A Review on Supply Chain Contracts in Reverse Logistics: Supply Chain Structures and Channel Leaderships **[[1]](#footnote-1)**

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**Abstract**

With the growing awareness of environmental sustainability, reverse logistics is a very timely and critical area. Traditionally, the use of supply chain contracts has been proven to be effective in enhancing the performance of logistics systems. However, the current literature on supply chain contracts in reverse logistics is scattered. As a result, we aim to review in this paper the recent state of the art literature (2006-2016) on supply chain contracts with a focus on reverse logistics systems. We explore the popularity of different kinds of supply chain contracts, and identify the most productive researchers in the area. We classify and examine the literature with respect to the supply chain structure (i.e. the involved supply chain links), and channel leaderships (i.e. who acts as the leader). Finally, we identify the research gaps, suggest five major categories of future research directions and discuss the respective research challenges.

*Keywords:* Supply chain contracts, coordination, reverse logistics, channel leaderships, supply chain structures, links

**1. Introduction**

Logistics processes include both forward logistics and reverse logistics. Reverse logistics covers a series of operations within a supply chain system which involves product returns from downstream members to the upstream, product reprocessing, and remanufacturing. In fact, proper reverse logistics management is related to many different measures which are implemented in the supply chain (Alshamsi and Diabat 2015). For instance, the product recalls and the returns of end-of-life products are some common schemes related to reverse logistics management. In recent years, owing to the significance and popularity of environmental sustainability, a lot of studies have been conducted in the field of reverse logistics. However, results on reverse logistics systems and their coordination[[3]](#footnote-3) challenges are scattered.

 Moreover, supply chain systems, including reverse supply chains, are widely acknowledged to fail to be optimal by themselves under a decentralized mode of operations (i.e., it is not coordinated). In the literature, it is well advocated that supply chain contracts can help dampen the inefficiency problem (such as double marginalization) and achieve coordination. This raises a critical question on what kind of supply chain contract[[4]](#footnote-4) (Govindan et al. 2013, Asian and Nie 2014) can help achieve supply chain coordination in the scope of reverse logistics[[5]](#footnote-5). As a remark, the 2016 Nobel prize in Economic Science was recently announced and it was granted to the contract theory. This also highlights the importance of supply chain contracts and supports the development of this review paper.

Motivated by the importance of supply chain contracts in reverse logistics and the relatively un-organized literature findings, this paper conducts a comprehensive review of the recent literature on supply chain contracts with a focal point on reverse logistics. We focus on two perspectives, namely the supply chain structure and the channel leadership, because they are critically important in reverse logistics but there is an absence of the related review in the current literature. We first report some basic and descriptive statistics of our searching results, which include the most popular journals and the most productive and active researchers in this area. Then, we examine how supply chain contracts perform with respect to the supply chain structure, i.e., in different “links” under reverse logistics. For the term “link” here, we refer to the connection and relationship between any adjacent supply chain members. As mentioned by Lambert and Cooper (2000), a “link” is formed when supply chain parties have cooperation and various “links” contributed to the establishment of the whole supply chain. “Links” help firms gain competitive advantages and supply chain contracts motivate players to properly participate in “links” with the efficient incentive alignment (Min and Zhou 2002). Furthermore, we also explore how the channel leadership (i.e. who acts as the leader) affects the performance of reverse logistics. To the best of our knowledge, this paper is the first one which systematically reviews supply chain contracts, with respect to supply chain structures and channel leaderships, in the scope of reverse logistics[[6]](#footnote-6). Our aims are to identify current research trends of supply chain contracting research in reverse logistics, and to uncover new future research directions.

The remainder of this paper is organized as follows. Section 2 introduces the methodology for this review. Section 3 presents a basic analysis of the related literature and highlights the list of most productive researchers. Section 4 and Section 5 respectively report the detailed analyses of supply chain contracts with the involved links and various channel leaderships. Section 6 proposes future research opportunities according to the results obtained from Section 4 and Section 5. Section 7 concludes this paper.

**2. Methodology**

The steps of the research methodology applied in this paper follow the recent literature (see Govindan et al. 2015). Specifically, it starts with material collection, then category selection and material evaluation.

**2.1. Material Collection**

Google Scholar is utilized to search related articles written in English. Since we focus on the recently published papers from Thomson Web of Science listed journals, the time line of coverage is from 2006 to 2016[[7]](#footnote-7). The selected keywords for our searching are exhibited in Table 1. During the research process, both main keywords and supplementary ones are included to ensure the comprehensiveness and relevance of searching outcomes.

**Table 1. The keywords for searching related articles**

|  |  |
| --- | --- |
| **Main keywords:**1. Supply contract, reverse logistics
2. Contract, reverse supply chain
3. Contract, reverse flow
4. Contract, reverse channel
5. Coordination, reverse logistics
6. Coordination, reverse supply chain
7. Coordination, closed loop
 | **Supplementary keywords:**(1) sustainability (2) remanufacture (3) reuse(4) recycle (5) recover(6) redesign(7) reprocess(8) replace (9) resale(10) leftover (11) Wholesale price(12) Revenue sharing(13) Cost sharing(14) Risk sharing(15) Rebate contract(16) Quantity flexibility (17) Quantity discount contract(18) Buyback(19) Return |

After the searching, a screening of the paper’s content is conducted: The first step of the analysis is to judge whether the article belongs to “reverse logistics”. We do so by scanning the titles and all articles that are not satisfied will be excluded even if they may concern supply chain contracts. Then for each filtered paper from the first step, the abstract and introduction are analyzed in the second step to determine whether it relates to supply chain contracts. As a result, only those articles studying supply chain contracts in the reverse logistics area will be kept and further analyzed. Based on our screening, 173 papers are obtained after the first step while only 62 papers are finally selected based on the content analysis.

**2.2. Category Selection**

To obtain a systematic analysis, we classify the selected papers into various “categories”. We have the major categorization by “links” (Section 4) and by “channel leaderships” (Section 5). For each major category, we have sub-categories. This is a top down classification approach. For example, under the category “links”, papers are divided into “single link” and “multiple links” sub-categories. For each sub-category, further discussions are made based on the involved kind of supply chain contracts.

**2.3. Material Evaluation**

Articles selected in the previous stages are crossed-checked with the results in Thomson’s Web of Science database to ensure the reliability of the whole process, which means all analyses performed later are based on articles published in SCI indexed journals only. This makes sure the covered articles are from reputable peer refereed sources.**3. Basic Models and Descriptive Statistics**

Before conducting a further analysis, we consider several basic reverse logistics models, which consist of a supplier, a manufacturer[[8]](#footnote-8), a retailer, a remanufacturer, and a third party collector[[9]](#footnote-9). Notice that the reverse logistics system can exhibit different structures and links. For example, from Figures 1a, 1b and 1c (please refer to Appendix), we can observe that just by looking at the 2nd echelon with the “manufacturer” and the “third part collector”, the specific structures and flows of products are different. For instance, in Figure 1a, the flow is from the retailer to the manufacturer first, and then the third party collector gets the returned products from the manufacturer and passes to the remanufacturer. In Figure 1b, the third party collector collects the products from the retailer first and then sends to the manufacturer, which further delivers the products to the remanufacturer. In Figure 1c, the third party collector and the manufacturer both receive products from the retailer and they separately pass the products to the remanufacturer. Figures 1a, 1b and 1c illustrate the fact that: Reverse supply chains exhibit a large variety of structures. It is basically impossible to depict them in a single diagram and explore them in a single “structure”. As such, in this paper, we focus on exploring the specific links, e.g., the link between the retailer and the manufacturer, the link between the manufacturer and the remanufacturer, etc.

 For a notational purpose, we have the following abbreviation:

|  |
| --- |
| R: retailer, which sells to the consumer;M: manufacturer, which produces and supplies to the retailer;RM: remanufacturer;S: supplier, which supplies to the manufacturer;T: third party collector;C: consumer;X+Y: The link between X and Y. For example, M+R refers to the link between the manufacturer and the retailer;X-led: X acts as the leader. For instance, M-led means the manufacturer is the leader in the related link of the reverse supply chain. |

A preliminary descriptive analysis of the selected papers is shown in Table 2a, which analyzes the publication years’ and journals’ distribution. Both Table 2a and Figure 2a indicate that the number of papers exploring supply chain contracts under reverse logistics is increasing recently. Figure 2b reveals that relevant articles appear most frequently in *International Journal of Production Economics*, followed by *European Journal of Operational Research, Production and Operations Management, International Journal of Production Research, Journal of Cleaner Production*, *Manufacturing & Service Operations Management* and *Transportation Research Part E*, all are well-established leading journals in operations management.

**Table 2a. Distribution of publications by journals across the study period (62 articles: 2006-2016)**

|  |  |
| --- | --- |
| Academic Journals | Year of publication |
| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | Total |
| Journals covering more than one related articles | 50 |
| International Journal of Production Economics | 1 | 0 | 1 | 0 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 15 |
| European Journal of Operational Research | 0 | 2 | 1 | 0 | 2 | 2 | 0 | 0 | 2 | 2 | 0 | 11 |
| Production and Operations Management | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 4 |
| International Journal of Production Research | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 3 |
| Journal of Cleaner Production | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 3 |
| Manufacturing & Service Operations Management | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Transportation Research Part E: Logistics and Transportation Review | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 3 |
| Annals of Operations Research | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Journal of Intelligent Manufacturing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| Mathematical Problems in Engineering | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 |
| Omega | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| Journals only covering one related paper | 12 |
| 4OR-A Quarterly Journal of Operations Research | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Asia-Pacific Journal of Operational Research | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Applied Mathematical Modelling | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Central European Journal of Operations Research | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Computers & Industrial Engineering | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| International Journal of Systems Science: Operations & Logistics | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Journal of Optimization Theory and Applications | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Management Science | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Naval Research Logistics | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Operations Research Letters | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Production Planning & Control | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Sadhana | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 6 | 2 | 4 | 2 | 5 | 5 | 6 | 6 | 9 | 9 | 8 | 62 |

**Figure 2a. Distribution of publications per year across the period of the study (2006-2016).**

**Figure 2b. Distribution of publications according to different journals (62 articles: 2006-2016).**

Furthermore, from the searching, the list of most active and productive researchers (from 2006-2016) are listed in Table 2b. From Table 2b, we can see that the most active and productive researchers are located in Asia, Europe, and North America. It is interesting to observe that the top 3 researchers are located in different parts of the world, namely Denmark (K. Govindan), China (Y.J. Li), and the USA (A. Atasu). In terms of the geographical distribution of these productive researchers, 53% of them are from Asia, 30% are from Europe and only 17% are affiliated with North American schools.

**Table 2b. The list of productive researchers in reverse logistics supply contracts research (2010-2016)**

|  |  |  |
| --- | --- | --- |
| **Researcher** | **Location** | **Number of Relevant Published Papers in this Review (from 2010-2016)[[10]](#footnote-10)** |
| K. Govindan | Denmark | 10 |
| Y.J. Li | China | 9 |
| A. Atasu | USA | 5 |
| J. Chen | Canada | 4 |
| T. M. Choi | Hong Kong | 4 |
| X. Li | China | 3 |
| T.C.E. Cheng | Hong Kong | 3 |
| T.J. Xiao | China | 3 |
| L.N. Van Wassenhove | France | 3 |
| A. Diabat | United Arab Emirates | 3 |
| M.N. Popiuc | Denmark | 3 |
| L. Xu | China | 3 |

**4. Supply Chain Structures: The Links**

In this section, we explore the literature on supply chain contracts with respect to the links. We first examine the papers under the “single link” domain, and then the papers under the “multiple links” context.

4.1. Single Link

The single link case includes many possible links in the supply chain. For example, we have the link between the manufacturer and the retailer (M+R), the link between the manufacturer and the supplier (M+S), etc. For the use of supply chain contracts under this case, we have two separate scenarios, namely the “single contract” scenario and the “hybrid contracts” scenario, where a hybrid contract is one which combines multiple traditional single contracts together.

**4.1.1. Single supply chain contracts**

For the single supply chain contract scenario, we refer to the papers which focus on the exploration of a single supply chain contract (not the hybrid ones). In total, 50 articles are investigated here[[11]](#footnote-11), and we call this Situation A (definitions of all “situations” are shown in Table A1 in the Appendix). A comparison is exhibited in Table 3 where the supply chain contracts are classified into several categories according to the selected articles and the first four kinds are the more common ones. Meanwhile, it is obvious that the most popular link being examined in the literature under Situation A is the manufacturer-retailer link, which includes 37 articles. The details in each contract under different categories are to be further explained (for instance, the detailed terms in that contract, whether competition is considered, and the involved players in each link, etc).

**Table 3. Cross analyses of the supply chain contracts with involved links under Situation A**

|  |  |
| --- | --- |
| **SC contracts** | **Involved links** |
| **M+R** | **M+S** | **M+T** | **M+RM** | **R+T** | **R+RM** | **RM+T** | **Total** |
| **Buyback and returns contract** | 15 | 1 | 0 | 0 | 1 | 0 | 1 | 18 |
| **Revenue sharing contract** | 5 | 0 | 0 | 0 | 1 | 0 | 0 | 6 |
| **Wholesale pricing contract** | 2 | 1 | 1 | 0 | 0 | 0 | 2 | 6 |
| **Two-part tariff contract** | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 4 |
| **Quantity discount contract** | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| **Risk sharing contract** | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 2 |
| **Consignment contract** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Rebate contract** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| **Papers mentioning more than one contracts and exploring them separately** | 8 | 0 | 0 | 1 | 0 | 1 | 0 | 10 |
| **Total** | 37 | 3 | 2 | 1 | 2 | 2 | 3 | 50 |

We start by exploring the buyback and returns contract, which are closely related to reverse logistics and are most popularly studied in the literature (see Table 3). Here, buyback and returns mean the “seller” would buyback the product from the “buyer” with a refund (which can be partial or full). This buyback can happen during the end of the season (for leftover) or at anytime (e.g., the consumer returns under the money back guarantee scheme). Among the reviewed literature on buyback and returns contract, 15 of them investigate the more traditional channel returns in which it is implemented in the manufacturer-retailer (M+R) link[[12]](#footnote-12). This type of study is the most commonly seen one among all links as shown in Table 3. Following that, Huang et al. (2015) examine the situation of consumer returns in the retailer-third-party collector (R+T) link, Gu and Tagaras (2014) explore the use of buyback and returns contract in the remanufacturer-third party collector link and Hou et al. (2010) examine the link between the manufacturer and the supplier.

In addition to buyback and returns, the revenue sharing contract is also popularly examined. Under a typical revenue sharing contract in reverse logistics, the manufacturer would share a part of the revenue generated from remanufacturing to the retailer. In our review, a few papers employ the revenue-sharing contract and it is interesting to observe many different configurations and arrangements. For instance, Zeng (2013) studies the case when a part of the manufacturer’s revenues from selling remanufactured products are shared with the retailer in order to encourage the retailer to support the program. Mafakheri and Nasiri (2013) and Zou and Ye (2015) examine the supply chain when the manufacturer would share his revenue (from recycling or reselling remanufactured items) with the retailer to compensate the collection costs spent by the retailer. Notice that in the above 3 articles, the retailer is responsible for collecting product returns and the manufacturer is the one who shares the corresponding revenue with the retailer. Other papers have examined the reverse supply chain in a different setting. For example, Wu et al. (2015) study the supply chain in which the manufacturer is responsible for collecting used products from consumers under competitive environment. Ran et al. (2016) assume both the manufacturer and the retailer would collect used items from the market. Weraikat et al. (2016) discuss a contractual arrangement where the retailer will share extra bonus with the third party collector to motivate a complete collection of products from customers. From the reviewed papers on the revenue sharing contract, we can see that the implementation of revenue sharing takes different forms under different settings.

Reverse logistics in the presence of the wholesale pricing contract has also been examined in the literature. In fact, the wholesale pricing contract is the simplest and most commonly adopted contract in supply chain management in which there is a constant unit wholesale price offered by the wholesaler (Atasu et al., 2013b; Li et al., 2012a; Chen and Wan, 2011). In the literature, Atasu et al. (2013b) design a wholesale pricing contract in which the same wholesale price is offered to both the newly produced and the remanufactured items provided by the manufacturer. Li et al. (2012a) examine both the make-to-stock policy and the make-to-order system in the presence of a wholesale pricing contract. Both of these two papers explore the reverse supply chains with the wholesale pricing contract for the link between the manufacturer and the retailer. Notice that for the manufacturer-supplier link, Li and Li (2016) investigate a chain-to-chain competition concerning product sustainability. Each chain includes a supplier and a manufacturer and the product demand increases with products’ sustainability. In addition, Hong and Yeh (2012) explore the cooperation between the manufacturer and the third-party collector via a wholesale pricing contract for collecting end-of-life products from consumers. Hong et al. (2008) and Ye et al. (2016) investigate a structure where the remanufacturer interacts with the third party collector to purchase recycled items via a wholesale pricing contract and recovers the remaining value of these products.

The two-part tariff contract is widely explored. Under a typical two-part tariff contract, the seller provides a wholesale price and also a fixed credit transfer to the buyer. In our review, four papers, have examined the two-part tariff contract, and three of which explore the manufacturer-retailer link. We review them as follows. Kaya (2010) studies a supply chain with the two-part tariff contract implemented between the manufacturer and the third party collector. In Kaya (2010)’s paper, the fixed transfer price is a price paid by the manufacturer to the third party collector in the presence of a unit wholesale price. Gao et al. (2016) set up a low wholesale price provided by the manufacturer while charging a fixed franchise fee as the channel entrance allowance. Dobos et al. (2013) consider the situation when the remanufactured items are perfect substitutes for new ones and a two-part tariff contract is specified to achieve Nash equilibrium. Hong et al. (2015) establish the condition with which the retailer takes up the role as the collector and the manufacturer offers a two-part tariff contract. In particular, the retailer provides a fixed payment to the manufacturer to compensate the loss incurred in the manufacturer level.

The other related contracts include the quantity discount contract (Huang et al., 2011; Jena and Sarmah, 2016), the risk sharing contract (He, 2015; He and Zhang, 2010), the rebate contract (Ferguson et al., 2006) and the consignment contract (Hu et al., 2014).

Moreover, since different supply chain contracts may have different performance, there are also 10 papers considering more than one kind of supply chain contracts separately. Among them, 3 papers focus on exploring different independent supply chain contracts with a goal to uncover the best one. In this scope, Chen and Chang (2014), De Giovanni (2014) and Zhao and Zhu (2015) examine the different performance of the wholesale pricing contract and the revenue sharing contract under different links in reverse logistics. To be specific, Chen and Chang (2014) consider the manufacturer-remanufacturer link where the manufacturer collects returns for the remanufacturer. De Giovanni (2014) investigates the link between the manufacturer and the retailer, and assumes the manufacturer could generate revenues from the returns provided by the retailer. Zhao and Zhu (2015) study the retailer-remanufacturer link in which the retailer is the collector and the government will offer additional subsidies to the remanufacturer.

Then the following four papers analyze the effectiveness of the buyback and returns contract and another contract separately in reverse logistics under the retailer-manufacturer link. Huang et al. (2014) and Su (2009) compare the buyback and returns contract with the rebate contract. Huang et al. (2014) assume that both returns and leftovers would be salvaged in a secondary market and Su (2009) assumes that the manufacturer could have an additional monitoring capability. Xiao et al. (2010) conduct a comparison between the buyback and returns contract and the markdown contract considering the influences of strategic factors like the salvage value and refund amount. Another comparison involving a buyback and returns contract is with the wholesale pricing contract, which is explored by Ruiz-Benitez and Muriel (2014). The authors investigate the contract which can better manage extra reverse logistics costs induced by customer returns. Different from the above, Zhang et al. (2014) conduct a comparison between a two-part tariff contract and a collection effort requirement contract based on the retailer-manufacturer link, under a partial information sharing (on the retailer’s collection costs for returns) environment.

Apart from the comparison between two contracts, there are two articles (by Song et al., 2008 and Yoo et al., 2015) which compare three different contracts in reverse logistics under the retailer-manufacturer link. To be specific, Song et al. (2008) compare efficiencies among the wholesale pricing contract, the buyback and returns contract, and the consignment contract from the viewpoints of the consumers, the manufacturer, the retailer, and the whole channel. Yoo et al. (2015) investigate the wholesale pricing contract, the buyback and returns contract and the quantity discount contract. They evaluate how each contract affects the retailer’s pricing decisions and the respective return policies.

**4.1.2. Hybrid supply chain contracts**

Supply chain coordination in reverse logistics may not be achievable by a single simple contract. To cope with this challenge, hybrid contracts, which are based on the combination of multiple supply chain contracts, can be applied. In this paper, we consider the situation where multiple supply chain contracts are combined and used together under one reverse supply chain link, as Situation B and it refers to five articles. A quick finding is that, 60% of the related articles in Situation B explore the manufacturer-retailer link (refer to Figure 3). We review them as follows.

**Figure 3. Distribution of involved links under Situation B.**

Jacobs and Subramanian (2012) propose a hybrid contract including multiple parameters, like the responsibility sharing level and the recovery target, to coordinate the supplier-manufacturer link of the reverse supply chain in which both the supplier and the manufacturer are responsible for collecting and recycling activities. Savaskan and Van Wassenhove (2006) design a hybrid contract, which includes the decisions in a buyback and returns contract and a two-part tariff contract, to coordinate the channel when the manufacturer interacts with two competitive retailers to collect postconsumer goods. Chen et al. (2006) and Shi (2006) incorporate the decisions in a buyback and returns contract and a risk sharing contract into a new mechanism in order to optimize the interaction between the manufacturer and the retailer. As a remark, the major focus in Chen et al. (2006) is demand information updating while Shi (2006) emphasizes more on the risk attitude of the decision makers. Apart from the above, Chiu et al. (2011) explore a hybrid policy by combining the wholesale pricing contract, the rebate contract, and the buyback and returns contract in the retailer-manufacturer link. Components like the unit wholesale price, partial refund value for each unsold unit, and rebate value for each unit sold beyond the target sales level, are considered under this contract. Notably, the performance of these hybrid contracts highlights that sometimes a single simple contract is not enough for achieving reverse supply chain coordination and hence we need to use the hybrid contracts.

**4.2. Multiple Links**

We explored the single link papers in Section 4.1, and now present the multiple-link papers in this section. One example is the reverse supply chain which includes the retailer, the manufacturer and the third party collector (R+M+T). The analyses in this part are divided into two subgroups, which refers to the papers which focus on “multiple links only” one and the one which examines “both single link and multiple links”.

**4.2.1. Multiple links only**

With respect to the “multiple links only” scenario, we explore the situation when more than one links in reverse supply chains are discussed in one paper. Such situation is regarded as the Situation C and it contains 6 articles.

Among these 6 papers, two of them utilize the same contracts to coordinate multiple links in reverse logistics. To be specific, Choi et al. (2013) examine the different performance of a two-part tariff contract and a spanning revenue-cost sharing contract which can align the incentives in the retailer-manufacturer link and the manufacturer-third party collector link simultaneously. Zhang and Ren (2016) establish a network including a manufacturer, a remanufacturer, and a retailer where a competitive market is formed between the newly produced items from the manufacturer and the remanufactured ones from the remanufacturer. They apply a mechanism incorporating both a revenue sharing contract and a two-part tariff contract to achieve the coordination among these three parties. The other 4 articles study how different contracts can be implemented to coordinate different links in the reverse supply chains. We review them as follows. Bhattacharya et al. (2006) apply two different two-part tariff contracts to the link between the retailer and the manufacturer, and the manufacturer-remanufacturer link where the manufacturer purchases remanufactured products from the remanufacturer and sells both the new and remanufactured ones to the retailer. Arshinder et al. (2009) propose two different buyback and return contracts to coordinate the link between the manufacturer and the distributor, and the link between the distributor and the retailer. They assume that the retailer can return all the leftovers back to the distributor and the distributor will further return those items back to the manufacturer. Ding and Chen (2008) explore the applicability of two different hybrid contracts, both of which combine the decisions in a buyback and return contract and a profit sharing contract, in the manufacturer-retailer link as well as the manufacturer-supplier link. In Ding and Chen (2008), the unsold inventories are also returned level by level and each member shares the cost induced by overstocking. Apart from these papers, Yan and Sun (2012) investigate a model with a manufacturer, a retailer and a third party collector. The manufacturer-retailer link is connected by a wholesale pricing contract, while the manufacturer is linked with the third party collector under a target rebate-punish contract. One of the emphases in using the target rebate-punish contract is to ensure the right quantity of returns is provided by the third party collector.

Under the observation of the above 6 reviewed articles, we find that combinations of supply chain contracts for different links can achieve better reverse supply chain management. The corresponding matching and implementation deserve deeper exploration.

**4.2.2. Both single link and multiple links**

Different from these papers analyzed before, Govindan and Popiuc (2014) examine an exceptional case comprising both the single-link and multiple-link situations in reverse logistics, which is defined as Situation D. The single link consists of a retailer and a manufacturer under which the retailer directly delivers returns to the manufacturer. While in the multiple-link situation, a third party collector is considered for buying returns from the retailer and then selling them to the manufacturer. In Govindan and Popiuc (2014), these two scenarios are both coordinated by a revenue sharing contract and the revenues are from remanufacturing and reselling activities conducted by the manufacturer.

**4.3. Discussions**

From the above review, we have Figure 4. In fact, the above analyses and Figure 4 indicate that in the reverse logistics literature, most supply chain contract papers focus on studying a single link with the focal point on coordination using a single contract (i.e., Situation A), which occupies 81% of the total reviewed papers. This is followed by the studies which focus on multiple links (10%).

Moreover, by further investigating Table 4 and Table 5, we can find that the hybrid contract and the two-part tariff contract are relatively more common under multiple links instead of the buyback and returns contract (i.e. the most popular one in the single link scenario). It is also obvious that the buyback and returns contract, as well as the two-part tariff contract, have a higher likelihood to be simultaneously utilized with another supply chain contract. For instance, a buyback and returns contract can be applied together with a two-part tariff contract or a risk sharing contract. Meanwhile, the combination of a wholesale pricing contract is quite common at the manufacturer level while the conjunction with a two-part tariff contract is more practical from the perspective of the retailer.

**Figure 4. The number of supply chain contracts and involved links.**

**Table 4. The joint occurrence of supply chain contracts under the hybrid contracts setting**

|  |  |
| --- | --- |
| **SC contracts** | **Involved links** |
| **M+S** | **M+R** | **M+D** | **M+T** | **R+D** | **R+RM** | **M+RM** |
| **Scenario 1** |  | A buyback and returns contract + A two-part tariff contract |  |  |  |  |  |
| **Scenario 2**[[13]](#footnote-13) |  | A buyback and returns contract + A risk sharing contract |  |  |  |  |  |
| **Scenario 3** | A wholesale pricing contract + A responsibility sharing contract |  |  |  |  |  |  |
| **Scenario 4** |  | A wholesale pricing contract + A rebate contract + A buyback and returns contract |  |  |  |  |  |

**Table 5. The joint occurrence of supply chain contracts under the multiple links setting**

|  |  |
| --- | --- |
| **SC contracts** | **Involved links** |
| **M+S** | **M+R** | **M+D** | **M+T** | **R+D** | **R+RM** | **M+RM** |
| **Case 1** |  | A two-part tariff contract + A hybrid contract |  | A two-part tariff contract + A hybrid contract[[14]](#footnote-14) |  |  |  |
| **Case 2** |  | A hybrid contract |  |  |  | A hybrid contract[[15]](#footnote-15) |  |
| **Case 3** |  | A two-part tariff contract |  |  |  |  | A two-part tariff contract |
| **Case 4** |  |  | A buyback and returns contract |  | A buyback and returns contract |  |  |
| **Case 5** | A hybrid contract | A hybrid contract[[16]](#footnote-16) |  |  |  |  |  |
| **Case 6** |  | A wholesale pricing contract |  | A rebate contract |  |  |  |

**5. Channel Leaderships**

After exploring the application of supply chain contracts in different links in reverse supply chains, we explore the supply chain contracts with various channel leaderships in this section. The corresponding details are exhibited in Table 6 where the channel leaderships are divided into three subdivisions: 1) Single leader, 2) Nash bargaining and 3) Multiple scenarios. As a remark, the “multiple scenarios” group collects the papers in which either two or three kinds of channel leadership scenarios are investigated in each paper.

**Table 6. Cross-analyses of supply chain contracts with various channel leaderships**

|  |  |
| --- | --- |
| **Supply chain contracts** | **Channel leaderships**  |
| **Single leader** | **Nash Bargaining** | **Multiple****scenarios** | **Total** |
| **M-led** | **R-led** | **RM-led** | **S-led** |
| **1. Single link** |
| **(1). Single contract** | **50** |
| **Buyback and returns contract** | **10** | **3** | **1** | **1** | **3** | **0** | **18** |
| **Revenue sharing contract** | **5** | **1** | **0** | **0** | **0** | **0** | **6** |
| **Wholesale pricing contract** | **2** | **0** | **0** | **0** | **1** | **3** | **6** |
| **Two-part tariff contract** | **2** | **0** | **0** | **0** | **1** | **1** | **4** |
| **Quantity discount contract** | **1** | **0** | **1** | **0** | **0** | **0** | **2** |
| **Risk sharing contract** | **1** | **1** | **0** | **0** | **0** | **0** | **2** |
| **Consignment contract** | **1** | **0** | **0** | **0** | **0** | **0** | **1** |
| **Rebate contract** | **1** | **0** | **0** | **0** | **0** | **0** | **1** |
| **Papers mentioning more than one contracts separately** | **8** | **0** | **0** | **0** | **2** | **0** | **10** |
| **(2). Hybrid contracts** | **2** | **0** | **0** | **1** | **2** | **0** | **5** |
| **Total** | **33** | **5** | **2** | **2** | **9** | **4** | **55** |
| **2. Multiple link** | **3** | **0** | **0** | **0** | **2** | **1** | **6** |
| **3. Both single link and multiple links** | **1** | **0** | **0** | **0** | **0** | **0** | **1** |
| **Total** | **37** | **5** | **2** | **2** | **11** | **5** | **62** |

**Figure 5. Distribution of different channel leadership situations.**

5**.1. Single Leader**

From Figure 5 and Table 6, it is observed that supply chain coordination under the leadership of the manufacturer is the most widely analyzed scenario in reverse logistics. It comprises 33 articles under the single-link condition, 3 articles from the multiple-link scenario, and 1 article considering both the single link and multiple links. The reason for this distinct popularity is that few papers explore reverse logistics links without the participation of the manufacturer and the most frequently studied link is the manufacturer-retailer one (refer to Figure 6). Moreover, the popularity of the manufacturer-retailer link also explains why the retailer as the leader is the second prevailing single-leader situation based on Table 6. Apart from these two popular categories, there is also 2 papers investigating the leadership of the supplier in the supplier-manufacturer link, 1 paper exploring the leadership of the remanufacturer under the link between the remanufacturer and the third party collector, and another one examining the leadership of the remanufacturer in the remanufacturer-retailer link. Among these four kinds of single-leader conditions in reverse logistics, we first analyze the manufacturer-leader game since it is the most widely explored one.

**5.1.1. M-led scenario**

As aforementioned, the manufacturer-leader scenario in reverse logistics covers 37 articles in total, the sources of which are exhibited in Figure 6. Under this scenario, we start by discussing the details of the manufacturer’s leadership in various supply chain contracts under the manufacturer-retailer link, which includes 29 articles.

**Figure 6. Manufacturer-led supply chain contracting under different links.**

First of all, we examine the buyback and returns contract. To be specific, Arcelus et al. (2011), Chen (2011), Lee and Rhee (2007) and Liu et al. (2014) assume that the manufacturer would buyback both leftover and customer-returned items. Besides, the manufacturer in Arcelus et al. (2011) only permits returns within a specified time period, the manufacturer in Chen (2011) requires a high level of information sharing about customer returns, the manufacturer in Lee and Rhee (2007) suffers from limited salvage capacities and the manufacturer in Liu et al. (2014) faces the influence of a refund-dependent demand on the number of the final returns. Li et al. (2012b) consider the case in which the manufacturer receives full information shared by the retailer and allows those off-season products to be returned. Xu et al. (2015) present a scenario where the manufacturer provides different credits for items returned at different time periods to motivate a timely return from the retailer. He et al. (2006) as well as Ohmura and Matsuo (2016) establish a model in which the risk preferences of the manufacturer are influential to the retailer’s decision on order quantities. Yao et al. (2008) analyze the scenario when the manufacturer permits the return of unsold goods at the end of the selling season in order to overcome the negative impact of the price-sensitivity factors on the retailer’s decisions. Wu (2013) discusses the impact of the buyback incentive offered by the manufacturer on the retailer’s retail price and ordering quantity under a competing environment, which comprise two manufacturer–retailer supply chains.

Secondly, the revenue sharing contract is also popularly examined. There are five related papers and they are examined below. Zeng (2013), Mafakheri and Nasiri (2013), Zou and Ye (2015) and Ran et al. (2016) hypothesize that the manufacturer would share its revenues from recycling, remanufacturing and reselling actions with the retailer to motivate the retailer to exert higher collection efforts for returns. Different from the above, Wu et al. (2015) consider the situation when the responsibility of collecting used items is assigned to the manufacturer and the contract is to guarantee the retailer’s participation when facing remanufacturing cost disruptions.

Apart from the buyback and returns contract and the revenue sharing contract, other papers which study the use of single contracts in the manufacturer-led M-R link include Atasu et al. (2013b), Huang et al. (2011), Hu et al. (2014), Hong et al. (2015) and Ferguson et al. (2006). In Atasu et al. (2013b), the manufacturer provides a wholesale pricing contract to the retailer in order to lift order quantities and achieve higher sales volume as both of these two aspects relate to a higher probability of collecting more returns. Hu et al. (2014) assume that the manufacturer applies a consignment contract aiming at mitigating the consumer misfit returns behaviors. Hong et al. (2015) focus on a situation where the manufacturer exerts its influence on the retailer, via a two-part tariff contract, to endeavor more on local advertising for collecting returns. Besides, both Ferguson et al. (2006) and Huang et al. (2011) explore the case when the manufacturer provides a contract to the retailer in order to decrease the false failure returns’ amount, although Huang et al. (2011) consider the case when the manufacturer provides a quantity discount contract while Ferguson et al. (2006) analyze the scenario where the manufacturer proposes a target rebate contract.

In addition, seven articles considering the comparison of different contracts have studied the manufacturer-led game in the manufacturer-retailer link in reverse supply chains. Xiao et al. (2010) investigate the different effectiveness of the buyback and returns contract and the markdown contract in ensuring the manufacturer’s profits. Ruiz-Benitez and Muriel (2014) compare the buyback and returns contract and the wholesale pricing contract to figure out a more appropriate way to allocate the burden of leftover from the manufacturer’s perspective. Huang et al. (2014) study the performance of the buyback and returns contract and the rebate contract in increasing the retailer’s order quantity when there is a secondary market. De Giovanni (2014) examines the revenue sharing contract and the wholesale pricing contract to simulate as much returns’ residual value as possible for the manufacturer. Zhang et al. (2014) conduct the comparison study between a two-part tariff contract and a collection effort requirement contract. They discuss how the manufacturer determines the more efficient one with respect to the given varied collection effort of the retailer. Yoo et al. (2015) examine how various contracts provided by the manufacturer influence the retailer’s decisions by comparing among the wholesale pricing contract, the buyback and returns contract and the quantity discount contract. Song et al. (2008) explore the optimal retail decisions and the optimal profit allocation under the contracts of wholesale pricing, buyback and returns, and consignment, respectively, when the retail demand presents a multiplicative form (price-sensitive and stochastic). Then different from the single-contract scenario we examined above, Savaskan and Van Wassenhove (2006) analyze how a hybrid contract, which is based on a buyback and returns contract and a two-part tariff contract, helps a manufacturer to guarantee two retailers’ collection effort since he can incorporate remanufacturing of used items into the original production system. Chiu et al. (2011) design a hybrid contract combining the wholesale pricing contract, the rebate contract and the buyback and returns contract, under which the manufacturer has the absolute power to decide all contract variables like the wholesale price, the buyback price, target sales level and rebate value.

After discussing the impact of manufacturer’s leadership under the M-R link, we explore other links in reverse logistics that are also led by the manufacturer in the selected literature. Both Hong and Yeh (2012) and Kaya (2010) explore the case when the manufacturer interacts with the third party collector to collect consumer returns, although Kaya (2010) investigates the performance of a two-part tariff contract in collecting more returns for remanufacturing while Hong and Yeh (2012) focus on maximizing the profit of the manufacturer by efficiently handling the collected items under a wholesale pricing contract. He (2015) analyzes a manufacturer-supplier link where the manufacturer utilizes its power to motivate the supplier to acquire more returns in the recycle channel under a risk-sharing contract. Chen and Chang (2014) study the link between the manufacturer and the remanufacturer under the assumption that the manufacturer could control customers’ behaviors. The authors aim to identify the way to attain a more reasonable profit allocation, regarding the manufacturer’s dominant power, by comparing the revenue sharing contract and the wholesale pricing contract.

The manufacturer-led scenario in reverse logistics has also been explored in the case involving multiple links. For example, Bhattacharya et al. (2006) examine both the manufacturer-remanufacturer link and the manufacturer-retailer link, under which two different two-part tariff contracts are applied to encourage the cooperation of the retailer and the remanufacturer so as to guarantee the manufacturer's efficiency gains. Yan and Sun (2012) assume that the manufacturer expects a high effort level for collecting returns and therefore provides a wholesale pricing contract and a target rebate-punish contract to manage the retailer-manufacturer link and the manufacturer-the third party collector link, respectively. Zhang and Ren (2016) consider a network controlled by a manufacturer, including a remanufacturer and a retailer, and the manufacturer would utilize its power to influence the other members by deciding the wholesale price charged to the retailer and the patent licensing fees charged to the remanufacturer. Lastly, Govindan and Popiuc (2014) discuss both the single-link and multiple-link structures, under both of which the manufacturer provides a revenue sharing contract to the other supply chain player(s) aiming at stimulating more returns for the remanufacturing process.

**5.1.2. R-led scenario**

Compared to the manufacturer-led configuration, the popularity of the retailer-led game under the reverse logistics is relatively low. We first analyze the situation concerning the retailer-manufacturer link. Jeong (2012) and Matsui (2010) both find that the information about customers’ product expectations and market demand, which is entirely possessed by the retailer, is quite crucial to the manufacturer and therefore, this contributes to the leadership of the retailer when cooperating with the manufacturer under the buyback and returns contract. The focal points of these two papers, however, are quite different. To be specific, Jeong (2012) studies the collection and transmission of this piece of information while Matsui (2010) mainly explores the influence of the demand uncertainty. He and Zhang (2010) consider a secondary market, which is employed by the manufacturer to acquire or dispose products. They argue that the retailer would share the yield randomness with the manufacturer to encourage a higher production performance at the manufacturer’s side, in the presence of the secondary market.

For other links, under the retailer-led case, we have a few more papers. Huang et al. (2015) develop a model where the retailer offers a buyback and returns contract to the third party collector in order to acquire enough returns for remanufacturing. Weraikat et al. (2016) explore the link between the retailer and the third party collector under a revenue sharing contract, in which the third party collector is required to meet a target of collected leftover set by the retailer.

**5.1.3. Other channel leadership scenario**

One relatively under-explored channel leadership situation in reverse logistics is the one led by the remanufacturer as only two papers study such situation. Gu and Tagaras (2014) investigate a structure comprising a third party collector and a remanufacturer where the remanufacturer would only buy back those remanufacturable ones and the proposed buyback and returns contract is to guarantee the remanufacturer’s profit by considering the high uncertainty in returns’ quality conditions. Jena and Sarmah (2016) design a network consisting of two competitive remanufacturers and one common retailer. The authors assume that the retailer faces an uncertain demand of remanufactured items. Under this network, the remanufacturers offer a quantity discount contract to the retailer to motivate a larger order quantity and a lower retail price to ensure the remanufacturers’ market share for their remanufactured products.

Similarly, the supplier-led scenario is also under-explored. Hou et al. (2010) and Jacobs and Subramanian (2012) explore the coordination challenge between the supplier and the manufacturer in reverse logistics. Hou et al. (2010) study a buyback and returns contact between a manufacturer and its backup supplier considering its main supplier’s supply uncertainty and such structure also gives the dominant power to the backup supplier since it can help the manufacturer mitigate the risk from the main supplier. Jacobs and Subramanian (2012) propose a hybrid contract to share the responsibility of product recovery, under which, apart from the supplier, the manufacturer is also responsible for meeting the collection and recycling targets set by the legal regulation.

**5.2. Nash Bargaining**

In some supply chains, decisions are made under bargaining and there are no clear leaders. We hence have the Nash bargaining scenario. In fact, under Nash Bargaining, the equilibrium choices of related parameters depend on relative power of the participated members. In this domain, Bose and Anand (2007), Chen and Bell (2011), Dobos et al. (2013) and Zhang et al. (2015) study the retailer-manufacturer link. Among them, Dobos et al. (2013) focus on the two-part tariff contract while Chen and Bell (2011) as well as Zhang et al. (2015) investigate a buyback and return contract under the influence of consumers’ satisfaction or environmental awareness. At the same time, Bose and Anand (2007) examine the efficiency of a buyback and return contract when the wholesale price is exogenous. Different from the above, Hong et al. (2008) discuss the material flow allocation and pricing decisions in the link between the remanufacturer and the third party collector based on the application of a wholesale pricing contract. Furthermore, Zhao and Zhu (2015) explore the retailer-remanufacturer game in which both a revenue sharing contract and a wholesale pricing contract are examined about their effectiveness in stimulating more returns of used items from the retailer. Su (2009) analyzes the impact of full customer returns policies on channel coordination by comparing the performance of a buyback and returns contract with a rebate contract under the retailer-remanufacturer link. At the same time, both Chen et al. (2006) and Shi (2006) discuss the management of the link between the retailer and the remanufacturer via a hybrid contract (i.e., by combining a buyback and return contract with a risk sharing contract), but with different focal points. To be specific, Shi (2006) focuses on the overstock risk while Chen et al. (2006) consider both the overproduction and overstock risk. In addition to the above papers that are based on the single-link scenario, Arshinder et al. (2009) explore the mutual decision-making process on the decision variables under the buyback and return contracts in both the manufacturer-distributor link and the distributor-retailer link, which help all members to achieve more profits by sharing risks and rewards. Ding and Chen (2008) concentrate on negotiation of the parameter design in the final hybrid contracts, such as the return price and the profit allocation ratios, under a three-level supply chain network. This network consists of a supplier, a manufacturer and a retailer.

**5.3. Multiple Scenarios**

We define the multiple scenarios in which different leaderships with/without bargaining are explored. In our review, we have identified a few in which 2 articles examine the manufacturer-retailer link, 1 paper focuses on the manufacturer-supplier link, 1 paper explores the remanufacturer-third party collector link and 1 paper involves multiple links in the reverse supply chain. We review these papers in the following.

Gao et al. (2016) study the impacts of channel power configurations on participants’ profits and their collection effort of returns by comparing the manufacturer-led, the retailer-led and the vertical Nash scenarios under the coordination by a two-part tariff contract. Li et al. (2012a) analyze the different performance of the wholesale pricing contract, referring to the return quantities and profits for both members, under both the retailer-led and the Nash bargaining cases. As a remark, these 2 papers are based on the link between the manufacturer and the retailer.

Li and Li (2016) discuss the Nash bargaining and the supplier-led cases using the wholesale pricing contract. They aim to reveal the more efficient one in a competitive environment. Ye et al. (2016) measure the efficiency loss of reverse logistics by comparing three competitive structures with the implementation of a wholesale pricing contract. Both the remanufacturer Stackelberg and the third party collector Stackelberg scenarios are analyzed. Choi et al. (2013) explore when higher effectiveness in collecting used products and better performance of the whole reverse supply chain could be attained by considering three different kinds of channel leaderships. They further propose effective coordination mechanisms which include the two-part tariff contract and the revenue-cost sharing contract.

**5.4. Discussions**

Based on the discussion above, we have Table 7, which indicates the most popular supply chain contract under different channel leaderships as well as the performance of these leaderships. It can be observed that the buyback and returns contract is always the most prevailing supply chain contract in the field of reverse logistics regardless of the channel leaderships. As for the performance of various channel leaderships, after deeply investigating the selected papers, we find that the R-led game has the best performance in guaranteeing the collecting effort for returns and in the meantime, the M-led structure indicates the highest feasibility when exploring multiple supply chain contracts and multiple links in reverse logistics.

**Table 7. Results analysis of channel leaderships**

|  |  |
| --- | --- |
| **Category** | **Channel leaderships** |
| **M-led** | **R-led** | **RM-led** | **S-led** |
| **Most popular supply chain contract** | Buyback and returns contract | Buyback and returns contract | Both buyback and returns contract and quantity discount contract | Buyback and returns contract |
| **Positive effect on collection effort** |  | 1st | 2nd |  |
| **Feasibility in multiple contracts** | 1st |  |  |  |
| **Feasibility in multiple links** | 1st |  |  |  |

**6. Discussions and Future Research Opportunities**

From the above review, we can see that a few areas are underexplored. This opens avenues for future research. In the following, we propose several areas, which are based on our discussions in Section 4 and Section 5. Moreover, Table 8 presents a summary of the core future research opportunities, the respective details and expected challenges.

**6.1. Types and Scenarios of Supply Chain Contracting**

1. **Contract types:** From Figure 7, we can see that under the single-contract scenario (excluding the papers mentioning more than one contracts separately), the buyback and returns contract, the revenue sharing contract, the wholesale pricing contract and the two-part tariff contract are relatively well-explored but not the others. In particular, those supply chain contracts focusing on cost sharing and risk sharing are currently under-explored. As we all know, reverse supply chain operations invariably relate to proper cost control (e.g. on additional collection costs, transportation costs) and risk (e.g. the uncertainty of returned amount and qualities), reasonably sharing costs and risks can definitely contribute to a more sustainable cooperative relationship (Atasu and Souza, 2013; El-Sayed et al., 2010; Govindan et al., 2012; Guide Jr et al., 2000; Pishvaee & Torabi, 2010). Moreover, many contracts not well-explored are also of high research relevance and value. For instance, the retailer or the remanufacturer may explore the proper outsourcing contract for the collection function to a third party collector when its capability of handling returns is not enough (Weraikat at al., 2016; Ye et al., 2016). Under this situation, examining how the retailer (or remanufacturer) utilizes a contract to simulate more qualified returns and enhance reverse supply chain performance can be really meaningful. The existence of information asymmetry (Mukhopadhyay et al. 2008) may also be explored. Expectedly, pursuing this research extension will require developing innovative formats of supply chain contracts.
2. **Hybrid contracts and other contracting scenarios:** From our review, most papers published in the literature focus on the single link single contract setting, it is obvious that more research should be done for the other settings. For instance, the hybrid contracts, which are popular in traditional supply chain operations (see Chiu et al. 2011), are under-explored in reverse supply chain management. This calls for more studies on them. In addition, from Figure 4, we can see that very few articles have analyzed multiple links in reverse logistics. Thus, future research should be conducted on the multiple-link scenario, which is essential considering the increased number of activities in reverse logistics (e.g. collecting or remanufacturing) compared with the forward logistics counterpart (Kumar & Putnam, 2008; Ravi et al., 2005). For instance, it is interesting to examine the situation when the manufacturer should cooperate and contract with both the third party collector and the retailer to improve reverse supply chain performance. Of course, the exploration of the hybrid supply chain contracts is more complicated and challenging than the simpler supply chain contracts.

**Figure 7. Popularity of various supply chain contracts in reverse logistics.**

**6.2. Specific Links**

A reverse supply chain has many links and each link is in fact important because a weak link can kill the whole chain! Results in Figure 3 and Figure 8 show that the most popular link being studied in the literature (under the single-link scenario) is the manufacturer-retailer link which occupies 73% of all papers. However, the other links are under-explored. If we take a closer look, only very little literature has studied the supply chain contracts in the manufacturer-remanufacturer link, while this link is interesting because competition exists (Atasu et al., 2008; Jung & Hwang, 2011; Webster & Mitra, 2007). Such competition can affect the final return rate for reverse supply chains and hence examining how the manufacturer interacts and contracts with the remanufacturer is interesting. Moreover, from Figure 3 and Figure 8, we have the following proposals**[[17]](#footnote-17)**:

1. **Under Situation A:** Other links involving the participation of the remanufacturer, like the retailer-remanufacturer link, can also be further explored. For example, it is meaningful to explore the remanufacturer’s role in deciding the re-manufacturability of products and the retailer’s knowledge in returns (Galbreth & Blackburn, 2010; Hatcher et al., 2012). In order to yield promising results, real world practices should be incorporated into the analysis for this extension.
2. **The third party collector related links:** Studying the link between the manufacturer and the third party collector and the one between the remanufacturer and the third party collector are all of high research value since few papers have considered them, while these links are all important. In particular, the links involving the third party collectors are very important because their presence and efforts determine the quantity and quality of returns (Agrawal et al., 2015; Choi et al., 2013; Kaya, 2010; Kim et al., 2009; Li et al., 2014; Shi et al., 2012). Moreover, some collectors even hold a leadership role in the link, such as for the IBM's Global Asset Recovery Services (Choi et al. 2013). Undoubtedly, a lot of scenarios need to be examined which is a critical challenge.
3. **Multiple-link:** Few reported studies have examined the coordination mechanism across multiple links. As reverse supply chains usually have multiple links and all links are important, exploring supply chain contracting mechanisms for multiple links is a challenging topic and deserves deeper explorations.

**Figure 8. Popularity of different links under Situation A.**

**6.3. Channel Leadership**

1. **Remanufacturer-led and retailer-led cases:** For the channel leadership scenarios in reverse logistics, as analyzed in Section 5, the manufacturer-led case is the most common one (regardless of the number of involved links). The remaining channel leadership scenarios, such as the remanufacturer-led one, are hence under-explored. Concerning the remanufacturer’s capability of determining the quantities and prices of remanufactured items (Karakayali et al., 2007; Sun et al., 2013), the remanufacturer-led scenario should be explored further. Preferably, real world remanufacturer-led cases should be investigated. In addition, given the growing power of retailers and the existence of many retail programs such as mass customization (Chen & Xiao, 2009; Choi 2013; Huang et al., 2002; Liu et al., 2012; Wang & Liu, 2007; Xiao et al., 2014; Yue et al., 2006), the retailer-led scenarios also deserve further investigations. As a remark, for the retailer-led scenarios, marketing decisions like sales effort and pricing are important. However, incorporating them in the analysis will lead to much more complex models which makes the analysis challenging.
2. **Who should be the leader?** In a reverse supply chain system, there are multiple members. Revealing the system performance under different channel leadership is important. From Table 6, we can see that only 5 articles have studied this issue, and the reverse supply chains being explored are relatively similar. Thus, a complete answer to this important question is still widely open. This calls for more further studies, from both empirical and analytical areas. Observe that for this future research extension, in order to yield convincing insights, comparisons among various channel leaderships must be made. This is an uneasy task.

**6.4. More Sophisticated Reverse Supply Chains**

Apart from the aspects mentioned above, it is also observed from the reviewed articles that the prior studies mainly (nearly 90% in total) focus on exploring supply chain contracting in a one-to-one relationship scenario, e.g., a single retailer and a single manufacturer. However, in reality, we have other structures and they are all important. For example, a retailer should open itself to contract with multiple manufacturers as it is unwise to depend solely on one manufacturer (Minner, 2003). The same applies to the manufacturer who should produce for multiple retailers. Studying the one-to-many, many-to-one, and many-to-many relationships in supply chain contracting would definitely enrich the literature. In addition, issues such as competition among supply chain agents of the same echelon (e.g., among manufacturers) can be explored when we have these reserve supply chain structures. Of course, expectedly, the corresponding analytical models are more complex and challenging to investigate.

**6.5. Optimization Objective**

Among the reviewed papers on supply chain contracting in reverse logistics, most of them look at profit maximization. Only one paper considers the cost-minimization objective. This is probably driven by the fact that supply chain coordination is conventionally defined as the situation when the supply chain profitability is maximized. However, this situation may not fit the reality in reverse logistics well because cost minimization is a common measure there (Dobos et al. 2013). We hence argue that studying supply chain contracts with the cost minimization objective, such as minimizing the collection costs, holding costs and disposal costs, is an important issue for future research. However, for this future research extension, how to accurately measure the cost related parameters and model the cost function deserves full attention. In addition, pursuing desirable environmental performance and suitable consumption of energy can also be two valuable objectives in the future (Atasu and Van Wassenhove, 2012; Atasu et al., 2013a).

**Table 8. A Summary of Future Research Opportunities**

|  |  |  |  |
| --- | --- | --- | --- |
| **Category** | **Topics** | **Details** | **Challenges** |
| Types and scenarios of supply chain contracting | Contract type | Cost and risk sharing contracts, outsourcing contracts should be conducted | New and innovative formats of supply contracts need to be explored. |
| Hybrid contracts | The combination of multiple contracts together is interesting to explore | The hybrid contracts are more complicated and difficult to implement in practice. |
| Specific links | Single-link single-contract | It is important to explore the remanufacturer’s role in deciding the re-manufacturability of products and the retailer’s knowledge in returns | Incorporating real world practices becomes critically important. |
| The third party collector related links | More research on the links associated with the third party collector should be conducted | There are many different scenarios to be considered. |
| Multiple-link | Generalize the results from single-link research to multiple-link research | Studies involving multiple links are challenging  |
| Channel leadership | Remanufacturer-led | Manufacturer-led cases are commonly explored, but not the remanufacturer-led cases | Finding relevant industrial cases in which the re-manufacturer acts as supply chain leaders |
| Retailer-led | Retailer-led scenarios should be explored | Including marketing effort and pricing decisions makes the model more complex. |
| Who should be the leader? | Deciding the optimal choice of channel leadership in reverse supply chains is very important | Addressing this research question requires exploring and comparing the reverse supply chain under all relevant leaderships.  |
| More sophisticated reverse supply chains | More general reverse supply chains | Investigating more general reverse supply chains | More complex analysis. |
| Optimization objective | Cost minimization, environmental performance, and energy consumption | Measuring reverse logistics and the performance of contracts in the “cost minimization”, as well as environment and energy domains | Careful estimates and considerations of the associated costs and environment/energy related issues are crucial. |

**7. Concluding Remarks**

Reverse logistics, as an area that is crucial and highly related to the global trend of sustainability, has already attracted attentions from an increasing number of researchers in supply chain operations management. In this paper, we have examined the reverse logistics literature with the focal point on supply chain contracts. First of all, we have reported some descriptive statistics, which include a list of most productive scholars and popular journals, related to supply chain contracting research in reverse logistics. Then, we have established that supply chain contracts are crucial and they help to achieve the optimal reverse supply chains (i.e. coordination). We have extensively searched the recent literature and deeply analyzed the relevant studies. By focusing on the supply chain links involved as a part of the supply chain structure and the channel leadership, we have explored how different supply chain contracts have been studied in the literature. Based on them, we have proposed a research agenda which indicates some specific under-studied research areas for future studies. We believe that these proposed research directions and topics are useful and important to help foster future research in the related area.

 Similar to all review papers, this paper suffers some limitations. First, even though our searching is systematic, personal bias still exists in the selection of papers. Second, this paper only surveys the technical papers published in Thomson Web of Science listed journals. Thus, many related studies are excluded.

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**Appendix: Supplementary Tables and Figures 1a,b,c.**

**Table A1. Definitions of different “situations”**

|  |  |  |
| --- | --- | --- |
|  | **Link** | **Contract** |
| Situation A | Single | Single |
| Situation B | Single | Multiple |
| Situation C | Multiple |  |
| Situation D | Single and Multiple together |  |

**Table A2. Articles under Situation A**

|  |  |
| --- | --- |
| **SC contracts** | **Corresponding reference** |
| **Buyback and returns contract** | Arcelus et al. (2011), Bose and Anand (2007), Chen (2011), Chen and Bell (2011), Gu and Tagaras (2014), He et al. (2006), Hou et al. (2010), Huang et al. (2015), Jeong (2012), Lee and Rhee (2007), Li et al., (2012), Liu et al., (2014), Matsui (2010), Ohmura and Matsuo (2016), Wu (2013), Xu et al. (2015), Yao et al. (2008), Zhang et al., (2015); |
| **Revenue sharing contract** | Mafakheri and Nasiri (2013), Ran et al. (2016), Weraikat et al. (2016), Wu et al. (2015), Zeng (2013), Zou and Ye (2015); |
| **Wholesale pricing contract** | Atasu et al. (2013b), Hong, et al. (2008), Hong and Yeh (2012), Li and Li (2016), Li et al. (2012a), Ye et al. (2016); |
| **Two-part tariff contract** | Dobos et al. (2013), Gao et al. (2016), Hong et al. (2015), Kaya (2010); |
| **Quantity discount contract** | Huang et al. (2011), Jena and Sarmah (2016); |
| **Risk sharing contract** | He (2015), He & Zhang (2010); |
| **Consignment contract** | Hu et al. (2014); |
| **Rebate contract** | Ferguson et al. (2006); |
| **Papers mentioning more than one contracts separately** | Chen and Chang (2014), De Giovanni (2014), Huang et al. (2014), Ruiz-Benitez and Muriel (2014), Song et al. (2008), Su (2009), Xiao et al. (2010), Yoo et al. (2015), Zhang et al. (2014), Zhao and Zhu (2015); |

Retailer

Retailer

Retailer

Third party collector cocollector

Manufacturer

Manufacturer

Third party collector cocollector

Remanufacturer

Remanufacturer

Supplier

Supplier

**Figure 1a. The reverse logistics model 1. Figure 1b. The reverse logistics model 2.**

Retailer

Manufacturer

Third party collector cocollector

Supplier

Remanufacturer

**Figure 1c. The reverse logistics model 3.**

1. This paper is a part of the PhD thesis of the first author, under the supervision of the other co-authors. The authors sincerely thank the editors and the anonymous reviewers for their helpful and important comments. [↑](#footnote-ref-1)
2. Corresponding author. [↑](#footnote-ref-2)
3. In logistics and supply chain management, the term coordination commonly refers to the scenario when the supply chain system is optimized. [↑](#footnote-ref-3)
4. Notice that in this paper, following the common case in the supply chain management literature, we use the terms “supply contract” and “supply chain contract” interchangeably. [↑](#footnote-ref-4)
5. Observe that for forward supply chains, contracts help to align the incentive of the supply chain members such that the decisions on the buyer’s ordering quantity and pricing decisions are the same as the optimal supply chain’s decisions. In most cases, these decisions are on the buyer side. However, in reverse logistics and supply chains, contracts are used to ensure the related members will apply the optimal effort and production process in collecting and utilizing the reverse materials. The decisions are mostly from the supplier/collector side. [↑](#footnote-ref-5)
6. Observe that another excellent review on supply chain contracts related to both forward and reverse logistics systems is reported by Govindan et al. (2013). However, this paper differs from it in several ways. First, the perspectives are different as this paper focuses on exploring supply chain links (i.e. the detailed structures) and channel leaderships. Second, this paper focuses on examining the most recent reverse logistics literature with leading journals listed in Thomson Web of Science. Third, the identified specific research gaps and open questions are different.

 [↑](#footnote-ref-6)
7. We choose this 10-year period because (i) this paper focuses on the recent literature and there are some earlier reviews which cover the older literature, (ii) some prior papers, such as Pokharel and Mutha (2009), indicate that there is a distinct increase in the number of reverse logistics related papers from 2006. In fact, after 2006, there are a lot of special issues devoted to reverse logistics and CLSC management, and the ten-year period from 2006-2016 well-covers all of these recent developments in the literature. [↑](#footnote-ref-7)
8. In this paper, providing raw materials to the manufacture is the major role of the supplier and producing corresponding products is under the responsibility of the manufacturer. [↑](#footnote-ref-8)
9. Handling returns is not necessarily limited to the duty of the third party collector. For example, both the manufacturer and the retailer may have the ability to handle returns and the related remanufacturing activities. [↑](#footnote-ref-9)
10. Notice that some of the papers may be co-authored by several researchers listed in this table. Each authorship or co-authorship is counted equally. [↑](#footnote-ref-10)
11. See Table A2 in the Appendix for the details of the 50 papers. [↑](#footnote-ref-11)
12. Interested readers can refer to Arcelus et al. (2011), Bose and Anand (2007), Chen (2011), Chen and Bell (2011), He et al. (2006), Jeong (2012), Lee and Rhee (2007), Li et al., (2012), Liu et al., (2014), Matsui (2010), Ohmura and Matsuo (2016), Wu (2013), Xu et al. (2015), Yao et al. (2008) and Zhang et al., (2015). [↑](#footnote-ref-12)
13. This scenario covers two papers. [↑](#footnote-ref-13)
14. It combines both a revenue sharing contract and a cost sharing contract. [↑](#footnote-ref-14)
15. It combines both a revenue sharing contract and a two-part tariff contract. [↑](#footnote-ref-15)
16. It combines both a profit sharing contract and a buyback and returns contract. [↑](#footnote-ref-16)
17. See the Appendix for the definitions of the respective “situations”. [↑](#footnote-ref-17)