Reverse Logistics Recovery Option On The Product Return And Sorting Policy

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Abstract

In order to balance economic and environmental strategies through the reconciliation of end of life or end of use product value, reverse logistics and product recovery management are an important concept. Valuable components and materials in the used returned products can produce value in monetary forms when retrieved efficiently. This study's primary purpose is to explore and develop a model that recovers the economic value of end of life or end of use product returns and the sorting policy to optimize demand and maximize income over time. The model proposed focuses on reverse logistics recovery options, i.e., refurbish, remanufacture, recycling, and disposal, combining all possible means of return quality standards. A range of decisions on trade-off management systems is evaluated to maximize the revenue created by collecting used products by reverse logistics services using restoration, remanufacturing, and recycling options. The findings showed the process of acquiring less of the acquisition quantity at a minimum overall cost with the sorting policy. Finally, the model offers various potential scenarios for maximizing the total cost recovery options of end of life or end of use products.

Keywords: reverse logistics; end-of-life; refurbish; remanufacturing; recycling

1. INTRODUCTION

This template Once considered a competitor, ecology and manufacturing are now linked to the sustainability concept to help the three social, economic, and environmental pillars of sustainable development. A significant problem for the manufacturer is the "Green" movement, which is sustainable practices in reducing raw material use, decreasing waste material, and improving energy usage by using end-of-life (EoL) or End-of-Use (EoU) strategies. Manufacturing companies, as well as academic researchers around the world, have given considerable attention toward reverse logistics (RL) [1], [2]. The typical product cycle is linear from cradle to landfill, where products are manufactured, consumed, and thrown away at their EoL/EoU. However, nowadays, companies are under pressure in considering the obligation of the environment and social responsibility towards sustainable development. Studies have shown RL will provide businesses with a substantial profit by recapturing the returns' value and providing a chance to develop the visibility of different costs across the supply chain [3], [4]. In managing RL, the consistency of the returned EoL/EoU units are considered vital. Returns EoL/EoU quality is correlated with a unit's ability to effectively withstand restoration operations such as repair, refurbishing, remanufacturing, and other recovery options. Studies by [5]–[9] mentioned the quality uncertainty of returns EoL/EoU is the main issue for efficient RL EoL/EoU recovery. End-users' returns are not the same concerning the age, physical damage, functionality, and other factors during the usage period. Thus, running expenses and recovery strategies are distinct. This variability can decrease product recovery operations' profitability and also affect various operational issues. A certain amount of supply for EoL/EoU is required to be economically justified by processes of refurbishing or remanufacturing in meeting the required demand.

Starting with EoL/EoU products' return, recovery involves repair, refurbishment, remanufacturing, cannibalization, and recycling to extract potential economic value from the returned products. However, the process of product recovery is more complicated than the usual manufacturing process. The potential monetary value has motivated researchers to review different RL dimensions and has suggested various structural methods to recapture the value of returns EoL/EoU products [10]–[12]. Many businesses have been drawn into strategic involvement with product recovery by such growing attention. A significant problem for businesses is the inherent variability in the return of EoL/EoU products. Therefore, efficient management of their acquisition is important, although it has not attracted many researchers [13]–[15]. In order to assess the required level of acquisition management, the remanufacturer must consider the market outlook for refurbished/remanufactured goods and their process and storage capacity.

While remanufacturing-related studies have been comprehensive, relatively few studies have included acquisition and sorting. Few researchers have examined sorting effects. Ref [16] discuss the effect on cost savings of early quality evaluation of the returned product, compounded by higher return rates and lower quality. Ref [17], [18] show the benefits of sorting, and they note that such sorting's economic value depends on other related costs, such as disposal or disassembly and precision of sorting. Ref [19] shows the feasibility of initial sorting by comparing conditions with no sorting, local sorting, and central sorting. They concluded that a significant procurement decision is carried out via a single sorting from the local sorting. However, the above studies do not consider the acquisition policy and the recovery option to refurbish high-quality EoL/EoU returned items.

This paper reverse logistics recovery options for product return and sorting by focusing on optimizing the balance between return and demand to provide efficient renovation and remanufacturing that ultimately redistributes to the market that better matches demand and maximizes profits. A simple structured model was developed to provide an overview of the relationship between parameters and the interactions and the problem's characteristics, as this subject was not widely discussed in the literature. The purpose is to understand the acquisition and the attractiveness of a simple sorting policy just before the refurbishing and remanufacturing options. Specifically, this paper would address the optimal amount of EoL/EoU product return for refurbishing or remanufacturing to satisfy the demand while maximizing profits.

2. LITERATURE REVIEW

RL has played a significant role in solving resource scarcity and waste management [20]–[22] and has become an integral part of green businesses among manufacturers, mainly the Original Equipment Manufacturer (OEM) [23], [24]. With strict environmental policies such as Extended Producer Responsibility (EPR), Waste of Electrical and Electronics Equipment (WEEE) [3], [25]–[27], and ever-increasing sustainability growth, the organization could gain more revenue and sustain their business over the long term.

According to [6], [28], [29], potential economic benefits from EoL/EoU products can be derived from the recovery options, as illustrated in Figure 1 that includes reuse, refurbish, remanufacture, recycle, cannibalization, and recycle. RL starts with the acquisition and collection of EoL/EoU products from the end-user, where the returns are inspected, sorted, and classified into different level categories. It is crucial at the acquisition and collection processes due to uncertainty of returned unit quality, quantity, and timing increase the complexity of the decision-making process of sorting [28], [30]–[32]. There are two main pieces of information for companies involve in value-recovery operations: accuracy and timing. Hence, acquisition and collection sites use a variety of standard approaches to collect quality return information. For instance, [33] introduce nominal measurements based on particular product specifications and transfer the role of inspecting and grading the returned product to the supplier. Another way, as mentioned by [34]–[36], incorporating an electronics device to measure the usage data would yield a piece of timely information indirectly related to the quality of each unit upon collection. However, both practices provide an initial classification of returns according to their quality with limited accuracy. On the other hand, the accuracy of the quality grading is critical. The remanufacturer prefers to disassemble and inspect the returned EoL/EoU products even though a significant loss of time and effort can result from delayed detection of lots of inferior quality.

RL supply chain modeling is considered a complex problem involving multi-perspective decision-making. These perspectives are strategic and tactical/operational, or a mix of both. The RL strategic decisions commonly involve the network and facilities planning models in determining the best location for collection centers, remanufacturing plants, and/or recycling plants. The strategic decision is also the facility's optimum capability to process these EoL/EoU products or waste [37]–[39]. Tactical/operational decision-making models are the optimum processes and production planning for RL recovery options operation. The decision making involves the number of EoL/EoU products or components to be allocated for various RL recovery options and other related production planning [27], [28], [37], [40]–[42].

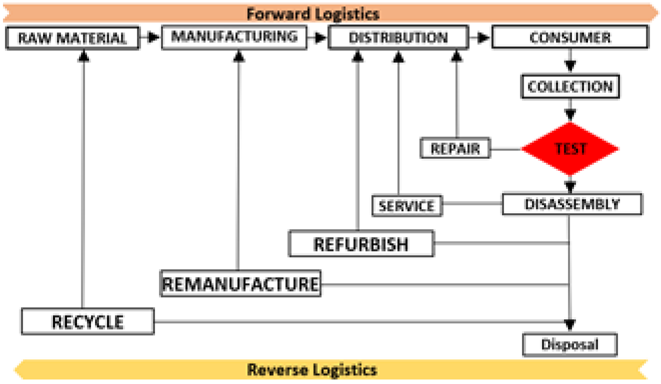

Figure 1: Forward and Reverse Logistics [29].

A mixed-integer linear programming (MILP) model by [37] addressed several problems related to the multi-period and capacity of the processing at the facilities with a profitoriented objective function. Their model serves to designate inspection centers and remanufacturing facilities. A generic for RL integrating two recovery options, namely, repair and remanufacturing using mixed-integer, was developed by [38]. Ref [39] addressed three aspects: uncertainty of end-of-life vehicle (ELV) quantity, the optimum location for various facilities' types, and the recovery system financial scheme for Mexican ELV. They used linear programming modeled production planning processes in a vehicle recycling plant using linear programming to assess whether the investment required to fully transform the existing vehicle recycling equipment into modern sorting equipment shows a profitable income even though the price decreased by 50%.

The RL network model presented by [43] associates within the supply chain was introduced to decide the optimum number, flexibility, location, and tactical/operational planning. According to [44], the most common tactical/operation decision is planning and controlling different recovery options concerning the pricing strategy. For example, [45] analyzes the policy, quality, and pricing plan for customer purchasing and return behaviour. Similarly, [46] studied the effect of customer behaviour and pricing strategies, taking into account the types of recovery and the best quantity for each form of recovery. The impact on the decision made for pricing strategy and quality on consumer behaviour was also studied by [47] through the analytic model. In the area of a forecasting model for EoL/EoU return, in attempting to promote decision-making on the amounts to be produced, demand and inventory costs, as well as the recovery options that are most convenient to realize, have been investigated by [48]–[51].

In the literature analysis, the decisions made on the RL are primarily focused on technical and practical measures; the decisions to be adopted on the RL: return policy, product quality, pricing strategy, production and inventory control, selection of components for the processing of recovered materials, strategic routes, and selection of the best recover options are generally dependent on tactical/operational approach. However, few studies have included the sorting in the return policy depending on the EoL/EoU product quality. Furthermore, no one assesses the trade-offs between the value of the EoL/EoU product and the benefit of its sorting and the recovery of the disassembled products separately. The concern to limit the EoL/EoU products received to various recovery processes within their defined physical conditions was ignored. Our study, however, contributes to the acquisition management emphasis on the relationship between the processes of acquisition, sorting, and recovery (refurbishing, or remanufacturing, or recycling).

3. PROBLEM, DESCRIPTION

RL has played a significant role in This study considers a scenario in which a manufacturer decides to accept EoL/EoU of its product from end-users. The returned products collected are classified and sorted according to various recovery options, including refurbishing, remanufacturing, and disposal during the sorting process.

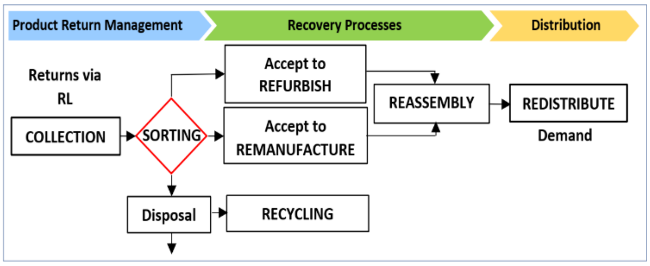

Figure 2: Recovery options process

Figure 2 represents the framework of this study. EoL/EoU returned products via RL are accepted and stored in the collection center. The product accepted for refurbishing will undergo minor modifications and repair such as product repackaging or exterior correction and repair that the final product can be treated as a finished good with a high-quality standard. Returned products identified for the remanufacturing process have parts that are considered recoverable, and items marked for disposal have no recoverable parts and will be recycling and disposed of. The sorting level will depend on the recovery processing capability and inventory. Three different types of inventories are available: finished goods to be sold based on market demand, used parts that will be reassembled in the remanufacturing recovery option, and recycling inventory. The recoverable parts are retained as used parts when disassembled. Finished goods are the returned product, which has been restored and repaired in the refurbishing and remanufacturing process and ready to be redistributed based on demand. (refurbishing, or remanufacturing, or recycling).

4. PROBLEM ASSUMPTIONS AND NOTATIONS

This section presents the model assumptions and the notes before the model formulation is presented. This study is to understand the collection of EoL/EoU products and simple sorting policy to meet the demand with limited accuracy. The following assumptions are used to represent the model as mentioned earlier scenario. The EoL/EoU collected's quality level is known and categorized in three levels, as illustrated in Table 1 before the recovery processes (refurbish, remanufacture, disposal (recycling).

Table 1: Recovery assigned to each EoL/EoU products

Condition	Recovery Options
1 - High quality	1. Refurbishing, $\boldsymbol{Q_{REF}}$
2 - Medium quality	2. Remanufacturing, $\boldsymbol{Q_{REM}}$
3 - Low quality	3. Recycling, $\boldsymbol{Q_{RECY}}$ 4. Disposal (Landfill), $\boldsymbol{Q_{DISP}}$

All processes with different quality of returned have a different cost associated. The medium quality, QREM returned products yield a fraction of good recoverable modules/parts that feed to the remanufacturing process. The good and bad modules/parts after disassembly are represented by two γg and γb level percentages, respectively. The market demand is known, and the processing capacities are unlimited. The notations of the model are summarized as below:

Decision Variables

$\mathcal{D}$	Quantity of returned EoL/EoU products required
Q_{REF}	Quantity of refurbishing
Q_{REM}	Quantity of remanufacturing
Q_{DISP}	Quantity of disposal
Q_{RECY}	Quantity of material recycle
ST	ST = 1 if product $\mathcal{D}$ remanufactured and 0 if otherwise. ST = 0 represents all demand that will be met by the refurbishing process only.

Parameters

D	Demand for finished goods
α	Price for the returned product
υ^{SELL}	Price of finished goods
δ^{SELL}	Price for recycling material
$ʎ$	Ratio of a high, medium and low quality received ($ʎ_{HQ}$, $ʎ_{MQ,}$ and $ʎ_{LQ}$) based three percentages
γ	Fraction of good and bad part (γ_g and γ_b) based on two percentages
W	Weight of recycling material
C_{REF}	Cost for the refurbishing process
C_{REM}	Cost for the remanufacturing process
C_{DISP}	Cost for the disposal of low quality
C_{ASSY}	Cost of assembly for refurbishing and remanufacturing process

5. MODEL FORMULATION

In this study, we considered a single-demand ***D*,** which the recovery facility needs to determine how many used products to acquire. The facility's decision variable is to collect a number of returned EoL/EoU products η, where $\eta \geq D$. Received EoL/EoU products are classified into three categories based on their physical or known operating condition. The categories are denoted as $ʎ_{HQ}$, $ʎ_{MQ}$, and $ʎ_{LQ}$ where it refers to high quality, medium quality, and low quality. The recovery options of refurbishing (Q_{REF}), remanufacturing (Q_{REM}), recycling (Q_{RECY}), and disposal (Q_{DISP}) are considered separate processes, as shown in Figure 3. The returned products that do not meet the refurbishing or remanufacturing requirements will be recycled or disposed of. The sorting policy ($ST = 0$) is classified for refurbishing or remanufacturing ($ST = 1$) in this decision-making model to satisfy demand (D) that is known.

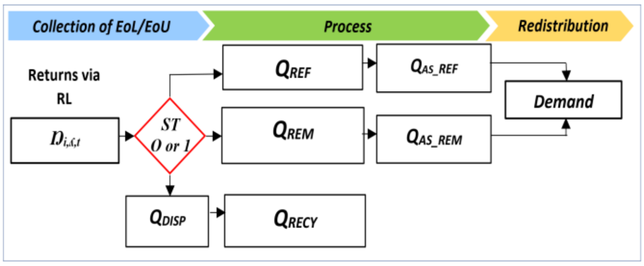

Figure 3: Recovery options scenario of EoL/EoU

The refurbishing process aims to return the equipment to its original state, i.e., "like new" with a high-quality level, only minimal repair. It may include other procedures to return the product to OEM requirements, tested, and calibrated. EoL/EoU return products can have some reusable modules or parts/components in remanufacturing, while returned products with insufficient reusable parts are recycled/disposed of. All finished products are product lines that have undergone all the necessary processes, checked and certified, and are ready for redistribution based on demand.

The mathematical equation of the problem is presented as follow:

$$\textbf{\textit{Maximize Profit = Total Revenue - Cost of Processing}} \qquad (1)$$

Revenue is generated from the selling of refurbishing, remanufactured, and recycling of material. $\boldsymbol{\upsilon}^{\boldsymbol{SELL}}$ is the price of selling the product of refurbishing or remanufacturing, and $\boldsymbol{\delta}^{\boldsymbol{SELL}}$ the price of selling the recycled material.

Total Revenue

$$\sum_{i.t} {}_{o\in\{1,2\}} \sum_{i,t} {}_{i\in\eta} \upsilon^{SELL}_{i,o,t} Q_{REF} Q_{REM} D_{i,t} + \sum_{i,3,t} {}_{m\in M} \delta^{SELL} \sum_{i,t} W Q_{RECY} \qquad (2)$$

Cost of Processing

$$\sum_{i,t} {}_{i\in\mathrm{P}} \eta_t \alpha_{i,t} \sum_{i,1,t} C_{REF} Q_{REF} \sum_{i,2,t} C_{REM} Q_{REM} \sum_{i,1,2,t} C_{ASSY} Q_{REF} Q_{REM} \sum_{i,4,t} C_{DISP} Q_{DISP} \qquad (3)$$

Process assignments for each of the EoL/EoU products based **ƛ-ratio** as in Table 2 for the 36 simulation cases.

Table 2: Ratio of high, medium and low quality EoL/EoU

Case	$ƛ_{HQ}$	$ƛ_{MQ}$	$ƛ_{LQ}$	**Case**	$ƛ_{HQ}$	$ƛ_{MQ}$	$ƛ_{LQ}$
1	0.8	0.1	0.1	**19**	0.3	0.3	0.4
2	0.7	0.2	0.1	**20**	0.3	0.2	0.5
3	0.7	0.1	0.2	**21**	0.3	0.1	0.6
4	0.6	0.1	0.3	**22**	0.2	0.7	0.1
5	0.6	0.2	0.2	**23**	0.2	0.6	0.2
6	0.6	0.1	0.3	**24**	0.2	0.5	0.3
7	0.5	0.4	0.1	**25**	0.2	0.4	0.4
8	0.5	0.3	0.2	**26**	0.2	0.3	0.5
9	0.5	0.2	0.3	**27**	0.2	0.2	0.6
10	0.5	0.1	0.4	**28**	0.2	0.1	0.7
11	0.4	0.5	0.1	**29**	0.1	0.8	0.1
12	0.4	0.4	0.2	**30**	0.1	0.7	0.2
13	0.4	0.3	0.3	**31**	0.1	0.6	0.3
14	0.4	0.2	0.4	**32**	0.1	0.5	0.4
15	0.4	0.1	0.5	**33**	0.1	0.4	0.5
16	0.3	0.6	0.1	**34**	0.1	0.3	0.6

17	0.3	0.5	0.2	**35**	0.1	0.2	0.7
18	0.3	0.4	0.3	**36**	0.1	0.1	0.8

Model Formulation

The model was solved using Lingo 18.0. Figure 4 shows the profit created by our experiment model with the assumption of market demand, ***D*** for a total of 100 from the refurbish and remanufacture products. The model is analyzed if the quality level of EoL/EoU product returns impacts its output with a 10 % increase or decrease of ***ʎ-ratio***. All 36 cases evaluated with a requirement that all output levels are higher than or equivalent to 10%, indicating that all processes for refurbishing, remanufacturing, recycling, and disposal coexist.

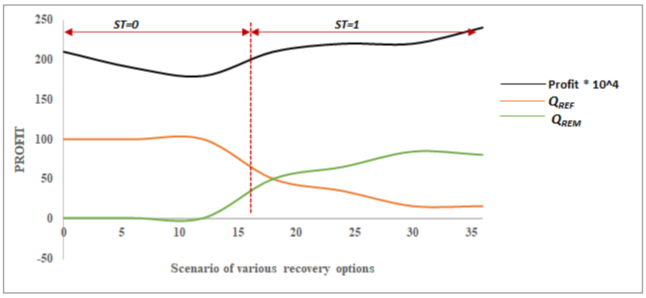

Figure 4: Impact of different recovery options scenario

The high quality of EoL/EoU causes all demand to be met with only refurbished products ($\boldsymbol{Q_{REF}}$) from scenario 1 to 16 with ***ST*** at 0. Hence, all the other returned products classified as medium and low quality are sent for recycling and disposal. The highest profit generated within the scenario was 2100000. The profits tend to decrease gradually when the quality level of ʎ_{HQ} constant and ʎ_{MQ} starts to decrease. Regardless of the change in quality for ʎ_{MQ} and ʎ_{LQ} the quantity of $\boldsymbol{Q_{REF}}$ are identical when ʎ_{HQ} are 0.8, 0.7, 0.6, and 0.5. As a result, the revenue within case 1 to 16 is also being generated by the selling recycled material, δ^{SELL}. Table 3 summarizes the overall quantity of EoL/EoU returned products acquisition, $\mathcal{D}$ refurbishing, $\boldsymbol{Q_{REF}}$ and remanufacturing, $\boldsymbol{Q_{REM}}$.

Table 3: Result of acquisition, refurbish, remanufacturing.

Case	$\mathcal{D}$	Q_{REF}	Q_{REM}	Case	$\mathcal{D}$	Q_{REF}	Q_{REM}
1	125	100	0	19	190	47	53
2	143	100	0	20	222	45	55
3	143	100	0	21	266	42	58
4	143	100	0	22	137	39	61

5	143	100	0	23	154	37	63
6	143	100	0	24	174	35	65
7	200	100	0	25	200	30	70
8	200	100	0	26	235	28	72
9	200	100	0	27	286	25	75
10	200	100	0	28	310	23	77
11	250	100	0	29	150	20	80
12	250	95	5	30	160	16	84
13	250	92	8	31	182	15	85
14	250	85	15	32	210	15	85
15	250	80	20	33	250	15	85
16	133	60	40	34	307	15	85
17	148	56	44	35	337	15	85
18	166	50	50	36	350	15	85

The quantity of demand determines the quantity of acquisition resulting from the model. In cases between 1 to 11, when the quality level of α_{HQ} is greater than or equal to 50 percent, given market demands, only refurbished products are met by increasing the acquisition process's quantity of returns. Cases 12-36 show that the demand for 100 products is met with refurbished and remanufactured products. For instance, the profit increases 15 percent, although the α_{HQ} levels decrease compared to cases 15 and 16. Similar findings also occur in cases 28 to 29. However, the increase in profit margin is just 6 percent.

Due to their low cost for recovery and high profitability, the recovery facility would prefer better quality returned products, based on the results and as expected. In contrast with low quality, the high quality returned product is limited. As mentioned above, the outcome of scenarios 15 and 16 also demonstrated clearly how the different quality levels of the returned products are compared and would result in higher profits even if the quality of the returned EoL/ EoU with lower quality grades. Therefore, the decision-maker must prioritize the solution based on the optimal margin and the recovery's targeted percentage.

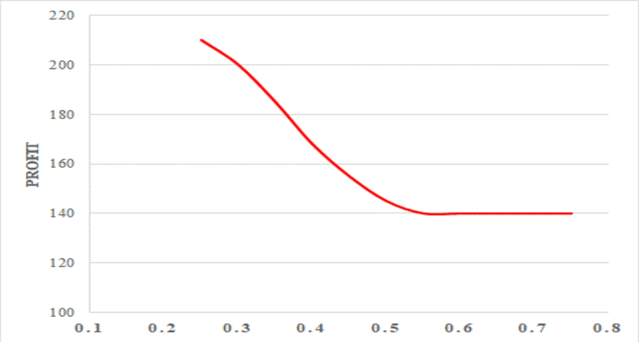

Figure 5: Change of Fraction γ_b in Profit

The result in Figure 5 indicates the change of γ_b with an increase of 5%. The change in γ_b significantly impacts the recoverable components/parts that affect the remanufacturing process, which eventually increases the processing cost for acquiring more returned EoL/EoU products. However, the profits remain constant as the fraction of γ_b increases since the revenues of δ^{SELL} for material recycling increases.

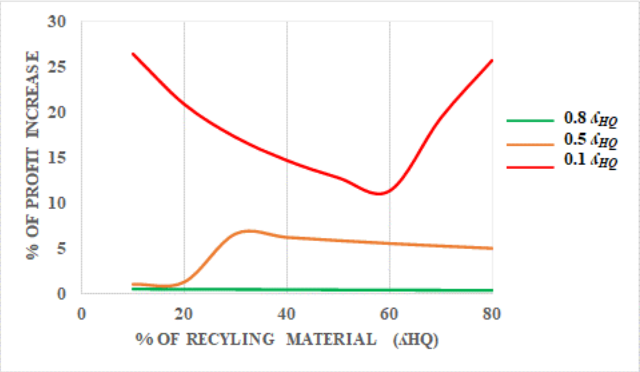

Figure 6: Changes in profit depending on % of Q_{RECY},

The result in Figure 6 shows that the percentage of profit to the amount of $\boldsymbol{Q_{RECY}}$. With only 10% of ℓ_{HQ} EoL/EoU product return, the recovery option of recycling generated up to 25% of the profit compared to the 80% of ℓ_{HQ} acquired. With a proper strategy of material recycling, ℓ_{LQ} would also provide a substantial amount of profit.

6. CONCLUSION

The stochastic aspect of the product quality returned is one of the critical features of a product recovery method. Given the wide variability in return conditions, the returned items must be graded according to their quality. In this study, we develop a model to determine the appropriate acquisition quantity and sorting process to meet demand and maximize profit. The study provides a simple analytical expression that determines when such a process, either refurbished or remanufactured, is economically justified and shows the simultaneous consideration of relationship among acquisition, sorting, refurbishing, or remanufacturing should contribute to a better understanding of the dynamic characteristics in dedicated product recovery processes. We conclude the paper by focusing on the modeling aspects of this study. Our model assumes that in recovery processes, there are no limitations of capability and a deterministic value. This is a simplifying theory that, in some situations, might not be accurate.

REFERENCES

[1] ST John, R Sridharan and PNR Kumar. Multi-period reverse logistics network design with emission cost. *Int. J. Logist. Manag.* 2017; **28**, 127-149.

[2] H Soleimani, K Govindan, H Saghafi and H Jafari. Fuzzy multi-objective sustainable and green closed-loop supply chain network design. *Comput. Ind. Eng.* 2017; **109**, 191-203.

[3] R Batarfi, MY Jaber and SM Aljazzar. A profit maximization for a reverse logistics dual-channel supply chain with a return policy. *Comput. Ind. Eng*. 2017; **106**, 58-82.

[4] CY Chiou, HC Chen, CT Yu and CY Yeh. Consideration Factors of Reverse Logistics Implementation -A Case Study of Taiwan's Electronics Industry. *Procedia - Soc. Behav. Sci*. 2012; **40**, 375-381.

[5] A Alnoor, B Eneizan, HZ Makhamreh, and IA Rahoma. The Effect of Reverse Logistics on Sustainable Manufacturing. *Int. J. Acad. Res. Account*. 2019; **9**, 71-79.

[6] TA Banihashemi, J Fei, and PS-L Chen. Exploring the relationship between reverse logistics and sustainability performance. *Mod. Supply Chain Res. Appl*. 2019; **1**, 2-27.
[7] R. Pal. Value creation through reverse logistics in used clothing networks. *Int. J. Logist. Manag*. 2017; 28, 864-906.
[8] JL Mishra, PG Hopkinson and G Tidridge. Value creation from circular economy-led closed loop supply chains: a case study of fast-moving consumer goods. *Prod. Plan. Control*, 2018; **29**, 509-521.
[9] ME Ketzenberg, E Van Der Laan and RH Teunter. Value of information in closed loop supply chains. *Prod. Oper. Manag*., 2006; **15**, 393-406.
[10] S Pokharel and A Mutha. Perspectives in reverse logistics: A review. *Resources, Conservation and Recycling*. 2009; **53**, 175-182.
[11] YR Awan and Q Liu. Network design for reverse logistics and remanufacturing under uncertainty. *In*: 2011 IEEE 18th International Conference on Industrial Engineering and Engineering Management, Changchun. 2011, p. 1473-1477.
[12] A Jayant, P Gupta and SK Garg. Design and simulation of reverse logistics network: A case study. *In*: Proceedings of The World Congress on Engineering 2011, WCE 2011, London, U.K. 2011, p. 872-876.
[13] K Li, J Liu, H Fu and B Liu. Acquisition and pricing strategies in hybrid manufacturing-remanufacturing systems. *J. Manuf. Syst*. 2020; **57**, 217-230.
[14] SC Bulmuş, SX Zhu and RH Teunter. Optimal core acquisition and pricing strategies for hybrid manufacturing and remanufacturing systems. *Int. J. Prod. Res*. 2014; **52**, 6627-6641.
[15] X Cai, M Lai, X Li, Y Li and X Wu. Optimal acquisition and production policy in a hybrid manufacturing/ remanufacturing system with core acquisition at different quality levels. *Eur. J. Oper. Res*. 2014; **233**, 374-382.
[16] N Aras, T Boyaci and V Verter, “The effect of categorizing returned products in remanufacturing. *IIE Trans*. 2004; **36**, 319-331.
[17] C Zikopoulos and G Tagaras. On the attractiveness of sorting before disassembly in remanufacturing. *IIE Trans*. 2008; **40**, 313-323.
[18] APS Loomba and K Nakashima. Enhancing value in reverse supply chains by sorting before product recovery. *Prod. Plan. Control*. 2012; **23**, 205-215.
[19] C Zikopoulos and G Tagaras. Reverse supply chains: Effects of collection network and returns classification on profitability. *Eur. J. Oper. Res*. 2015; **246**, 435-449.
[20] AA Hervani, MM Helms and J Sarkis. Performance measurement for green supply chain management. *Benchmarking: An International Journal*. 2005; **12**, 330-353.
[21] BM Eneizan, K Abd Wahab, and ZMS. Effects of Green Marketing Strategies on Sales Volume of Green Cars. *Singaporean J. Bus. Econ. Manag. Stud*. 2016; **5**, 41-54
[22] K Govindan and H Soleimani. A review of reverse logistics and closed-loop supply chains: a Journal of Cleaner Production focus. *J. Clean. Prod*. 2017; **142**, 371-384.
[23] W Gyasi-Mensah and X Hu. Towards Developing a Green Manufacturing Environment: What is Ghana doing?. *Environ. Manag. Sustain. Dev*. 2018; **7**, 170-180.
[24] C Wen Chiet, N Tan Ching, S Lip Huat, M Fathi, and T Jaw Tzuu. The Integration of Lean and Green Manufacturing for Malaysian Manufacturers: A Literature Review to Explore the Synergies between Lean and Green Model. *In*: International Conference on Sustainable Energy and Green Technology 2018, Kuala Lumpur, Malaysia. 2019, p. 012066.
[25] J Aitken and A Harrison. Supply governance structures for reverse logistics systems. *Int. J. Oper. Prod. Manag*. 2013; **33**, 745-764.

[26] V Goodship, A Stevels and J Huisman. *Waste electrical and electronic equipment (WEEE) handbook*. Woodhead Publishing, 2019.
[27] B Zheng, C Yang, J Yang and M Zhang. Pricing, collecting and contract design in a reverse supply chain with incomplete information. *Comput. Ind. Eng*. 2017; **111**, 109-122.
[28] VDR Guide, TP Harrison and LN van Wassenhove. The challenge of closed-loop supply chains. *In*: Proceedings of the 13th CIRP International Conference on Life Cycle Engineering, LCE 2006. 2006, p. 11-13.
[29] M Thierry, M Salomon, J van Nunen and L van Wassenhove. Strategic Issues in Product Recovery Management. *Calif. Manage. Rev*. 1995; **37**, 114-136.
[30] S Agrawal, RK Singh and Q Murtaza. A literature review and perspectives in reverse logistics. *Resources, Conservation and Recycling*. 2015; **97**, 76-92.
[31] M Fleischmann, HR Krikke, R Dekker and SDP Flapper. A characterisation of logistics networks for product recovery. *Omega*. 2000; **28**, 653-666.
[32] VDR Guide, TP Harrison and LN Van Wassenhove. The Challenge of Closed-Loop Supply Chains. *Interfaces*. 2003; **33**, 3-6.
[33] VDR Guide and LN Van Wassenhove. Managing product returns for remanufacturing. *Prod. Oper. Manag*. 2001; **10**, 142-155.
[34] L. G. Debo, R. C. Savaskan, and L. N. Van Wassenhove. *Coordination in Closed-Loop Supply Chains*. *In*: R Dekker, M Fleischmann, K Inderfurth, LN Van Wassenhove (eds). Reverse Logistics. Springer, Berlin, Heidelberg, 2004.
[35] VDR Guide, GC Souza, LN Van Wassenhove and JD Blackburn. Time value of commercial product returns. *Manage. Sci*. 2006; **52**, 1200-1214.
[36] R. Asif. Reverse logistics: RFID the key to optimality. *Journal of Industrial Engineering and Management*. 2011; **4**, 281-300.
[37] SA Alumur, S Nickel, F Saldanha-Da-Gama and V Verter. Multi-period reverse logistics network design. *Eur. J. Oper. Res*. 2012; 220, 67-78.
[38] YS Zhou and SY Wang. Generic model of reverse logistics network design. *J. Transp. Syst. Eng. Inf. Technol*. 2008; 8, 71-78.
[39] R Cruz-Rivera and J Ertel. Reverse logistics network design for the collection of End-of-Life Vehicles in Mexico. *Eur. J. Oper. Res*. 2009; **196**, 930-939.
[40] BT Hazen. Strategic reverse logistics disposition decisions: From theory to practice. *International Journal of Logistics Systems and Management*. 2011; **10**, 275-292.
[41] M Rahmatian. 2008, Multi-objective reverse logistics network design and analysis. Masters Thesis. Concordia University, Montreal, Quebec, Canada.
[42] V Simic and B Dimitrijevic. Production planning for vehicle recycling factories in the EU legislative and global business environments. *Resour. Conserv. Recycl*. 2012; **60**, 78-88.
[43] S Rezapour, RZ Farahani, B Fahimnia, K Govindan and Y Mansouri. Competitive closed-loop supply chain network design with price-dependent demands. *J. Clean. Prod*. 2015; **93**, 251-272.
[44] DW Steeneck and SC Sarin. Pricing and production planning for reverse supply chain: A review. *International Journal of Production Research*. 2013; **51**, 6972-6989.
[45] Y Li, L Xu and D Li. Examining relationships between the return policy, product quality, and pricing strategy in online direct selling. *Int. J. Prod. Econ*. 2013; **144**, 451-460.
[46] X Han, H Wu, Q Yang and J Shang. Reverse channel selection under remanufacturing risks: Balancing profitability and robustness. *Int. J. Prod. Econ*. 2016; **182**, 63-72.

[47] MA Ülkü and J Hsuan. Towards sustainable consumption and production: Competitive pricing of modular products for green consumers. *J. Clean. Prod*. 2017; **142**, 4230-4242.

[48] L Zhou, J Xie, X Gu, Y Lin, P Ieromonachou and X Zhang. Forecasting return of used products for remanufacturing using Graphical Evaluation and Review Technique (GERT). *Int. J. Prod. Econ*. 2016; **181**, 315-324.

[49] H Zerhouni, JP Gayon and Y Frein. Influence of dependency between demands and returns in a reverse logistics system. *Int. J. Prod. Econ*. 2013; **143**, 62-71.

[50] P Desport, F Lardeux, D Lesaint, A Liret, C Di Cairano-Gilfedder and G Owusu. Model and combinatorial optimization methods for tactical planning in closed-loop supply chains. *In*: 2016 IEEE 28th International Conference on Tools with Artificial Intelligence (ICTAI), San Jose, CA. 2017, p. 888-895.

[51] N Zaarour, E Melachrinoudis, MM Solomon and H Min. Optimal collection period for returned products in the reverse supply chain. *IFAC Proceedings Volumes*. 2013; **46**, 123-127.