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Knowledge Sharing in Closed-Loop Supply Chain Management

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Abstract. In the recent decades, closed-loop supply chain has been studied extensively due to the increased concern on sustainable development. It integrates forward and reverse flows where the collaborative supply chain takes place. Knowledge management is one important part of an organization that can improve the effectiveness of the processes within the organization. Knowledge sharing is significant in a collaborative supply chain since it affects the organizational performance and competitive advantage. The complexity in closed-loop supply chain can be managed better by encouraging knowledge sharing among the supply chain members. This paper presents a conceptual framework to implement knowledge sharing in a closed-loop supply chain management, for improving the CLSC members' performance. The success factors have been identified, and a framework has been presented, it consists of knowledge flows, management aspect and socio-technical aspect.

Keywords: Closed-Loop Supply Chain, Supply Chain Relationship, Knowledge Management, Tacit Knowledge, Knowledge Capability.

1. Introduction

Knowledge Management is one important part of an organization, that can helps the organization to perform effective processes through sharing and re-using knowledge, as well as to gain competitive advantage. De Geus [1] claimed that sustainable competitive advantage is mainly supported by the ability to learn faster than our competitors. Therefore, it is important to be able to retrieve knowledge. The process of retrieving knowledge was described by Nonaka [2] in five interrelated phases. The first phase is to share tacit knowledge, which usually is not directly obtainable by the organization. Generally, tacit knowledge is held or owned by individuals and obtained mainly from a several period of experience and not easily expressed in words. In contrast to the explicit knowledge that can usually be expressed among others through manual procedures, work documents, or images and data, tacit knowledge requires a more complicated effort. It is influenced by emotions, feelings and individual mental models that need to be shared in order to build mutual trust. Therefore, knowledge sharing becomes an important challenge for the success of the process of knowledge capture.

In the recent decades, the study on closed-loop supply chain (CLSC) has been growing rapidly due to the increased concern on sustainable development. Process recovery has been improved to increase product's life-time, hence end-of-use or end-of-life products are collected, recovered, and further released back to the market. Therefore, there is a need to consider the processes in supply chain management, not only the forward channel, but also the reverse one in an integrative manner. In doing so, there are several parties involved. Previous studies showed that the relationship among CLSC members is important [3-4]. In Dyer & Nobeoka [5], a Toyota case demonstrated the power of knowledge sharing which has been able to improve the productivity of the Toyota's supplier network. Also, from a knowledge-based perspective, knowledge can give significant contribution to intangible strategic resources within the supply chain.

In this paper, we develop a conceptual framework to implement knowledge sharing in a closed-loop supply chain management, for improving the CLSC members' performance. In section 2 and 3 we provide the relevant theories about knowledge management and closed-loop supply chain, respectively. In section 4 we present a comparison on the implementation of knowledge sharing in two case studies. Section 5 presents the conceptual framework with the development rationality, followed by conclusion in section 6.

2. Knowledge Management

According to Alavi [6], based on the work of Nonaka [7] and Huber [8], "*knowledge is a justified belief that increases an entity's capacity for taking effective action*". Davenport & Marchard [9] suggested that managing knowledge means having a structured approach to develop methods for recognizing, assessing, organizing, storing and applying knowledge, such that the need and aims of the organization are achieved. Allameh et al. [10] defined knowledge management as "*a set of processes for understanding and applying knowledge strategic resources in an organization*". Nowadays, knowledge has been considered as the main source for competitiveness, since it could improve efficiency and effectiveness of the organization.

Nonaka [7] classified knowledge into two categories, tacit and explicit. Tacit knowledge is implicit; it is stored in one's head [11] and usually rooted in action, experience, and involvement in a specific context. The explicit knowledge is codified and can be communicated in a symbolic form or a systemic language. Nonaka & Von Krogh [12] explained further that explicit knowledge has a universal character and supporting capacity to act across contexts. It is accessible through consciousness. On the other hand, tacit knowledge is tied to the senses, tactile experiences, movement, skills, intuition, unarticulated mental models, or implicit rules of thumb. It can be accessible through consciousness if it leans towards the explicit side of the continuum.

Davenport & Prusak [13] claimed that three main objectives in most of the knowledge management projects are (1) knowledge becomes visible, (2) develops knowledge sharing culture, and (3) builds knowledge infrastructure beyond technical system.

Alavi & Leidner [6] provided knowledge definitions and the implications. Knowledge capability is defined as the potential within the knowledge to influence action. The implication of knowledge management is about building core competencies and understanding strategic know-how. They also claimed that the role of Information technology (IT) in terms of knowledge capability is to enhance intellectual capital by supporting development of individual and organizational competencies. Lee et al. [14] studied the interaction between knowledge management infrastructure, knowledge process capability, organizational creativity, and performance. They suggested that collaboration, learning culture, and top management support positively knowledge process capabilities, i.e., acquisition, conversion, application, and protection. Information technology (IT) is the core infrastructure of knowledge management, and IT support is the most crucial factor in determining knowledge process capabilities. They also found that knowledge process capabilities positively affect creative organizational learning, and consequently, creative organizational learning positively affects organizational performance.

3. Closed-loop Supply Chain and Knowledge Sharing

Many of CLSC definitions are mainly concerned with combining forward and reverse supply chains. According to Guide et al. [15], closed-loop supply chain is "*supply chains that are designed to consider the processes required for returns of products, in addition to the traditional forward processes".* The additional activities are product acquisition; reverse logistics; test, sort and inspection; recovery processes – direct reuse, repair, remanufacture, and recycle – and disposal; as well as remarketing. Ferguson & Souza [16] defined CLSC as "*supply chains where, in addition to the typical forward flow of materials from suppliers to end customers, there are flows of products back to manufacturers*". Pochampally et al. [17] and Lebreton [18] presented similar definition or description of CLSC. Moreover, Le Blanc [19] and Guide & Van Wassenhove [20] considered not only the combined practice of forward and reverse supply chain and additional activities in the reverse flow, but also value creation and recovery over the entire life-cycle of a product, as well as the whole business processes involved.

Guide & Van Wassenhove [20] defined closed-loop supply chain management as "*the design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time*". This definition has been evolved from merely integration of forward and reverse channels of supply chain. They also argued that managers start to recognize the potential of reverse supply chain, and therefore researchers should seek ways to maximize value recovery and innovative way to release value from product returns. Further, they believed that the research models should consider the entire product life-cycle.

Closed-loop supply chain involves reverse supply chain. Guide & Van Wassenhove [21] suggested that key activities in reverse supply chain can be categorized as (1) front end, which deals with product returns management; (2) engine, which covers remanufacturing operations issues; and (3) back end, which handles market development of remanufactured product.

The previous studies clearly showed that the implementation of closed-loop supply chain would require

1. knowledge capability for implementing the reverse flow, in addition to the forward flow;
2. knowledge sharing to improve the value creation over the entire life-cycle;
3. knowledge infrastructure to support the supply chain's performance.

The importance of knowledge management for collaborative supply chain has been established by Lin et al. [22]. They examined the knowledge flows and categorize knowledge into seven kinds according to the functions, i.e., design & development, pre-sales, sales, manufacturing, distribution, service & support, and finance. In this paper we propose the knowledge in closed-loop supply chain into three main categories, i.e., manufacturing processes as the core activity, the other activities in the forward flow, and the activities in the reverse flow. Collins et al. [23] argued that translating a firm's knowledge resources into usable knowledge management capabilities may improve the firm's competitive advantage.

In a closed-loop supply chain management, there are several members, such as manufacturer, supplier, distributor, core collector, and sometimes third party logistics and recovery firms. The supply chain performance is not achieved by a single member but it requires the whole members' performance. The weakest link in the chain would cost the supply chain performance. Therefore, it is important to promote knowledge sharing among supply chain members such that the knowledge capabilities in the strongest member could be transferred to the others.

4. Comparison of two case studies in implementing knowledge sharing

In building the conceptual framework, we study two cases, i.e., a Toyota case and a joint-venture construction project. We study the success factors and combine the results with the theories from previous studies.

4.1 Toyota Case [5]

The automotive industry offers exciting opportunities to empirically observe inter-organizational learning. Automobile production involves a network of suppliers that often contribute significantly in the proportion of components, up to 70% of the value of the vehicle. Therefore, the quality and cost of a car will depend on the productivity of suppliers within the automotive industry's network. According to Nishiguchi (1994) and Lieberman (1994), as cited by Dyer

& Nobeoka [5], Toyota is a company that is superior in transferring knowledge in a way that significantly increases the productivity of the suppliers within the network. On the other hand, automakers and suppliers in the United States stagnated until 1980s, and only increased after the Japanese automotive company began to establish transplants in the United States. Dyer found that Japanese automakers, particularly Toyota, have built the habit of sharing knowledge in bilateral and multi-lateral with its suppliers, which can lead to a superior inter-organizational learning.

In this exploratory study, the production network comprises a group of companies that collaborate in car manufacture. Toyota becomes the center of a network because (1) it is the only company that has a direct relationship with all the other companies in the network, (2) Toyota coordinates all the activities of all companies in the network

The success of Toyota's network knowledge sharing was attained through initiation and evolution. Toyota's initiation is an innovative approach by establishing Supplier association, On-site Consulting, and Supplier Learning Teams (*Jishuken*). Supplier association process is linked to Toyota's purchasing and the knowledge shared here is mainly explicit knowledge. In the initial phase, Toyota provided free consultancy to share knowledge, especially tacit knowledge. These consultants acted as a catalyst for creating knowledge sharing norms, stimulating openness to share knowledge among suppliers. After the social bonds and norms have been formed, Toyota made small groups, and arranged carefully in order to maximize the willingness and ability of suppliers to learn from each other. For example, direct competitors are not placed in the same group, rotate members of the groups in order to maximize diversity of ideas. Thus, Toyota has established nested networks, which were formed to facilitate the tacit knowledge sharing within themselves and reduce the role of Toyota. In time, these networks became more effective in facilitating the sharing of knowledge both explicit and tacit. So, the evolution occurred. Toyota also consistently monitors the sharing of knowledge, even provides incentives by giving bigger business contract to outstanding suppliers.

The study managed to find traits that are important in creating and managing knowledge sharing in a network effectively, i.e., (a) create organizational units to gather knowledge in the network, (b) eliminate ownership of knowledge, (c) create nested networks in the knowledge sharing network.

4.2 Joint-venture Construction Project [24]

In a construction project, the problems encountered in the field are usually resolved on a case by case basis and that knowledge stops at the team involved in the project. Therefore, knowledge management becomes an important issue in an effort to manage knowledge related to problems in the field, so that when similar cases occur, the team already has a basic knowledge of how to solve the problem, and does not re-invent the wheel. Dulaimi's study [24] took the social and technical perspective, which becomes critical when the case at hand is an international joint venture project where knowledge sharing must occur between different companies and different national culture.

Dulaimi referred to Trist and Bamforth (1951), Pasmore et al. (1982), and Riege (2005), which stated that an organization needs to combine technology and people in order to implement effective knowledge sharing. Dulaimi also adopted a model by Pan and Scarborough (1998), which explains the social aspects of knowledge within the organization, where there are three layers of knowledge sharing system. The first layer is infrastructure that is hardware or software. The second layer is info-structure, in the form of formal rules that govern the exchange of knowledge. The third layer is info-culture that represents the background knowledge embedded in social relations within the group.

The case study conducted on four construction projects operating in Singapore. For the first layer, cases were evaluated whether the infrastructure is flexible and structured. In the second layer, cases were analyzed whether the exchange of knowledge is organized, implicit or explicit. For the info-culture layer, the openness and compatibility were studied. Dulaimi found that knowledge sharing occurs only when foreign contractors are motivated by the need to learn from the local industry.

The organizational structure, information technology systems, and different practices in the joint venture were usually directed on the completion of the work, not on knowledge sharing. In addition, there was very little evidence showing the attempts to implement knowledge sharing. Fragmentation of labor between local and foreign contractors further reduced technical need to share knowledge as well as the opportunity to work collaboratively. This condition was exacerbated by cultural differences in learning, and language differences.

4.3 Success Factors in the Knowledge Sharing Implementation, lessons learned from the case studies.

Although both cases have identified the need for knowledge sharing, but the implementation in Toyota's approach is very different to the approach of the international joint venture (JV) contractor in Singapore. There are several areas of differences:

a. The form of the cooperation
   The cooperation between Toyota and its suppliers is interdependent relationship and centered on one company, that is Toyota. In the JV contractor, there is a fragmentation of labor so that the interdependence is very low, each party can do her job separately with a little need for interaction with others.
b. Benefit sharing
   In the case of Toyota, all parties in the network share the benefits of knowledge sharing because it can increase the productivity of each party, which in turn brings out superiority against their competitors. Whilst in the case of JV contractor, the objective of cooperation varies among projects. Most of the time, the cooperation is focused on joining resources and expertise, as well as sharing commercial risk. Only one of the JV projects shows a common objective, which is getting control of the market and the price through cooperation with local companies, which demonstrates good knowledge sharing practices. It can be concluded that one of the keys to

successful knowledge sharing is finding advantages that lead to economic benefit that can be shared by both parties.

c. Commitment
Toyota shows a very high commitment to support the knowledge sharing, by facilitating, monitoring and intensifying knowledge sharing activities, such as forming an association of suppliers, *Jishuken*, and the transfer of employees. In all these processes, Toyota becomes the core company in the network. On the other hand, in the JV contractor, each company conducts knowledge sharing activities independently, so it depends on those who need to initiate, and there is no commitment to do it continuingly. Additionally, no company is at the core of the network so that no one is responsible for monitoring and ensuring the process of knowledge sharing. Cultural and language barriers encountered in the JV contractor case have become an obstacle to the process of knowledge sharing, yet it is not an issue in the case of Toyota. Therefore, it can be concluded that cultural differences and language barriers are not obstacles as long as each party has a high commitment to implement knowledge sharing.

d. Infrastructure
Toyota provides an adequate infrastructure for the knowledge sharing, where a unit exists there to accumulate knowledge in a structured manner. Knowledge ownership is also eliminated so that the data access is more flexible, can be acquired rapidly, and does not need to go through a long bureaucracy. In the case of JV contractor, the four companies studied turn out to have an infrastructure that is not flexible even though structured. It can be concluded that the flexibility of the infrastructure is very important in the process of knowledge sharing.

e. Info-structure
Under the nested networks, in the case of Toyota, the exchange of information becomes organized and explicit, such as via the process of on-site consulting, *Jishuken*, and team problem-solving. This allows the transfer of tacit knowledge. In contrast, in the JV contractor case, most of the knowledge sharing process is done implicitly.

f. Info-culture
In the Toyota case, during the transplants of Toyota's way in the United States, there certainly exist cultural differences, both national culture and corporate culture. However, all parties in the network demonstrate a willingness to share knowledge, hence the cultural differences do not become a bottleneck. On the other hand, the JV contractor fails to demonstrate a desire to share knowledge through action. There are contractors who declare the desire to implement knowledge sharing, but it is not followed by a consequent action.

5. Conceptual Framework

In a supply chain where the forward and reverse flows form a closed loop, hereinafter referred to as CLSC (Closed-Loop Supply Chain), the members are connected in a network. Suppliers, manufacturers, distributors, and retailers are in the forward chain to reach the consumer. On the reverse chain, the parties involved are collectors (this role can be carried out by retailers, third party or the manufacturer), the manufacturer in the role of doing the recovery process, the distributor of recovered product, and retailers to market the recovered products, as given in Figure 1.

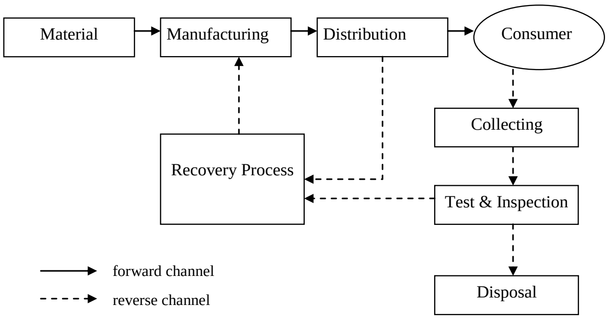

Figure 1. A closed-loop supply chain forward and reverse chains [25]

In order to implement the right knowledge management system, the type of knowledge-work needs to be recognized in advance. Davenport & Prusak [13] proposed a classification based on the complexity of work vs. the level of interdependence, and came up with four approaches for knowledge-work, i.e., integration model, collaboration model, transaction model, and expert model. He stated that collaboration model is the most difficult to treat because it is iterative and needs lots of improvisation, and is highly dependent on workers' skills in the relevant area of expertise. In the Davenport's knowledge-work matrix, CLSC can be classified as collaboration model, because the level of interdependence is high with the involvement of several parties in the process loop, while the complexity of the work can be ranked high because it requires interpretation and the decision is primarily related to a number of uncertainties appearing in the CLSC, such as the uncertainty of demand, variability of product returns, and the degree of recovery.

Since CLSC involves a closed cycle, the management, which includes efficiency, quality, speed of service, innovation, and environmental impact, will be influenced by knowledge of a product throughout its life cycle, which is described as follows:

- Raw materials
  Knowledge of the properties of raw materials and the right treatment can improve the performance of the product design as well as the production process and minimize transportation cost and speed of manufacturing services.
- Process
  Knowledge of the production process from design to assembly would be beneficial to distributors in arranging transport and capacity, the parties addressing the maintenance and improvement of products (can be a distributor, retailer or other contracted third parties), the collector when performing disassembly, recovery process departments – whether remanufacturing or recycling process, and the department handling the production waste. Apparently, there is a limitation to the knowledge that can be shared, such as the design of

innovative and superior products, which is not always able to be shared openly.

- Use-period

  Knowledge of how users use the product can be an advantage to the product design improvements, increase efficiency of energy use in the active product, and increase environmentally friendly design. Similarly, for the collector, knowledge about user behavior can facilitate the process of collecting the product at the end of the useful life (end-of-use) or at the end of its life cycle (end-of-life). For product recovery department, knowledge regarding the users' treatment can improve the effectiveness of the recovery process.
- End-of-life

  Knowledge sharing can play an important role in this phase because there are various stages of product's condition at its end-of-life. This information is essential to the department that handles the recovery process. Also, knowledge about the various handling methods applicable to a product at the end of its useful life cycle would enable product design improvements. For the finance department, the information regarding product's condition at its end-of-life would increase the valuation process. Knowledge of the recovery process will be useful for determining the selling price, the appropriate distribution channel, and the marketing strategy that could improve the consumers' interest in buying the product recovery results.

The raw material suppliers do not benefit directly from this knowledge sharing. In the reverse chain of the CLSC, the need for pure raw material requirements is significantly reduced. However, manufacturers still require the services of the suppliers for the continuity of the overall production. Therefore, the benefits that can be gained by the suppliers are focused more on tacit knowledge sharing to increase productivity, as done by Toyota.

We have argued the importance of knowledge management in a CLSC management from the product's life-cycle aspect. Lee et al. [14] and Collins et al. [23] supported the role of knowledge management in collaborative supply chain that could enhance the supply chain's performance. Furthermore, the idea of knowledge management in closed-loop supply chain will be focused on knowledge sharing, as shown in Figure 2.

The knowledge sharing conceptual framework is developed by considering three aspects, namely knowledge sharing flows, management aspect, and socio-technical aspects.

1. Knowledge sharing flows

   The flows of knowledge sharing within a closed-loop supply chain are constructed by studying the forward and reverse flows in the CLSC, and then identifying the flows of knowledge-work in each of the CLSC members that would form a knowledge capability, as can be seen in Figure 2. In a study by Yalabik et al. [26], the interactions between product properties, such as value extraction, market properties, and production costs, are taken into account in order to choose a remanufacturing strategy that would improve profitability and environmental performance.
2. Management aspect

   This aspect consists of leadership, strategy, and commitment. In a CLSC, manufacturer is the member who has the highest interest in the successful implementation of knowledge sharing, because she usually becomes the leader in the CLSC knowledge sharing network (CLSC-KSN), although not necessarily so. Channel leadership, performance, and coordination in CLSC are also significant to the effectiveness of the CLSC [27]. Leaders

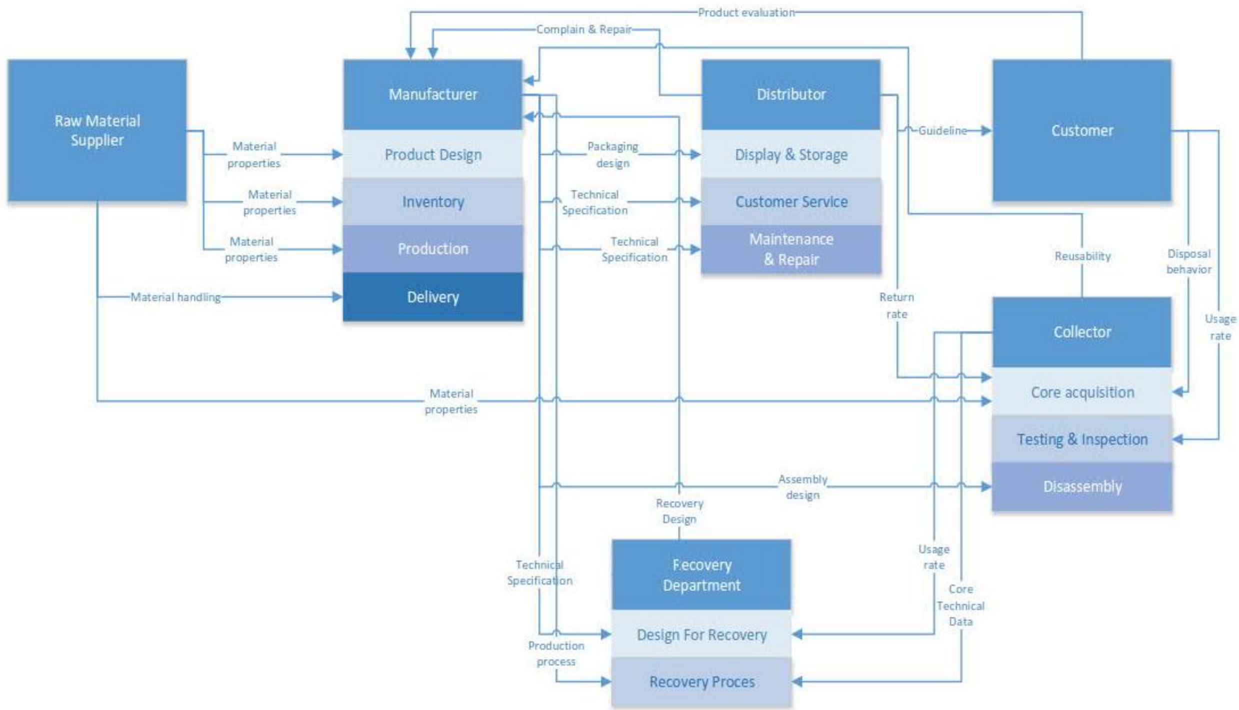

Figure 2. Knowledge Sharing in a Closed-loop Supply Chain

must initiate the establishment of a network that has groups with regular agenda, which can be done through real meetings or through cyberspace, and must have strong leadership to mobilize the groups. From the strategic aspect, in order to make sure that the network is working as expected, the groups need to find common objectives that benefit all members within the network, and then elaborate the strategy for each party in the supply chain. On the issue of commitment, as in the case of Toyota, the commitment of the network's leader is vital, because it determines whether the knowledge sharing process is managed well or just be a slogan.

3. Socio-technical aspect
   There are three layers in the socio-technical aspect:
   a. Infrastructure
      The infrastructure can be built with the social-web type, whose characteristics are flexible, in which all parties can access the required knowledge without excessive prohibition or restriction [28]. As an illustration, manufacturer puts product information and knowledge such as technical specifications, handling procedures, packaging information, how to perform maintenance and repairs, as well as the disassembly process. Other parties, such as retailers who act as a repair center can add knowledge about the kind of damage that often occurs and the way retailers handle. All network members can comment and provide ideas or propose improvements, so that the exchange of knowledge takes place. The social-web type infrastructure can also be organized with a good search facility, so that the stored knowledge can be easily found and accessed. Trust could be an issue here, so the network leader should establish a sound agreement where security, process ownership, and access levels are carefully protected.
   b. Info-structure
      The info-structure of knowledge sharing using the social-web has the ability to capture the tacit knowledge and makes it explicit, because the social-web is easy to use and able to stimulate discussion. In order to make sure that the knowledge exchange is conducted in a structured manner, the social-web can be designed with formal and informal rules. Wiki is a good example for such practice; it provides a set of rule for anyone who wants to add and change information in the Wiki. The users in CLSC-KSN are not anonymous, because they are inherent in the collaboration among members in the supply chain so that the knowledge shared through this forum is more reliable, within the preset quality standard, and protected from vandalism. Wang & Wang [29] and Wang et al. [30], considering the modern manufacturing industry and a new generation of integration models, had reviewed the cloud-based information system for WEEE (Waste Electrical and Electronic Equipment) recovery and remanufacturing, and proposed a novel service-oriented remanufacturing platform based on cloud-manufacturing concept. They had shown that this approach enables remanufacturing firms to respond quickly and effectively.
   c. Info-culture
      The social-web characteristics that are always available anywhere and anytime would encourage the members to be more actively involved in sharing knowledge. According to Dulaimi [24], when an organization has a culture that promotes openness and trust, the chance to be successful in implementing knowledge sharing is high. The web-social, together with strong leadership of CLSC-KSN, could ensure openness and trust. This way, the process of knowledge sharing improves and further enables the improvement of CLSC performance.

6. Conclusion

Knowledge sharing is an important factor in knowledge management. Through an effective knowledge sharing, tacit knowledge can be made explicit, and further diffused into the organization.

Through several case studies, we have identified several factors that determine the success of knowledge sharing between different organizations. Those factors are management aspect (which includes leadership, strategy, and commitment) and socio-technical aspect (which includes infrastructure, info-structure and info-culture).

The concept of knowledge sharing is needed in a CLSC network because it can improve the performance of the supply chain network, ranging from the efficiency, quality, speed of service, and innovation to handle the environmental impact. The idea to apply knowledge sharing within a closed supply chain networks has also been presented, using the social-web whose characteristics comply with the ones in the socio-technical aspect. This idea still needs to be further explored in order to obtain a detailed framework and strategies as well as techniques for implementation.

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