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Empirical research opportunities in reverse supply chains

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Abstract

This study reviews the literature in reverse supply chains (RSCs) and develops 10 research propositions to be studied using empirical research methods. Businesses increasingly have to cope with product returns, mandated environmental regulations and increasing costs associated with product disposal. Through effective management of the RSC, managers can improve process efficiencies, customer service, supply chain design, product design, after-market product sales and after-sales service. Most research in RSCs has relied on case studies and optimization models. Opportunities exist to use survey-based research methods to explain current practices, predominant and critical issues, and managerial techniques used to manage the RSC.

Keywords: Reverse supply chains; Reverse logistics; Empirical research methods

1. Introduction

Supply chain management (SCM) has received tremendous attention both from the business world and from academic researchers during the last 15 years. SCM can be defined as "a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements" [1].

Most of the SCM research concentrates on the forward movement and transformation of the materials from the suppliers to the end consumer and on the impact that information has on the bullwhip effect as it transverses upstream. However, the reverse flow of products from consumers to upstream businesses has not received much interest [2,3]. Yet, according to the Reverse Logistics Executive Council the cost of handling, transporting and determining the disposition of returned products is $35 billion annually for U.S. firms [4]. Remanufacturing in the U.S. is a $50 billion per year industry [5].

The management of the reverse flows is an extension of the traditional supply chains with used product or material either returning to reprocessing organizations or being discarded. Reverse supply chain management (RSCM) is defined as the effective and efficient management of the series of activities required to retrieve a product from a customer and either dispose of it or recover value.[1] The importance of studying reverse supply chains (RSCs) has increased in recent years for several reasons:

- The amount of product returns can be very high, with some industries experiencing returns at over 50% of sales [9].

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[1] Several authors (e.g., [2,6]) have defined reverse logistics rather broadly and similarly to our definition of reverse supply chains. In alignment with Guide and Van Wassenhove [7], Vachon et al. [8] and others, we attempted to delineate between RSCM and reverse logistics management, which focuses on transportation, warehousing and inventory management activities.

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- Sales opportunities in secondary and global markets have increased revenue generation from previously discarded products [4].
- End-of-life take-back laws have proliferated over the past decade both in the European Union and in the United States, requiring businesses to effectively manage the entire life of the product [10,11].
- Consumers have successfully pressured businesses to take responsibility for the disposal of their products that contain hazardous waste [12].
- Landfill capacity has become limited and expensive. Alternatives such as repackaging, remanufacturing and recycling have become more prevalent and viable [13,14].

Although the use of RSCM activities is increasing [2], business managers struggle with how to better manage their time and resources with these sometimes "pesky" activities. Managers view several impediments to successful RSCM:

- Delayed returns, which are especially important for technological and time-sensitive products;
- Variation in quantity of product returns;
- Severity and breadth of product defects and
- Unknown product quality since information at the consumer or retail level is typically not communicated through the RSCs.

Companies that overcome these challenges expect to see improved revenue generation [4] and reduced costs associated with product returns [15].

The studies on RSCM have relied predominantly on normative research methods (see Fleischmann et al. [16] for a review), case studies (see de Brito et al. [17] for a review) or theoretical frameworks (e.g., [11,13,18]). Although there are a few studies that have relied on survey-based empirical methods, most have provided only descriptive statistics [2,19–22]. The exceptions, Autry et al. [23] and Daugherty et al. [6,24], were based on one small sample of 71 U.S. catalog retailers.

Studies using survey research methods are important for several reasons. First, these studies may explain the predominant and critical issues in RSCM. In addressing an actual business problem, many of the normative studies have relied on data from one or a few businesses without addressing whether these businesses are representative of the industry (e.g., [25,26]). In addition, normative models rely on selected influencing factors, which may or may not be critical in a generalized business environment. Second, researchers using empirical methods hope to explain the current business environment and managerial behavior, whereas researchers using normative methods attempt to optimize a specific business situation. The research objectives are quite different, and we would argue that survey-based empirical research on RSCM is essential to addressing the needs of the business community.

The purpose of this research is to explore the literature in RSCs and suggest 10 research propositions that could be studied empirically. Issues in RSCM are complex, and our understanding of these issues could significantly influence managerial decisions and environmental impact. Although decisions regarding green SCM and the effects of environmental issues can influence RSCs, we considered them to be outside the scope of this study. The green supply chain, which links the natural environment both with the forward and RSCs, has a growing stream of research and is quickly becoming a well-established field of its own [27,28]. In the next section, the literature on RSCs will be discussed. The propositions are presented in the following section.

2. Literature

The RSC process can be organized sequentially by five key steps: product acquisition, reverse logistics, inspection and disposition, reconditioning, and distribution and sales [7]. We found that many normative studies focused exclusively on only one step in the RSC process. The following discussion of the literature, therefore, is organized around these five steps.

2.1. Acquisition

Acquisition is the process of obtaining the product from the customer. There are three predominant sources of product: from the forward supply chain, such as with returns of defective or damaged products; from an established RSC, called market-driven systems; or from the waste stream, when the consumer has discarded the product [2,29].

Examples of acquisition from the forward supply chain include product returns and recalls. The product typically is "pushed" upstream via the same channel members in which it flowed downstream. With product returns, quality-related data and other information is usually not passed upstream. Many manufacturers and retailers have developed contractual agreements to manage or reduce the amount of product returned upstream [2,30].

In market-driven systems, the product is "pulled" upstream using various incentive policies, such as deposits, cash for product return, leasing and credit towards a replacement purchase. Because of the economic viability of reconditioning these products, companies within market-driven systems are willing to obtain higher caliber products for a fee. Market-driven systems have less variability in quality since a minimal standard usually is established [29]. Although the RSC could include the same channel participants as the forward supply chain, usually the reverse flows are either supplemented or entirely supported by alternative channel participants such as junkmen, scavengers, dealers, brokers and non-OEM remanufacturers [31]. Several alternative RSC structures are shown in Fig. 1.

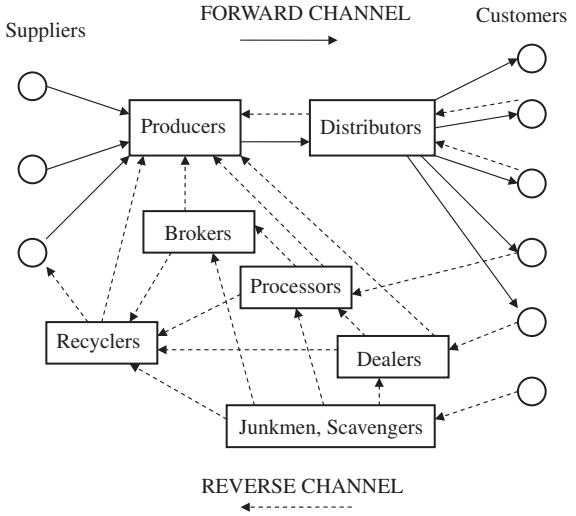

Fig. 1. Possible channel participants on the reverse supply chain.

Products that enter the RSC via the waste streams can either be landfilled or they can be diverted from landfills and reused because there is recoverable value. Examples of products that are diverted from the waste stream include recyclables via a retail deposit-refund collection system [32] and automotive parts via junkyard scavengers [33]. Since products that are acquired from the waste stream are highly variable, availability and quality of these returns are generally not known beforehand [25].

An additional distinction can be made between closed- and open-loop systems. Closed-loop systems are supply chains designed to consider the processes required for product returns in addition to the traditional forward supply chain processes [34]. In closed-loop systems, the product or packaging often returns to the original producer [16]. Examples include Kodak's single-use cameras, Xerox Europe and U.S. Naval Aviation Depots [34]. Closed-loop systems can lead businesses to make adjustments in product design and procurement practices [35]. In open-loop systems, products do not return to the original producers but will be recovered by other parties willing and able to reuse the materials or products [35].

2.2. Reverse logistics

Reverse logistics is the *process of retrieving* the product from the end consumer for the purposes of capturing value or proper disposal [36]. Activities include transportation, warehousing, distribution and inventory management. Transportation is usually the largest component of reverse logistics costs [37, p. 76]. Past literature has focused on a variety of issues in reverse logistics including facility location decisions [25], vehicle routing (see de Brito et al. [17] for several references) and the storage and transportation of reusable containers (e.g., [38]). If the total cost associated with the reclamation efforts exceeds the total cost of new materials or products, firms would have no financial incentive for implementing a RSC system [39]. Therefore, effective management of reverse logistics activities is essential.

Several recent studies address the debate on using in-house distribution centers, which combine forward and reverse distribution services, versus using centralized returns centers (CRCs) [15]. Rogers and Tibben-Lembke [2] and Gooley [15] both emphasize the importance of CRCs, which are independent facilities where the returns are managed in a central location. First, due to economies of scale, CRCs improve efficiency in sorting and repacking activities [15,35]. Second, due to the higher volumes, CRCs enable firms to purchase specialized assets [30]. Third, managers and employees are able to focus exclusively on issues related to returns rather than being pulled to pressing issues with the forward supply chain [2,15]. Fourth, incentives, goals and results are directly attributable to the CRCs due to the centralization [15]. Finally, with large volumes, managers gain increased experience with different disposition strategies. Yet, decision-makers need to be cautious in accepting the CRCs as the best alternative. The strategic priorities of the RSC, regulatory constraints, product characteristics, return volumes, transportation costs, disposal costs and viable disposition alternatives all have a direct impact on the distribution center decision [15,25].

Although firms have relied upon third-party logistics (3PL) providers for years, the reliance on 3PL providers for reverse logistics activities is fairly new [39]. When compared to the United States, Western European countries have used 3PL providers for a longer period of time and more extensively for product returns [21]. Traditionally, 3PL providers offered a standardized service for an established fee. As the number of 3PL providers has increased, however, both the service alternatives and customization offerings have also increased [39]. Third-party logistics providers must decide whether they will be a full- or limited-service provider, and if they choose the latter, they must also determine which services will be offered [40]. As noted in Knemeyer et al. [41], 80 of the top 100 3PL providers currently offer reverse logistics services and CEOs of 3PL providers recognize and emphasize opportunities in reverse logistics.

2.3. Inspection and disposition

An objective of inspection and disposition is to determine the level of quality of a returned product and an appropriate product recovery strategy[2] for each product in

[2] Several studies refer to the product recovery strategies as reverse logistics activities (e.g., [42,43]).

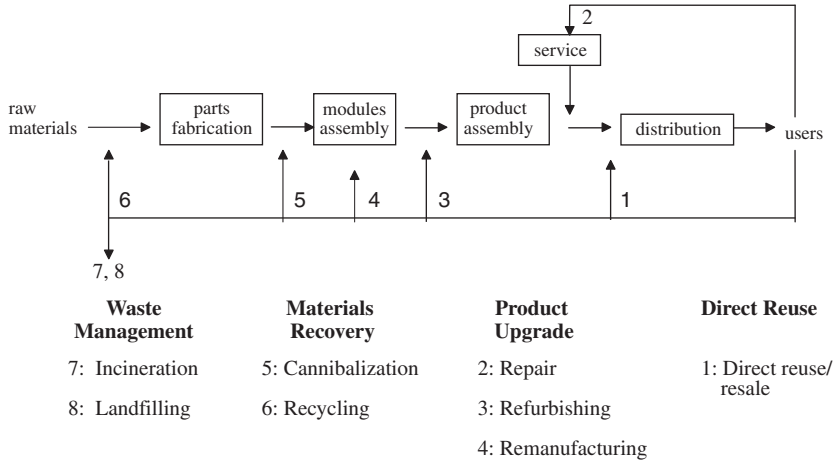

Fig. 2. Disposition alternatives on the reverse supply chain [13].

the RSC. There are four disposition alternatives, as shown in Fig. 2:

- Reuse, that is, to immediately reuse or resell the product;
- Product upgrade, which is to repackage, repair, refurbish or remanufacture the product;
- Materials recovery, which includes cannibalization and recycling and
- Waste management, which includes incineration and landfilling the product [13]. Although not directly related to the focus of our study, Bloemhof-Ruwaard et al. [44] considered an extension to the RSC by developing the environmental chain, recognizing emissions waste, pollution, etc. as relevant and integral in the development of effective RSCM and environmental management techniques.

Rogers and Tibben-Lembke [2] and Mannella [45] found that there were a variety of reasons as to why customers return products. When the manufacturer receives the returned product, the reasons for the return may not be obvious. During the inspection and disposition process, employees must determine functionality and reprocessing requirements. In closed-loop systems, managers should attempt to collect and use this information in the forward supply chain, e.g., to modify product design for ease of usability.

2.4. Reconditioning

If the product upgrade or material recovery option is determined to be the most appropriate disposition strategy, the product is transferred to a reconditioning operation, such as repair, refurbishing, remanufacturing and recycling. The reconditioning literature has centered on the operational process and design for disassembly [46,47]. Complexity in the disassembly operation is due to the completely manual process [14], the intricacy in separating components, the difficulty in sorting the components, and the variety and complexity of materials [47,48]. Less emphasis has been placed on the reassembly process, which is complicated by the availability of parts and the lack of design and testing specifications, if the remanufacturer is not the OEM producer.

Other reconditioning literature has focused on planning and control issues, such as MRP II [49], bill of material structure [50], inventory control [51] and capacity planning [52]. See Guide [20] for an overview of the production planning and inventory control issues and literature.

2.5. Distribution and sales

The literature on distribution and sales of reconditioned and used products is sparse. Most literature is anecdotal, describing legal issues [53], customer service opportunities [54,55], and characteristics that drive used product demand [56].

There are a number of channels that can be utilized for the sale of a refurbished or used product. One alternative is to use the same channel that is being utilized for new products, while distinguishing new and used products. Another option is to sell the product to a specialty broker, such as one that specializes in close-out, job-out, surplus or defective items within a particular industry. Products that are sold to brokers are typically resold to third parties, such as low-priced value retailers, end consumers, etc. For example, Estee Lauder sold returned products that were still good at employee stores, offshore markets or distributed the products to charities [4].

By reselling the product, the product life can be extended. Guide [20] and Guide and Van Wassenhove [29] recognized several factors that influence the resale of the product: the product's expected life, the rate of technological innovation, the original product design, the resale market demand and

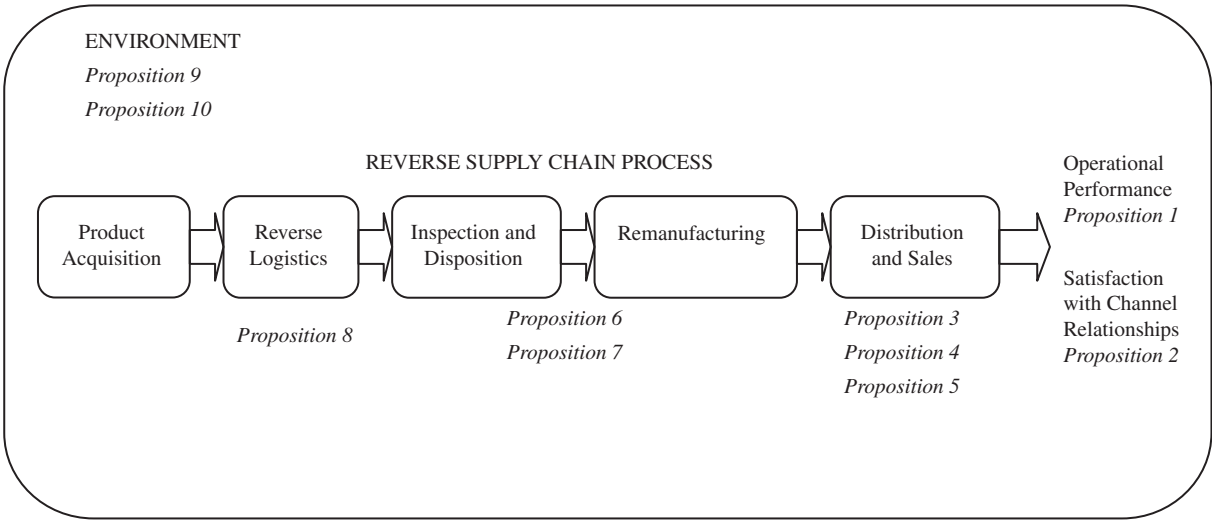

Fig. 3. Research propositions with an RSC framework.

the resale market value. Research opportunities to assess product-life extension decisions exist for both empirically- and modeling-based methods.

One particularly interesting issue raised by Purohit [57] concerned the way that pricing of used products affects new product introduction and designs. The potential of cannibalization and its impact on OEM suppliers is a concern for some business managers [58].

3. Propositions

Based on our review of the literature and our understanding of managerial concerns in RSCs, we created 10 research propositions. The propositions were developed using a two-step process. First, we utilized the framework of Guide and Van Wassenhove [7] to classify past research and identify managerial concerns that have not been adequately addressed, perhaps due to the selected methodology. Second, the RSC activities were viewed from a holistic perspective to understand issues relating to business involvement in RSCs.

In alignment with the framework presented in the literature review section, we created Fig. 3 to represent an overview of the propositions as each fits within the framework. As mentioned earlier, most of the studies in RSC have relied on normative or analytic methods. Additional emphasis on empirical research methods may expose alternative and equally viable frameworks.

Rather than commence with the acquisition process, as we did in the literature review, we begin by describing propositions that address the outcome of an RSC process. We then work backwards in the RSC stages, from distribution and sales to the acquisition process. As can be seen in Fig. 3, additional propositions could be developed to fit within this framework, which we leave to the interested reader. We conclude with two propositions that explore business environment factors that affect managerial decisions for RSC involvement.

Proposition 1. *Organizational commitment in the RSC positively influences operational performance.*

Organizational commitment has been extensively studied in the organizational behavior and marketing literature and, more recently, in the operations literature. In transactional cost analysis literature, organizational commitment has been defined as investments in the trading partner's business [59,60]. However, in social exchange literature, the definition of organizational commitment has been expanded to include loyalty and longevity [61–63]. We will rely on the latter definition.

In regards to investments, and similar to Klassen and Vachon [64], we would make a distinction between the *level* and *form* of investments. The investment *level* captures the proportion of RSC investments as compared to the overall logistical investments. The *form* of investment depicts distinctions between structural and infrastructural investments.

In the forward supply chain, suppliers' commitment to a specific partnership has been found to directly influence the supplier's operational performance, as measured by cost, delivery, flexibility, price and service [63]. In the RSC, however, an additional concern is how managers balance their commitment between the forward and RSC, and how their commitment in the RSC, or lack of it, influences operational performance. The balance needs to be better understood. The study by Rogers and Tibben-Lembke [2] indicated that while managers are less likely to invest in the RSC than in

the forward supply chain, investment is critical to the success of the RSC effort. Although the study's focus was on investments, the authors' argument could easily be extended to include other aspects of commitment.

Daugherty et al. [6] studied the impact of managerial and financial resource commitment in the RSC on the achievement of operational performance objectives. Both managerial and financial resource commitment were measured by single items that assessed the extent (*level*) of resource commitments. Performance objectives under consideration were environmental regulatory compliance, improved customer relations, recovery of assets, cost containment, improved profitability and reduced inventory investment. The survey results indicated that managerial resource commitment in RSC was positively related to all of the performance measures except improved customer relations and cost containment. Financial resource commitment was found to be positively related only to environmental regulatory compliance. The authors conclude that the commitment of managerial resources in the RSC had a greater level of influence on operational performance than on financial resource commitment. Future research could measure organizational commitment as it has been defined in social exchange theory and test its relationship to operational performance.

Our understanding of the impact of the commitment of different resources (e.g., money, time, energy) on RSC performance is fairly limited. Although the relationship between organizational commitment and RSC performance is implied in several studies [9,23,65,66], research has not addressed how organizational commitment and the *form* of the investments influence operational performance. We anticipate that perceived organizational commitment, as measured through various structural and infrastructural investments, would influence different aspects of operational performance.

Proposition 2. *Organizational commitment positively influences satisfaction with RSC channel relationships.*

In the RSC literature, Stock et al. [3] state "returns handling, if done right, can enhance relationships with consumers and supply chain partners." Developing this conviction, we posit that organizational commitment to RSCs has a positive influence on the satisfaction with RSC channel relationships. Similar to the previous proposition, we define organizational commitment as loyalty, longevity and investments made.

In the marketing literature, Jap and Ganesan [67] segmented the control mechanism of transaction-specific investments from the relationship commitment, which was measured as dedication, time, effort and sacrifices to the relationship. They found that both the supplier and retailer transaction-specific investments influenced the retailer's perceptions of the supplier's commitment to the relationship, and this commitment directly influenced relationship satisfaction. They concluded that supplier commitment mediates the effects of various control mechanisms on satisfaction.

We were able to find only one RSC study on the impact of organizational commitment on relationship satisfaction. Daugherty et al. [24] analyzed the moderating effect of commitment on the relationship between information systems support and performance, one dimension of which was satisfaction. They found partial support.

To understand the impact of organizational commitment on operational performance or on customer satisfaction with the RSC process, volume needs to be accounted. In his study of plants that produce ferrous scrap as byproducts, Johnson [43] found that only plants with high volumes of ferrous scrap had extensive investments in material-handling and processing equipment. In addition, the results showed that "high volume plants . . . were the only ones capable of structuring strategic supply relationship with important raw material suppliers" (p. 226). Further investigation is warranted.

Proposition 3. *Service quality and recovery strategies influence satisfaction and dissatisfaction, which in turn influences repurchase intentions in the RSC.*

Proposition 3a. *Improved service quality in the RSC positively influences customer satisfaction.*

We define service quality as controlling the variability in the RSC transactional processes through the design and management of tasks to be performed, tangibles in the environment (e.g., servicescapes) and the treatment of the customer. Stewart [68] described the tasks, tangibles and treatment, as well as the interaction between them, as a means of organizing and synthesizing the important components of service quality. Several determinants of perceived service quality that are particularly relevant in the RSC include reliability of service, responsibility, competence, access, communication, credibility, understanding and knowing the customer. (See Parasuraman et al. [69] for further information.)

Parasuraman et al. [69] developed the model to identify the service quality gaps in satisfying the customer. Two particularly relevant gaps in RSCs are: the gap between customer expectations and customer perceptions of service quality, and the gap between customer expectations and managerial perceptions of those expectations.

An example of the gaps in service quality lies in the retailers' recent shift to more restrictive return policies [2]. The customers' perceptions of a business are based on past experiences, media promotions and word-of-mouth discussions. When the customer becomes aware of a more restrictive return policy, the policy shift could negatively influence their perceptions of service quality. Consequently, the changes in the policies are likely to widen the gap between customer expectations and their perceptions of the quality of the service. In addition, the more restrictive return policies could be due to managers' lack of perception as to how their customers view return policies and how it influences their expectations, thus widening the gap between customer expectations and managers'

perceptions of those expectations. These gaps warrant further attention.

The impact of the gap between customer expectations and perceptions of service quality on customer satisfaction has been well established in the service quality literature [70,71]. In the RSC literature, Autry et al. [23] found that retailers were only somewhat satisfied with the reverse logistics service provided by their trading partners. Future research should establish the linkage between the steps that managers can take to reduce the gap between customer expectations and perceived service quality in the RSC.

Proposition 3b. *Customer satisfaction in the RSC positively influences repurchase intention.*

Encouraging repurchases is perhaps more important than attracting new customers [72], given that retaining existing customers is less costly than obtaining new customers [73]. Research has not addressed how customer satisfaction with the RSC activities, such as with product returns, product recalls and warrantees, influences repurchase intentions in either the forward or RSCs.

Although we were unable to find studies that address the relationship between customer satisfaction and repurchase intention in RSC literature, a number of studies in service quality literature provide support [70,74–76]. We anticipate that the relationship between satisfaction and repurchase intentions would hold in the RSC.

Proposition 3c. *Service recovery strategies within the RSC reduce the effects of customer dissatisfaction.*

As important as it is to keep customers satisfied, it is equally important to establish a service recovery strategy in the event of a service failure. Anderson and Sullivan [70] found that customer perception of service quality that falls short of expectations has a greater impact on satisfaction than does service quality that exceeds expectations. Hart et al. [77] emphasized that companies need to anticipate and plan for service recovery solutions in their attempts to retain customers. Zeithaml et al. [76] showed that intention to repurchase is much higher when companies have service recovery strategies than when they do not.

RSC researchers have not explored the antecedents of dissatisfaction and how businesses should recover from incidences of service failure. Businesses may require service recovery strategies to a greater extent in RSCs than in forward supply chains due to higher variability in products and processes and customers' pre-performance expectations of reconditioned products. In addition, dissatisfied customers may hold service providers, as well as the remanufacturer, liable. To restore customer satisfaction, businesses in RSCs may rely more heavily on and may use a greater variety of service recovery strategies.

As an example, insurance companies have been held liable for the poor product quality of aftermarket parts that were installed in insured customers' automobiles [78,79]. Several insurance companies made attempts at service recovery by initially withdrawing from the aftermarket parts market [80], which was perhaps not the most effective strategy in retaining customers, while they considered various alternatives [78]. Service recovery strategies within the RSC may have a more significant impact on the effects of customer dissatisfaction than they have in forward supply chains and should be further researched.

Proposition 4. *The time erosion of a product's value in the secondary market is dependent on attributes and pricing of products in the primary and secondary markets.*

In several operations management studies, salvage value in the primary market is considered a static value or is determined based on a uniform distribution (e.g., [81,82]). In marketing research studies, the possibility of reselling the product for a positive financial return is not explicitly considered [26]. In business, however, the value of a product on the secondary market is influenced by a variety of factors in both the primary and secondary markets. Business managers must attempt to determine the resale value of their product, the incentive policies to have customers return used products in market-driven systems, and the feasible disposition options based on the cost–benefits analysis and fair-market value of the product. More realistic estimation parameters are needed.

Based on economics, marketing and RSC literature, the following factors were seen to influence pricing of products in the secondary market:

- Price of the new product [57],
- Design and technological changes [2,20,57],
- New product's expected life [20,26],
- Expected length of the product model life [83],
- Product recalls [84],
- Demand for the used product [29,57,83],
- Availability of used products [83,85],
- Age of the used product [57,86],
- Quality of the used product [29],
- Cost and feasibility to recondition the used product [29,83,85],
- Operating and maintenance cost of the used product [86] and
- Material salvage value [82,85,86].

Based on his study using archival data of the automotive auction prices, Purohit [57] found that most of the variance in the secondary market prices was explained by the age of the used vehicle and dummy variables representing time (which measured inflationary characteristics). In addition, he found that positively perceived changes in new cars may increase the depreciation in the price of used cars, whereas negatively perceived changes in new models would enhance the price of used cars. Although this study was important for the development of a pricing model in secondary

markets, Purohit [57] did not explicitly consider the demand, availability or quality characteristics of the used vehicle.

Proposition 5. *Concerns of market cannibalization limit disposition alternatives.*

Many managers have expressed concern about entering the reconditioning business and reselling products in secondary markets due to the apprehension of market cannibalization [58]. Market cannibalization is defined as the decline of product or service sales due to the introduction of another product or service that is a substitute [87].

In the context of RSCs, market cannibalization occurs when a company offers used, refurbished or remanufactured products in direct competition with its new products. Market cannibalization may be more of a challenge for companies in open-loop systems rather than for those in closed-loop systems. As previously mentioned, in a closed-loop system, a company plans and manages aspects of the RSC as well as the traditional forward supply chain [34]. By contrast, in open-loop systems, companies do not control or proactively manage the RSC. In these systems, products may not return to the original producers but are recovered by other parties willing and able to reuse the materials or products [35]. As a result, the independent parties could compete directly against the original producers.

Companies have a number of options to reduce or avoid the effects of market cannibalization in the RSC. One option is to utilize a significantly different sales channel, such as targeting a different customer base or different geographical region. A second option is to de-mark the returned product, thus eliminating any association with the new product [88]. A third and frequently used option is to minimize the impact of the secondary market on the primary market by buying back older versions of the product or announcing future product introductions to reduce demand for older models [89].

To our knowledge, there is only one study on market cannibalization in the context of the RSC. Purohit [57] considered the price impact of new product introductions on used car sales. He considered three sources of competition for a used car—a new version of the model, a similar new vehicle made by the same manufacturer, and a similar new vehicle made by a competitor. Purohit found that styling changes influenced customers' excitement for the new model, which expanded the market for the new model and also lowered customer expectations on the resale value of used models. Although this study is invaluable in providing some understanding of market cannibalization in RSCs, research is needed to grasp the consequences of choosing different disposition strategies on market cannibalization. On a broader scale, Purohit [57] asked whether the secondary market influences primary market demand. We were unable to find any research that specifically addressed market cannibalization or brand de-marking on disposition alternatives in the primary and secondary markets.

Proposition 6. *Remanufactured product quality is as good as new.*

Lund [18] defined remanufacturing as "worn-out products [that] are restored to like-new condition ... [which are] sometimes superior—in performance and expected lifetime—to the original new product." Yet, past studies on remanufactured product quality have provided conflicting evidence. On one hand, a number of articles imply that quality of remanufactured products is superior, relative to that of new products, and two underlying reasons are given for this. First, when some products are remanufactured, they tend to be upgraded to the most recent version of the model [18]. Since more recent versions are usually superior in design and performance to the original design, remanufacturers conclude that the product quality is superior to that of the original product. Second, because every part is assumed to be faulty until proven otherwise, a remanufactured product usually undergoes rigorous quality inspection and testing [18,34].

On the other hand, some reports have indicated that the quality of a remanufactured product is inferior to that of a new product. In reference to a recent State Farm Insurance court case, "the jury determined that aftermarket parts are of lower quality than parts made by original equipment manufacturers" [90]. In addition, customers' impressions of product quality were found to be lower than that of a new product [79].

One reason for the inconsistent perspectives on remanufactured product quality may stem from how quality was defined. According to Garvin [91], there are eight dimensions of quality: performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality (e.g., reputation) [91]. Previous research in operations management has indicated that there may be a clear distinction between qualitative and quantitative factors. Curkovic et al. [92] factor analyzed seven dimensions of quality and found two factors: product quality (i.e., quantitative dimensions) and service quality (i.e., qualitative dimensions). They argued that both factors were related to firm performance, with the service quality having a slightly stronger influence. This could very well be the reason that customer impressions of remanufactured products are less favorable than customer impressions of OEM products; even if the remanufactured product scores high on quantitative dimensions of quality, it is the qualitative dimensions of quality that may influence customer perceptions more heavily.

Previous studies on remanufactured products appear to have focused on one or a few quality dimensions or have not delineated between these dimensions. We suggest that quality should be segmented into a minimum of two dimensions: quantitative factors and qualitative factors. Future research with clear distinctions between the dimensions should help explain the divergence between measures of product quality. A clearer understanding may also help integrate results of past studies.

Proposition 7. *Remanufacturing influences production planning and control (PP&C) system performance.*

PP&C systems are used to manage the quantity and timing of resources during production while minimizing costs and meeting customer demands [93]. PP&C systems perform at their optimal level with mature, stable and semi-complex products [93]. Studies that assessed the impact of remanufacturing on traditional PP&C system performance—measured as overall production, inventory and backorder costs—found mixed results (e.g., [94]). The influencing factors of remanufacturing on PP&C performance are threefold.

First, remanufacturing processes are significantly different from traditional manufacturing processes [34]. Remanufactured products increase the complexity in PP&C systems due to uncertainties in the timing and quantity of returns; the need to balance returns with demand for remanufactured products; the difficulty in disassembling returned products; the variability in materials recovered; the need for a reverse logistics network; the complication of material matching restrictions, if applicable; and variations in routing and processing times [20]. Due to uncertainties in product returns, inventory of remanufactured components is unpredictable and limited.

A second challenge is found in the differing cost structures of new products versus the remanufactured product. The remanufactured product has lower material costs and variable costs since the components are being reused. However, due to the greater uncertainties, inventory holding costs and back-order costs can be significantly greater than similar costs of new products [94]. In addition, due to lower production volumes, the remanufactured product has a higher cost per unit as compared to the new product. Due to the greater uncertainties and lower volumes, operating costs can offset savings from materials and variable expenses, all of which influence the PP&C system performance.

The third possible influencing factor on PP&C systems is the product life cycle. Product life cycle (PLC) theory describes the stages a product goes through during its lifetime, specifically, the stages of introduction, growth, maturity and decline. There are significant differences between these stages in terms of the rate of technological change, the rate of market growth and the ease of entry into the market [95], all of which have a direct impact on marketing, operations and logistics activities [30,96]. For operations, PP&C systems need to be modified as a product evolves through the four stages [97].

Remanufacturing is usually conducted on mature and stable products [22]. As an OEM product matures, remanufacturing of that product may commence. Thus, while the OEM product is at the mature stage, the remanufactured product tends to be in the introductory stage of the remanufacturing life cycle (RLC), as shown in Fig. 4. As a result, when OEMs are involved with the remanufacturing process, their PP&C system needs to be capable of coping with two products that are at different stages of their life cycle.

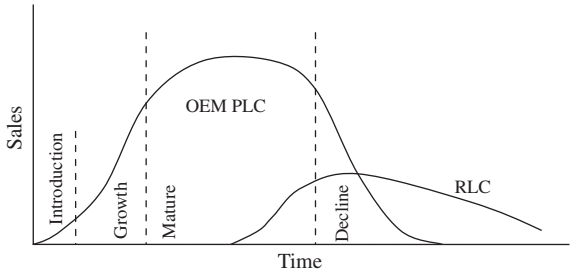

Fig. 4. Product life cycle for OEM and remanufactured product.

We are only beginning to develop an understanding of the constraints in remanufacturing that challenge our traditional PP&C systems. Previous work on traditional PP&C systems (e.g., [93]), recent PP&C case studies in RSCs (e.g., [20,34]) and normative research on remanufacturing systems (e.g. [94,98]) provide a good foundation for future work. To extend our current understanding of the difficulties of using PP&C systems with both remanufacturing and new products, empirical research can be used to audit the applicability of PP&C systems in different remanufacturing environments and the PP&C system's influence on performance.

Proposition 8. *The selection of returns facility (e.g., third-party logistics provider, in-house or centralized returns center) is aligned with the competitive priorities.*

Previous conceptual studies in operations management have argued that competitive priorities—whether the company focuses on cost reduction, better quality, higher flexibility or better delivery—influence the capabilities of a company [99]. Capabilities are established through decisions regarding the structure and infrastructure of the organization. The best fit is when the capabilities are aligned with business and functional strategies [99]. One such decision regarding the structure is the level of vertical integration versus outsourcing; competitive priorities should aid in determining the level of vertical integration for a company. Similarly, the competitive priorities of an RSC should influence the selection of a returns facility.

While operations strategy literature generally agrees that there is a relationship between business strategies, competitive priorities and capabilities, there is a disagreement on the nature of this relationship. On one hand, a number of studies propose a top–down approach where business strategies determine competitive priorities, which in turn drive the decisions related to the infrastructural and structural elements of a company [99–101]. On the other hand, this approach has been challenged by studies that show that manufacturing strategy changes slowly through incremental steps driven by necessity and opportunity [102–104]. As a result, strategy formulation and capability development may be carried out simultaneously. Regardless of the perspective, it is clear there is a relationship between competitive priorities and

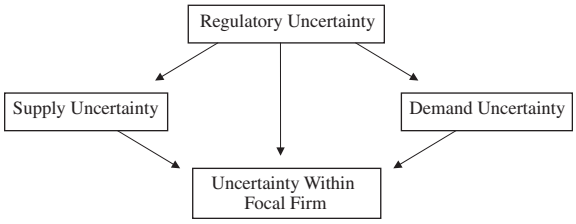

Fig. 5. Sources of uncertainty in reverse supply chains.

capabilities. The returns facility decision, as it relates to the company's capabilities, needs to be aligned with the competitive priorities of the business. Yet, the relationship between competitive priorities and the choice of return facilities is unclear at this point [105].

The results of a study by Autry et al. [23] indicated that managers perceived higher levels of environmental regulatory compliance when reverse logistics was carried out in-house rather than being outsourced. In Lieb et al. [21], the results suggested that Western European managers outsourced to third-party logistics (3PL) providers because they perceived flexibility as a primary benefit, whereas U.S. manufacturers outsourced to 3PL providers to reduce and control costs, as well as to improve productivity and service. Both parties perceived that using third-party providers reduced costs, although Western European companies perceived this improvement to be more significant. The alignment of competitive priorities with the returns facility selection decision should be further developed and explored.

Proposition 9. *Environmental uncertainty influences RSC channel relationships.*

An organization's environment influences managerial decisions [106,107]. One aspect of the environment, environmental uncertainty (also called dynamism), is defined as the rate of change and innovation in an industry as well as the unpredictability of the actions of suppliers, competitors and customers [108,109]. These influencing factors on a focal firm are reflected in Fig. 5.

In the RSC literature, environmental uncertainty has been described from two frameworks. First, Carter and Ellram [42], using a model developed by Achrol et al. [110], stated that RSC disposition strategies are affected by several external forces or constituents, namely suppliers, government, buyers and competitors. Each of these groups influences the level of uncertainty in the environment of the focal firm. Second, Guide and Van Wassenhove [7] discussed types of uncertainties that affect different steps in the RSC process. Uncertainty associated with product acquisition (supply uncertainty) is influenced by variances in quality, quantity and timing of the product returns. Uncertainty in distribution and sales (demand uncertainty) is influenced by consumer education, price and historical quality levels. Both of these studies focused on the antecedents of environmental uncertainty in the RSC rather than focusing on the impact of uncertainty on business processes. For future research, a third possible framework would be to assess the impact of environmental uncertainty on the competitive strategy, reconditioning business strategy and operational performance, similar to the study by Ward and Duray [111].

This proposition specifically addresses the impact of environmental uncertainty on channel relationships: suppliers and customers. Marshall Fisher [112] asked us to reflect on what is the right supply chain for a product. We could also ask, what is the right reverse supply chain for this same product? Business managers select their channel partners and influence the structure of their interorganizational relationships. Their decision is influenced by environmental uncertainty [113].

Transaction cost theory suggests that as environmental uncertainty and frequency of transactions between organizations increase, firms would prefer vertical integration to reduce transaction costs [114]. Yet, high levels of vertical integration can be risky for firms in industries with excess capacity, rapidly changing technology or fluctuating demand since vertical integration limits a firm's abilities to respond quickly to change [115]. Consequently, during greater levels of environmental uncertainty, business managers may tend to rely on closer interorganizational relationships, such as alliances and joint ventures [116–118]. Managers hope to achieve stability, predictability and dependability because of the relationship. In contrast, however, Klein et al. [119] found that more complex, diverse environments promoted greater reliance on transactional relationships [120].

As a firm experiences greater uncertainty in its supply environment, managers are increasingly likely to implement behavior-based management techniques [121]. Management techniques to control for supply uncertainties could include: supplier selection, supplier development, supplier alliances and backward vertical integration [122,123]. In the demand environment, managers could implement similar techniques to control for demand uncertainties, such as customer or channel selection, customer development, customer alliances and forward vertical integration [116,117].

We were unable to find any research that investigated how managers used RSC channel relationships to mitigate environmental uncertainty. Based on the literature, we anticipate that environmental uncertainty influences both structural and infrastructural (behavioral) RSC channel relationships.

Proposition 10. *The regulatory environment, industry and volume effects influence the level of involvement in the RSC.*

Anecdotal evidence suggests that a company's level of involvement in the RSC is heavily influenced by industry practices, government legislation and volume. As discussed in the introduction, the decision to become involved with the RSC and the extent of the involvement vary significantly across businesses, with two primary drivers being legislation and consumer pressures. The consumer pressure may range

from customer service issues, such as accepting product returns, to improvements in hazardous waste management. Consumer pressures and environmental awareness play a significant role in organizations' RSC involvement [19].

A regional effect should be expected as a result of the different levels of environmental laws and environmental awareness of local consumers and business managers. Legislation has been used as an impetus for establishing RSC collection systems to divert product from the waste stream and extend product or material life. In their comparison of environmental regulations between U.S. and Germany, Klassen and Angell [124] recognized that U.S. legislation was focused on reducing the environmental impact of the manufacturing process, such as emissions waste control, whereas the German legislation was focused on reducing the waste associated with the distribution and usage process, such as regulations related to materials recovery and product upgrade. Even within the U.S., there can be significant regulatory differences for the same product between states and also between municipalities [11]. Carter and Ellram [42] postulated that managers perceive that the regulatory sector influences product recovery strategies to a greater extent than suppliers, customers and competitive factors. To our knowledge, no studies have empirically tested this proposition. Legislation, however, does not always bring about a change in fundamental attitudes about the environment [125].

An industry effect would explain the significant differences in RSC capabilities and adoption of practices. Some industries are more conducive to product reconditioning [22]. Other industries, such as magazine publishing and catalog retailers, experience a larger percentage of product returns [9]). Therefore, certain industries should reap larger benefits from RSCM. Empirical studies on industry effects in RSCs, however, are nascent. In their comparison between household goods and computer/office/communication industries, Autry et al. [23] found there were significant industry effects on managers' satisfaction with RSC practices but insignificant effects on RSC operational performance. Additional research on the impact of industry on RSC practices is needed.

Volume appears to influence the plant involvement with the RSC, with larger facilities placing greater emphasis on RSC processes and obtaining substantial financial benefits [43]. "The economics of segregation, transportation and secondary processing activities are volume-dependent" [43, p. 225]. Therefore, we postulate that volume influences the degree of RSC involvement at the firm level.

There can be a significant overlap with respect to industry, volume and regulatory effects. Regulations are frequently established to monitor and control specific industries. For example, industries that affect consumer health are legally required to segregate their product returns from the forward flow to prevent possible mingling between the two flows [15].

Similarly, the size of the company appears to influence managers' knowledge of regional regulations. Livingstone and Sparks [125] found that managers' awareness—and, in particular, exporters' awareness—of Germany's packaging laws was dependent on the size of the company, where smaller firms were more uncertain about the legislation. They also found that a high proportion of these smaller companies had not sought for information about the legislation, perhaps, according to the authors, suggesting a degree of complacency.

Based on our review of the RSC literature, we would suggest that industry, region and company volume should be used as either independent or control variables within empirical studies on RSC.

4. Conclusion

The objective of this study was to encourage and provide researchers with future research directions in RSCM for which empirical research methods are appropriate. In addition, the propositions would address several opportunities and challenges that currently face business managers operating in RSCs.

The propositions were presented and organized according to an RSC framework presented in Guide and Van Wassenhove [7]. Managers' concerns with performance are attended to in Propositions 1 and 2. Propositions 3–5 are related to the challenges in distribution and sales. Propositions 6 and 7 focus on inspection, disposition and remanufacturing. A gap in research on reverse logistics is addressed in Proposition 8. The relationship between the business environment and RSCs is explored in Propositions 9 and 10.

Studies using survey-based research methods are complementary to existing research in that they are used to develop generalizations about a representative group of firms, to clarify predominant and critical issues in the RSC and to explain the current business environment and managerial behavior. In addition, most studies have focused on the retailer (with consumer product returns) or the remanufacturer (with process concerns). With the exception of qualitative studies conducted by Johnson [43] and Knemeyer et al. [41], intermediaries have been ignored. We believe there are several opportunities to conduct survey-based research along all tiers of the RSC. There are many opportunities for future research using empirical-based research methods in RSCs.

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