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## CLOSED LOOP SUPPLY CHAIN MANAGEMENT PERFORMANCE EVALUATION CRITERIA

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**ABSTRACT**
Evaluating chain performance to develop an effective supply chain has become a necessity because it plays a critical role in the success of businesses. The most important decision to evaluate the chain performance is the correct selection of indicators. The closed-loop supply chain method consists of a whole of forward and reverse logistics activities. For this reason, advanced supply chain management and reverse supply chain management performances are handled separately in this study. The performance evaluation criteria which are discussed by the authors who work on the supply chain management performance evaluation issues are analyzed and it is stated that the authors make a study by taking into consideration the evaluation criteria. At the same time, the articles examined in reverse supply chain management performance evaluation studies are examined and all criteria are summarized as a table. In the light of these studies, the planned criteria for the use of closed loop supply chain management performance evaluation of the enterprises have emerged. With the main criteria being divided into Economic, Social and Environmental headings, which are supposed to bring innovation to the literature, the sub-criteria are detailed. These titles were brought together both for the first time in closed loop supply chain management performance evaluation and as a main topic in advanced supply chain management. The performance criteria reduced to subheadings will help the experts to continue their studies, and it is thought that they will guide the future studies.

***Keywords:*** *Closed Loop, Supply Chain Management, Performance Evaluation*

## 1. INTRODUCTION

The closed loop supply chain concept was first described by Thierry *et al.*. made in 1995 by "strategic issues related to product recovery" is at study "integrated systems" has been defined as. Closed loop supply chain management is a concept that emerges when product recovery is both economically and environmentally valuable and growing in importance. Research on the subject has a history of about 20 years and the origin of this concept stems from the reverse logistics literature.

Closed loop supply chain is expressed as the implementation and re-introduction of the end-of-life products (End-Of-Life) from the end-use point and to recycle them to make them re-valued. (Thierry *et al.* 1995, Guide *et al.* 2003).

Another general recognition by the forward and reverse supply chain system operates as an integrated structure (Fig. 1) is expressed as (Fleischmann *et al..*, 1997; Paksoy, 2012; Talbot, 2006);

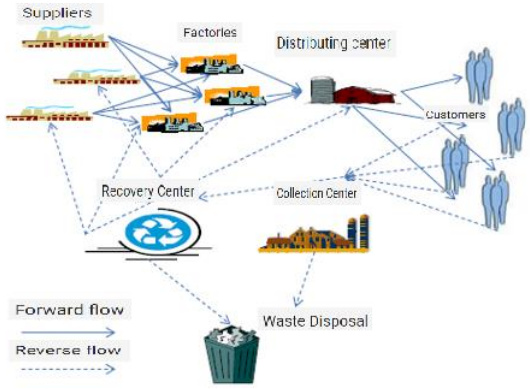


Fig. 1. Closed loop supply chain

The closed loop supply chains collect products from the raw material suppliers through the collection channels of the products used by the customers and produced in the production facilities of the products and delivered to the customers with various distribution channels. Then, by providing recycling, it considers the entirety of a forward and reverse logistics operations.

The closed loop supply chain is an important structure that integrates reproduction and reverse logistics. The closed loop enables the establishment of a triple network between the community, the enterprise and the environment.

According to Van Nunen and Zuidwijk (2004), Prahinski and Kocabaşoğlu (2006), the main reasons for supply chain and closed loop supply chain to be more important (Mondragon *et al.*. 2011):

- the amount of product returns which can be very high;
- sales opportunities in secondary of products considered previously discarded;
- the adoption of recycling and environmentally friendly recycling and disposal policies;
- the adoption of laws making manufacturers responsible for handling their products once their life ends;
- the emergence of alternatives including repackaging, remanufacturing and recycling; and
- consumers have more rights to return products that do not meet their expectations.

The most important of these basic reasons are the high return on product quantities. Because the technological rapid changes in the electronic sector cause the users to change their products frequently.

As a result, businesses that integrate product recycling systems into existing supply chain structures can lead to the following opportunities (Pochampally *et al.* 2009):

- Saving natural resources
- Energy saving
- Clean air and water saving
- Save waste
- Economic savings

With this information, it can be said that the reverse supply chain and closed loop supply chain network structures increase the competitiveness and customer satisfaction levels of the enterprises and lower the production costs (Demirel and Gökçen, 2008a). It is a fact that these benefits have been provided by various companies such as Dell, HP, Kodak, GM and Xerox for years (Akçalı and Çetinkaya, 2011). Kodak and Xerox reproduce the used products and take them to secondary markets for resale. For example, Xerox has saved approximately $ 200 million over the last five years from the reproduction of single-use cameras (Vishwa *et al.* 2010). According to another example, Kodak uses an average of 76% of a used camera in the production of a new camera (Savaşkan *et al.* 2004). In the US, 20% of glass, 30% of paper products and 61% of aluminum cans are recycled; 10 million cars and 95% of the trucks are recycled every year and 75% of these vehicles can be recycled for reuse (Demirel and Gökçen, 2008a). Dell has implemented the 'Recycling your Dell' program to recover useful components from used computers. According to a study, 58% re-use and re-fabrication can be made in products such as washing machines, computers, telephones and refrigerators. Recycling activities performed at these rates have been found to reduce the production costs significantly (Akçalı and Çetinkaya, 2011).

## 2. LITERATURE REVIEW

Extensive preliminary studies on reverse supply chain and closed loop supply chain networks were conducted by Fleischmann *et al.* 1997. In these studies, quantitative models of recycling in logistics activities were examined and a general framework was provided to the researchers. Within the framework of the presented framework, it was emphasized that 3 main topics should be included in distribution design (forward and reverse direction), stock control (zero and used product) and production planning (assembly and disassembly) in the network designs containing recycling.

In this study, closed loop supply chain management in many subjects such as network design, solution-oriented modeling studies, production planning, capacity planning, vehicle routing and facility selection has been discussed in the literature.

Bloemhof-Ruwaard *et al.*. (2005), Amaro and Barbosa-Povoa (2009), in the closed-loop supply chain, have studied in mixed integer programming model. Amin and Zhang (2013), studied stochastic mixed integer linear

programming model, Paydar *et al.*. (2017), studied a mixed integer linear programming model.

In addition to these modeling studies, other studies that have been published in the literature that Hu *et al.*. (2002), a model of discrete / continuous analytical structure, Krikke *et al.*. (2003), a model development in which both product design and logistics network design are discussed, Sheu *et al.*. (2005) have developed a multi-purpose inventory model with a multi-purpose optimization model, Özceylan *et al.*. (2014) developed an integrated model that optimizes both strategic and tactical decisions of a closed loop supply chain, Shakourloo *et al.*. (2016) developed with a general network model for closed loop procurement management.

Another area of work in closed loop supply chain management is network design. Qiang *et al.*. (2013), Aldemir (2016), have studied the issue of network design. At the same time Paksoy *et al.*. (2011) examined the network design for multiple product closed loop supply chain. Özceylan *et al.*. (2017) ELV realized a network design for the recycling system.

The literature gains increased with different studies. Schultmann *et al.*. (2006) worked on vehicle routing problem in closed loop supply chain management. Kenne *et al.*. (2012), Otay (2015) studied production planning. Chen *et al.*. (2017), also performed inventory control studies.

Lu and Bostel (2007) addressed the problem of plant layout in closed loop supply chain management. Tsao *et al.*. (2016) covered the literature by examining the effects of RFID in closed loop supply chain management. Finally, Olugu and Wang (2011) conducted a performance evaluation study on closed-loop supply chain management for the automotive sector.

After a detailed literature review of the closed loop supply chain management, it was observed that many subjects were studied. However, due to the low number of studies conducted with performance evaluation, it is thought that our study will have an important place in the literature.

## 3. PERFORMANCE EVALUATION CRITERIA AT CLOSED LOOP SUPPLY CHAIN MANAGEMENT

Performance is a qualitative or quantitative expression of what an individual, a group, or an organization doing a job can achieve and what they can achieve in order to achieve that goal (Karakaş *et al.*, 2003).

Evaluation of operational performance; is a sequence of operations that determines the extent to which businesses have reached their predetermined objectives, olup, determining performance objectives, performance measurement, feedback and motivation stages of the performance management process (Zerenler, 2005). It is difficult to analyze the target and the current situation for a process that cannot be evaluated, and identify the points that are open to improvement and direct the resources to these points. An effective management depends on an effective evaluation of performance results.

In this respect, it is a necessity to evaluate the chain performance in order to develop an effective and effective supply chain, as enterprises play a critical role in their success.

Closed-loop supply chain method, because it is a totality of forward and reverse of the logistics activities, it is necessary to combine performance criteria with forward supply chain management and reverse supply chain management performances, taking into account the studies conducted in the literature.

Supply chain performance has many elements in it. These elements are composed of many variables that can be measured by quantitative and qualitative methods. There are a number of studies on supply chain performance in the literature, and a significant part of them has been focused on the evaluation of supply chain performance and the criteria used in performance evaluation. However, there are few studies conducted for closed loop supply chain management performance evaluation.

Developing a system to measure the performance of the supply chain requires the right selection of criterias. In the Table 1, by evaluating the performance evaluation criteria of 53 authors, it is stated that the authors make a study by considering the evaluation criteria.

The authors of the criteria they use in their work are given in Table 1 as the main title, these main criteria were reduced to independent sub-headings. Criteria were used; Cost-18, Flexibility-18, Financial/Economic-13, Customer Satisfaction/Return-13, Innovation-12, Quality-10, Time-9, Internal Process-8, Responsiveness-8, Assets-7, Reliability-7 times in these studies. 19 criteria are used (Competitiveness, Lead Time, Lead-Time Variability, Dependent Variables, Independent Variables, Non-Financial, Society, Diagnostic Measures, Integration, Marketing, System Dynamics, Operations Research, Profitability, Order Book Analysis, Pricing, Facility, Human, Capacity, Including Trading Partners Measures) in performance evaluation by taking part in 1 study.

Table 1. Forward Supply Chain Performance evaluation metrics according to the authors

| Author / Metrics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fitzgerald et. al. (1991) | o | | | | o | | | o | o | | | | | | | | | | | | | | o | | | | | | | o | | | | | | | | | | | | | | | | | |
| Neely et. al. (1995) | o | o | o | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bagchi (1996) | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | o | | | | | | | | | | | |
| Kaplan and Norton (1997) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Beamon (1998) | | | | | | | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Narasihman and Jayaram (1998) | | | | | | | | | | | | o | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Van Hoek (1998) | | | o | | | | | | | | | | | | | | | | | | | | | | | | o | | | | | | | | | | o | | | | | | | | | |
| Beamon (1999) | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Brewer and Speh (2000) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bierlein and Miller (2000) | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pires and Aravechia (2001) | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Gunasekaran et. al. (2001) | | | | | | o | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| De Toni and Tonchia (2001) | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | o | | | | | | | | | | | |
| Persson and Olhager (2002) | o | | o | | | | | | | | | | | | | | | | | | | | | | | o | | | | o | o | | | | | | | | | | | | | | |
| Bullinger et. al. (2002) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chan et. al.(2003) | | | | | | | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Otto and Kotzab (2003) | | | | | | | | | | | | | | | | | o | | o | | | | | | o | | | | | | | | | | | | | | | o | o | o | | | | |
| Gunasekaran et. al. (2004) | | | | | | | | | | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Author / Metrics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fleisch and Tellkamp (2005) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | |
| Angerhofer and Angelides (2006) | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sen (2006) | | | | | | | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Shepherd and Günter (2006) | | | | | | o | | o | | o | | | | o | o | | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Li et. al. (2007) | | | | | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aramyan (2007) | o | | | | o | | | | | | | o | | | | | | | | | | o | | | | | | | | | | | | | | | | | | | | | | | | | |
| Yeong –Dong Hwang et. al. (2008) | | | o | o | o | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tao (2009) | | | | | | | | | o | o | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | |
| Stock and Mulki (2009) | o | | | | o | | | o | | | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Chimhamhiwa et. al. (2009) | o | o | o | | | | | o | | o | | | | | | | | | | | | | | | | | | | | | | | | | | o | | | | | | | | | | | |
| Cai et. al. (2009) | | | | | o | o | o | o | | | | | | | | | | | | | | | | o | | | | | | | | | | | | | | | | | | | | | | |
| Chae (2009) | | | | | | o | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Kocaoğlu (2009) | | | o | o | o | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Xu et. al.(2009) | | o | o | | o | | | | o | | | | | | | | | | | | | | | | | | o | | | | | | | | | | | | | | | | | | | |
| Rodriguez-Rodriguez et. al. (2010) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ağar (2010) | | | o | o | o | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Özbakır (2010) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Zhu (2010) | | | | | | | | | o | o | | | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | |

| Author / Metrics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ganga and Carpinetti (2011) | | | o | o | o | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aydoğdu (2011) | | | o | o | o | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Shafiee and Shams-e-alam (2011) | | o | o | | | o | | | o | | | | | | | | | | | | | | | | | | o | | | | | | | | | | | | | | | | | | o | o | |
| Carvalho and Azevedo (2012) | | | | | | | | | o | | | | | | | | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cho et. al. (2012) | | | | | | | | | | | | | | | | | | | | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | |
| Yavuz and Ersoy (2013) | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Elrod et. al.. (2013) | o | o | o | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Golrizgashti (2014) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Arif-Uz-Zaman and Ahsan (2014) | o | o | o | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Alomar and Pasek (2014) | | | | | | o | | | | o | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Anand and Grover (2015) | | | | | | o | | | | | | | | | | | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | |
| Sillanpaa (2015) | | o | | | | | | | | | | | | | | | | | | | | | | | | | | o | | | | | | | | | | | | | | | | o | o | | |
| Gamme and Johnson (2015) | | | | | | o | | | | | | | | | | | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | o | o | | |
| Sellitto et. al. (2015) | | | | | | o | | | | o | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Ayçın and Özveri (2015) | | | o | o | o | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Shi and Gao (2016) | | | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Özalp (2016) | | | o | | | | | | | | o | | | | | | | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | o |

(1-Quality 2-Time 3-Cost 4-Assets 5-Flexibility 6-Resource 7-Output 8-Innovation 9-Financial/Economic 10-Customer Satisfaction/Return 11-Internal Process 12-Responsiveness 13-Reliability 14-Plan 15-Make 16-Deliver 17-Strategic Measures 18-Tactical/Structural Measures 19-Operational Measures 20-Qualitative Measures 21-Quantitative Measures 22-Efficiency 23-Resource Utilisation 24-Information/Information Sharing Degree/Information Technology 25-Logistics Level/Transportation 26-Inventory 27-Service 28-Customer Services 29-Managerial Analysis/Corporate Management 30-Competitiveness 31-Lead Time 32-Lead Time Variability 33-Dependent Variables 34-Independent Variables 35-Non-Financial 36-Society 37-Diagnostic Measures 38-Integration 39-Marketing 40-System Dynamics 41-Operations Research 42-Profitability 43-Order Book Analysis 44-Pricing 45-Facility 46-Human 47-Capacity 48-Including Trading Partners Measures)

Following the forward supply chain management performance evaluation criteria, reverse supply chain management performance evaluation criteria have also been the subject of studies.

Evaluating the performance of reverse supply chain performance over the last decade has become a real necessity. In this study, 20 articles examined in reverse

supply chain management performance evaluation studies are discussed.

As in the supply chain performance evaluation analysis, in the case of reverse supply chain management performance evaluation studies, the evaluation criteria of the authors were studied. (Table 2).

The criterias used Customer/Customer Service/Stakeholder-13, Innovation and Growth-10, Financial-9, Process/ Internal and External-9, Environmental-7, Recovery (Asset/Value/Product/Facility)-5, Suppliers/Supplier Commitment-4 times in these studies. The 22 criterions used in the evaluation (Legal Programs, Manufacturers, Distributors, Intermediate Measures, Management Commitment, Material Features, Recycling Efficiency, Recycling Cost, Dependability, Cost Efficiency, Returns Flow and Time Related, Collection, Degree of Disassembly, Manufacturing Plant, Distribution Center/Warehouse, Lead Time, Products Reused, Products Remanufactured, Products Recycled, Products Parts Harvested, Input Quantity Level, Output Quantity Level) were included in the literature by the authors once.

Table 2. Reverse Supply Chain Performance evaluation metrics according to the authors

| Author / Metrics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellepeddi et. al. (2005) | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Wang (2006) | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Yellepeddi (2006) | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Yang et. al. (2009) | o | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Hernandez et. al. (2009) | | | | | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | |
| Tonanont (2009) | o | | | | | o | | | | o | | | | | | | | | | | | | | | | | | | | o | o | | | | | | | |
| Yang (2010) | o | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nizaroyani (2010) | | | | | o | o | | | | | | | | | o | o | | | | | | | | | | o | o | | | | | | | | | | | |
| Arun et. al. (2011) | | | | | | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Olugu and Wong (2011) | o | | | | | | | | | o | | | | | | | | | | | o | o | o | o | | | | | | | | | | | | | | |
| Shaik and Abdul-Kader (2012) | o | o | o | o | o | | | | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Momeni et. al. (2014) | o | | | | | | | | | o | | | | | | | | o | o | o | | | | | | | | | | | | | | | | | | |
| Bansia et. al. (2014) | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pandian (2014) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | o | o | o | o | o | o | o |
| Shaik (2014) | o | o | o | o | o | | | | | | o | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Guimaraes and Salomon (2015) | o | | | | | | | | | | | o | o | o | | | o | | | | | | | | | | | | | | | | | | | | | |
| Moshtaghfard et. al. (2016) | o | o | o | o | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Butar et. al. (2016) | | | | o | | | | | | | | | | | o | o | | | | | | | | | o | | | | | | | | | | | | | |
| Fernandes et. al. (2016) | o | o | o | o | o | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Sangwan (2017) | | | | | | o | o | | | | | | | | | | | | | | | | | | | | | | o | | | | | | | | | |

(1-Customer/Customer Service/Stakeholder 2-Financial 3-Process/ Internal and External 4-Innovation and Growth 5-Environmental 6- Recovery (Asset/Value/Product/Facility) 7- Sorting and Storing/Inspection and Sorting 8-Gate Keeping 9-Transportation 10-Suppliers/Supplier Commitment 11-Social 12-Economic Programs 13-Image Programs 14-Citizenship Programs 15-Flexibility 16-Quality 17-Legal Programs 18-Manufacturers 19-Distributors 20-Intermediate Measures 21-Management Commitment 22-Material Features 23-Recycling Efficiency 24-Recycling Cost 25-Dependability 26-Cost Efficiency 27-Returns Flow and Time Related 28-Collection 29-Degree of Disassembly 30-Manufacturing Plant 31-Distribution Center/Warehouse 32-Lead Time 33-Products Reused 34-Products Remanufactured 35-Products Recycled 36-Products Parts Harvested 37-Input Quantity Level 38-Output Quantity Level)

As a result of these studies, the performance criteria in forward supply chain and reverse supply chain management were analyzed in detail and the criteria that are planned to be used in performance evaluation in closed loop supply chain management are determined in our study. As shown in Fig. 2, the criteria of the study are exemplary of many studies.

The main headings and sub-headings that will bring innovation to the supply chain performance evaluation criteria are; It has been called Economic, Social and Environmental. These headings, which are used in different studies in reverse supply chain management, have been brought together both for the first time in closed loop supply chain management performance evaluation and as a main topic in forward supply chain management.

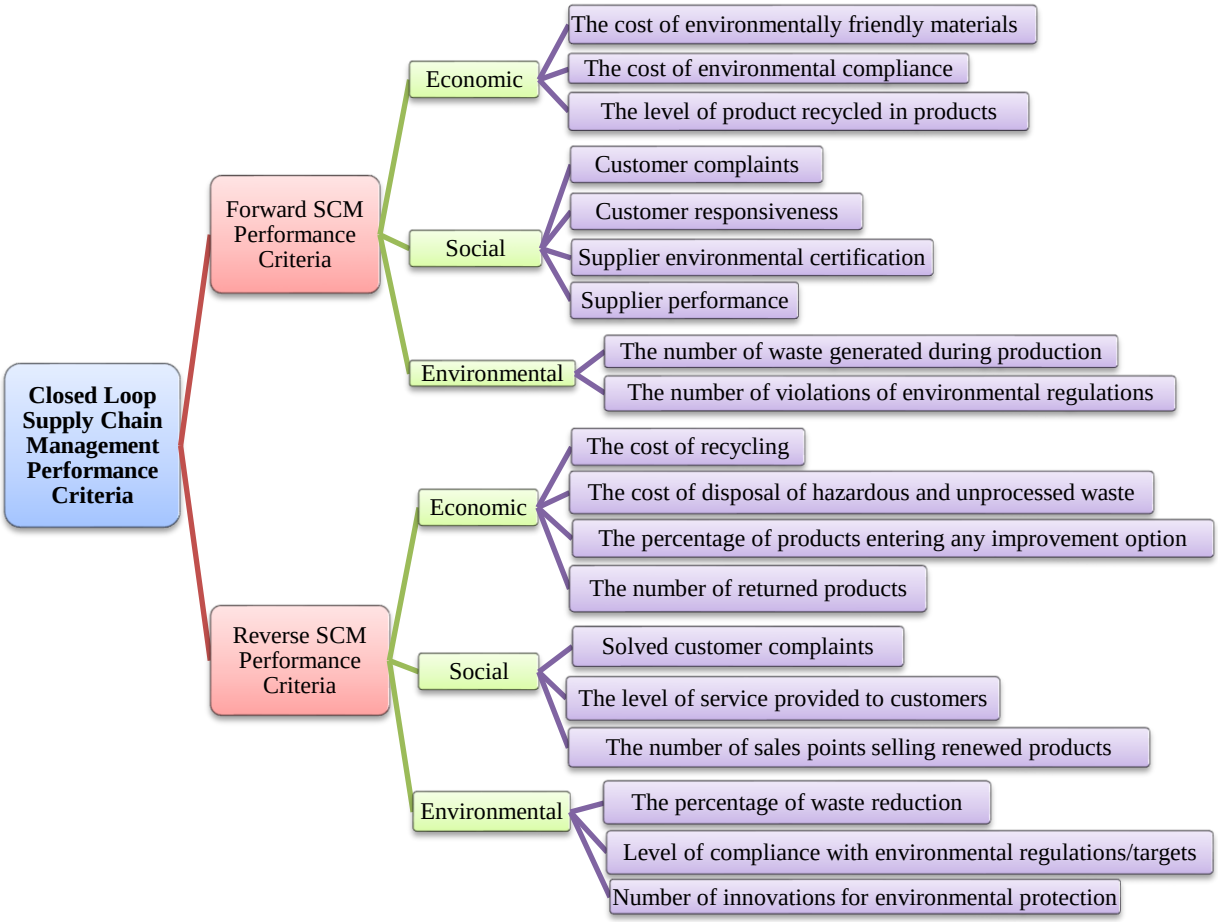


Fig. 2. Closed loop supply chain management performance criteria

Sub-headings of economic criteria in forward supply chain management performance criteria; the cost of environmentally friendly materials, the cost of environmental compliance, the level of product recycled in products. Sub-headings of social criterion; customer complaints, customer responsiveness, supplier environmental certification, supplier performance and Finally, the sub-headings of environmental criteria are the number of waste generated during production and the number of violations of environmental regulations.

The sub-headings of the economic criterion in the reverse supply chain performance evaluation criteria, which is another area of evaluation; the cost of recycling, the cost of disposal of hazardous and unprocessed waste, the percentage of products entering any improvement option, and the number of returned products. The sub-headings of the social criterion are selected as follows; solved customer complaints, the level of service provided to customers, the number of sales points selling renewed products. The sub-headings of the environmental criterion, which is another main topic; percentage of waste reduction, level of compliance with environmental regulations/targets and number of innovations for environmental protection.

As can be seen, businesses that want to examine their chain performances with their environmentally compatible, economic and social indicators can perform performance evaluation and analyze their deficiencies by using these criteria. Starting with the improvement studies, it allows businesses to increase their competition rate by keeping pace with our age with less waste and more efficient working methods.

## 4. CONCLUSION

In the literature on closed loop supply chain management, closed loop supply chain management has been the subject of many topics such as network design, solution-oriented modeling studies, production planning, capacity planning, vehicle routing, facility location

selection. However, performance evaluation in closed loop supply chain management is quite low. As a result of this, forward and reverse supply chain management performance evaluation studies were investigated. In our study; supply chain management issues 53 articles evaluating employee performance, employee performance evaluation reverse supply chain management issues 20 articles were discussed. The performance evaluation criteria discussed by these studies were analyzed. It is stated that the authors are working by taking into account the evaluation criteria. In 73 articles analyzed, performance criteria are summarized by converting them into tables. As a result of these studies, the criteria that are planned to be used in closed loop supply chain management performance evaluation of the enterprises are determined in our study.

The study's criteria are sufficient to be an example to many studies. The main topics that will bring innovation to the supply chain performance evaluation criteria, which are composed of main headings and sub-headings, have economic, social and environmental headings. These main criteria are handled separately by different authors in the literature. In the studies Yellepeddi *et al.*. (2005), Wang (2006) Yang (2010), Shaik and Abdul-Kader (2012), Bansia *et al.*. (2014), Shaik (2014), Moshtaghfard *et al.*. (2016), Fernandes *et al.*. (2016) studied this heading in reverse supply chain management. Likewise, in the forward supply chain management Fitzgerald *et al.*. (1991), Kaplan and Norton (1997), Brewer and Speh (2000), Bullinger *et al.*. (2002), Tao (2009), Xu *et al.*. (2009), Rodriguez-Rodriguez *et al.*. (2010), Özbakır (2010), Zhu (2010) Shafiee and Shams-e-alam (2011), Carvalho and Azevedo (2012) Golrizgashti (2014), Shi and Gao (2016) studied as the main criteria of the economic title. The environmental main criteria has not been studied as a head of forward supply chain management, as it involves more recycling issues. As a result, Yang *et al.*. (2009), Yang (2010), Nizaroyani (2010) Shaik and Abdul-Kader (2012), Shaik (2014), Moshtaghfard *et al.*. (2016), Fernandes *et al.*. (2016) considered environmental criteria in their studies. Although the social criteria is less preferred, Shaik and Abdul-Kader (2012), Shaik (2014), Fernandes *et al.*. (2016), Chimhamhiwa *et al.*. (2009) were used by.

In our study, economic, environmental and social criteria are compiled together. The main topics that will bring innovation to the supply chain performance evaluation criteria consisting of main headings and subheadings have been economic, social and environmental headings. These headings are put together for the first time in closed loop supply chain management performance evaluation. Innovations were made to the literature by using it as the main topic in forward supply chain management. The performance criteria, which are then reduced to subheadings, have been detailed to help the experts to continue their study. For this purpose, businesses that want to examine chain performances can perform performance evaluation using these criteria and they can analyze our deficiencies and implement improvement studies.

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