



Supply Chain Management Performance Factors Evaluation with Analytical Hierarchy Process (AHP) and SWARA

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Abstract

In today's increasingly globalized world, supply chains are of great importance. The success of companies depends on the performance of the supply chain. A raw material or the entire supply chain of activity and information flow of the service from the supplier to the customer it is the management. Supply chain management is a very wide range of processes that cover many activities occurs. Due to the complex structure of the supply chain, performance measurement can be challenging. When evaluating supply chain performance, each a member should not be evaluated individually, but should be looked at throughout the chain. While designing the supply chain performance system, criteria covering all processes of the chain should be selected. In this study, using the Analytical Hierarchy Process (AHP) and SWARA methods, some critical factors of supply chain performance have been identified by consulting experts. The most important criteria selected as a result of the applications were determined, and then the most important main and sub-criteria affecting the supply chain performance were selected. While using the supply chain performance model, other criteria were listed in order of importance, interpreted and necessary suggestions were made.

Keywords: Analytical Hierarchy Process, SWARA, Supply chain performance, Supply chain management

Tedarik Zinciri Yönetimi Performansını Etkileyen Kritik Faktörlerin Değerlendirilmesi

Öz

Günümüzde gittikçe küreselleşen dünyada tedarik zincirleri çok büyük önem taşır. Şirketlerin başarısı tedarik zincirinin performansına bağlıdır. Bir hammadde ya da hizmetin tedarikçiden müşteriye kadar geçen tüm faaliyet ve bilgi akışı tedarik zinciri yönetimidir. Tedarik zinciri yönetimi çok geniş ve birçok faaliyeti kapsayan süreçlerden oluşur. Tedarik zincirinin karmaşık yapısı dolayısıyla performans ölçümü zorlayıcı olabilmektedir. Tedarik zinciri performansını değerlendirirken zincir boyunca her bir üye tek tek değerlendirilmemeli zincirin geneline bakılmalıdır. Tedarik zinciri performans tasarımı yapılırken zincirin her sürecini kapsayan kriterler seçilmesine dikkat etmek gerekmektedir. Bu çalışmada tedarik zincirinin performansını etkileyen bazı kritik faktörler belirlenmiş ve alanında uzman kişilerin görüşü alınarak iki farklı çok kriterli karar verme tekniklerinden olan Analitik Hiyerarşi Süreci (AHP) ve Adım Adım Değerlendirme Oran Analizi (SWARA) yöntemleriyle değerlendirilmiştir. Bu uygulamalar sonucunda seçilen kriterlerden tedarik zinciri performansını etkileyen en önemli ana ve alt kriter belirlenmiştir. Diğer kriterler önem sırasına göre sıralanıp yorumlanmış ve tedarik zinciri performans modeli kullanırken gerekli önerilerde bulunulmuştur.

Anahtar sözcükler: Analitik Hiyerarşi Süreci, SWARA, Tedarik zinciri performansı, Tedarik Zinciri Yönetimi

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1. Introduction

Today, globalizing economies have a great impact on companies. In a rapidly increasing competitive environment, companies prefer to use supply chain management to maximize their efficiency. Companies need to use a systematic supply chain management to reduce inefficiency, increase customer satisfaction, reduce costs and increase profits. All of the value-added processes from the supplier to the customer of a product or service are called the supply chain. Supply chain management is the systematic integration of all these processes. Supply chain management is the management of all activities to deliver the product to the customer at the right time, at the right price, at the right place. In supply chain management, control cannot be done from a single hand. The supply chain has an integrated structure. It is understood that increasing the efficiency of one member of the supply chain will affect the entire chain. Also, as firms successfully streamline their operations, they will be better coordinated with suppliers and customers. Although the execution styles of all members are different, the general purpose is the same. While measuring the performance of the supply chain, the entire chain should be considered as a whole and a direct judgment should not be made about the success of the supply chain by looking at the individual performances of the members [1].

After the performance measurement system is prepared in accordance with the structure of the supply chain, it can be used regularly. Performance measurement is a measure of efficiency and productivity in general [2]. In order for businesses to work more effectively and efficiently, they always need to measure their supply chain performance and make improvement studies [3]. It is no longer enough for companies to compete on their own, they compete with the success of their supply chains.

2. Material and Method

2.1. AHP Method

Multi-criteria decision making methods are the methods used to make the most accurate decision when need to make a choice with more than one criterion [4].

Step 1: The problem to which the method will be applied is determined. The criteria to be used are determined.

Step 2: By creating a hierarchical structure, main and sub-headings are determined. At the top is the main goal to be achieved. While creating the hierarchy, it is calculated by considering that the criteria under the same plane are independent of each other.

Step 3: After the pairwise comparison matrices are made, they are scored between 1 and 9 points in order of importance. First of all, the main criteria and then the sub-criteria are evaluated. Finally, a matrix is created by comparing all criteria. The diagonal alignment of the comparison matrices must be 1. This matrix shape is a square matrix.

$$D = \begin{bmatrix} d_{11} & \dots & d_{1i} \\ \vdots & d_{ij} & \vdots \\ d_{ki} & \dots & d_{mm} \end{bmatrix}$$

By this matrix, the percentage importance distributions showing the degree of importance are found by evaluating among

the criteria. a i. by criterion j. is the pairwise comparison value of the criterion, and the $j i$ a value is obtained from $1 a_{ij}$. This property is called the reciprocity property. Decision matrices are scaled according to the Saaty Scale [5].

Step 4: The two comparison matrices are normalized. Each value in the matrix is normalized by dividing by the sum of the numbers in its column. The sum of the numbers in each column of this matrix must be 1. The following equation (1) is used.

$$r_{ij} = \frac{d_{ij}}{\sum_{i=1}^n d_{ij}^2} \quad (1)$$

Step 5: Then the calculation is done for the priority vector. The importance weights of the criteria are calculated using Equation (2) of the normalized matrix. Calculate the priority vector with these values.

$$w_i = \frac{\sum_{j=1}^n r_{ij}}{\sum_{l=1}^n \sum_{j=1}^n r_{lj}} \quad (2)$$

Step 6: The consistency ratio is calculated. After making a pairwise comparison and determining the criteria values, the consistency ratio is calculated by using the comparison matrices.

It is necessary to calculate the ‘‘Consistency Index’’ CI value for the A matrix that is formed after the pairwise comparisons matrices are made (Eq. 3,4,5).

$$CR = \frac{CI}{RI} \quad (3)$$

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (4)$$

$$\lambda_{\max} = \frac{\sum_{j=1}^n d_{ij} w_j}{w_i} \quad (5)$$

To check the consistency ratio, the Random Index (RI) value must be known. After the CI and RI values are found, the consistency ratio is calculated. In case the calculated CR value is greater than 0.10, it is concluded that a calculation error has been made in the AHP or the decision maker has inconsistency while making the comparison [6].

Step 7: The weight values are calculated by creating a pairwise comparison matrix for each criterion.

Step 8: Decision options are listed. The criterion with the highest weight has the most important value.

2.2. SWARA Method

The SWARA method, which is used to calculate criterion weights and has been used more frequently in recent years, is a criterion decision-making method based on expert opinion [7]. Unlike other methods, SWARA is a method that gives more importance to expert opinions. When hierarchy is used in the problem, it can be applied the method first to the main criteria and then to the sub-criteria in the same way [8].

Step 1: Experts identify the most important criterion and give a score of 1 to the criterion with the highest importance. Decision makers give points by comparing the most important criterion and other criteria with binary criteria. Ratings are ranked from 0 to 1 and multiples of 2, 3, 4, and 5.

The scores assigned to the criteria are shown as p^k ; $j=1, \dots, k=1, \dots, l$; $0 \leq p^k \leq 1$.

Step 2: The relative average importance score, which is the mean of each scoring for the scored criteria, is calculated by the equation below. The geometric mean for each criterion is taken as a result of the scoring given by the decision makers and it is calculated with the Eq. 6..

$$p_j = \frac{\sum_{k=1}^l p_j^k}{l} ; 1, \dots, n \quad (6)$$

Step 3: After the relative average importance scores of the criteria are determined, they are ordered from largest to smallest. As a result of the comparisons, the relative importance values of the relative mean values are calculated as s_j . Values are calculated by the difference of the $j+1$ criterion with respect to the j criterion. This value emerges as a result of the comparison of the two criteria. It shows how important they are to each other.

Step 4: The coefficient value for all criteria is calculated using the k_j equation (Eq. 7). When the most important criterion is given 1, the other criteria take the value $1 + s_j$.

$$k_j = \begin{cases} 1, & j = 1 \\ s_j + 1, & j > 1 \end{cases} \quad (7)$$

Step 5: Adjusted weights for all criteria are calculated with the following formula. The adjusted weight of the first-order criterion is $q_j = 1$. The q_j values are found by dividing the k_j values (Eq. 8).

$$q_j = \begin{cases} 1, & j = 1 \\ \frac{q_{j-1}}{k_j}, & j > 1 \end{cases} \quad (8)$$

Step 6: The final weights (w_j) are calculated for the main and sub-criteria with the help of the equation 9.

$$w_j = \frac{q_j}{\sum_{j=1}^n q_j} \quad (9)$$

2.3. Supply Chain Management Performance

Supply chain management, analysis and improvement are becoming increasingly important. Supply chain performance measurement is a tool that provides holistic monitoring of chain management, which can help to solve problems that may occur in strategic ways. Making performance measurements is used to increase all kinds of efficiency. When an effective performance system is applied, it provides a better view of problems and flow. Companies should measure their performance for the following reasons. The aim to obtain information about the past situation, to analyse the current situation and to shape their future plans and activities depending on them, to guide them on how to reach the determined goals, and to measure performance in order to see to what extent the determined goals have been achieved [9].

Due to today's fast competitive environment and globalization, the market has become quite dynamic. Customer demands are changing rapidly Customers have more options now. To be successful, companies must closely follow changing customer needs. Today, businesses take shape according to customers and compete to meet their demands. The target in the market is to provide both customer demand and quality products and keep the company cost at a minimum while doing these and carrying out the integration in the best way [10].

THE MAIN CRITERIA ARE SUB-CRITERIA	THE MAIN CRITERIA ARE SUB-CRITERIA
STRUCTURAL	Supply Chain Reliability
	Supply Chain Flexibility
	Agility in the supply chain
	Organizational Culture
STRATEGIC	Effective and Competitive Global Supply Chain Strategy
	Risk Management
	Process Planning
	Regulations
PROCESS	Trust And Communication Between Supply Members
	Shipping
	Supply Chain Integration
	Inventory Management
	Customer Satisfaction
	Product quality

The criteria collected under 3 headings are as follows in the table 1.

Structural criteria are the most important criteria when it is applied with AHP. Than it is applied to all main criteria. And results are in Fig. 1 and Fig. 2.

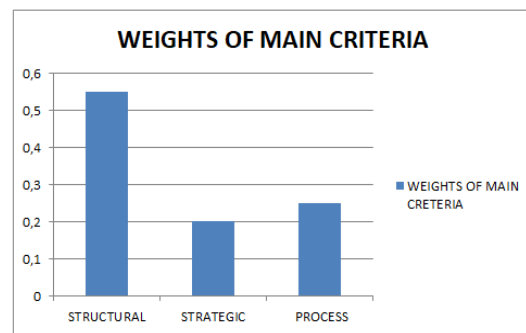


Fig. 1. Weights of main criteria

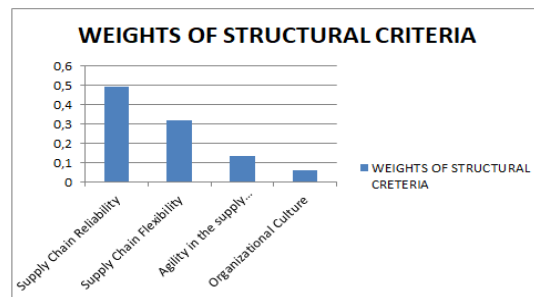


Fig. 2. Weights of structural criteria

It is seen from the Fig.2, the most important criteria is Supply Chain Reliability for structural main criteria.

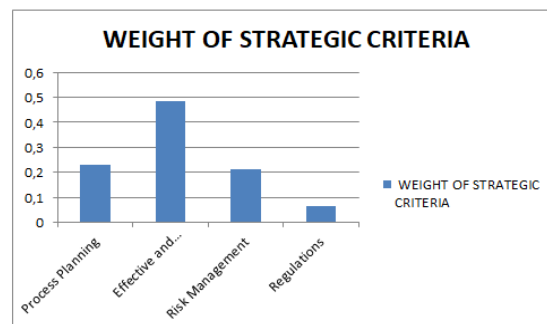


Fig. 3. Weights of strategic criteria

Effective and Competitive Global Supply Chain Strategy criterion has become the most important criterion among the strategic sub-criteria (Fig. 3).

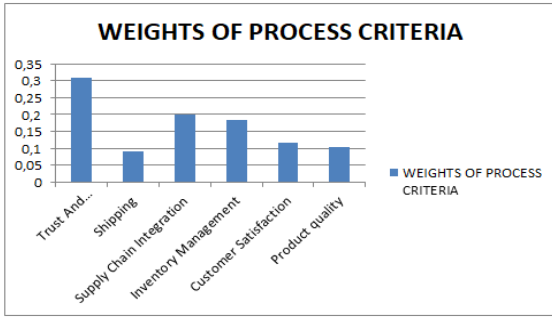


Fig. 4. Weights of process criteria

Trust and Communication Between Supply Members is the most important criterion among the process sub-criteria with AHP method (Fig. 4). First of all, the main criteria are compared with SWARA method. The Structural main criterion, which includes the Reliability of SC, Flexibility of SC, Agility of SC and Organizational Culture, has become the most important main criterion like AHP method.

Table 2. Main criteria weight for SWARA

THE MAIN CRITERIA	Order of importance	s_j	k_j	q_j	w_j
STRUCTURAL	1		1	1	0,43
STRATEGIC	2	0,32	1,32	0,76	0,33
PROCESS	3	0,37	1,37	0,55	0,24

Table 3. All global weight for SWARA

STRUCTURAL	W_j	Main Criterion Weight	Global Weight
Supply Chain Reliability	0,34	0,43	0,15
Supply Chain Flexibility	0,28	0,43	0,12
Agility in the supply chain	0,23	0,43	0,10
Organizational Culture	0,15	0,43	0,07
STRATEGIC			
Process Planning	0,35	0,24	0,11
Effective and Competitive Global Supply Chain Strategy	0,29	0,24	0,09
Risk Management	0,22	0,24	0,07
Regulations	0,14	0,24	0,05
PROCESS			
Product quality	0,29	0,33	0,07
Customer Satisfaction	0,25	0,33	0,06
Shipping	0,18	0,33	0,04
Supply Chain Integration	0,13	0,33	0,03
Trust And Communication Between Supply Members	0,09	0,33	0,02
Inventory Management	0,06	0,33	0,01

In the Table 3, the main headings and subheadings are calculated sequentially. And their global weights were found after multiplication. The most important criterion of the Swara method

is supply chain reliability. The same result was obtained in two methods with two different scoring systems.

3. Results and Discussion

In this study, critical factors were determined during the supply chain and criteria weights were calculated first with the AHP method and then with the SWARA method. In both methods, the most important main criterion is Structural, and the sub-criterion is Supply Chain Reliability.

Based on this result, the most important criterion is supply chain reliability. Due to the rapidly changing competitive environment today, reliability is of great importance. Trust is essential to get all tasks done on time and as planned. Firms with high reliability accelerate the information and cost flow of the chain. It reduces the uncertainties that may occur. Increasing the reliability first will ensure the success of the chain while planning the supply chain. Reliability covers multiple issues and requires that all tasks be performed as expected. For this reason, other features that will ensure reliability should be emphasized. The fact that the order of other criteria differs shows that each process is very important and indispensable for the supply chain. The fact that the values are close to each other and the different rankings in the two different methods show that every process is interconnected. In the study of Yuksel [3] critical factor affecting supply chain performance study, Excellent Order Fulfillment Ratio was the most important criterion. Although the most important criterion is different, it can be interpreted the underlying reason as meeting the expectations of the customer. In the study of Yavuz [2], the most important factor was found to be not holding stock.

It is possible to deduce from these different results that; The most important criterion may vary according to the sectors and criteria selection.

4. Conclusions and Recommendations

The conclusion of this study is that structural features in supply chain management significantly affect the performance of the chain. It is given recommendations to the companies that will carry out the supply chain process that should pay attention to the structural features of the chain.

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