A Review of the Criteria and Methods of Reverse Logistics Supplier Selection

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Abstract: This article presents a literature review on reverse logistics (RL) supplier selection in terms of criteria and methods. A systematic view of past work published between 2008 and 2020 on Web of Science (WOS) databases is provided by reviewing, categorizing, and analyzing relevant papers. Based on the analyses of 41 articles, we propose a three-stage typology of decision-making frameworks to understanding RL supplier selection, including (a) establishment of the selection criteria; (b) calculation of the relative weights and ranking of the selection criteria; (c) ranking of alternatives (suppliers). The main discoveries of this review are as follows. (1) Attention to the field of RL supplier selection is increasing, as evidenced by the increasing number of papers in the field. With the adaption of circular economy legislation and the need resource and business resilience, it is expected that RL and RL supplier selection will be a hot topic in the near future. (2) A large number of papers take "sustainability" as the theoretical approach to carry out research and use it as the basis for determining the criteria. (3) Multi-criteria decision making (MCDM) methods have been widely used in RL supplier selection and have been constantly innovated. (4) Artificial intelligence methods are also gradually being applied. Finally, gaps in the literature are identified to provide directions for future research. (5) Value-added service is underrepresented in the current study and needs further attention.

Keywords: reverse logistics; supplier selection; MCDM; sustainability

1. Introduction

In recent years, reverse logistics (RL) has attracted increasing attention from researchers and industrialists due to the fact that it can recover the surplus value of end-of-life (EOL) products, meet environmental requirements and attach importance to customers' rights and interests [1]. The earliest widely accepted definition of reverse logistics was proposed by Rogers and Tibben-Lembke [2]: "RL is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal". Nowadays, environmental protection and development problems are a severe issue at the global scale; with the growth of population and the consumption of natural resources, implementing reverse logistics activities will soon become a "must" for many organizations. RL can achieve a viable and appropriate balance between the economy and the environment. In this way, it enables companies to generate profits and protect the environment through value retention of second-hand goods [3]. However, RL is a key problem in the closed-loop supply chain [4]. The supply chain management for RL mainly includes three aspects, namely, products, suppliers and raw materials. Among them,

the evaluation and selection of suppliers is an important strategic decision to reduce operation costs, improve enterprise competitiveness and develop more business opportunities [5,6]. In recent years, the selection of suppliers has gradually become a problem with research value in reverse logistics practice. Issues include how to choose a third-party reverse logistics provider (3PRLP) when manufacturers want to implement remanufacturing activities and how electronics companies should choose recycling partners when recycling waste electrical and electronic equipment (WEEE).

There are many factors that prompt enterprises to implement RL, including stakeholders' concern about the environment, government's regulations on RL, cost effectiveness and sustainable development, etc., all of which contribute to the effective and efficient development of an enterprise [7]. In the current situation, the performance of an enterprise in a supply chain depends not only on its own performance but is also affected by the social performance and environmental performance of its partners. Any adverse effects produced by the other members of the supply chain could have negative effects on the enterprise [8]. Therefore, for enterprises involved in RL activities, whether they want to obtain better economic benefits or social prestige, there is a need to seriously evaluate and choose the suppliers they cooperate with. Under the buyer–supplier relationship, the primary problem that should be solved when choosing a supplier is often to achieve the ultimate goals of the buyer, such as maximizing economic benefit or achieving optimal environmental impact. Therefore, in RL practice, it is crucial to understand what theories and standards should be adopted and what methods should be employed to select partners to better achieve their goals. In this respect, the decisions mainly include supplier selection and supplier evaluation.

Few existing literature reviews on RL were focused on the analysis of supplier evaluation. For example, Govindan and Soleimani conducted a comprehensive review of the forefront areas of reverse logistics and closed-loop supply chains in clean production journals. The author did not take into account the aspect of suppliers in evaluation and decision; instead, their main focus was on manufacturing processes and remanufacturing processes. Govindan and Soleimani found that, between 2001 and 2014, RL research was mainly divided into eight categories, including general studies, remanufacturing, waste management, recycling, reuse, recovery, disassembling, and remanufacturing-recycling investigations [4]. Govindan et al. conducted a systematic review of 382 papers on RL and closed-loop supply chains published in scientific journals from January 2007 to March 2013 and found that 3PRLP selection accounted for only 2.9% of the total 382 papers. This means that, as the main supplier of RL, 3PRLP did not get much attention [9]. Prajapati et al. selected 449 related articles that respectively included the word "reverse logistics" in the title abstract and keywords and classified these articles into 11 different categories according to their structure and content. Although this category was not selected by 3PRLP, the author found that researchers often applied different multi-criteria decision-making (MCDM) technologies to help decision makers complete the decision when selecting suppliers. In all the literatures, there were 23 different MCDM technologies, among which the analytic hierarchy process (AHP) or fuzzy analytic hierarchy process (FAHP) was the most widely used method in the literature [7]. Aguezzoul reviewed the criteria and methods of third-party logistics (3PL) decision making. In terms of third-party logistics selection criteria, the author identified 11 key criteria, and found that cost was the most adopted criterion, followed by relationship service and quality. In terms of third-party logistics evaluation methods, this paper divides them into five categories: MCDM technical statistical methods, artificial intelligence mathematical programming and hybrid methods. In the conclusion, this paper pointed out that the study of third-party logistics choice is less theoretical and needs a more comprehensive conceptual framework, with a qualitative and quantitative combination [10]. Islam and Huda drew the conclusion that further research should be carried out in the area of 3PRLP selection [11].

In view of the existing research gaps in RL and third-party supplier selection, this paper makes a comprehensive review of the literature on two topics, including RL supplier evaluation and selection. This paper will also refer to the three stages of the decision-making process proposed in [8] to analyze and study the RL supplier question.

This article is structured as follows: Section 2 introduces the theoretical background, moving from logistics to RL and finally to RL supplier selection, as well as the steps of RL supplier selection which serve as the background of the literature review typology. Section 3 introduces research methodology and processes. Section 4 classifies and analyzes the selected sample of papers according to the selection process for RL suppliers. Finally, the conclusions of this paper and the limitations of this study are summarized, and suggestions for future research are given.

2. Theoretical Background

2.1. Background on RL

Logistics as an activity has a long history, but as a discipline it has only developed for a few decades. In 1918, an instant delivery corporation was established in the United Kingdom to deliver goods to wholesalers, retailers and consumers in a timely manner throughout the country. This activity is praised by some logistics scholars as an early document of logistics activities. During WWII, the United States first adopted the term "logistics management" in wartime arms supply from the perspective of military needs, and comprehensively managed the transportation and supply of arms. After WWII, the term "logistics" was borrowed by Americans into the management of enterprises, and was called "business logistics". Japan introduced the concept of "logistics" in the 1960s and interpreted it as "the circulation of goods". The concept of logistics varies from country to country, institution to institution, and period to period. In 1999, the United Nations logistics commission made a new definition of logistics. It pointed out that logistics is a process that realizes and controls the effective flow and storage of raw material inventory, final products and related information from the beginning to the end in order to meet the needs of consumers.

Since the 1990s, many countries in the world began to pay attention to the environment and raw material resources, which means RL has gradually received more attention [12]. RL has been proved to be beneficial to the economic situation and social image of enterprises; Jayaraman and Luo note that many of the things that companies dispose of, such as product waste resources, are actually valuable [13]. In a closed-loop supply chain, reverse flow can bring competitive advantage to enterprises. If enterprises fail to realize the importance of reverse logistics strategy, customer relations might be in jeopardy, which put them at a disadvantaged position in market competition. The value of reverse logistics has been reflected in many industries, such as the carpet industry [14], retail industry [15], bottling sector [16], paper industry [17], packaging industry [18], cell phone industry [19], pharmaceutical industry [20], and battery recycling industry [21]. Thus, it can be seen that reverse logistics has research significance in various degrees, whether it is the study of theory, such as what benefits it can bring to the enterprise, or the study of practice, such as how it should be applied in various fields. As for the manufacturing industry, studies on machining systems [22] and performance evaluation [23] are relatively mature, while there are relatively fewer studies on the combination of remanufacturing with RL.

According to the research conducted by Rachih et al., the process of RL can be described as collection, inspection and sorting, and the last step is re-processing [24]. Product recovery is the first step and also a key step in establishing an effective and profitable reverse logistics system [12]. 3PRLP has a better ability to respond to the complexity and randomness of the supply chain as well as the professionalism of reverse logistics activities [25], which makes the third-party collection model widely used. However, there are still three main collection modes—third-party take-back (TPT), manufacturer take-back (MT), and retailer take-back (RT)—which means manufacturers, retailers and 3PRLP can all act as reverse logistics suppliers. Moreover, the objectives of different types of supply chains are not the same, and different companies in different industries hope to get different benefits from reverse logistics activities [26]; the business scope and capabilities of each RL service provider are also different, which means that most enterprises will face a decision to choose the best RL supplier. Govindan et al. indicate that, if the reverse logistics system is operated effectively, it could be the main source of benefits [27]. Therefore, the selection of reverse logistics suppliers becomes one of the most

important activities in the entire supply chain system, due to the fact that enterprises tend to outsource reverse logistics activities in order to focus on core business operation.

2.2. Literature Review Typology

In this literature review, the articles are categorized according to a three-stage process of supplier selection, created through the synthesis of Govindan [27], Kumar and Dixit [28] and Liu et al.'s [29] frameworks (see Figure 1). The three stages are: (A) establishment of the selection criteria; (B) calculation of the relative weights and ranking of the selection criteria; (C) ranking of alternatives (suppliers).
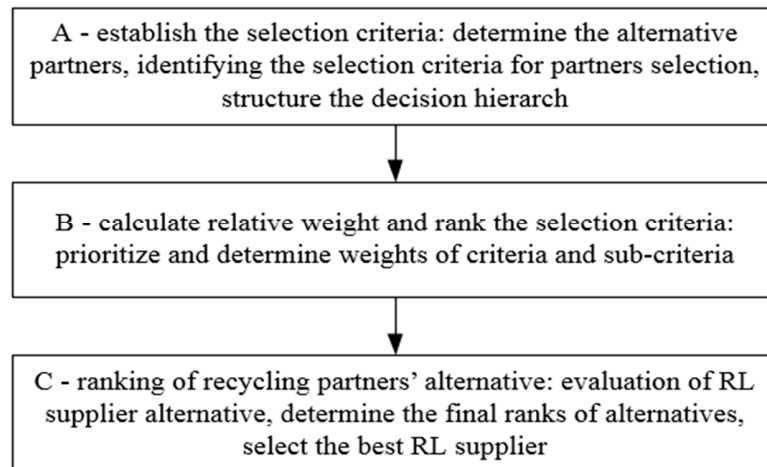

Figure 1. RL supplier selection process.

The starting point for this research is that the awareness of environmental protection and the concept of sustainable development in society are constantly improving, and understanding of the importance of reverse logistics in various industries is increasing year by year. In particular, with the stringent government environmental legislation implemented worldwide, the choice of suppliers has become an important issue for enterprises. In order to meet the demand of logistics activities in the supply chain and realize the requirements of environmental friendliness, enterprises tend to choose RL suppliers that can best match their own demand and maximize economic and environmental benefits. To understand the selection and evaluation of suppliers in RL activities, Kumar and Dixit [28] and Liu et al. [29]'s frameworks were studied, all of which started with the establishment of selection criteria (the Stage A). The completion of this stage usually requires a certain amount of literature review for support and expert opinion from the field of expertise as a reference [28]. As for the methods, these include, but are not limited to, Delphi and brainstorming methods. Determining the selection criteria is a complex and deliberate process, as each enterprise has different expectations. For example, Liu et al. [29] applied the triple bottom line (TBL) to establish sustainable supplier criteria. For the social aspect, it is necessary to meet the needs of customers as far as possible. For the economic aspect, it is necessary to make plans to reduce costs and maximize profits. For the environment aspect, it is required to consider resource consumption and waste disposal in actual activities, so as to minimize negative impact on the environment. These three aspects have their own sub-criteria, and there will be trade-offs when determining the indicator system under different circumstances.

At Stage B, which is to calculate the relative weight of the criteria, Kumar and Dixit explain that, due to the uncertainty in practical problems and the fuzziness of the criteria, it is usually necessary to combine the common evaluation method with the fuzzy theory to get a more reliable ranking of the criteria [28]. Liu et al. argued that a mixed model of the two evaluation methods can achieve roughly the same effect [29]. Govindan et al. used a systems analysis approach to deal with the criteria, but it is clear that the contextual relationships between these variables (criteria) are subject to the personal preferences of the decision makers, and their personal biases may affect the final result [27]. Therefore,

Stage B will analyze the applicability of various approaches to the relationship between criteria with consideration of the subjectivism of the criteria.

At Stage C, ranking methods are used to rank alternatives to make the final choice. In many cases, the hybrid method formed by combining the two phases B and C is called the MCDM method, or it forms a new hybrid MCDM framework. The MCDM method has been widely used, especially in research in the manufacturing industry which is closely related to reverse logistics [30,31]. At this stage, various ranking methods are applied to evaluate and sort the alternatives according to the processed criteria in order to select the best RL supplier.

3. Research Methodology

A valid literature review can improve knowledge of related fields by identifying patterns, themes and issues as well as identifying key concepts that work as a path to new theoretical developments and new directions of research [32,33]. Islam and Huda define a literature review as having four steps: material collection, descriptive analysis, category selection and, finally, material evaluation to support the topic [11]. A valuable literature review can summarize past research in the field and point out potential research directions in the future.

In this study, material collection is accomplished by a two-phase process. For the first phase, refer to the search method in [8]; articles in the Web of Science (WOS) database were searched using the terms ("reverse logistics" AND "evaluation" AND "supplier") in the title, abstract and keywords (at least one of the three elements should include the search terms). Although the range of dates searched is not limited, no papers were found from before 2005. The reason may be that the logistics industry was immature at that time, which led to little research on reverse logistics. Papers published after April 2020 are not included, as the final updated data were completed on this date.

In the second phase, based on the work of Alexander et al. [34], two exclusion criteria—semantic relevance and relevance to the research problem—were used to filter articles. Semantic relevance refers to the different meanings a word may have in different contexts. For example, "reverse logistics" and "selection" can capture articles that refer to the selection of reverse logistics recovery methods or modes [35]; "reverse logistics" and "evaluation" can include articles that refer to evaluation of reverse logistics barriers or performance. Such articles had to be excluded. Relevance to the research problem means that, in order to determine the relevance of an article's topic, the entire content of the article has to be reviewed, as the title or abstract may not present these contents clearly. After reviewing these papers, 41 of the 107 articles were ultimately selected for the review using the exclusion criteria.

4. Analysis

This section conducts a descriptive analysis of the selected papers and then categorizes these articles according to the three stages described in Section 2.2 and Figure 1.

4.1. Descriptive Analysis

The number of articles published each year is shown in Figure 2. From Figure 2, we can see that the first article about RL supplier selection was published in 2008; thus, the articles selected for this review were published between 2008 and 2020. Starting in 2015, the number of relevant articles has increased, and the growth rate has increased rapidly in the past two years. There were 11 articles published in 2019 and 7 in 2018, but no articles related to the topic were found among the articles published in 2010. It should be noted that the number of articles for 2020 is not complete, and there may be further growth after data collection.
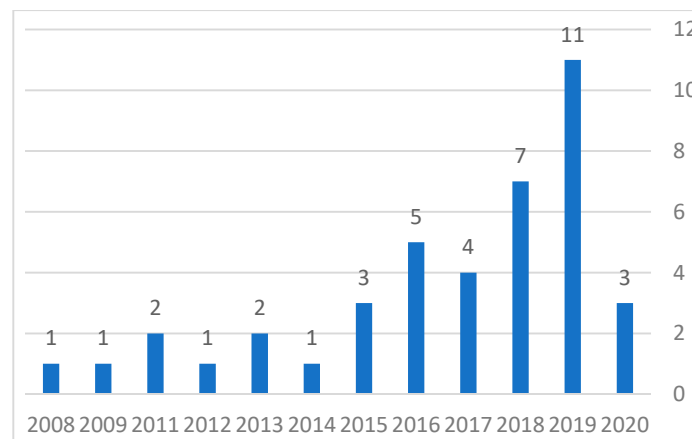
Figure 2. Number of papers per year.

Among the 41 articles, 12 were from the *Journal of Cleaner Production* (Table 1), which is the journal with the most published articles, accounting for 29%, followed by the *International Journal of Advanced Manufacturing Technology* (10%). The top contributing countries are shown in Table 2. (Since many articles are jointly published by scholars from multiple countries, only the countries of the first author of the articles are listed, and Table 2 only shows countries with more than three published articles.) India has the largest number of publications on the subject (15), followed by China (10). In addition, some articles are based on studies of enterprises in particular countries (Table 3). Overall, 14 articles chose Indian companies for case studies, 7 articles chose Iranian companies and 6 chose Chinese companies. The logistics industry in India has been developing rapidly due to its rapid economic growth, which has prompted more research on RL subjects in India. The implementation of circular economy promotion laws in China might be a driving force for the interest and the number of papers in China.

Table 1. List of journals and number of papers.

Journals	References	N.
Journal of Cleaner Production	[1,3,28,29,36–43]	12
International Journal of Advanced Manufacturing Technology	[44–47]	4
Applied Soft Computing	[48,49]	2
Expert Systems with Applications	[50,51]	2
Resources Conservation and Recycling	[27,52]	2
Annals of Operations Research	[53]	1
Computers Industrial Engineering	[54]	1
Computers Operations Research	[55]	1
Environment Development and Sustainability	[56]	1
International Journal of Information Technology Decision Making	[57]	1
International Journal of Production Economics	[58]	1
International Journal of Production Research	[59]	1
International Journal of Productivity and Performance Management	[60]	1
International Journal of Shipping and Transport Logistics	[61]	1
Journal of Environmental Management	[62]	1
Journal of Grey System	[63]	1
Journal of Intelligent Fuzzy Systems	[64]	1
Jurnal Teknologi	[65]	1
Mathematics	[66]	1
Omega International Journal of Management Science	[67]	1
Opsearch	[68]	1
Production Planning Control	[69]	1
Sustainability	[70]	1
Sustainable Production and Consumption	[71]	1

Table 2. Contributions by country.

Country	Number of Papers
India	15
China	10
Denmark	9
Iran	9
USA	5
Australia	3
Canada	3

Table 3. Number of articles for particular countries.

Country	Number of Papers
India	14
Iran	7
China	6
Brazil	2
USA	1
Korea	1
France	1

The top 10 most-cited articles were identified among the 41 articles analyzed (See Table 4), three of which were published in *the Journal of Cleaner Production. Resources Conservation and Recycling* published the most-cited articles, while the article with the highest average annual citation rate [42] was published in the *Journal of Cleaner Production.*

Table 4. Most cited articles.

References	Journal	Citations	Year of Publication	Average Citations/Year
[27]	Resources Conservation and Recycling	259	2009	21.58
[42]	Journal of Cleaner Production	176	2017	44.00
[58]	International Journal of Production Economics	171	2012	19.00
[54]	Computers & Industrial Engineering	138	2008	10.62
[50]	Expert Systems with Applications	85	2014	12.14
[41]	Journal of Cleaner Production	65	2018	21.67
[49]	Applied Soft Computing	64	2016	12.80
[51]	Expert Systems with Applications	60	2011	6.00
[43]	Journal of Cleaner Production	54	2015	9.00
[59]	International Journal of Production Research	50	2011	5.00

Each article is categorized based on the three stages of the RL supplier selection process, as described in Figure 1 (see Table 5). The following section describes the findings and analysis of these stages; the theories and methods used in each stage in the papers are discussed in detail in Section 4.2 to Section 4.4. It is important to note that [42] is discussed in a particular section as its content is a conceptual framework.

Table 5. Articles according to the three stages of the process.

References	Stages	No.
[1,3,27–29,36–45,47,48,50–54,56,57,59,61,63,64,66–71]	A, B and C	34
[46,49,58,62,65]	A and B	5
[55]	A and C	1
[60]	A	1

4.2. Stage A: Establish the Selection Criteria

In terms of the theoretical approaches used in the 41 articles selected, researchers mainly focus on "sustainability", which is utilized in 18 papers. Six papers use green supply chain management (GSCM) to investigate how to select RL suppliers. "Green" focuses more on the environment aspect than "sustainability". In addition, only one article uses circular economy (CE), which focuses more on the economic aspect than "sustainability". The remaining half mainly apply two theories to complete the classification of criteria. Of these, 11 papers summarize several "performance dimensions" [57] based on the business capabilities of the RL supplier. Organizational performance, RL Functions, IT application, service quality and user satisfaction are the most commonly used main groups. Four papers consider firms' requirements and operating strategies [36] to complete the classification of criteria. One article completes the criteria classification through strengths–weaknesses–opportunities–threats (SWOT) analysis [49] (Table 6).

Table 6. Theory of criteria classification.

Theory	References	No.
Sustainability	[3,29,38,42–45,48,53,55,56,60,62,64,66–68,70]	18
Performance dimensions	[27,40,46,47,50,52,57–59,61,65]	11
GSCM	[28,37,39,41,54,69]	6
Firm's requirements and operating strategy	[36,51,63,71]	4
SWOT	[49]	1
CE	[1]	1

Generally identifying the most-used criteria to select the 3PRLP was based on a systematic literature review (SLR), and several papers proposed a similar set of criteria: forward logistics; reverse logistics; financial; capacity; environmental; alliances [43,50,57,65]. In addition, different main parameters determine the selection process for an appropriate 3PRLP in different situations. Some of these parameters are common, such as the use of third-party logistics [46], service quality and service ability [63], and application of information technology [28,47,58], and some are used in special cases, like noise pollution [36]. Both Li et al. [40] and Prakash and Barua [52,71] consider firms' requirements and operating strategies. Momeni et al. [61], P.Sasikumar and A.Noorul Haq [59] determine the criteria according to the process of reverse logistics.

Sustainability is a popular research topic; many articles divide criteria into three categories, reflecting their impacts on society, economy and environment, respectively. The specific criteria, from economic, social and environmental perspectives according to previous sustainable/green practices and literature reviews, are explored [38,62,67]. Silva et al. define EES (economic, environmental and social) considerations as the three dimensions of sustainable development [8]. It should be noted that ISO14000 is often used as a reference for formulation of environmental criteria. Some authors add the consideration of risk, which includes operational risk and financial risk [48,66,68]; sometimes safety practices and health, along with compliance with the International Labour Organization (ILO) code [53] or respect for local rules and policies [45] are grouped together into the category of social factors. In the following research, Zarbakhshnia et al. [3] improve "risk and safety" by using the Delphi method to update the content of the criteria, and add two sub-criteria—organizational risk and safety— into the new dimension of "risk and safety". Garg et al. [56] take all sustainable outsourcing partners (SOPs) as alternative objects; reverse logistics and waste minimization are regarded as sub-criteria under the aspect of environmental factors, in which practices recovering materials, minimization of waste and disposal in an environmental friendly way are emphasized. Liu et al. [29] transform the criteria of the three sustainability dimensions based on customer needs (CNs) into engineering characteristics (ECs), which have nine criteria, including reverse logistics. Bai and Sarkis summarize cost, quality,

time, flexibility, and innovativeness as five economic/business attributes that can be considered from a sustainability perspective [55].

The papers also link a range of other criteria to RL supplier selection. Pourjavad et al. divides the crucial criteria of 3PRLP selection into environmental, social and cost [64]. The cost criteria consists of the quality of products, value-added services, transport capacity and level of advanced equipment. Jung [70] set social sustainability as the main aspect, with focuses on three social criteria: philanthropy, average salary and management policy.

When selecting suppliers in the sustainable supply chain, both the collection capability as well as green technology capability are considered [44]; others employ waste management and pollution prevention as evaluation criteria [42]. Gardas et al. add the "sustainable eco-friendly process/recycling" to the 3PLP selection criteria of the pharmaceutical industry [60]. Govindan et al. developed a model for circular supplier selection, in which three criteria are identified: quality, on-time delivery and circularity, among which the sub-criterion "environmental standards" requires suppliers to utilize environmental standards to recycle products [1].

Chatterjee et al. present the dimensions and corresponding criteria of the GSCM, including green design, green production, green warehousing, green transportation and green purchasing [41]. Tosarkani and Amin added "social-cultural enablers" to various criteria, representing green logistics practices [39]. EES assessment is also cited by some authors to select reverse logistics centers [69]. Efendigil et al. proposed that RL is an important part of the effective operation of "green supply chains". However, their twelve performance indicators for 3PRLP are biased towards logistics practices and neglect of green practices [54]. In contrast, the criteria for selection and evaluation of green suppliers summarized by Santos et al. [37] are more oriented towards green practices. A set of more comprehensive criteria is proposed in further research; Kumar and Dixit [28] studied recycling partner evaluation for the disposal of waste electrical and electronic equipment (WEEE) using green competencies (GC), and proposed a mode for GC and recycling partner selection, using opportunism, service and delivery performance, resource and environmental management capabilities, social responsibility benefits, green core competencies, management and organizational competencies, regulatory obligations and risk compliances as the criteria.

4.3. Stage B: Calculate the Relative Weights

In stage B, in order to determine the degree of importance of the criteria, the weights for each dimension and then the weights of the sub-criteria are calculated in their separate dimensions. For articles that use the concept of sustainability to establish criteria, the most heavily weighted dimensions are generally environment [28,42,56] and economy [45,48,67,68]. Some articles are specific to cost or price [64,70]. Only one of the selected articles places the highest weight on the society dimension [3]. Often, the most critical criteria are tailored to different situations and objectives. Tavana et al. conclude that the third-party logistics services (3PLS) criterion has the most important impact on the selection of 3PRLPs [46]. That is, the highest priority should be given to the 3PLS criterion if a decision maker aims at improving the performance when selecting 3PRLPs [47,52,71]. Articles with green practices as the purpose place the most emphasis on various environmental criteria, such as "circular" [1], environmental practice [37,39,40], environmental expenditure [54] and green design [41]. Others focus on technical/engineering capability [27,36,58].

According to decision making techniques, the majority of articles employ fuzzy theory to assist in this process. These articles use fuzzy logic to deal with the uncertainty of qualitative criteria. FAHP was used in 13 articles; four articles used FANP (fuzzy analysis network process). BWM (best–worst method), DEA (data envelopment analysis) and ISM (interpretive structural modeling) were employed in three papers each. SWARA (stepwise weight assessment ratio analysis) was employed in two papers each. CPT (cumulative prospect theory) and AEW (anti-entropy weighting) are used in one article each. More details are listed in Table 7.

Table 7. Decision making techniques.

Decision Making Technique	References	No.
FAHP	[3,28,42,49,50,52–54,63,67,68,70,71]	13
FANP	[1,39,46,47]	4
DEA	[44,51,61]	3
ISM	[27,58,60]	3
BWM	[36,56,62]	3
SWARA	[45,48]	2
Variable weight theory	[66]	1
Entropy	[37]	1
CPT	[40]	1
DEMATEL	[64]	1
Rasch Model	[65]	1
QFD and IVITFNs	[29]	1
Fuzzy DEMATEL-AEW	[38]	1
Rough DEMATEL-ANP	[41]	1
SWOT	[49]	1
VIKOR	[51]	1
Linguistic data	[57]	1

Although most articles do not mention it, there is some basis for the method selection. Kumar and Dixit [28] consider that, compared with ANP, the ease of applicability in pairwise comparisons made AHP become a more useful tool. However, the weakness of AHP is that the process of AHP is time consuming because there will be a large number of required pairwise comparisons [67]. Chatterjee et al. find that, in the R'DEMATEL method (rough Decision Making Trial and Evaluation Laboratory Model), the relationship between the criteria is closer to the real systems compared with ANP, because the levels of interdependence of criteria and dimensions do not have any reciprocal values [41].

4.4. Stage C: Ranking of Alternatives

In stage C, the articles determine the final results using appropriate ranking methods. As can be seen from the Table 8, VIKOR (ViseKriterijumska Optimizacija I Kompromisno Resenje) and TOPSIS (technique for order of preference by similarity to ideal solution) are the two commonly used methods; MOORA (multi-objective optimization by ratio analysis) and DEA were applied in three papers each, two papers used the FANP method, and the rest of the articles used a variety of novel approaches including IPHFS (interval Pythagoras hesitant fuzzy set), MAIRCA (multi-attribute ideal-real comparative analysis), COPRAS (complex proportional assessment), NRS (neighborhood rough set), PROMETHEE (preference ranking organization method for enrichment evaluation), F-AIO (fuzzy artificial immune optimization).

Luo et al. [66] compared the results of PDHFLT (possibility distribution based hesitant fuzzy linguistic term sets)-MOORA with those of PDHFLT-TOPSIS and PDHFLT-VIKOR. Although there was no difference in the final results, the overall ranking was still different. TOPSIS ignores individual regret, while the VIKOR-based method considers individual regret, but the result is very sensitive to individual regret proportion, which is difficult to determine. The PDHFL-MULTIMOORA method considers both the group utility values and individual regret values and can overcome this shortcoming. Bai and Sarkis [55] mainly make innovations in ranking methods. The NRS theory is used to reduce the number of 3PRLPs to be selected at first, and then a preferred 3PRLP is eventually selected by using VIKOR combined with the TOPSIS. The solution with the shortest distance from the ideal solution and the longest distance from the negative ideal solution can be determined by TOPSIS, but the relative importance and conflict criterion of distance could not be taken into account. The proposed new method integrated the advantages of the TOPSIS and VIKOR methods and can take into account factors such as the ideal solution, the negative ideal solution and conflicting criteria, which can make results more reliable [55].

Table 8. Decision making techniques.

Decision Making Technique	References	No.
VIKOR	[28,29,38,42,56,59,71]	7
TOPSIS	[27,37,50,52,53,63]	6
MOORA	[3,45,66]	3
DEA	[44,51,61]	3
FANP	[39,47]	2
IPHFS	[36]	1
MAIRCA	[41]	1
COPRAS	[48]	1
Fuzzy inference system	[64]	1
NRS-TOPSIS-VIKOR	[55]	1
TOPSIS-PROMETHEE	[68]	1
Dominance-based decision-making approach	[57]	1
Artificial neural networks	[54]	1
DEMATEL	[1]	1
CPT	[40]	1
FAHP	[70]	1
F-AIO	[69]	1
ELECTRE I	[67]	1

The IPHFS adopted by Liu et al. [36] can more accurately show the attitude of decision makers than traditional ANP, TOPSIS and BWM methods because it has more liberal restrictions on membership and non-affiliation. Govindan et al. consider that widely used approaches such as AHP, TOPSIS, and DEA, which require decision makers to make great cognitive effort, may lead decision makers to make some arbitrary transformation of the performances scales, or provide poor recognition ability [67]. The advantage of the new proposed ELECTRE and SMAA approaches is that they allow the qualitative nature of some criteria and heterogeneous criteria scales, and they provide the possibility of modeling the effects of high strengths or critical weaknesses in the comparison of a pair of alternatives. Li et al. [40] proposed the CPT-based hybrid-information MCDM method, which takes into consideration the bounded rationality of DM. This approach offers better consistency with reality, as it addresses the shortcomings of FTOPSIS. Chatterjee et al. compared the ranking results of rough TOPSIS, rough COPRAS, rough MAIRCA and rough VIKOR; the conclusion is that the R'VIKOR method focuses on seeking a balance between total and individual satisfaction, while the R'MAIRCA method emphasizes ranking and selecting from a set of alternatives in the presence of conflicting criteria. R'TOPSIS introduces the ranking index, including the distances from the ideal point and from the negative ideal point, but these distances are simply summed as numerical values, without taking into account their relative importance; similar problems may appear in the R'COPRAS method [41].

5. Conclusions and Discussions

5.1. Main Findings and Implications

In this paper, 41 articles on RL supplier selection are analyzed in depth to identify the criteria and methods most used in this selection. The following conclusions can be drawn:

(a) The number of papers on RL supplier selection has increased in recent years; this result demonstrates that RL supplier selection has attracted organizations and research centers from around the globe. Table 2 shows that research on this topic is mainly popular in developing countries (India, China, Iran) or developed countries where agriculture is a traditional industry (such as Denmark). These countries are focusing on developing industry and manufacturing to become pillar industries, and their emphasis on RL supplier selection shows that RL is an important part of this process and indicates that, from the perspective of world development, this topic still has space for further development in the future. With the recent adoption of the Circular Economy Action Plan by the

European Commission, one of the main building blocks of the European Green Deal in 2020 will be a driving force for the adaption of RL in Europe.

The interruption of global supply chains by the COVID–19 pandemic is forcing businesses to convert to RL and to the circular economy to enable the resource and business resilience. This will further promote the attention to RL-related research globally.

(b) Although a small number of authors use the "green" and circular economy, or other theories, most of the existing articles focus on the perspective of sustainable development. Among them, environment and economy are the dominant two criteria, and few articles focus on the social aspect. Although such a trend conforms to the trend in the development of the logistics industry, too much concentration on a single subject may have a negative impact on further research, and more new theories should be developed as the core of subsequent research. Those articles that do not employ any theory mainly focus on RL capability in terms of criteria, so, in further research, this criterion can be refined to consider what theories and indicators should be applied from the needs of different industries or to determine new attributes.

(c) The RL supplier selection process is based on a large number of attributes which are not fully considered in some criteria. Value-added services are mentioned in some articles but not taken seriously. It is conceivable that an RL supplier would be competitive if it met the needs of different customers for various types of value-added services. Value-added services can be used to reflect the strength of an RL supplier's professional capabilities and adaptability to different markets, from which researchers can discuss the subject of evaluation of RL supplier performance.

(d) Almost all studies use more than one decision method, with MCDM being the most frequently used decision technique, and fuzzy logic is the most common method used to eliminate uncertainty. AHP and ANP are favored by researchers for their simplicity and intuitiveness, and they are often combined with traditional ranking methods such as VIKOR or TOPSIS. Such a hybrid method has broad applicability, but it does not satisfy all decision requirements. In addition, many articles do not elaborate on the rationality of the hybrid method used. More attention should be paid to the choice of methods for solving specific problems.

(e) The artificial intelligence method is used in only two articles. This research method, which is closely related to the currently important field of big data analysis, should be developed for a wider range of applications. The strong learning ability and data processing ability of AI technology can help RL activities improve efficiency in the process of collecting data and decision making.

According to the results of the literature review, the concept of RL supplier selection can be concluded as a process of first identifying criteria based on industry characteristics and the topic in the frontier of the research field of the research object, then determining the appropriate decision method based on a comparison of the advantages and disadvantages of various methods and their applicability to a specific problem, and finally selecting the best RL supplier through specific criteria and methods. The results of the presented review can serve as a basis for selecting criteria and methods in future research. It is suggested for researchers and practitioners that in future that they should not overlook those criteria, and methods that are not widely used, novel criteria and better decision-making methods can be studied. Finally, from a more macro perspective, research on reverse logistics needs to be combined with research in many other fields. For example, the application and implementation of reverse logistics in various industries can also become a further research direction.

5.2. Research Limitations

This study's main limitation lies in its focus on the selection and evaluation of reverse logistics suppliers. Other decision-making processes or model building methods in the process of reverse logistics are not included in it. Since most of the references are based on the establishment of a decision-making framework and a case study, the research methods of these articles are not classified and summarized. When analyzing the criteria, this paper stops at the criteria and does not delve into the detailed composition and relation of the sub-criteria. A more extensive and comprehensive study

can be carried out by systematically summarizing relevant papers according to the whole reverse logistics process from consumer to manufacturer. In terms of the selection of references, due to the influence of various restrictions, this paper only contains the English papers that can be retrieved in WOS. If the search scope of is further expanded, a better analysis of the research on this topic may be obtained.

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