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Critical Barriers in Reverse Logistics Implementation: Case Study on Construction Machinery Remanufacturing Company in Indonesia

Evi Yuliawati[1], Hastawati Chrisna Suroso[2]
[1,2]Institut Teknologi Adhi Tama Surabaya, Indonesia

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ABSTRACT

Increasing customer awareness of environmental issues, including awareness of the decreasing capacity of landfills for final disposal, requires industries puts more thought into the reverse logistics (RL) process. Implementing this process requires an in-depth study, especially on barriers to implementing an effective RL system. Based on these problems, this study aims to analyze the RL system's barriers, especially in Indonesian construction machinery remanufacturing companies. In general, the barriers to implementing an effective RL system are categorized as internal and external barriers. Data gathering was carried out to identify internal and external barriers to implementing an effective RL system in construction machinery remanufacturing companies. This step was carried out through literature studies, interviews with academics and practitioners in the field of RL systems, and distributing questionnaires. Furthermore, the Analytical Hierarchy Process (AHP) approach ranks the barriers to implementing the RL system, which is a priority for construction machinery remanufacturing companies. This research contributes to a compilation of RL system barriers, especially in the construction machinery remanufacturing industry. The result analysis using AHP showed that the priority score of criteria activity front-end is the biggest.

Keywords: *Analytical hierarchy process, barriers, construction machinery remanufacturing, reverse logistics*

EMAIL

eviyulia103@itats.ac.id [1]
chrisna.suroso@itats.ac.id [2]

PUBLISHER

LPPM- Institut Teknologi Adhi Tama Surabaya
Address:
Arief Rachman Hakim Street No.100, Surabaya 60117,
Phone: 031-5997244

ABSTRAK

Meningkatnya kesadaran konsumen pada isu lingkungan, termasuk kesadaran akan menurunnya kapasitas tempat pembuangan akhir, menuntut industri untuk lebih fokus pada proses *reverse logistics* (RL). Implementasi proses ini memerlukan kajian yang mendalam terutama pada aspek hambatan agar perusahaan dapat menerapkan sistem RL yang efektif. Berdasarkan permasalahan tersebut, penelitian ini bertujuan untuk menganalisis hambatan penerapan sistem RL khususnya pada perusahaan remanufaktur mesin konstruksi di Indonesia. Secara umum, hambatan untuk menerapkan sistem RL yang efektif dikategorikan menjadi dua, yaitu: hambatan internal dan eksternal. Pengumpulan data dilakukan untuk mengidentifikasi hambatan internal dan eksternal terhadap penerapan sistem RL yang efektif di perusahaan remanufaktur mesin konstruksi. Langkah ini dilakukan melalui studi literatur, wawancara dengan pakar yang terdiri dari akademisi dan praktisi di bidang sistem RL, dan penyebaran kuesioner. Selanjutnya, pendekatan Analytical Hierarchy Process (AHP) dimanfaatkan untuk merangking hambatan penerapan sistem RL yang menjadi prioritas bagi perusahaan remanufaktur mesin konstruksi. Penelitian ini memberikan kontribusi pada kompilasi hambatan sistem RL, khususnya pada industri mesin konstruksi remanufaktur. Hasil analisis dengan menggunakan AHP menunjukkan bahwa nilai prioritas kriteria aktivitas front end memiliki nilai paling besar dibandingkan aktivitas yang lain. Sedangkan hambatan prioritas pada masing-masing aktivitas adalah sebagai berikut: kurangnya lokasi dimana konsumen dapat mengembalikan *used product (front end)*, teknologi dan infrastruktur green practice yang belom standar (*engine)* dan kurangnya saluran penjualan *(back end).*

Kata kunci: analytical hierarchy process, hambatan, remanufaktur mesin konstruksi, *reverse logistics*

INTRODUCTION

A waste, trash, and landfill problem in the metropolitan area with increasing population density encourage sustainable manufacturing. This concept is suitable for limited natural resource conditions. In the recent decade, issues related to reverse logistics (RL) and Closed-loop Supply Chain (CLSC) are increasing, accompanied by increasing consumer concern about the effect of environmental problems.

A manufacturing company with a forward supply chain based operation is often not responsible for its end of use product (end-of-use/EOU and end-of-life/EOL). The RL concept and CLSC appear as an answer to that problem. In the 90s, a researcher in the RL area found that this process benefits economics, social, and environmental aspects [1]. Economically, using and utilizing the used products in the production process can reduce the raw materials and total production costs. Meanwhile, corporate social responsibility (CSR) programs can see the social benefits. Moreover, the RL process also affects the environment, particularly in overcoming problems related to inadequate capacity for the final disposal and processing of particular waste. Some companies such as Xerox, IBM, and BMW successfully implement the RL process [2].

Nonetheless, the RL concept has major barriers before its implementation. RL system is a complicated process that needs detailed planning. Some barriers are lack of sufficient capable RL system, lack of attention from management, financial resources, and company policies. Those barriers influence the RL system individually and influence each other. Barriers identification influences the RL system able to help management implement this system. Analysis to determine the barrier priority can be an information resource for decision-makers to take the right action to solve a problem in implementing the RL system [3]. In this research, priority determination using the AHP approach. This method can know the decision-makers perception of who is the expert in the RL system.

The Indonesian Heavy Equipment Industry Association (HINABI) has around 45 members all over Indonesia. According to HINABI's data, in 2018, Indonesia succeeded in increasing heavy equipment production by as much as 42% compared to 2017. That growth affects the waste of heavy equipment, which is shown in 2019 construction sector has a market demand of as much as 35%. High investment in the heavy equipment industry increases the demand for the remanufactured product. Although, only around 10%-15% of HINABI members operate using the RL system.

The lack of a company that uses the RL system is influenced by its critical barriers. Government regulation such as specific constitution in the remanufacturing industry, logistics infrastructure, social condition, economic and environment, generates a big challenge for these industry players. Moreover, [4] illustrated that the RL system is a new concept in a developing country; however, it is different from the developed country where the RL system has the responsibility of industry players with clear regulations. Further research is still needed to identify the barriers to implementing the RL system in developing countries. As described above, this research aims to analyze critical barriers in implementing the RL system in the construction machinery remanufacturing industry in Indonesia.

LITERATURE REVIEW

American Reverse Logistics Executive Council describes RL as the planning process and controlling the flow of raw material from the consumer to the producer for value recovery or proper disposal [5]. In general, reverse logistics activity divide into three processes; return product management (front end), operational issues on the remanufacturing process (engine), and market development of a remanufacturing product (back end) [6]. Figure 1 shows each sub-process role.

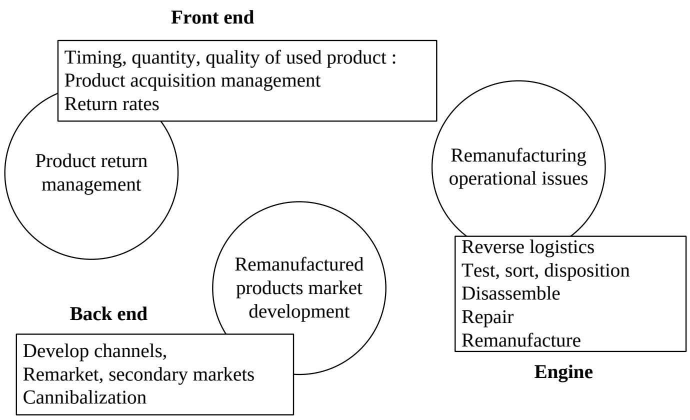

Figure 1. Reverse supply chain activities (source: [6])

Research related to RL by [7] is categorized into nine problem topics. Some of them are evaluation, survey, evaluation, conceptual framework, review, simulation, etc. RL's research topics of RL implemented on some industrial fields such as auto parts suppliers, vehicle manufacturer/remanufacturer and electronic&computer. Meanwhile, the RL field, which is mostly discussed, is related to remanufacturing, waste management, recycling, reuse, etc. The problem in decision making becomes a focused study in RL, which some of them are using the Analytical Hierarchy Process (AHP) as tools to achieve the aims in the research. AHP is one of the Multi-Criteria Decision Making (MCDM) methods that can create formulation and analyze decisions. Thomas Saaty introduced AHP in the 1970s. AHP method can detect a complex problem by using human perception as input so that this is reliable to process the quantitative and qualitative data [9].

Many papers used AHP to solve problems on macro-oriented or even managerial-subjective. Therefore, decision-making on supply chain management is the topic that AHP solves. The supply chain topic, which AHP has solved categorized into three: logistics and supply chain management, outsourcing dan managing stocks [10]. Problems related to logistics and supply chain management are supplier selection [7-8] and also another issue related to vendor selection [9-10]. Moreover, papers related to outsourcing, such as [15] which discussed decision making of outsourcing for an information system by using hybrid method between AHP and PROMETHEE, [16] discussed a problem of revenue management on the auctions internet by integrating the real options (RO) method, AHP, and Goal Programming (GP).

In the managing stock, fuzzy AHP was used by [17] to classify inventory on a small electrical appliances company. Therefore, [18] used integration pf fuzzy AHP and data envelopment analysis (FAHP-DEA) to efficiently control inventory items and define a proper regulation order by inventory classification ABC multi-criteria on the soft-drink biscuit production line. Moreover, [19] developed a hybrid method between AHP and K-means algorithm as a stage of decision making on the Multi-Criteria Inventory Classification (MCIC) problem.

METHODS

This stage explains the steps needed to achieve the aims. Those are data collecting and data processing by using the AHP approach. Each step is illustrated below:

Data Collection

The first step to do this research is data collection. The data collection is divided into two stages. The first stage is looking for information related to barriers facing construction machinery remanufacturing companies while implementing the RL system. The data was collected through literature review, survey, and interview. Barriers identification also considers two categories as internal barriers and external barriers [20]. Furthermore, the two categories of barriers are classified into three activity criteria according to the flow perspective process on the RL. Those are front-end, engine, and back-end [6]. The front-end aspect illustrated how company management gets the returned product from consumers. The engine aspect is how the company takes the recovery process for product return. Meanwhile, the back-end aspect is how the company understands market recovery products. Data are collected using a questionnaire. The questionnaires are formed in a pairwise comparison, which aims to get the information to process the data by using the AHP approach. The questionnaire is used to find out the barriers that significantly affect the implementation of the RL system in PT. ABC.

Data Processing using the AHP approach

AHP is a mathematics-based procedure that expresses both quantitative and qualitative data in pairwise comparison. An advantage of this method is the use of hierarchy structure as a consequence of the criteria and sub-criteria that have been chosen. It can also calculate the validity and inconsistency tolerance limit from various criteria and alternative which decision maker chooses. Therefore, this model is comprehensive decision making.

Stages within the AHP method

1. The Hierarchy Structure Arrangement
   In this stage, a problem will be created in a hierarchy form. Hierarchy is an abstraction of the system that learns about interaction function among the elements and the affection in the system. Each level of the hierarchy shows the character of elements in each level. The intermediate level shows criteria and sub-criteria, the lowest level shows the alternative decision, and the highest level shows purpose focus. Hierarchy framing or decision structure aims to illustrate the element of the system or alternative decision that has been identified.
2. Priority Setting
   The pairwise comparison on each criteria and its alternative compare each element with other elements on each hierarchy level in pairs. Therefore, a score of priority level will be provided in quantitative with rating score are below:

Tabel 1. Comparison of AHP Scale

Intensity (Importance)	Priority	Explanation
1	Equal	Same importance
3	Moderate	Element moderately favored than other
5	Strong	Element strongly favored than other
7	Very Strong	Element very strongly favored than other
9	Extreme	Element extreme important than other
2 , 4 , 6 , 8	Intermediate value between the adjective judgement	
Vice Versa	If activity I has one of the above numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	

   These scores will be processed to define the priority level from each alternative or relative rank from all alternatives.
3. Consistency
   AHP provides consideration to logical consistency from the evaluator. Consistency shows relation intensity among elements based on particular criteria. Inconsistency ratio is a mathematical calculation for each pairwise comparison, illustrating consistency deviation. Inconsistency ratio score must be lower than 0.10, which means that random consideration within the priority level rating for criteria or alternatives unlikely happens.

RESULT AND DISCUSSION

This part describes the analysis of reverse logistics implementations barriers at construction machinery remanufacturing company research results and its managerial implication overview. In this research, the study case was done at PT. ABC, which is located in East Jakarta. This company is experienced in its remanufacturing field for heavy equipment components such as excavators, bulldozers, and dump trucks.

Internal and External Barrier Identification

Based on the literature study, interviews, and surveys that have been done, we can identify 22 barriers, from both internal and external factors, that affect the RL implementation in PT. ABC. The internal barrier appears within the company; meanwhile, the external barrier comes from other parties, such as suppliers, distributors, third-party logistics (3PL), and consumers. A literature review was done using scientific data from reputable sources such as Springer, Elsevier, Emerald, Taylor, Francis, etc. In addition, interviews and surveys were done with the company's production unit staff as our respondents. The identified internal and external barriers are listed in Tables 2 and 3.

Table 2. Internal Barrier on Implementation of RL System

Code	Internal Barrier	References
B1	Lack of collection point	[21]
B2	Technology and infrastructure has not standardized	[22]
B3	High operational cost are needed	[23]
B4	Lack of support from organization and management	[24]
B5	The high complexity of the recovery process	[3]
B6	Special expertise from the human resource is needed	[25]
B7	Waste technology are needed	[26]
B8	No warranty	[27]
B9	Lack of consumer incentive	[28]
B10	Low inventory control	[29]
B11	Lack of sales channel	[30]
B12	Lack of product knowledge	[31]
B13	Lack of communication between the supplier of used product	[20]

Table 3. External Barrier on Implementation of RL System

Code	External Barrier	References
B14	Inconsistency of return product	[32]
B15	Legislative restriction	[33]
B16	Competition with the new product	[20]
B17	Low consumer perception of the quality of recovery product	[34]
B18	Lack of environmental awareness from the consumer	[35]
B19	Inconsistency of recovery product demand	[36]
B20	Inconsistency of *return product timing*	[37]
B21	Limitation of machine supplier for the recovery process	Survey
B22	Inconsistency of return product quality	[32]

Moreover, the two barrier categories are classified into three activity criteria based on the perspective flow process on the RL: front-end, engine, and back-end [6]. Front-end activity illustrates management activity to get the returned product from the consumer. Engine activity is a recovery process to product return. Meanwhile, the back-end aspect is how the company understands the product recovery. Academics' opinions become a consideration in the categorization of those barriers. The recapitulation of the three activities criteria can be seen in table 4. There are eight barriers categorized as front-end activity, ten barriers categorized as engine activity, and four barriers categorized as back-end activity.

Table 4. Barriers on Implementation of RL System in the Three Activities Criteria

Activity	Code	Barriers
Front-end	B1	Lack of collection point
	B9	Lack of consumer incentive
	B13	Lack of communication between the supplier of used product
	B14	Inconsistency of return product
	B15	Legislative restriction
	B18	Lack of environmental awareness from the consumer
	B20	Inconsistency of *return product timing*
	B22	Inconsistency of return product quality
Engine	B2	Technology and infrastructure has not standardized
	B3	High operational cost are needed
	B4	Lack of support from organization and management
	B5	The high complexity of the recovery process
	B6	Special expertise from the human resource is needed
	B7	Waste technology are needed
	B8	No warranty

Activity	Code	Barriers
	B10	Low inventory control
	B12	Lack of product knowledge
	B21	Limitation of machine supplier for the recovery process
Back-end	B11	Lack of sales channel
	B16	Competition with the new product
	B17	Low consumer perception of the quality of recovery product
	B19	Inconsistency of recovery product demand

The Hierarchy Structure of Priority Barrier Determination

The identification result of three criteria activity for barriers in the implementation of the RL system above becomes the basis hierarchy structure arrangement. Graphically, the hierarchy structure of AHP which is proposed as the determining model for priority barriers can be seen below in Figure 2:

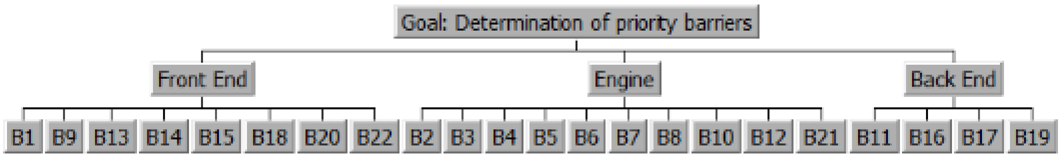

Figure 2. The Hierarchy for RL System Barriers Prioritization

Pairwise Comparison of Barriers on the Three Activity Criteria

Based on the hierarchy model above, the first step is to look for each activity criteria on RL system priority: front-end, engine, and back-end. Therefore, to measure the pairwise comparison consistency that the PT practitioner has given. ABC as a system player of RL, the inconsistency ratio was used. The inconsistency score allowed in this research is no more than 10%. Calculation of interest level was done by Expert Choice software. Table 5-8 shows the pairwise comparison for each criteria and each barrier in the specific criteria. The grading of each element used rules as shown in Table 1.

Inconsistency ratio calculation

Based on the pairwise comparison above, the inconsistency ratio is under 10% in all aspects. That score shows the pairwise comparison score which the facilitator gives is consistent. The inconsistency score which is found on each pairwise comparison are 0,05 ; 0,09; 0,09, and 0,06.

Determining of Barriers Priority on Three Activity Criteria

After the inconsistency ratio is fulfilled, the measurement of interest level should be done. The calculation was done by expert choice software. The calculation result of the interest level for criteria activity can be seen in Figure 3. Meanwhile, each activity's interest level can be seen in Figure 4 for determining priority on the front-end activity, Figure 5 for determining barrier priority on the engine activity, and Figure 6 for determining barrier priority on the back-end activity.

Figure 3. Priority of Activity Criteria on RL System

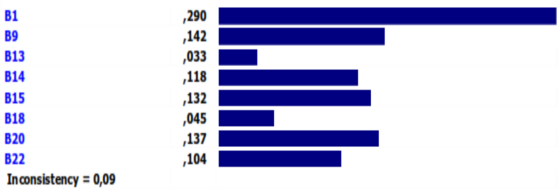

Figure 4. Priority of Barriers on Front-end Criteria

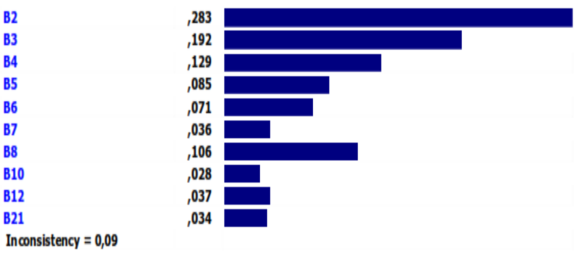

Figure 5. Priority of Barriers on Engine Criteria

Figure 6. Priority of Barriers on Back-end Criteria

The priority barrier on each activity criteria is: lack of collection point location (B1) on the front-end, technology and green practice infrastructure hasn't been standardized (B2) on the engine, and lack of seller line (B11) on the back-end.

Managerial Implication

Reverse logistics has been an interesting issue for the researcher in the last few decades due to the consumer and practitioner increasing concern, especially on the environmental problems which often happens. Management and stakeholders need support to eliminate the priority barriers to implementing the RL system. This study responds to the issues that correlated with barriers to implementing the RL system, especially in construction machinery remanufacturing companies.

In this research, 22 barriers are found, divided into an internal and external categories. In contrast, the internal barriers show the difficulty experienced by remanufacturing companies in implementing the RL system. Meanwhile, the external barrier is related to the stakeholders' problems. Therefore, by some consideration of academics, the barriers are categorized by the activity of the RL system. There were eight barriers in the front-end activity, 10 in the engine activity, and 4 in the back-end activity.

The analysis result using AHP from the pairwise comparison questionnaire obtained the activity front-end has the highest level of interest (score = 0,559) related to the implementation of the RL system. The front-end shows the activity of a remanufacturing company to get the returned product is the critical barrier for the company. Two of the three barriers that have the highest level of interest in implementing the RL system came from this activity. They lack a collection point location where consumers return the used product (B1) and lack incentive for the consumer (B9). It is the same with [38] that on the RL system implementation, the election of the structural relationship between a remanufacturing company and customer defines the success of front-end activity performance, so a proper strategy is needed to guarantee sustainability RL system operational.

Meanwhile, the rest of the engine activity, the technology and green practice infrastructure haven't been standardized (B2). The three barriers are identified as internal barriers. Therefore, the handling should be easier because it is the company's responsibility, which is fully authorized in the sustainability of the implementation. However, coordination and collaboration among stakeholders are still needed due to each part's involvement in the implementation of the RL system.

In the construction machinery remanufacturing industry, the company needs green practice-based technology and infrastructure to recover major and minor heavy equipment components. A reverse logistics process is initiated when the consumer returns the used product to the collection point. Determinating the collection point location is a strategic decision. The different company strategies will affect the determination of collection point location. A company with an efficient strategy will locate the collection point near the workshop, where some tools or infrastructure for component recovery is placed. Otherwise, a company by responsive strategy will put the collection point nearby of heavy equipment user this ease consumer in return of the used product with big and heavy size. Management commitment is needed to solve the collection point location problem so that consumer awareness to return the used product is accommodated. The collection point location problem relates to the company need for raw materials in the RL process to be maintained.

CONCLUSION

According to the result, some conclusions can be settled. Implementation of the RL system in the construction machinery remanufacturing industry needs coordination from internal and external parties. The identification process of barriers in implementing the RL system, especially on the construction machinery remanufacturing company, is quite complex. This result outlines the hierarchy structure as benchmarking result from experts, which ease the decision-maker to eliminate the priority barriers. A Literature review was done to expose all barriers to implementing the RL system in the construction machinery remanufacturing industry.

The recapitulation result generates 22 barriers that should eliminate to implement the RL system effectively. Eight barriers are on front-end activity criteria, ten are on engine activity criteria, and four are on back-end activity criteria. In the early implementation stage, it is impossible to eliminate all the barriers at once. Therefore, the decision-maker should identify the main barriers that should eliminate, considering their effect on the implementation of the RL system. AHP approach aims to rank 22 barriers according to the expert's assessment in PT. ABC. The result of the research shows three main priority of barriers in each activity are: lack of location where consumers can return the used product (front-end), technology and green practice infrastructure that has not been standardized (engine), and lack of incentives that consumer gets (front-end).

Similar to other research, this research has some limitations. The involvement of barriers category on implementation of RL system are expandable to other aspects, so that hopefully able to identify a phenomenon that hasn't been identified in this research. Moreover, the following study can be directed into analysis related to an alternative solution for management to resolve the identified barriers.

In this research, the AHP approach's barriers analysis generates a structural model that involves quantitative and qualitative attributes. However, the mathematical model developed hasn't been statistically proven. The researcher can expand further research opportunities by implementing the Structural Equation Modelling (SEM) approach to examine the model validity. Furthermore, the following research should also implement the Interpretive Structural Modelling (ISM), which could expand the showing the structural relations within the barriers of RL system implementation.

REFERENCES

[1] M. Matsumoto and W. Ijomah, "Handbook of Sustainable Engineering," *Handb. Sustain. Eng.*, pp. 1149–1173, 2013.
[2] R. Ayres, G. Ferrer, and T. Van Leynseele, "Eco-efficiency, asset recovery and remanufacturing," *Eur. Manag. J.*, vol. 15, no. 5, pp. 557–574, 1997.
[3] S. K. Sharma, B. N. Panda, S. S. Mahapatra, and S. Sahu, "Analysis of Barriers for Reverse Logistics: An Indian Perspective," *Int. J. Model. Optim.*, vol. 1, no. 2, pp. 101–106, 2011.
[4] T. Zhang, J. Chu, X. Wang, X. Liu, and P. Cui, "Development pattern and enhancing system of automotive components remanufacturing industry in China," *Resour. Conserv. Recycl.*, vol. 55, no. 6, pp. 613–622, 2011.
[5] D. and Rogers and R. Tibben-Lembke, *Going Backwards : Reverse Logistics Trends and Practices*. 1998.
[6] V. D. R. Guide and L. N. Van Wassenhove, "The Evolution of Closed-Loop Supply Chain Research," *Oper. Res.*, vol. 57, no. 1, pp. 10–18, 2009.
[7] 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.
[8] J. Heydari, K. Govindan, and A. Jafari, "Reverse and closed-loop supply chain coordination by considering government role," *Transp. Res. Part D Transp. Environ.*, 2017.
[9] T. L. Saaty, *Fundamentals of Decision Making and Priority Theory With The Analytic Hierarchy Process*. Pittsburgh, PA: RWS Publications, 2000.
[10] N. Subramanian and R. Ramanathan, "A review of applications of Analytic Hierarchy Process in operations management," *Int. J. Prod. Econ.*, vol. 138, no. 2, pp. 215–241, 2012.
[11] T. J. Kull and S. Talluri, "A supply risk reduction model using integrated multicriteria decision making," *IEEE Trans. Eng. Manag.*, vol. 55, no. 3, pp. 409–419, 2008.
[12] A. Zouggari and L. Benyoucef, "Simulation based fuzzy TOPSIS approach for group multi-criteria supplier selection problem," *Eng. Appl. Artif. Intell.*, vol. 25, no. 3, pp. 507–519, 2012.
[13] S. Koul and R. Verma, "Dynamic vendor selection based on fuzzy AHP," *J. Manuf. Technol. Manag.*, vol. 22, no. 8, pp. 963–971, 2011.
[14] A. N. Haq and G. Kannan, "Fuzzy analytical hierarchy process for evaluating and selecting a vendor in a supply chain model," *Int. J. Adv. Manuf. Technol.*, vol. 29, no. 7–8, pp. 826–835, 2006.
[15] J. J. Wang and D. L. Yang, "Using a hybrid multi-criteria decision aid method for information systems outsourcing," *Comput. Oper. Res.*, vol. 34, no. 12, pp. 3691–3700, 2007.
[16] W. H. Tsai and S. J. Hung, "Dynamic pricing and revenue management process in Internet retailing under uncertainty: An integrated real options approach," *Omega*, vol. 37, no. 2, pp. 471–481, 2009.
[17] O. Cakir and M. S. Canbolat, "A web-based decision support system for multi-criteria

inventory classification using fuzzy AHP methodology," *Expert Syst. Appl.*, vol. 35, no. 3, pp. 1367–1378, 2008.
[18] A. Hadi-Vencheh and A. Mohamadghasemi, "A fuzzy AHP-DEA approach for multiple criteria ABC inventory classification," *Expert Syst. Appl.*, vol. 38, no. 4, pp. 3346–3352, 2011.
[19] F. Lolli, A. Ishizaka, and R. Gamberini, "New AHP-based approaches for multi-criteria inventory classification," *Int. J. Prod. Econ.*, vol. 156, pp. 62–74, 2014.
[20] P. González-Torre, M. Álvarez, J. Sarkis, and B. Adenso-Díaz, "Barriers to the implementation of environmentally oriented reverse logistics: evidence from the automotive industry sector," *Br. J. Manag.*, vol. 21, no. 4, pp. 889–904, 2010.
[21] S. K. Srivastava, "Value recovery network design for product returns," *Int. J. Phys. Distrib. Logist. Manag.*, vol. 38, no. 4, pp. 311–331, 2008.
[22] S. Luthra, V. Kumar, S. Kumar, and A. Haleem, "Barriers to implement green supply chain management in automobile industry using interpretive structural modeling technique-an Indian perspective," *J. Ind. Eng. Manag.*, vol. 4, no. 2, pp. 231–257, 2011.
[23] S. Luthra, D. Garg, and A. Haleem, "An analysis of interactions among critical success factors to implement green supply chain management towards sustainability: An Indian perspective," *Resour. Policy*, 2015.
[24] C. Walsh and P. Thornley, "Barriers to improving energy efficiency within the process industries with a focus on low grade heat utilisation," *J. Clean. Prod.*, vol. 23, no. 1, pp. 138–146, 2012.
[25] G. C. Wooi and S. Zailani, "Green Supply Chain Initiatives: Investigation on the Barriers in the Context of SMEs in Malaysia," *Int. Bus. Manag.*, vol. 4, no. 1, pp. 20–27, 2010.
[26] M. D. Abdulrahman, A. Gunasekaran, and N. Subramanian, "Critical barriers in implementing reverse logistics in the Chinese manufacturing sectors," *Int. J. Prod. Econ.*, vol. 147, no. PART B, pp. 460–471, 2014.
[27] C.-H. Wu, "Price and service competition between new and remanufactured products in a two-echelon supply chain," *Int. J. Prod. Econ.*, vol. 140, no. 1, pp. 496–507, Nov. 2012.
[28] S. Statham, "Remanufacturing – Towards a More Sustainable Future," *Electron. Enabled Prod. Knowledge-trans. Netw.*, pp. 1–24, 2006.
[29] S. Barker and A. King, "Organizing reuse: managing the process of design for remanufacture (DFR)," *Proc. POMS 18th Annu. Conf.*, no. 007, 2007.
[30] N. Choudhary and N. K. Singh, "Remanufacturing in India: Approaches, Potentials & Technical challenges," *Int. J. Ind. Eng. Technol.*, vol. 3, no. 3, pp. 223–227, 2011.
[31] R. Subramoniam, D. Huisingh, and R. Babu, "Remanufacturing for the automotive aftermarket-strategic factors : literature review and future research needs," *J. Clean. Prod.*, vol. 17, no. 13, pp. 1163–1174, 2009.
[32] M. R. Galbreth and J. D. Blackburn, "Optimal acquisition quantities in remanufacturing with condition uncertainty," *Prod. Oper. Manag.*, vol. 19, no. 1, pp. 61–69, 2010.
[33] S. Liu, D. Kasturiratne, and J. Moizer, "A hub-and-spoke model for multi-dimensional integration of green marketing and sustainable supply chain management," *Ind. Mark. Manag.*, vol. 41, no. 4, pp. 581–588, 2012.
[34] M. S. Bhatia and R. K. Srivastava, "Resources , Conservation & Recycling Analysis of external barriers to remanufacturing using grey-DEMATEL approach : An Indian perspective," *Resour. Conserv. Recycl.*, vol. 136, no. February, pp. 79–87, 2018.
[35] J. Zhao, "Whither the car? China's automobile industry and cleaner vehicle technologies," *Dev. Change*, vol. 37, no. 1, pp. 121–144, 2006.
[36] K. Govindan, M. Kaliyan, and D. Kannan, "Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process," *Intern. J. Prod. Econ.*, vol. 147, pp. 555–568, 2014.
[37] S. Mondal and K. Mukherjee, "An empirical investigation on the feasibility of remanufacturing activities in the Indian economy," *Int. J. Bus. Environ.*, vol. 1, no. 1, pp. 70–88, 2006.
[38] E. Yuliawati, P. Pratikto, S. Sugiono, and O. Novareza, "A Review of Structural

Relationships in Closed-Loop Supply Chain Model," *IPTEK J. Proc. Ser.*, vol. 0, no. 6, pp. 90–97, 2018.