



# Values of information sharing: A comparison of supplier-remanufacturing and manufacturer-remanufacturing scenarios



Yanting Huang<sup>a,b,\*</sup>, Zongjun Wang<sup>a</sup>

<sup>a</sup> School of Management, Huazhong University of Science and Technology, Wuhan 430074, China

<sup>b</sup> Department of Industrial Systems and Engineering, National University of Singapore, 117576, Singapore

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## ABSTRACT

This paper investigates values of information sharing in supplier-remanufacturing and manufacturer-remanufacturing scenarios where the retailer possesses private demand information. In the supplier-remanufacturing scenario, the supplier acts as the mere component provider. While in the manufacturer-remanufacturing, the supplier acts as both a component provider and a competitor to the manufacturer. We find that information sharing is profitable for both the supplier and the manufacturer, while it is detrimental to the retailer. The supplier with shared information would adjust the wholesale price and acquisition price to reach an equilibrium between forward and reverse flows.

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## 1. Introduction

Remanufacturing, defined as an industrial process where used products are restored to useful life (Östlin et al., 2008), involves sorting, inspection, disassembly, reprocessing and reassembly. This process helps reduce the natural resources needed, landfill space and air pollution (Atasu et al., 2008; Ferrer and Swaminathan, 2006). The critical contributions of remanufacturing to both the environment and company excess economic benefits have been addressed in practice and literature (Atasu and Souza, 2013; Jia et al., 2016; Mutha et al., 2016). In real-cases, many companies have been engaged in remanufacturing activities to obtain more revenues in their production process. For instance, Xerox and Canon, saved several million US dollars by conducting remanufacturing activities (Jayaraman and Luo, 2007; Zhou et al., 2017). Three interesting issues arise in remanufacturing: (1) determining what party should conduct the core collecting and reprocessing (e.g. Savaskan et al., 2004), (2) equilibrium pricing decisions for remanufactured products (e.g. Wu, 2012b), and (3) influences of competition with respect to partners' strategies and revenues (e.g. Mitra and Webster, 2008). Regarding the first issue, most studies consider the scenario where the original equipment manufacturer (OEM) and/or the third-party remanufacturer (3PR) are engaged in the remanufacturing process (Chen and Chang, 2012; Örsdemir et al., 2014). However, in real-life, there are also some cases where a supplier takes responsibility of producing both new and remanufactured components. For example, most Chinese auto manufacturers are not capable of fabricating high-quality automotive engines and gearboxes and they have no capacity to remanufacture such key components. Therefore, the key component suppliers will be engaged in the remanufacturing procedure.

Although supplier-remanufacturing is an extremely important branch of closed-loop supply chains (CLSCs), related research is quite scarce. Recently, Xiong et al. (2013) investigate the interaction between a key component supplier and a

\* Corresponding author at: School of Management, Huazhong University of Science and Technology, Wuhan 430074, China.

E-mail address: [ythuang4028@hust.edu.cn](mailto:ythuang4028@hust.edu.cn) (Y. Huang).

non-integrated manufacturer, and suggest this interaction would bring significant impact on both economic and environmental performance of CLSCs. They (Xiong et al., 2016) further compare manufacturer-remanufacturing and supplier-remanufacturing modes in terms of remanufacturing cost. Specifically, they indicate that, when the unit remanufacturing cost is high enough, manufacturer-remanufacturing is more profitable to the manufacturer and more valuable to the consumers, while less valuable for the supplier and environment than supplier-remanufacturing.

Existing research on supplier-remanufacturing has not taken information sharing into consideration. Most studies assume all chain members know the complete information and carry on decisions based on their view of information symmetry (Debo et al., 2005; Tsay and Agrawal, 2000; Wu, 2012b). This scenario deviates from the real-life in some cases. In practice, each chain member usually has access to private information, and other chain members know nothing about this information in a supply chain (Lee and Whang, 2000). Suntory, one of the largest Japanese food and beverage companies, has no information on product returns when it remanufactures polyethylene terephthalate (PET) bottles from reused resin (Hosoda et al., 2015). This case of information asymmetry often affects the enterprises' efficiency and benefits. To overcome this obstacle, so far, many firms have proposed some schemes such as Collaborative Planning, Forecasting and Replenishment (CPFR) to facilitate sharing of demand forecast information among chain members (Yue and Liu, 2006). Additionally, it has been revealed that information sharing is important in promoting the performance of a supply chain and improving firms' efficiency and revenues (Li and Zhang, 2015; Shamir, 2012).

In this paper, we assume that the retailer, who is near to the market, first acquires the market demand information and subsequently determines whether to share the information with other chain members (i.e., the manufacturer and/or the supplier). This consideration is widely adopted in literature (Keifer, 2010; Lee et al., 2000; Shamir and Shin, 2016). As an example, Sanyo, one key component supplier, provides batteries to the manufacturer Lenovo for assembling computers. Lenovo is also engaged in recycling used computers and related key components at an appropriate price after attaining the market analysis report from the retailers. Intuitively, assuming Lenovo successfully recovers some batteries from the used computers, it would decrease battery purchases from Sanyo. Therefore, Lenovo's acquisition behavior leads to a competition threat to the battery supplier Sanyo. In addition, similar competition can be also found in above mentioned case. The remanufactured products from the automobile manufacturer will erode the sales of engines from the key component supplier.

Although there is the evidence of this combination between supplier-remanufacturing and information sharing in a CLSC, relative systematic research has not ever been investigated. Therefore, we extend Xiong et al. (2016)'s model by inserting information sharing into manufacturer-remanufacturing and supplier-remanufacturing scenarios, and study the effect of information sharing on supplier-remanufacturing with respect to pricing strategies and profits of chain members. Regarding the benefits of information sharing, we make a comparison between manufacturer-remanufacturing and supplier-remanufacturing scenarios. Specifically, we consider four cases of information sharing in a remanufacturing system: (1) no information sharing, (2) the retailer sharing information with the manufacturer, (3) the retailer disclosing information to the supplier, and (4) the retailer sharing information with both the manufacturer and the supplier. This paper is the first to examine information sharing in supplier-remanufacturing and analyze which information sharing mode allows the maximum profit for each chain member. Our work aims to address the following issues:

- (1) What are the equilibrium decisions and chain members' profits in the supplier-remanufacturing scenario?
- (2) From the view of each chain member, which is the best information sharing pattern?
- (3) Within the same information sharing pattern, which is better for chain members, supplier-remanufacturing or manufacturer-remanufacturing?

The remainder of this paper is structured as follows. We summarize the related literature in Section 2. Section 3 presents model assumptions, and develops manufacturer-remanufacturing and supplier-remanufacturing modes under four information sharing patterns. Based on Section 3, we further make comparisons between two remanufacturing scenarios with respect to pricing decisions and the profit of each chain member, and analyze the value of information sharing in each scenario in Section 4. The numerical examples are conducted in Section 5. The last section is the conclusion and further research prospects. Proofs are provided in Appendix A.

## 2. Literature review

Two research streams are relevant to this paper, namely remanufacturing in a CLSC and information sharing, each of which we review below.

### 2.1. Remanufacturing in a CLSC

In the first stream of study, remanufacturing including recycling and reprocessing activities is undertaken by OEMs, third-party collectors/remanufacturers or the retailers. Savaskan et al. (2004) first propose three collection patterns, including retailer collection, manufacturer collection and third-party collection, and derive that the retailer collection is the most effective approach for the manufacturer. Afterward, Atasu et al. (2013) further develop collection cost functions to compare three collection formats and confirm that cost collection structure plays an important role in the manufacturer's strategy. Choi

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