FIELD STUDY ON DETERMINING PERFORMANCE EVALUATION CRITERIA IN SUSTAINABLE SUPPLY CHAIN MANAGEMENT

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Keywords

Sustainability, Supply Chain Management, Performance Evaluation, Sustainable Supply Chain Management

Abstract

The most important factors for the sustainability of supply chain management are economic, social and environmental factors. In order to maintain sustainability in this field, companies need to see areas where they can improve by performing performance evaluation. For this purpose, in this study, it is aimed to determine the criteria to be used in the performance evaluation of sustainable supply chain management. In this respect, firstly, the performance criteria of supply chain management and reverse supply chain management studied in the literature are examined separately; these main criteria have been defined by taking into account economic, social and environmental factors. As a result of the literature review, 46 sub-criteria are determined which are in line with the main economic, social and environmental criteria. It is planned to make priority ranking of these criteria and to use the criteria which are obtained at a high rate according to their importance levels in performance evaluation. Representatives and academicians from the sector are asked to score 46 performance evaluation criteria according to their importance level. With the findings obtained, it is aimed to determine the criteria of high importance by performing Pareto Analysis. As a result of the studies carried out, nine new criteria can be added to the literature and a total of 33 criteria have been determined for performance evaluation. The criteria that companies can use for performance evaluation in the field of sustainable supply chain management are finalized and it is aimed to gain value for the sectors to improve themselves.

SÜRDÜRÜLEBİLİR TEDARİK ZİNCİRİ YÖNETİMİNDE PERFORMANS DEĞERLENDİRME KRİTERLERİNE YÖNELİK ALAN ARAŞTIRMASI

Anahtar Kelimeler

Sürdürülebilirlik, Tedarik Zinciri Yönetimi, Performans Değerlendirme, Sürdürülebilir Tedarik Zinciri Yönetimi

Öz

Tedarik zinciri yönetiminin sürdürülebilirliği için en önemli faktörler ekonomik, sosyal ve çevresel faktörlerdir. Bu alanda sürdürülebilirliği korumak için şirketlerin performans değerlendirmesi yaparak gelişebilecekleri alanları görmeleri gerekmektedir. Bu amaçla, bu çalışmada sürdürülebilir tedarik zinciri yönetiminin performans değerlendirmesinde kullanılacak kriterlerin belirlenmesi amaçlanmıştır. Öncelikle literatürde incelenen tedarik zinciri yönetimi ve tersine tedarik zinciri yönetiminin performans kriterleri ayrı ayrı incelenmiştir ve ana kriterler ekonomik, sosyal ve çevresel faktörler dikkate alınarak tanımlanmıştır. Literatür taraması sonucunda ekonomik, sosyal ve çevresel kriterlere uygun 46 alt kriter belirlenmiştir. Bu kriterlerin öncelik sıralamalarının yapılması ve önem düzeylerine göre yüksek oranda çıkan kriterlerin performans değerlendirmede kullanılması planlanmıştır. Sektörden temsilciler ve akademisyenlerden önem düzeylerine göre 46 performans değerlendirme kriterlerini önem düzeyine göre puanlanması istenmiştir. Elde edilen bulgularla Pareto Analizi yapılarak yüksek öneme sahip kriterlerin belirlenmesi istenmiştir. Yapılan çalışmalar sonucunda literatüre dokuz yeni kriter kazandırılarak, toplam 33 performans değerlendirme kriteri belirlenmiştir. Şirketlerin sürdürülebilir tedarik zinciri yönetimi alanında performans değerlendirmesi için kullanabileceği kriterler sonuçlandırılmıştır ve sektörlerin kendilerini geliştirmeleri için çalışmalarına değer kazandırılması hedeflenmiştir.

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1. Introduction

Sustainability has been an issue that has been emphasized by businesses, non-profit organizations and governments since the 1990s. In this process, businesses had difficulties in measuring their sustainability or sustainable growth rates. On this issue, John Elkington created a framework for measuring sustainability performance in the mid-1990s (Hall, 2011). This is a concept that evaluates and balances economic, environmental and social goals from a micro-economic perspective and is called the "Triple Bottom Line" (TBL / Triple Responsibility) (Carter and Rogers, 2008).

In order to ensure the sustainability of Supply Chain Management (SCM), the most important elements to be addressed are economic, social and environmental. The purpose of sustainability in the supply chain is to create, maintain and improve environmental, economic and social values for all stakeholders involved in this process, from the manufacturer to the consumer. There are many reasons for companies to address sustainability in the supply chain. One of the main reasons is to comply with legal regulations, to adhere to and support the standards established for business ethics. At the same time, firms tend to engage in activities that produce better environmental, economic and social impacts, because taking action in this direction has commercial benefits (Sisco, Chorn and Pruzan, 2010).

Supply chain performance evaluation problems cover a wide area for evaluating the performance of the entire supply chain system. These problems are also one of the most comprehensive strategic decision problems to consider. Chain performance covers a number of factors. These factors consist of many criteria that can be measured both quantitatively and qualitatively. Developing a system to measure the performance of the supply chain requires the correct selection of indicators. When the business management evaluates the supply chain structure, it should compare the performance of the activities inside and outside the enterprise with the components in the chain and identify the weaknesses of the chain. In this process, it should develop performance evaluation criteria over time (Fredendall and Hill, 2001). Measuring sustainable supply chain performance gives positive results in many areas such as reducing cycle time, reducing costs, increasing quality and increasing transport efficiency. While these factors are taken into account, they also eliminate environmental concerns.

In this study, we aim to enable companies to see their own shortcomings by evaluating their performance in this sense and to allow them to make improvements in these areas, reflecting the main purpose of the study. For this, priority will be the determination of indicators, ie criteria.

The main objectives of this study are:

i. To examine the performance parameters of advanced supply chain management and reverse supply chain management in detail to determine the criteria of sustainable performance of supply chain management and to take into consideration economic and social environmental dimensions.

ii. To establish the final list with Pareto Analysis by evaluating the resulting criteria by the persons working in this field.

iii. To introduce new criteria to the literature that will be included in performance evaluation for sustainable supply chain management.

The rest of the article is organized as follows; Section 2 presents a literature review of Advanced SCM and Reverse SCM performance evaluation studies. Section 3 uses the Pareto Analysis methodology for SSCM performance criteria. The final table is prepared to determine the performance criteria that each sector can achieve. Finally, Section 4 discusses the results and further research.

2. Literature Review

The first stage in the performance evaluation of Sustainable Supply Chain Management (SSCM) is literature review. In this study, firstly evaluate Advanced SCM performance evaluation criteria and Reverse SCM performance evaluation criteria (Table 1) are tabulated. The Advanced SCM performance evaluation criteria table is presented in Appendix 1. The criteria of these two fields are examined since compilation of classical SCM and Reverse SCM studies will add important values to the completion of missing fields.

In the SCM evaluation variables and applications in the literature (Appendix 1), firstly Neely, Gregory and Platts (1995) draws attention to their work. Neely et al. (1995) analyzed performance measures in the supply chain, identified the main headings in terms of time, flexibility, cost and quality and established sub-criteria for each. In addition to this study, many studies define supply chain performance criteria as time, flexibility, cost and quality. Bagchi (1996), focuses on quality, cost, time, internal criteria (internal processes). Fitzgerald, Johnston, Brignall, Silvestro and Voss (1991), again as the main title, quality, flexibility, financial, resource use, innovation and competitiveness have been identified as. Kaplan and Norton (1997) developed a supply chain performance measurement model on financial, innovation, customer satisfaction and internal processes.

Beamon (1998) examined the performance measures in two groups as qualitative (flexibility, customer satisfaction, material flow, risk management,

information and supplier performance) and quantitative (resource utilization, cost and customer responsiveness), and continues to work, and quantitative measures as financial and non-financial measures. Beamon (1999) evaluated performance measures in three parts: output, resource and flexibility. As a source, it has gathered variables such as production cost, distribution cost, total cost, stock, investment return rate under a group. As output; occupancy rate, timely delivery rate, sales, profit, customer response time, order cycle, transportation errors, customer complaints production preparation time variables are also grouped under a group. He described the flexibility criteria as volume flexibility, delivery flexibility, new product flexibility and mixed flexibility. Yavuz and Ersoy (2013) developed this study by taking into consideration the main topics of resource, output and flexibility in their studies. Under the criterion of welding; production cost, distribution cost, warehouse cost, inventory cost, production center profit; under the output criterion; sales, retailing profit, timely delivery rate, quality, fullness rate, stock turnover rate, probability of lack of stock, product preparation time, customer response time, customer complaints, economic order quantity, accuracy; as a criterion of flexibility; delivery, volume, product mix and new product flexibility. In Pires and Aravechia (2001) and Angerhofer and Angelides (2006), based on the work of Beamon (1999) in their work, they also distinguished three main criteria: resource, output and flexibility in the assessment of supply chain performance.

Tao (2009) used criteria in four main categories as customer satisfaction, logistics level, information sharing degree and financial situation. Fleisch and Tellkamp (2005) evaluated supply chain performance as dependent and independent variables.

Li, Xu and Kumar (2007), who developed a model by separating the variables related to supply chain performance at the structural and operational levels as a different headline from these studies; structural factors, cost factors; as operational level, customer satisfaction, value added and flexibility were used. Gunasekaran, Patel and McGaughey (2004) wanted to measure the criteria at strategic, tactical and operational levels and formed a model.

As in the supply chain performance evaluation analysis, in reverse SCM performance evaluation studies, it was mentioned that the evaluation criteria of the authors were taken into consideration (Table 1). Fernandes, Rodriguez, Bornia, Trierweiller, Silva and Freire (2016) investigated ways of measuring reverse logistics performance. They showed that the most commonly used indicators are financial and economic performance and customer related indicators. Also, Sangwan (2017), because of the lack of academic research with performance evaluation and decision variables for reverse logistics; in the context of reverse logistics, they aimed to develop various activities based on four main activities with decision variables and performance indicators.

After these researches, these studies brought together the economic, social and environmental criteria of our main criteria to create a very useful. The SCM performance evaluation criteria in Appendix 1 are 60 criteria and the Reverse SCM performance evaluation criteria in Table 1 are 41 criteria. Determining the criteria in the literature and following this determination is a very important point. The fact that there are 60 main criteria in the studies conducted for advanced SCM performance evaluation criteria and 41 in the reverse SCM performance evaluation criteria has enabled us to search the sub-criteria for these studies. Consequently, if performance evaluation criteria for SSCM are to be determined in this study, the main criteria should be economic, social and environmental. However, from this point on, what should be the desired sub-criteria and the way to determine these sub-criteria will be followed.

In this study, a number of rankings were followed by taking the literature review into consideration and sub-criteria were detailed in the main economic, social and environmental criteria.

Table 1

Performance criteria used in Reverse SCM

Author	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
Yellepeddi et al. (2006)	✓	✓	✓	✓																																					
Wang (2006)	✓	✓	✓	✓																																				
Yellepeddi (2006)						✓	✓	✓	✓																																
Yang (2009)	✓	✓	✓	✓	✓																																				
Hernandez et al. (2009)												✓	✓	✓																											
Tonanont (2009)	✓					✓																								✓	✓										
Yang (2010)	✓	✓	✓	✓	✓																																				
Nizaroyani (2010)				✓	✓										✓	✓										✓	✓														
Arun et al. (2011)					✓	✓	✓	✓	✓																																
Olugu and Wong (2011)	✓									✓											✓	✓	✓	✓																	
Shaik and Abdul-Kader (2012)	✓	✓	✓	✓	✓						✓																												✓	✓	✓
Hall et al. (2013)	✓																																								
Momeni et al. (2014)	✓									✓								✓	✓	✓																					
Bansia et al. (2014)	✓	✓	✓	✓																																					
Pandian (2014)																																✓	✓	✓	✓	✓	✓	✓			
Shaik (2014)	✓	✓	✓	✓	✓						✓																														
Guimaraes and Salomon (2015)	✓											✓	✓	✓			✓																								
Moshtaghfard et al. (2016)	✓	✓	✓	✓	✓																																				
Butar et al. (2016)				✓											✓	✓									✓																
Fernandes et al. (2016)	✓	✓	✓	✓	✓					✓	✓																														
Sangwan (2017)						✓	✓																					✓	✓												
Butzer et al. (2017)	✓	✓	✓	✓										✓	✓																										

1-Customer / Customer Service / Stakeholders 2-Financial 3-Internal and External Processes 4-Innovation and Development 5-Environmental 6-Improvement (Asset / Value / Product / Facility) 7-Sorting and Storage / Inspection and Sorting 8-Information Flow 9-Distribution 10-Suppliers / Supplier Commitment 11-Social 12-Economic Programs 13-Visual Programs 14-Citizenship Programs 15-Flexibility 16-Quality 17-Legal Programs 18-Manufacturers 19-Distributors 20-Medium Criteria 21-Management Commitment 22- Material Properties 23-Recycling Efficiency 24-Recycling Cost 25-Reliability 26-Cost Efficiency 27-Return Flows and Related Time 28-Collection 29-Disassembly Degree 30-Production Plant 31-Distribution Center / Warehouse 32-Delivery Time 33- Recycling of Products 34-Reproduction of Products 35-Recycling of Products 36-Collecting Parts of Products 37-Input Quantity Level 38-Output Quantity Level 39-Costs 40-Authorization 41-Process Efficiency

3. Methodology

3.1. Determination of Sustainable Supply Chain Method Performance Criteria

Economic, social and environmental aspects are an important area for SSCM. These parameters, which are identified as the main criteria for this research, will be the cornerstones of our study. Prioritizing the performance criteria step by step was to address the literature.

If we open the criteria in Appendix 1 and Table 1, these criteria are taken as the main title by the authors. In this case, all these studies have been examined in detail and it has been among our targets to reach the sub-criteria of the criteria, which are the main criteria. In order to achieve this goal, sub-criteria in accordance with economic, social and environmental headings were considered in our study. Here, those listed and incompatible are not included in the sub-criteria list. The resulting criteria list is associated with economic, social and environmental headings and is given in Table 2. As a result of this analysis;

The sub-criteria associated with the economic main criterion are; collection of return products, recycling of recyclable products, disposal of waste, annual sale of returning products, quality of incoming returns, recycling management capability, recycling rate / material quantity, return rates by product group / product category, number of returned products, reduction in recycling time (%), recycled and / or recycled packaging (%), return packing reuse, level of compliance with environmental regulations / objectives, returns (%) with different recovery options (reuse, repair, renewal, recycling, scrap and storage, etc.), revenue from selling repaired products, reusability of parts / products (product modularity / durability), material improvement time rate of on-time deliveries, level of supplier's flawless deliveries error-free order fulfillment, flexibility (flexibility to change production plan), training costs for employees to develop new technologies and work in the opposite direction, fines

paid or number of fines due to non-compliance, amount invested in social actions (internal and external) related to environment and recycling, disposal ability, emission and waste reduction (%), reduction of consumption of scarce materials and non-renewable energies, use of environmentally friendly raw materials and materials (%), ability to respond to customers, level of waste generated during production (Table 2).

The sub-criteria associated with the social main criterion are; recycling management capability, level of compliance with environmental regulations / objectives, number / level of ISO 14000 and environmental protection agency (EPA) certification, supplier reliability, rate of on-time deliveries, level of supplier's flawless deliveries, sensitivity to emergency deliveries, supporting the development of suppliers on environmental issues, information flow efficiency, comprehensive customer satisfaction and service level, after-sales service for the customer, customer complaints, reduce complaints rate (%), resolved customer complaints, the level of distribution of information to the customer, whether a waste management plan exists, presence of recycling standard, corporate image, error-free order fulfillment training costs for employees to develop new technologies and work in the opposite direction, fines paid or number of fines due to non-compliance, amount invested in social actions (internal and external) related to environment and recycling, number of employees benefiting from training programs in reverse logistics activities, emission and waste reduction (%), use of environmentally friendly raw materials and materials (%), ability to respond to customers (Table 2).

The sub-criteria associated with the main environmental criteria; disposal of waste, recycling management capability, recycling rate / material quantity, reduction in recycling time (%), recycled and / or recycled packaging (%), return packing reuse, level of compliance with environmental regulations / objectives, reusability of parts / products (product modularity / durability), number / level of ISO 14000 and environmental protection agency (EPA) certification, supporting the development of suppliers on environmental issues, whether a waste management plan exists, presence of recycling standard, amount invested in social actions (internal and external) related to environment and recycling, number of innovations for environmental protection (reverse logistics projects), disposal ability, emission and waste reduction (%), reduction of consumption of scarce materials and non-renewable energies, use of environmentally friendly raw materials and materials (%), level of waste generated during production (Table 2).

3.2. Ranking of Sub-Criteria by Importance

After extensive research, the sub-criteria are numerous and therefore, the importance of simplification is determined and Pareto Analysis is applied. Pareto Analysis is a method used to determine priorities. This method is usable in almost every field since it also helps to determine the priorities in order to show a problem by graph and to emphasize the most important cause of the problem.

3.2.1. Pareto Analysis

In the 19th century, the famous economist and sociologist Vilfredo Pareto developed Pareto Analysis. Pareto conducted several different investigations in firms and stated that most of the problems found in the firms are usually due to a small number of interrelated reasons (QCC, 1984): In the normal distribution, the most important 20% of the causes constitute 80% of the performance, the next 30% constitute 15% of the performance and the remaining 50% constitute only 5% of the performance. Because of this approach, Pareto Analysis has become known as the 80-20 Rule.

Spending time or money above the value of low-value jobs in real life leads to considerable losses. In order to prevent this problem, by separating the jobs according to their importance; It is possible to prevent these losses in the case of transactions according to the values. For this purpose, Pareto Analysis, which classifies the works under three main headings as “very important”, “moderately important” and “less important” is also called ABC Analysis. In the ABC analysis, group A, very important; group B, moderately important and group C constitutes less important jobs (Özgüvenç, 2011).

In addition, the benefits of Pareto Analysis are listed as follows (Bozkurt, 1998);

- Table according to importance
- To list problems and causes
- Calculating the percentage of each problem
- To determine the factor with the highest importance in the problem
- Determine the total number of errors in the list
- Taking a joint decision in teamwork.

As can be seen, with Pareto Analysis, the severity of problems, the number of errors and the causes are determined. In this way, the areas where the improvements will be applied first are determined and the studies are initiated (Özgüvenç, 2011).

Table 2

Sub criteria affecting Sustainable Supply Chain

No	Criteria Affecting Sustainable Supply Chain Management	References	Eco	Soc	Env
1	Collection of return products	Yellepeddi (2005) Yellepeddi (2006), Arun et. al. (2011)	✓		
2	Recycling of recyclable products	Olugu and Wong (2011)	✓		
3	Disposal of waste	Yang et. al. (2009), Yang (2010) Olugu and Wong (2011)	✓		✓
4	Annual sale of returning products	Yellepeddi (2005) Moshtaghfard et. al. (2016) Shaik and Abdul-Kader (2012), Shaik (2014)	✓		
5	Quality of incoming returns	Nizaroyani (2010)	✓		
6	Recycling management capability	Yang et. al. (2009), Yang (2010)	✓	✓	✓
7	Recycling rate / material quantity	Yang et. al. (2009), Yang (2010) Guimaraes et al. (2015)	✓		✓
8	Return rates by product group / product category	Nizaroyani (2010) Shi and Gao (2016)	✓		
9	Number of returned products	Guimaraes et al. (2015)	✓		
10	Reduction in recycling time (%)	Olugu and Wong (2011)	✓		✓
11	Recycled and / or recycled packaging (%)	Guimaraes et al. (2015)	✓		✓
12	Return packing reuse	Hernandez et. al. (2009)	✓		✓
13	Level of compliance with environmental regulations / objectives	Nizaroyani (2010) Moshtaghfard et. al. (2016) Shaik and Abdul-Kader (2012), Shaik (2014)	✓	✓	✓
14	Returns (%) with different recovery (recovery) options (reuse, repair, renewal, recycling, scrap and storage, etc.)	Nizaroyani (2010) Yellepeddi (2006), Arun et. al. (2011) Moshtaghfard et. al. (2016)	✓		
15	Revenue from selling repaired products	Nizaroyani (2010)	✓		
16	Reusability of parts / products (product modularity / durability)	Nizaroyani (2010)	✓		✓
17	Material improvement time	Olugu and Wong (2011)	✓		
18	Number / level of ISO 14000 and Environmental Protection Agency (EPA) certification	Yellepeddi (2005) Olugu and Wong (2011)		✓	✓
19	Supplier reliability	Gamme and Johnson (2015)		✓	
20	Rate of on-time deliveries	Gamme and Johnson (2015)	✓	✓	
21	Level of supplier's flawless deliveries	Golrizgashti (2014)	✓	✓	
22	Sensitivity to emergency deliveries	Golrizgashti (2014)		✓	
23	Supporting the development of suppliers on environmental issues	Guimaraes et al. (2015)		✓	✓
24	Information flow efficiency	Yellepeddi (2006), Arun et. al. (2011), Yellepeddi (2005) Moshtaghfard et. al. (2016)		✓	
25	Comprehensive customer satisfaction and service level	Momeni et. al. (2014) Özalp (2016) Shaik and Abdul-Kader (2012), Shaik (2014) Yang et. al. (2009), Yang (2010)		✓	
26	After-sales service for the customer	Yang et. al. (2009), Yang (2010)		✓	
27	Customer complaints	Özalp (2016) Butar et. al. (2016)		✓	
28	Reduce complaints rate (%)	Moshtaghfard et. al. (2016)		✓	
29	Resolved customer complaints	Nizaroyani (2010)		✓	
30	The level of distribution of information to the customer	Olugu and Wong (2011)		✓	
31	Whether a waste management plan exists	Olugu and Wong (2011)		✓	✓
32	Presence of recycling standard	Olugu and Wong (2011)		✓	✓
33	Corporate image	Shaik and Abdul-Kader (2012), Shaik (2014) Yang et. al. (2009), Yang (2010) Moshtaghfard et. al. (2016)		✓	
34	Error-free order fulfillment	Özalp (2016) Ayçın and Özveri (2015)	✓	✓	
35	Flexibility (Flexibility to change production plan)	Momeni et. al. (2014)	✓		
36	Training costs for employees to develop new technologies and work in the opposite direction	Guimaraes et al. (2015)	✓	✓	
37	Fines paid or number of fines due to non-compliance	Guimaraes et al. (2015)	✓	✓	
38	Amount invested in social actions (internal and external) related to environment and recycling	Guimaraes et al. (2015)	✓	✓	✓
39	Number of innovations for environmental protection (reverse logistics projects)	Guimaraes et al. (2015)			✓
40	Number of employees benefiting from training programs in reverse logistics activities	Guimaraes et al. (2015)		✓	
41	Disposal ability	Moshtaghfard et. al. (2016) Yang et. al. (2009), Yang (2010) Olugu and Wong (2011)	✓		✓
42	Emission and waste reduction (%)	Moshtaghfard et. al. (2016) Nizaroyani (2010)	✓	✓	✓
43	Reduction of consumption of scarce materials and non-renewable energies	Moshtaghfard et. al. (2016)	✓		✓
44	Use of environmentally friendly raw materials and materials (%)	Authors	✓	✓	✓
45	Ability to respond to customers	Authors		✓	
46	Level of waste generated during production	Authors	✓		✓

Various application areas, Pareto Analysis has been the subject of this study. This analysis is used to determine the severity of the criteria and to determine which of these criteria should be considered during the next performance evaluation stages. The criteria listed in Table 2 are firstly compiled into a list of 46 items. The scoring column has been added to the list containing economic, social and environmental topics. According to the level of opinion of 24 people, 6 representatives and 18 academicians from the sector, these criteria are required to be scored between 1 and 5. These individuals working in the textile, automotive and food sectors are individuals in the supply chain band and working in the executive position. At the same time, the academicians to whom we have consulted are experts in Engineering and Logistics. The graph (Pareto Analysis) created for 46 criteria where importance levels are determined is given in Figure 1.

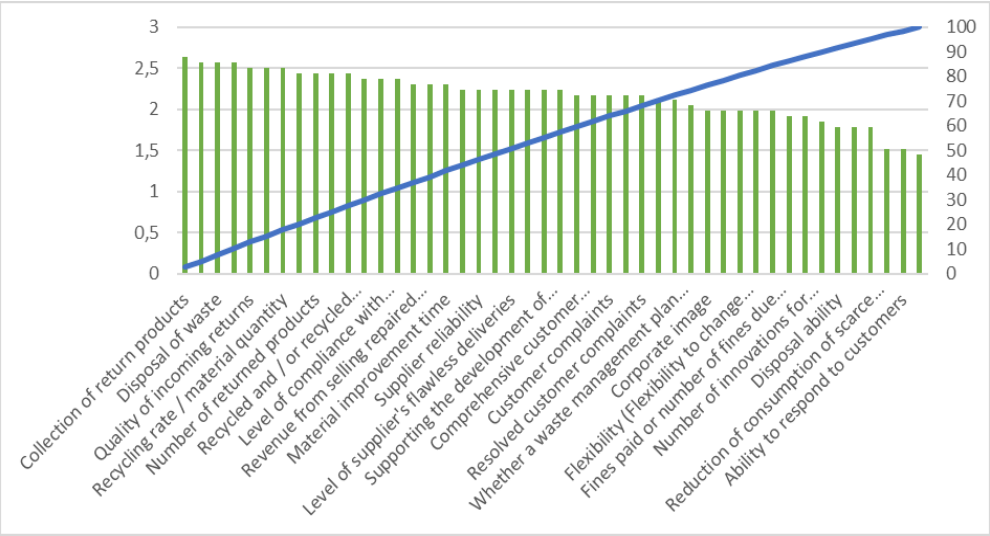

Figure 1. Pareto analysis graph showing the criteria sorted by importance levels

To interpret Figure 1, the ranking of the criteria according to the order of importance is as follows; comprehensive customer satisfaction and service level. Then, the level of compliance with environmental regulations / targets, customer complaints, ability to respond to the customer were the second with the same scores, customer complaints solved, disposal ability, emission and waste reduction (%) were determined as third. On-going sequencing includes;

- Disposal of waste,
- Use of environmentally friendly raw materials and materials (%),
- After-sales service level for the customer,
- Reduce complaints rate (%),
- Recycling of recyclable products,
- Recycling management capability,
- Reduction of consumption of scarce materials and non-renewable energies,
- Number/level of ISO 14000 and Environmental Protection Agency (EPA) certification,
- Information flow efficiency,
- Number of innovations for environmental protection (reverse logistics projects),
- Returns (%) with different recovery options (reuse, repair, renewal, recycling, scrap and storage, etc.),
- Supplier reliability,
- Rate of on-time deliveries,
- Whether a waste management plan exists,
- Presence of recycling standard,
- Corporate image,
- Error-free order fulfillment,
- Annual sale of returning products,
- Number of returned products,
- Reduction in recycling time (%),
- Supporting the development of suppliers on environmental issues,
- Level of waste generated during production,
- Level of supplier's flawless deliveries,
- Sensitivity to emergency deliveries,

- Training costs for employees to develop new technologies and work in the opposite direction,
- Recycling rate / material quantity,
- Return rates by product group/product category

At the intersection of the 80% line and the cumulative total curve, in the separation of the criteria which are very close to each other according to the rule 80/20, 12 sub-criteria can be said to be insignificant compared to others. These criteria are as follows;

- Recycled and or retrieved packaging,
- The level of distribution of information to the customer,
- Flexibility (flexibility to change production plan),
- Collection of return products,
- Number of employees benefiting from training programs in reverse logistics activities,
- Amount invested in social actions (internal and external) related to environment and recycling,
- Return packing reuse,
- Reusability of parts/products (product modularity/durability),
- Fines paid or number of fines due to non-complience,
- Revenue from selling repaired products,
- Material improvement time,
- Quality of incoming returns.

However, it also does not change the fact that the scores are not insignificant due to the close scores. Taking this scoring result into consideration, instead of elimination (instead of deleting sub-criteria), the study of simplification and criterion merging was considered appropriate in line with this table, which was the result of Pareto Analysis. A new sub-criterion table is created due to the existence of criteria that could be equivalent and the existence of criteria having more than one meaning (Table 3).

Here, 46 sub-criteria (Table 2) are taken into account, 26 criteria are combined and using more general meanings, these 46 criteria are not ignored. Criteria have been updated with more general meanings. Seven additional criteria were added to the literature and nine new criteria were included in the performance evaluation criteria in this study. These criteria are;

- Sustainable product use (%) (Reduction of consumption of scarce materials and non-renewable energies): The product should be produced or improved not only according to quality and economic criteria, but also taking into account both social and environmental factors. For this reason, it means increasing the use of these products.
- Level of waste generated during production: Reduction of annual waste produced as a result of production.
- Availability of warranty period of manufactured product: In the event that deficiencies that are not noticeable during production and during the final checks occur during the use of the product, the application of eliminating the deficiency under the responsibility of the manufacturer is called a warranty. The warranty is valid for the goods that are required to be issued by the Ministry and it is the period starting from the delivery date of the goods.
- Return rate of products covered by warranty: It is the ratio of products covered by the warranty from the customer to the total returned products.
- Supplier performance ratio: The companies that make up the supply chain cannot be considered as independent organizations. Each chain member should be concerned both with developing his own performance and with the performance of other chain members. The purpose of the enterprises is to supply the materials needed at the right time, in the right amount, in the desired quality, at the most affordable cost, from the right source. Meeting these requirements is possible with an effective supplier evaluation study. Supplier performance should be proportioned by determining the methods and criteria in the literature in line with the needs of the industry.
- Return time/Product life cycle time: It can be used to determine the location of the returned product during the product life cycle phase. Return periods and product age cycles differ from industry to product and from product to product. The consumption life of the food products and the life of a machine part should not be kept. Each sector has given a certain rate for this criterion and its evaluation has been deemed appropriate.

Table 3
Final criteria table

No	Criteria Affecting Sustainable Supply Chain Management	Eco	Soc	Env
1	Overall customer satisfaction rate (Comprehensive customer satisfaction and service level-After-sales service for the customer-Ability to respond to the customer)		✓	
2	Level of compliance with environmental regulations / objectives	✓		✓
3	Resolved customer complaints / Total customer complaints (Customer complaints-Resolved customer complaints-Reduce complaints rate (%)		✓	
4	Cost of waste disposal (Disposal ability-Emission and waste reduction (%)-Disposal of waste)	✓		✓
5	Sustainable product use (%)(Reduction of consumption of scarce materials and non-renewable energies)	✓		✓
6	Cost of reprocessing recyclable products (Recycling management ability)	✓		✓
7	Information flow efficiency (The level of distribution of information to the customer)		✓	
8	Number / level of ISO 14000 and Environmental Protection Agency (EPA) certification (Whether there is a waste management plan-Presence of recycling standard)		✓	✓
9	Number of innovations for environmental protection (reverse logistics projects)			✓
10	Supplier reliability		✓	
11	Corporate image		✓	
12	Fines paid or number of fines due to non-compliance	✓	✓	
13	Amount invested in social actions (internal and external) related to environment and recycling	✓	✓	✓
14	Number of employees benefiting from training programs in reverse logistics activities		✓	
15	Revenue from selling repaired products (Annual sale of returning products)	✓		
16	Training costs for employees to develop new technologies and work in the opposite direction	✓	✓	
17	Supporting the development of suppliers on environmental issues		✓	✓
18	Number of products recycled / Number of returned products (Recycling rate / material quantity-Number of returned products-Return rates by product group / product category-Recycled and / or recycled packaging (%)-Returns with different recovery (recovery) options (%)	✓		
19	Reusability of parts / products (product modularity / durability) (Return packing reuse)	✓		✓
20	The importance given to deliveries (Rate of on-time deliveries-Sensitivity to emergency deliveries-Level of supplier's flawless deliveries)	✓	✓	
21	Flexibility (Flexibility to change production plan)	✓		
22	Return cost of collection of products	✓		
23	Error-free order fulfillment	✓	✓	
24	Material improvement time (Reduction in recycling time (%))	✓		✓
25	Quality of incoming returns (%)	✓		
26	Level of waste generated during production	✓		✓
27	Availability of warranty period of manufactured product		✓	
28	Return rate of products covered by warranty	✓		
29	Supplier performance ratio		✓	
30	Return time / Product life cycle time	✓		
31	Number of supplier collaborations for environmental responsibility		✓	
32	Product availability	✓		
33	Order tracking		✓	

- Number of supplier collaborations for environmental responsibility: Companies should signed agreements with suppliers due to their importance to the environment (For example, in cooperation with the packaging company, the use of materials in packaging is minimized.)
- Product availability: It means that any product, service, technology or environment is accessible and available to everyone.
- Order tracking: Consumers have access to the delivery information of the product ordered at any time. It refers to the traceability of the process until the delivery with the order, by the customer.

In addition, in the final table of criteria (Table 3), a total of 33 sub-criteria are associated with economic, social and environmental headings.

These sub-criteria, which are seen as gains in the literature, reveal the originality of the study. Although it is already specific to compile performance evaluation criteria for SSCM, in addition, defining criteria has made the study even more important. Following this study, this criterion Table 3 can be considered by companies and different solution techniques can be developed and sustainability of the supply chain within the company can be evaluated. As a result of the findings of the evaluation, it is a fact that the company and country gains will be of considerable importance. Also in this article, research and publication ethics was considered for each step of the study.

4. Conclusion

Sustainable Supply Chain Management develops economic, social and environmental values for all stakeholders involved in the delivery of products to the market. Firms are increasingly turning to studies that generate better economic, social and environmental impacts. For this reason, in this study, we aim to enable companies to see their own shortcomings by evaluating their performance in this sense and to allow them to make improvements in these areas, reflecting the main purpose of the study.

In this study conducted to find the performance evaluation criteria in Sustainable Supply Chain Management (SCM), firstly, the performance criteria in the literature are examined and the main criteria of sustainability are divided into three main criteria: economic, social and environmental criteria, and sub-criteria that are compatible with these main titles are brought together. Following the review, Sustainable Supply Chain Management was determined by complying with three main criteria and 46 sub-criteria for performance evaluation. Then, it is planned to make priority ranking of these criteria and to use the criteria which are high according to their importance levels in performance evaluation. For this reason, a total of 24 people, including six representatives from sectors and 18 academicians, were asked to score 46 performance evaluation criteria according to importance. These individuals working in the textile, automotive and food sectors are individuals in the supply chain band, the academicians to whom we have consulted are experts in Engineering and Logistics. With the findings obtained, it was aimed to determine the criteria of high importance by performing Pareto Analysis. Pareto analysis is a technique used to distinguish different numbers of important causes from less important causes. This technique can be used in every field outside of the economy, as it shows graphics with the help of graphics and focuses attention on the most important cause of the problem or issue encountered and helps prioritize. However, with this graph, which is quite close to each other, it is concluded that these 46 criteria should not be ignored. Then, due to the fact that the similar criteria which have similar meaning are gathered together under a single heading and the fact that performance evaluation will yield positive results, the criteria have been compiled and a total of 33 criteria have been determined by adding nine new criteria that can be added to the literature. The criteria that companies can use for performance evaluation in the field of Sustainable SCM have been finalized. With this study, nine specific criteria (sustainable product use, level of waste generated during production, availability of warranty period of product manufactured, return rates of products covered by warranty, supplier performance ratio, return period / product life cycle period, number of supplier cooperation for environmental responsibility, product availability, order follow-up) as a performance evaluation criterion in Supply Chain Management. Apart from the existing criteria, the addition of these criteria is planned to make the performance evaluation stage more efficient. With this study, performance evaluation criteria will have an important effect on measuring their performance in the field of sustainable SCM. As a result of the deficiencies, the companies will continue to develop with the improvement works and it will be inevitable that the firms will gain economic, social and environmental gains. This study, which is very open to development, is followed by these criteria which are prepared by using different methods (Multi Criteria Decision Making Methods (AHP, ANP, PROMETHEE etc.), Artificial Neural Networks) as an academic study, and also to perform performance evaluation studies in different sectors. There are also limitations to sustainable supply chain management performance evaluation studies. In this study, the average calculation was made by taking the opinions of 24 people, but more sector employees can be included. The range of sectors accessible was automotive, textile and food. In addition, it can

contribute to work from different sectors. Sustainable SCM will close the gap in the performance assessment area.

Author Contributions

In this article, Süleyman ERSÖZ proposed the concept, designed the research, discussed the results and reviewed the manuscript. Emel YONTAR jointly conceptualized the paper, developed the methodology, wrote the manuscript, and discussed the results.

Conflict of Interest

There is no conflict of interest.

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Appendix 1. Performance criteria used in SCM

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	49	50	51	52	53	54	55	56	57	58	59	60
Fitzgerald et al. (1991)	✓			✓			✓	✓															✓						✓																																				
Neely et al. (1995)	✓	✓	✓		✓																																																												
Bagchi (1996)	✓	✓	✓																																		✓																														
Kaplan and Norton (1997)								✓	✓	✓	✓																																																									
Beamon (1998)																				✓	✓																																															
Narasihman and Jayaram (1998)												✓			✓																																																					
Van Hoek (1998)			✓																								✓												✓																										
Beamon (1999)					✓	✓	✓																																																												
Brewer and Speh (2000)								✓	✓	✓	✓																																																								
Bierlein and Miller (2000)	✓	✓	✓	✓																																																																
Pires and Aravechia (2001)					✓	✓	✓																																																												
Gunasekaran et. al. (2001)						✓								✓	✓	✓																																																			
De Toni and Tonchia (2001)			✓																																✓																													
Persson and Olhager (2002)	✓		✓																						✓						✓	✓																																
Bullinger et al. (2002)								✓	✓	✓	✓																																																								
Chan et al.(2003)																				✓	✓																																															
Otto and Kotzab (2003)																	✓		✓						✓																																										
Gunasekaran et al. (2004)																	✓	✓	✓																																																
Fleisch and Tellkamp (2005)																																	✓	✓																																
Angerhofer and Angelides (2006)					✓	✓	✓																																																												
Sen (2006)																				✓	✓																																															
Shepherd and Günter (2006)						✓		✓		✓			✓	✓					✓																																																
Li et al. (2007)																		✓	✓																																															
Aramyan (2007)	✓				✓							✓										✓																																													
Yeong Dong Hwang et al. (2008)			✓	✓	✓							✓	✓																																																					
Tao (2009)									✓	✓														✓	✓																																									
Stock and Mulki (2009)	✓				✓			✓					✓																																																				
Chimhamhiwa et al. (2009)	✓	✓	✓					✓		✓																											✓																												
Cai et al. (2009)					✓	✓	✓	✓																✓																																								
Chae (2009)						✓								✓	✓	✓																																																		
Kocaoğlu (2009)			✓	✓	✓							✓	✓																																																			

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	49	50	51	52	53	54	55	56	57	58	59	60
Xu et al.(2009)		✓	✓		✓				✓																		✓																																							
Rodriguez-Rodriguez et al. (2010)								✓	✓	✓	✓																																																								
Ağar (2010)			✓	✓	✓							✓	✓																																																				
Özbakır (2010)								✓	✓	✓	✓																																																								
Zhu (2010)									✓	✓														✓	✓																																									
Ganga and Carpinetti (2011)			✓	✓	✓							✓	✓																																																			
Aydoğdu (2011)			✓	✓	✓							✓	✓																																																		
Shafiee and Shams-e-alam (2011)		✓	✓		✓				✓																		✓																								✓	✓											
Carvalho and Azevedo (2012)									✓										✓																																													
Cho et al. (2012)																											✓	✓	✓																																					
Yavuz and Ersoy (2013)					✓	✓	✓																																																										
Elrod et al. (2013)	✓	✓	✓		✓																																																											
Golrizgashti (2014)								✓	✓	✓	✓																																																							
Arif-Uz-Zaman and Ahsan (2014)	✓	✓	✓		✓																																																											
Alomar and Pasek (2014)						✓				✓					✓	✓																																																	
Anand and Grover (2015)						✓																		✓	✓	✓																																						
Sillanpaa (2015)		✓																											✓																			✓	✓											
Gamme and Johnson (2015)																								✓	✓	✓																						✓	✓											
Sellitto et al. (2015)						✓			✓						✓	✓																																																
Ayçın and Özveri (2015)			✓	✓								✓	✓																																																		
Shi and Gao (2016)								✓	✓	✓	✓																																																					
Özalp (2016)			✓							✓												✓	✓																												✓											
Sun et al. (2017)							✓																																												✓	✓										
Kozarevića and Puškab (2018)	✓				✓			✓																																																								
Huang (2018)							✓																																																							
Ramezankhani et al. (2018)																																																														
Dissanayake and Cross (2018)			✓	✓								✓	✓																																																		
Lima-Junior and Carpinetti (2019)			✓	✓								✓	✓																																																		
Deva et al.(2019)																										✓																																					

1-Quality 2-Time 3-Cost 4-Assets 5-Flexibility 6-Source 7-Output 8-Innovation 9-Economic / Financial 10-Customer Satisfaction / Return 11-Internal processes 12-Ability to respond 13-Reliability 14- Planning 15-Production 16-Delivery 17-Strategic Measures 18-Tactical / Structural Measures 19-Operational Measures 20-Qualitative Measures 21-Quantitative Measures 22-Efficiency 23-Resource Utilization 24-Knowledge / Knowledge Sharing Level / Information Technologies 25-Logistics Level / Distribution 26-Stock 27-Service 28-Customer Service 29-Management Analysis / Collaborative Management 30- Competitiveness 31-Delivery Time 32-Delivery Time Variability 33-Dependent Variables 34-Independent Variables 35-Non-Financial 36-Social 37- Diagnostic Criteria 38-Integration 39-Marketing 40-System Dynamics 41-Operations Research 42-Profitability 43-Order Book Analysis 44-Price 45-Facility 46-Human 47-Capacity 48-Criteria Containing Commercial Partners 49- Input 50- Intermediate Measure 51- Agility 52-Sustainability 53- Radial Output 54-Non-radial Input 55- Tier2 Supplier 56- Main Supplier 57- Manufacturer 58- Average Inventory Time 59- Average Fill Rate 60- Average Cycle Time