risk	Risk related to consequences of not complying with the appropriate regulations (local and global) and uncertainty about changing return policies.

All the above identified risks are present in various stages of values reclamation in a product recovery system. The various acknowledged risks are the causes of product recovery system disruptions. It is essential to control these risks associated with return system for enhancing its efficiency and achieving the desired results. Accordingly, for managing these identified risks present in PRS, risk management framework is proposed in the next section.

Product Recovery System Risk Management Framework

The word “risk” is derived from early Italian word “risicare, which means to dare” (Ghadge et al. 2013). Risk means the possibility of loss or injury and can be referred as an event that, if occurs, has unwanted consequences. In the scientific and specialized literature on the subject, the word risk is used to imply a measurement of the chance of an outcome, the size of the outcome or a combination of both. According to the Association of Project Managers, risk is defined as an uncertain event or set of circumstances which can have an effect on achievement of one or more objectives (Tang and Tomlin 2008). Nowadays, organizations have become a complicated and sophisticated system, which consists of various operations that are exposed to risks and vulnerabilities. Controlling these risks is necessary for the organizations to accomplish their goals and for enhancing their market performance. Strategic-minded organizations have acknowledged that risks can never be completely eliminated; however their realization and consequences can be minimized. Hence, the traditional perspective of avoiding risks is changing and organizations are attempting to manage their risk exposures so that, they incur just the adequate amount of the right kind of risks, which do not hamper the performance and progress. For the above mentioned reasons, it is essential for the organizations to control the risks in a way towards the achievement of overall goals. To accomplish this, a risk management process is required that is practical, sustainable, and easy to understand.

Risk management is a formal process used to continuously identify, analyze, and adjudicate events that, if they occur, have unwanted impacts on a system's ability to achieve its outcome objectives (Bradley 2014). Successful enterprises require deliberate and continuous attention to managing risk. A typical process of risk management contains four basic steps:

1. Risk Identification, which helps in recognizing potential risks in order to manage these scenarios effectively.
2. Risk Assessment, which refers to the determination of probability, consequences and ability of risks to trigger other risks and detection of extremely critical risks that require pro-active management.
3. Risk Mitigation, which refers to recognition and implementation of actions for managing and mitigating risks.
4. Risk Monitoring, where system is supervised to detect risks when they occur.

Risk Assessment process can further be divided into Risk Quantification and Risk Prioritization. Risk quantification is done to enumerate the criticality of risks by computing the risk severity. Further, risks are prioritized based on their severity to identify the extremely high risks, which require pro-active mitigation. The conceptual framework of risk management process is as shown in Figure 2.

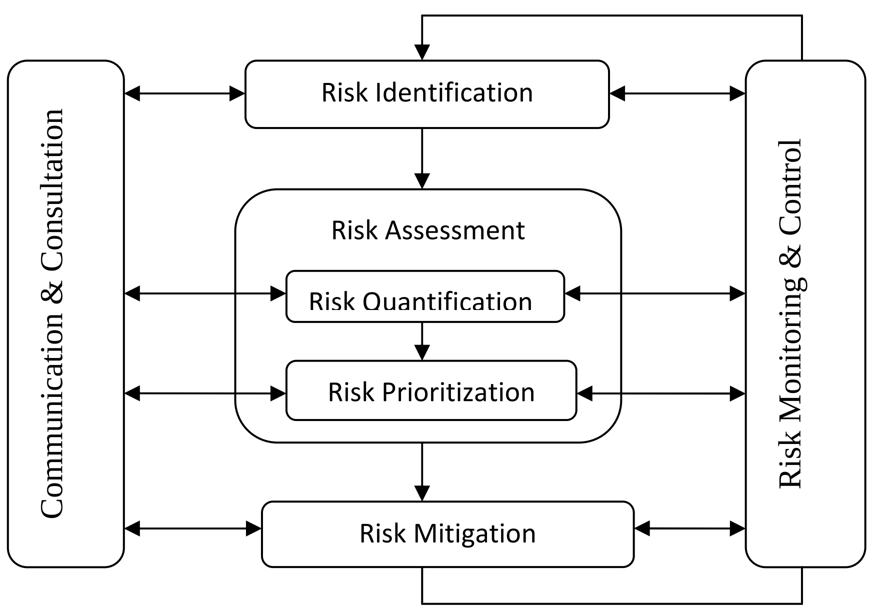

Figure 2- Risk Management Process (Modified version from SCRLC 2011)

In accordance with the first step of the risk management process, various risks persisting in recovery system have been identified as presented in Table 2. These risks are present in various phases of PRS and are essential to manage for the proper functioning of recovery systems in order to achieve the desired results. Accordingly, an attempt has been made to incorporate risk management practices in PRS structure to obtain a conceptual Product Recovery System Risk Management framework as shown in Figure 3. The proposed framework can assist the organizations in controlling the risk exposure of the reverse channel by minimizing the disruptions.

The proposed framework can lay the groundwork for successful PRS risk management, which in turn can assist the enterprises to achieve their foremost objectives of Growth, Survival and Profit while abiding the legislative regulations related to recovery operations. The framework suggests the incorporation of risk management steps in all the recovery phases in order to control the risk exposure of the recovery system. It includes identification of risks existing in PRS followed by quantifying the considered risks on the basis of their occurrence probability, operational impact, environmental and safety impact, cost impact and their interactions with other risks. Subsequently, risk prioritization needs to be done in order to determine the high priority risks, which require pro-active mitigation. Accordingly, strategies are formulated to mitigate the critical risks present in all the PRS phases and continuous monitoring is done to ensure the optimum risk exposure of reverse channel.

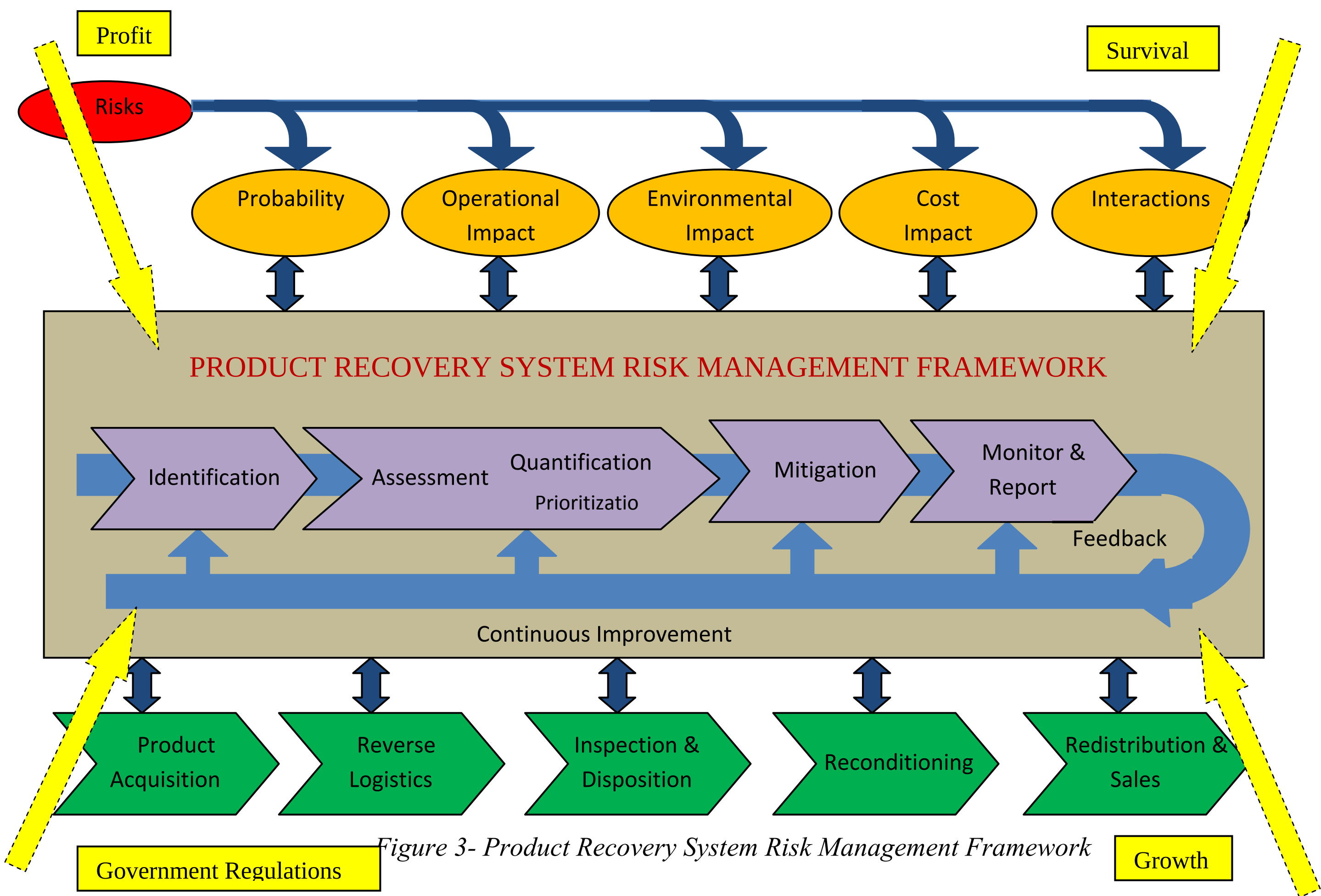

Figure 3- Product Recovery System Risk Management Framework

Conclusion and Future Research Direction

Emerging sustainable practices and growing green concerns are encouraging the concept of value retrieval through various recovery options such as reuse, remanufacture, recycle, refurbish etc. In this context, organizations are adopting product returns system for managing their returns in order to gain competitive advantage in the market as well as to comply with imposed regulations**.** Managing product returns at a societal level in an effective and cost-efficient way will help develop sustainable economies. Additionally, PRS offers great potential to cost reduction, revenue generation, customer retention and value addition. Accordingly, it is essential for the organizations to ensure the efficient functioning of return channel in order to accomplish their overall goals. In order to so, it is required to curb the risks associated with PRS, as they can disrupt the flow of returns and hinder the recovery system performance. These risks and disruptions are a result of various uncertainties and vulnerabilities existing in the return system, which can be due to the changing quantity, quality, time and type of returns. Consequently, in order to handle the uncertainties and complexities of returns, it is necessary to develop a product recovery system risk management framework.

In the literature, prior studies have not explicitly investigated the risk aspects of product returns system. To address this gap, the paper has attempted to identify the various risks present in return system under the categories of return collection risk, inspection & disposition risk and reprocessing risk. Further, building upon the literature of supply chain risk management and recovery system, the study has introduced a framework in order to manage the various recognized risks in PRS. The framework emphasizes the importance of incorporating risk management practices at all the stages of reverse channel i.e. throughout product recovery system. Accordingly, the research can guide managers in mitigating the PRS risks and thus, enhancing its performance and efficiency. Additionally, it will also illustrate the practical implication of deploying risk management practices in return channel. The study is of the earliest works closing the links of PRS and risk management.

The proposed framework can lay the groundwork for further research in the direction of risk management in PRS. Accordingly, research can be conducted to empirically analyze the relationships among the identified risks present in return channel. Multi attribute decision making techniques can be utilized to quantify the risks in order to prioritize them. Further, studies can be conducted to investigate the influence of various conventional supply chain risk mitigation strategies on the acknowledged recovery system risks.

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