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Hybrid Use of Business Process Management and Analytical Hierarchy Process Method in Supplier Selection in the Automotive Industry

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Abstract

The fact that businesses act with certain systematics while continuing their operations in constantly changing market conditions enables businesses to increase their internal communication activities, reduce costs, and thus increase productivity. Business Process Management studies allow businesses to gain the privileges they should have. The supplier selection process is a complex problem involving many factors simultaneously, and many different applications are used to solve these problems. The Analytical Hierarchy Process method is one of the most popular multi-criteria decision-making techniques. It is mentioned in many studies in the literature and is known as an effective supplier selection method that combines qualitative and quantitative data. In this study, the supplier selection operation of a significant company in the automotive industry has been made more systematic by using a hybrid of Business Process Management, Analytical Hierarchy Process method, and Responsibility Assignment Matrix. It is aimed to fill the gap in this field by guiding the effective supply chain management integration and supplier selection operation in the automotive sector.

Keywords: Optimization, Supply Chain Management, Business Process Management (BPM), AHP, Responsibility Assignment Matrix, Automotive Industry

1. Introduction

In today's increasingly competitive environment, businesses are trying to increase their market shares while simultaneously aiming to reduce costs. In order to achieve these goals, the demanded products should be delivered at the desired time; the raw materials or semi-products used must be supplied at the appropriate time, at the desired quality level, and at a low cost. Accordingly, Supply Chain Management (SCM), which was developed in the 1980s, emerged as a management philosophy that focuses on the external environment of businesses and is based on integration with their suppliers. The SCM can be defined as the network of producers and distributors where raw materials are procured, raw materials are converted into semi-product and final products, and these products are distributed to customers [1].

The SCM involves demand-supply management, raw material supply, production, assembly, stock management, distribution of products, and information systems necessary for the sustainability of all these activities. SCM is the management of the information, product, and money flow between suppliers, manufacturers, distributors, retailers, and customers, from the raw material supply of the final product to its delivery to the end customer [2]. SCM can be defined as ensuring the coordination of information and material flow between suppliers, manufacturers, distributors, and retailers to meet customer needs [3]. The purpose of SCM is to select the most effective ways of generating the relevant product by working for the same purposes in each unit of the supply stages of a product [4].

The Analytical Hierarchy Process (AHP) method is one of the SCM tools and was first studied by Myers and Alpert. It was developed as a model by Saaty in 1980 and started to be used to solve decision problems. AHP can be explained as a decision and estimation method that calculates the percentage distributions of decision points by considering the factors affecting the decision. With this method, the results are obtained by making pairwise comparisons of the criteria [5].

Business Process Management (BPM) methodology comprises method, technique, and technology components that design, maintain, analyze and control active business processes [6]. BPM is a process-oriented approach that combines processes and control mechanisms with information technologies for performance improvement. BPM is based on the cooperation of employees and information technologies for efficient, agile, and transparent business processes. This methodology is defined as the structure where systems, functions, businesses, customers, suppliers, and all stakeholders are brought together in the same pool. It is the last point of experience, thought and professional development. In this system, the customer is the priority, and the system is business-oriented [7]. Businesses need their employees to fulfill their responsibilities; this does not mean that every enterprise personnel will fulfill all responsibilities. Responsibility Assignment Matrix (RASCI) can be defined as the matrix that facilitates the assignment of responsible, informed, approving, auditing, supporting and consulted persons to the transaction steps in BPM. Thanks to RASCI, it is ensured that the works are carried out by responsible personnel; management gaps are also prevented from forming [8].

In this study, the importance of using BPM in SCM is mentioned. A supplier selection study was carried out in the automotive sector by using the AHP, one of the process management and supplier selection tools at X Corporation. For privacy reasons, company names are encoded with alphabetic symbols. In different industries, processes can be disrupted due to human-dependent operations and authority confusion. When dealing with problems, local improvements are made instead of integrated solutions. While this situation improves some of the processes, integrated improvements are insufficient. This study was carried out to eliminate the problems and fill the gaps arising from the inadequacy of the process-oriented approach and the complexity of assigning responsibility in supply chain management in the automotive industry. As a result, works are provided independently of people, and management gaps are prevented. In addition, an end-to-end contribution was made to supply chain management using a hybrid of process management, responsibility assignment matrix, and AHP approaches. Many studies have been carried out in the automotive industry using the AHP technique. However, these studies are limited to supplier selection and contain inadequacies in the process management perspective and responsibility assignment matrix. This study eliminated these inadequacies in supply chain management from end to end. While adapting this study to different sectors, a scenario should be prepared in line with the needs of the relevant field. This study will guide companies that continue their activities in similar sectors by including the factors used in supplier selection, evaluation, and development processes. In particular, the supplier selection study made with the BPM methodology is significant in enabling companies to take one step further in today's competitive conditions.

2. Supplier Selection with Business Process Management

BPM is a vital management discipline that enables organizations to achieve their goals with continuous improvement, sustainable performance management, and main sustainable process audits [9]. The increase in the process management methodology's effect on the enterprises will positively increase the competitive advantage in the market. The success of enterprises is not only dependent on their performance. It is directly related to the performance of all units in the supply chains established for the realization of product or service production. The importance given to supplier selection is not limited to the price and lead time of the product to be supplied. It is very important to increase the competitiveness of the business by ensuring sustainable and long-term relationships with suppliers.

While customer needs constantly evolve depending on technological developments, the desire to simultaneously have low prices and high quality is increasing daily. Moreover, in many countries, competition in the market is increasing with new developments, and businesses have to meet customer needs with new products and services and cooperate with new suppliers.

One of the primary purposes of the enterprises is to supply the products and materials needed at the

desired time, in the desired quantity, in the desired quality, at low cost, and with other required criteria from the appropriate supplier. This target can be realized with effective and comprehensive supplier selection and evaluation [10]. Since working with quality and reliable suppliers is an essential factor in reducing the costs of the customer company, the supplier selection process is a critical stage [11]. Therefore, one of the most important decisions of organizations is supplier selection. The supplying function is generally defined as the procurement of raw materials, equipment, and supplies of appropriate quality, sufficient quantity, at a reasonable price, and with appropriate delivery. Supplier selection includes many criteria, such as quality, cost, performance, and technology. The operation, maintenance, development, and support costs are also considered in supplier selection. For this reason, there is a need to evaluate various criteria with a scientific approach and prioritize them [12].

2.1. Criteria Used in Supplier Selection

Business performance is measured according to financial and non-financial (operational) criteria. Non-financial criteria are divided into competitive success factors such as quality, delivery, and flexibility and internal indicators such as defects, schedule realization, and cost [13]. The supplier assessment problem is a multi-criteria problem. Establishing a relationship between tangible and intangible factors is necessary to determine the best supplier performance [14]. Dickson has defined 23 criteria for supplier selection. Quality, price, delivery time, and previous performance are essential criteria [15]. Price, delivery time, warranty liability, financial situation, technical support, response to customer requests, references, position in the industry, technical capacity, and impression criteria were used by Lehmann and O'Shaugnessy [16]. In the studies carried out, the criteria to be considered for supplier selection are grouped into financial, technical, and operational success [12, 14, 17, 18]. While Nydick and Hill focused on four criteria as quality, price, delivery and service in supplier selection, Siying and Jinlong used price, performance, quality and geographical location criteria [19]. While selecting the supplier, Verma is based on quality, cost, just-in-time delivery, delivery time, and flexibility [20]. Boer, supplier's financial situation, distance, affordability, and quality [21]; Jayaraman, on the other hand, consider cycle time, quality, production capacity, and storage adequacy [22]. The criteria used in supplier selection as a result of the literature review are given in Table 1.

Table 1. Supplier Selection Criteria [23]

Price	Technology	Production Capacity
Quality	Geographical Location	Storage Adequacy
Delivery	Service	Experience
Past Performance	Flexibility	Product View
Warranties and Obligations	Just-in-Time Delivery	Cycle Time
Financial Status	Delivery Time	E-Commerce Capability
Technical Support	Bilateral Agreements	Product Development
Response to Customer Demands	Management - Organization	Product Availability
References	Technical Capacity	Product Range
Risk Factor	Supplier Profile	Application Control
Speed	Resources	Problem Solving
Quality System	Human Resources	Manufacturing
Information Technologies	Packaging Capability	Contact
Position in the Industry	Impression	Number of Technical Personnel

Concerning suppliers, the speed of response to market demand varies according to the competitive conditions of the environment and the state of environmental conditions. Long-term relationships have replaced short-term customer-supplier relationships in the past. In addition, customer-supplier coordination and established strategic partnerships have become important [24]. Supplier relationship management is vital in evaluating suppliers in the long run. Businesses may encounter various problems by having to deal with more than enough supplier companies. Supplier relationship management, among other benefits, also reduces the number of supplier centers of companies. By reducing the number of supply centers, businesses can achieve less busyness and lower total costs.

Determining the number of supplier companies as low as possible and at a sufficient level ensures that stronger relations are established with these suppliers [25]. Effective management of relations with suppliers is of great importance in increasing the performance of enterprises.

Because the slightest problem originating from the supplier directly affects the final product offered to the end customer. The selection and selection method of suppliers is of high importance for businesses.

3. Analytical Hierarchy Process

Analytic Hierarchy Process is one of the most popular multi-criteria decision-making methodologies [26]. AHP enables the transformation of subjective priorities of individuals or groups into objective mathematical values in decision processes and helps to determine priorities for the criteria used while evaluating alternatives [27, 28]. In order to make the best choice with AHP, it is necessary to establish a hierarchical structure among the criteria. This hierarchical structure consists of different decision alternatives [29]. Pairwise comparisons obtained the data. Pairwise comparisons are used to determine the importance of decision criteria based on the decision maker's judgment. While making a pairwise comparison, a scale developed by Saaty is used to determine the relative importance of the compared factors. This scale shows one criterion's importance compared to the other criterion [5]. The AHP method ensures that the decision-making process is completed most efficiently. The heuristic of the decision maker and the consistency of the option comparison are taken into account according to the scale of the relevant priorities. AHP can enable the criteria and sub-criterion advantages to be determined, systematically compared, and evaluated. Based on this information, the best option can be selected, and the effectiveness of alternative systems can be compared [30].

The application steps of AHP developed by Saaty are as follows [30]:

- Defining the problem and the objective
- Starting from the objectives, placing the middle-level criteria and the lowest-level options in a hierarchical structure in order
- To determine which alternative or criterion is dominant over which, pairwise comparisons between both alternatives (lowest level) and criteria (intermediate level) and preparation of pairwise comparison matrix ($n \times n$) dimension
- For each column in the pairwise comparison matrix, taking the sum of the columns and dividing the elements in the matrix by the corresponding column sum, normalizing the matrix
- The row sums for each alternative or criterion are taken in the normalized matrix (Calculated values are priority values, and the matrix is the priority matrix).
- Multiplying the priority values in the priority matrix generated with the priority vector with all the elements in the column in the pairwise comparison matrix of that criterion or option (The matrix generated with the calculated values is the weighted total matrix)
- Calculating the λ_{max} value by dividing the row total values in the weighted total matrix by the row values of the priority matrix obtained in Step 5 and calculating the arithmetic average of the values in the last matrix of ($n \times 1$) size.
- Calculation of consistency index

  $$Consistency\ Index\ (CI) = (\lambda_{max} - n) / (n - 1)$$

- Calculation of the consistency ratio using Table 2 and CI (RI = Mean Random Consistency)

  $$Consistency\ Ratio\ (CR) = CI / RI$$

Table 2. Average Random Consistency

Average Random Consistency										
N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

- Calculate the final priority value by multiplying the alternative priorities calculated on the basis of the criteria and the criteria priorities obtained as a result of pairwise comparison of the criteria among each alternative.

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4. Hybrid Use of BPM and AHP Methods in Supplier Selection

This study was carried out for the success of the operational excellence journey of X Company, which is the headlight supplier of many automotive brands such as Toyota and Renault in the automotive industry. The automotive sector's diversity of companies and models forces X Company to choose effective suppliers because there are many criteria and sub-criteria, such as price, quality, and delivery times. The more complex the criteria and sub-criteria, the more difficult it becomes to solve the problem. The Company generally bases on price and quality criteria when choosing its supplier. However, during production, order delays may occur due to supply. Thus, loss of customers can be encountered. In addition, some orders from customers cannot be accepted due to supply problems. Within the scope of the project, effective supplier selection was made for the undesired supplier problems of X Company. In the project, BPM and AHP were used hybrid in the supplier selection of X Company and in managing this process. The process chart prepared for the path to be followed by the business in supplier selection is given in Figure 1-Figure 2, and Figure 3.

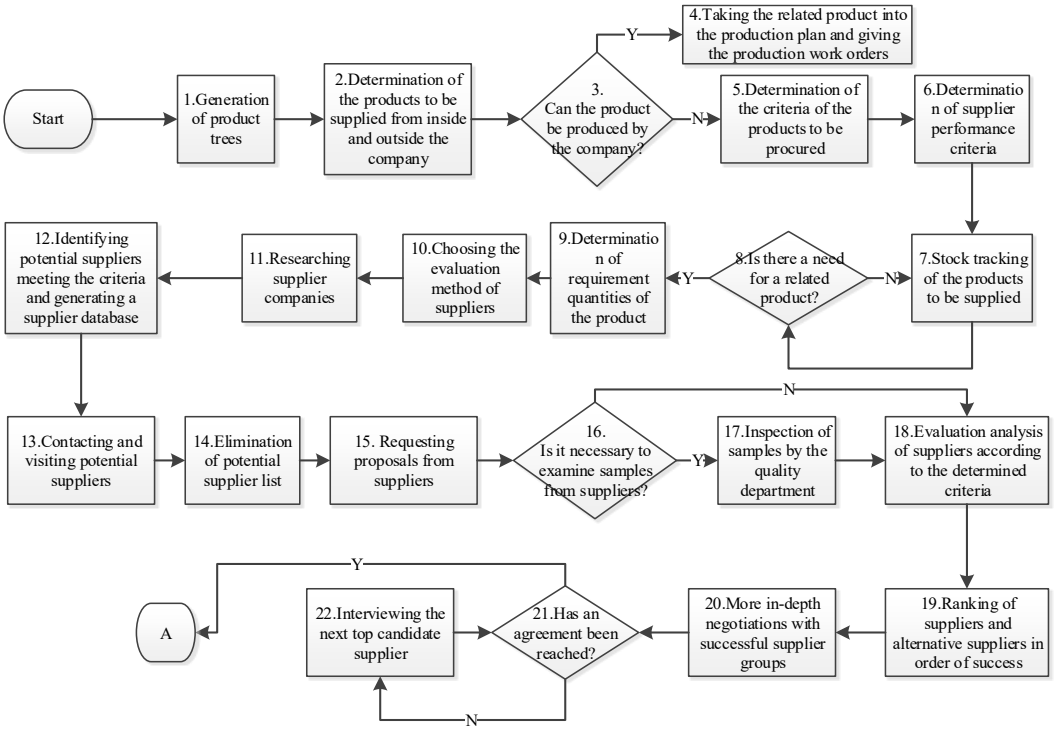

Fig. 1. Pre-supply process

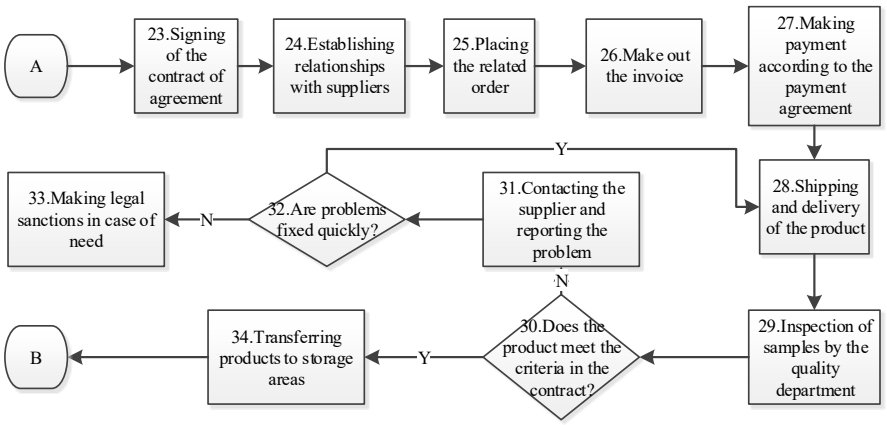

Fig. 2. Supply process

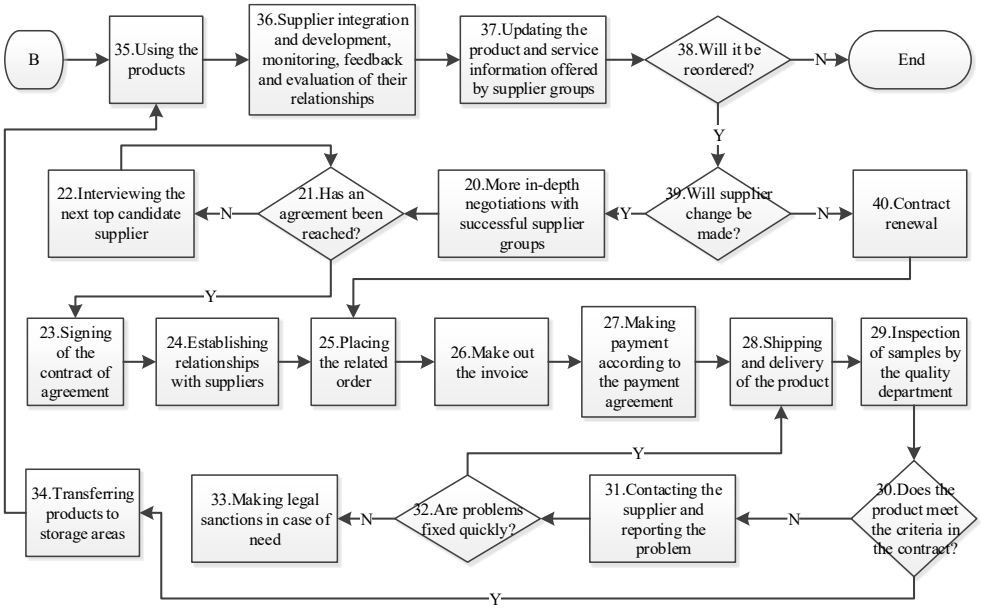

Fig. 3. Post-supply process

The responsibility assignments of the process steps in the supplier selection process to the positions in the Company and the key performance indicators are given in Table 3. The definitions of relevant responsibility assignments when generating Table 3 are shown as follows: R:Responsible, I:Informed, A:Approving/Controlling, S:Supporter/Consultant.

Table 3. Supplier selection process steps, performance indicators, and tasks assigned to positions

No	Processing Step	Production Department	Production Manager	Operations Manager	Purchasing Department	Purchasing Manager	Supplier	Quality Department	Quality Control Manager	Financing and Accounting Department	KPI
1	Generation of product trees	R	A	I	I	I		R	I	I	
2	Determination of the products to be supplied from inside and outside the Company	R	R	A	S	S		I	I	I	
3	Can the Company produce the product?	R	A	I	I	I		I	I	I	
4	Taking the related product into the production plan and giving the production work orders	R	A	A				R	A	I	
5	Determination of the criteria for the products to be procured	R	A	I	I	I		R	A		
6	Determination of supplier performance criteria	R	A	I	I	I		R	A		Delivery time, the failure rate
7	Stock tracking of the products to be supplied	R	I	I	R	I				I	Percent stock reduction, min safety stock
8	Is there a need for a related product?	R	I	I	R	I				I	
9	Determination of required quantities of the product	R	A	I	R	A				I	Safety stock level
10	Choosing the evaluation method of suppliers	R	A	I	I	I	I	R	A		
11	Researching supplier companies	S	I	I	R	A		I	I		

12	Identifying potential suppliers meeting the criteria and generating a supplier database	R	A		R	A		I	A		
13	Contacting and visiting potential suppliers	S	I		R	A		S	S		Number of visits, duration, cost, rate of return
14	Elimination of potential supplier list	R	A		R	A		R	A		Suitability rate for determining criteria
15	Requesting proposals from suppliers				R	I	R				Arrival time of offers
16	Is it necessary to examine samples from suppliers?	R	A	I	I	I	I	R	A		
17	Inspection of samples by the quality department	I	I		I	I	I	R	A		Failure rate
18	Evaluation analysis of suppliers according to the determined criteria	I	I		I	I	I	R	A		Suitability rate for determining criteria
19	Ranking of suppliers and alternative suppliers in order of success	R	I		R	I	I	R	A		
20	More in-depth negotiations with successful supplier groups	S	I	I	R	A	I	S	I		
21	Has an agreement been reached?	I	I	I	R	A	R	I	I		
22	Interviewing the next top candidate supplier	I	I	I	R	A	I	I	I		
23	The signing of the contract of agreement	I	I	A	R	A	A	I	I		
24	Establishing relationships with suppliers	I	R	I	R	R	R	I	I		Number of meeting with supplier/6 months
25	Placing the related order	I	A	A	R	A	I	I	I		Order frequency/year, order quantity/year
26	Make out the invoice	I	I	I	I	I	R				Rate of error-free invoice
27	Making payment according to the payment agreement		I	I	I	A	I			R	Payment amount/year, payment frequency
28	Shipping and delivery of the product	I	I	I	I	I	R	I	I	I	Delivery time, shipping error rate, product accuracy rate
29	Inspection of samples by the quality department	I	I	I	I	I	I	R	A	I	Error rate
30	Does the product meet the criteria in the contract?	I	I	I	I	I	I	R	A	I	
31	Contacting the supplier and reporting the problem	R	I		R	R/I	I	R/I	I		
32	Are problems fixed quickly?	A	A	I	I	A	R	A	A	I	
33	Making legal sanctions in case of need	I	A	A	R	R	I	I	A	I	
34	Transferring products to storage areas	R	I	I	R	I		I	I	I	
35	Using the products	R	A	I	I	I		I	I	I	Usage amount/month
36	Supplier integration and development, monitoring, feedback, and evaluation of their relationships	S	R	I	S	R	I	S	R	I	Supplier error rate/total production
37	Updating the product and service information offered by supplier groups	R/I	I/S	I/S	R	A/S	I/S	R/I	I/S	I	Update frequency
38	Will it be reordered?	R	A	A	R	A	I	R	A	I	
39	Will supplier change be made?	R	A	A	R	A	I	R	A	I	
40	Contract renewal	I	A	A	R	A	R	I	A	I	

In the Company, four raw materials or semi-products, such as sheet metal, plastic, adhesive, and fastener are needed to produce headlights.

- Sheet metal: During the headlight production process, very critical operations are performed on sheet metal. Unsuitable sheets puncture, especially in the pressing department. Quality is an important criterion for sheet metal supply due to the severity of the deformation level in the process. M Company is the only supplier that can meet X A.Ş' s quality and price needs.
- Plastic raw material: The plastic raw material required in the production process is melted under all conditions and poured into molds to form the necessary apparatus. No specific features such as high quality are sought in the parts where the produced apparatus is used. The only thing expected from the supplier is the appropriateness of the price. X Company supplies plastic from Y Company, which has given the most suitable offer.
- Adhesive: The adhesive is used primarily in the glass closing process in production.
- Fasteners: X Company prescribes many criteria and sub-criteria for the supply of fasteners. The business has six choices in terms of supplier company. These are

respectively A, B, C, D, E, and F Company. The criteria and sub-criteria foreseen for the supply of fasteners were determined due to the meetings held with the expert and responsible personnel. Table 4 shows the criteria and sub-criteria determined for the supply of fasteners by X Company.

Table 4. Main and Sub-Criteria for Fasteners.

Main Criteria	Sub-Criteria
Quality	Number of parts rejected from incoming quality control (IQC) / Number of parts coming to IQC
	Number of delivery rejected from IQC / Number of delivery coming to IQC
Price	Period of payment
	Price uptrend
	Submit cost analysis
	Average price validity period
Delivery Performance	Suitability to date
	Suitability to quantity
	Flexibility
	Certificate and label status of delivered parts
Manufacturing Capability	Production capacity
	Packaging capability
	Machine capability
Collaboration	Design support
	Investment policy
	Communication

AHP hierarchy consisting of criteria, sub-criteria, and supplier companies (A,B,C,D,E,F) is shown in Fig. 4.

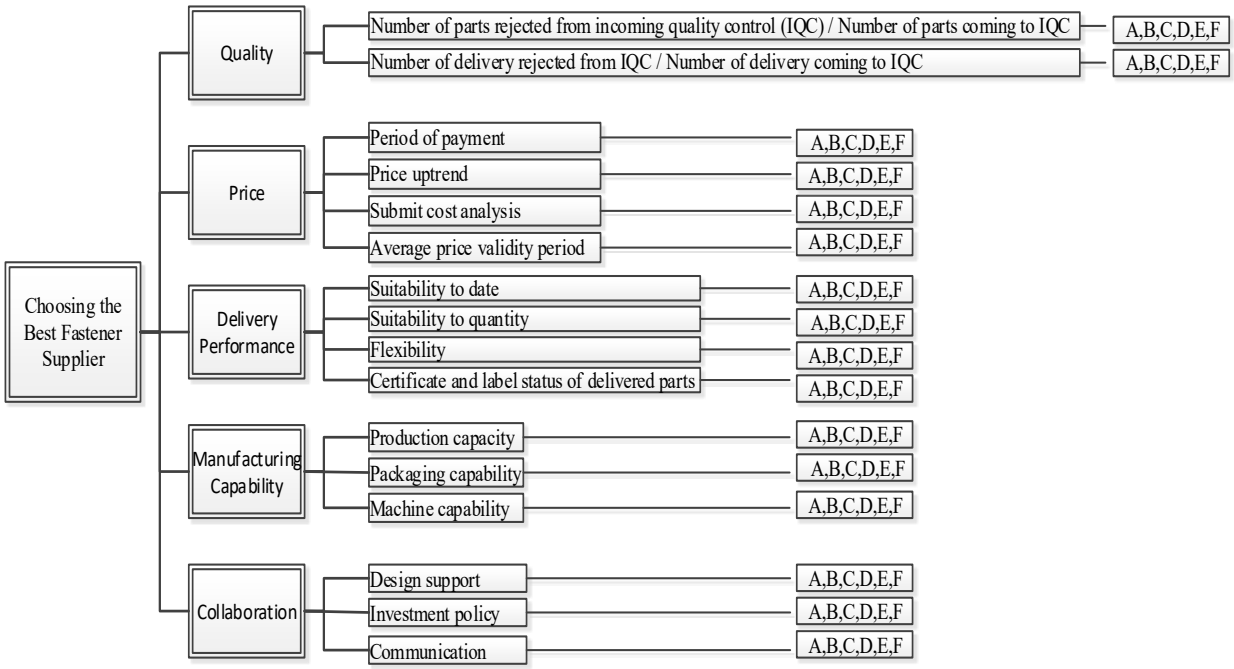

Fig. 4. AHP model hierarchy

The values corresponding to the levels in the stages were determined by collaborative work, and AHP pairwise comparison tables were generated for each level. Table 5 shows the importance levels used in pairwise comparisons in detail.

Table 5. Importance Level Definitions.

1	Equally Important	Both choices contribute equally.
3	Moderately Important	It makes one criterion more important than the other.
5	Strongly Important	It makes one criterion stronger than the other.
7	Very Strong Degree Important	The strength of one criterion over the other is also evident in practice.
9	Definitely Important	Evidence showing that one criterion is stronger than the other has great credibility.
2-4	Intermediate Values	Values between two consecutive importance levels
6-8	Intermediate Values	Values between two consecutive importance levels

4.1. Supplier Selection for Fasteners

X Company considers the criteria and sub-criteria in Table 4 for the supply of fasteners. All operations, including the calculation of consistency ratios, were made using Expert Choice Software.

Table 6. Importance Levels of the Main Criteria of Fasteners.

Criteria	Quality	Price	Delivery Performance	Manufacturing Capability	Collaboration
Quality	1	1	1	2	3
Price	1	1	1	3	3
Delivery Performance	1	1	1	2	2
Manufacturing Capability	1/2	1/3	1/2	1	3
Collaboration	1/3	1/3	1/2	1/3	1

As a result of the calculations made according to Table 6, it was observed that the inconsistency rate was 0.03. Since this value is less than 0.10, it is understood that the calculations are consistent. Among the main criteria, price is 28%, quality is 25%, delivery performance is 24%, and collaboration is 8%. In the following stages, calculations similar to these calculations were made for the sub-criteria of all main criteria.

Table 7. Importance Levels of Sub-Criteria of Quality.

Criteria	Number of parts rejected from incoming quality control (IQC) / Number of parts coming to IQC	Number of delivery rejected from IQC / Number of delivery coming to IQC
Number of parts rejected from incoming quality control (IQC) / Number of parts coming to IQC	1	1
Number of delivery rejected from IQC / Number of delivery coming to IQC	1	1

The matrix is consistent because the *inconsistency rate = 0 < 0.10*. According to the results obtained from Table 7, both sub-criteria have 50% importance.

Table 8. Importance Levels of Sub-Criteria of Price.

Criteria	Period of payment	Price uptrend	Submit cost analysis	Average price validity period
Period of payment	1	1	3	3
Price uptrend	1	1	3	2
Submit cost analysis	1/3	1/3	1	1
Average price validity period	1/3	1/2	1	1

The matrix is consistent since the *inconsistency rate = 0.008 < 0.10*. According to the results obtained from Table 8, the Company payment period is 38%, the price uptrend is 35%, the average price validity period is 14%, and submitting cost analysis has 13% importance.

Table 9. Importance Levels of Sub-Criteria of Delivery Performance.

Criteria	Suitability to date	Suitability to quantity	Flexibility	Certificate and label status of delivered parts
Suitability to date	1	2	5	4
Suitability to quantity	1/2	1	5	3
Flexibility	1/5	1/5	1	1
Certificate and label status of delivered parts	1/4	1/3	1	1

The matrix is consistent since the *inconsistency ratio = 0.02 < 0.10*. According to the results obtained from Table 9, suitability to date is 49%, suitability to quantity is 32%, certificate and label status of delivered parts is 10%, and flexibility is 9%.

Table 10. Importance Levels of Sub-Criteria of Manufacturing Capability.

Criteria	Production capacity	Packaging capability	Machine capability
Production capacity	1	5	3
Packaging capability	1/5	1	1/2
Machine capability	1/3	2	1

The matrix is consistent because the *inconsistency rate = 0.003 < 0.10*. According to the results obtained from Table 10, the production capacity is 65%, machine capability is 23%, and packaging capability is 12%.

Table 11. Importance Levels of Sub-Criteria of Collaboration.

Criteria	Design support	Investment policy	Communication
Design support	1	1	4
Investment policy	1	1	3
Communication	1/4	1/3	1

The matrix is consistent since the *inconsistency rate = 0.009 < 0.10*. According to the results obtained from Table 11, design support is 46%, investment policy is 42%, and communication is 13%.

After determining the importance levels, the comparison matrix of the suppliers for each sub-criterion was generated as in Table 12. However, due to the high number of tables, all tables belonging to the sub-criteria were not included in the study. Instead, six potential candidate suppliers are matched with letters A to F and placed in the tables.

Table 12. Importance Levels of 1st Sub-Criteria of Quality.

Supplier	A	B	C	D	E	F
A	1	2	2	4	6	4
B	1/2	1	1	3	7	3
C	1/2	1	1	3	5	3
D	1/4	1/3	1/3	1	3	1
E	1/6	1/7	1/5	1/3	1	1/3
F	1/4	1/3	1/3	1	3	1

The matrixes of the supplier companies for the determined sub-criteria were analyzed with the Expert Choice program prepared as in Table 12. The priority percentage results of the companies belonging to each sub-criteria are shown in Table 13.

Table 13. Result Percentage Table of the Sub-Criteria for the Suppliers Determined in the Selection of Fasteners

Sub-Criteria	Percentage Priority Values of Supplier Companies by Sub-Criteria						
	A	B	C	D	E	F	Overall Inconstintency
Importance Levels of 1st Sub-Criteria of Quality	35%	23%	22%	9%	4%	9%	0,02
Importance Levels of 2nd Sub-Criteria of Quality	35%	23%	22%	9%	4%	9%	0,02
Importance Levels of 1st Sub-Criteria of Price	33%	19%	21%	11%	9%	7%	0,01
Importance Levels of 2nd Sub-Criteria of Price	25%	25%	25%	8%	8%	8%	0
Importance Levels of 3rd Sub-Criteria of Price	37%	20%	20%	6%	11%	7%	0,01
Importance Levels of 4th Sub-Criteria of Price	17%	17%	17%	17%	17%	17%	0
Importance Levels of 1st Sub-Criteria of Delivery Performance	35%	21%	11%	11%	11%	11%	0
Importance Levels of 2nd Sub-Criteria of Delivery Performance	36%	11%	22%	7%	12%	12%	0,01
Importance Levels of 3rd Sub-Criteria of Delivery Performance	38%	21%	21%	7%	7%	7%	0
Importance Levels of 4th Sub-Criteria of Delivery Performance	28%	13%	15%	14%	14%	16%	0,02
Importance Levels of 1st Sub-Criteria of Manufacturing Capability	38%	21%	21%	7%	7%	7%	0
Importance Levels of 2nd Sub-Criteria of Manufacturing Capability	17%	17%	17%	17%	17%	17%	0
Importance Levels of 3rd Sub-Criteria of Manufacturing Capability	38%	21%	21%	7%	7%	7%	0
Importance Levels of 1st Sub-Criteria of Collaboration	27%	25%	11%	27%	7%	5%	0,01
Importance Levels of 2nd Sub-Criteria of Collaboration	25%	25%	13%	25%	7%	5%	0
Importance Levels of 3rd Sub-Criteria of Collaboration	28%	13%	15%	14%	14%	16%	0,02

As a result of calculating the criteria weights and the importance levels of the suppliers for each sub-criterion, the total weights obtained by the supplier companies were calculated. In the calculation made by considering all the criteria and sub-criteria, for fasteners, “A-Company” was determined as the most suitable supplier with a value of 31%. Alternative suppliers were identified as B with 20.5%, C with 19%, D with 11.2%, E with 8.8%, and F with 9.4%, respectively.

5. Conclusion

Supplier selection is difficult due to the excess of criteria and candidate suppliers. The necessity of making qualitative evaluations in addition to quantitative calculations in supplier selection may cause some errors in the decision-making process. Some comparisons are tried to be made on non-numerical data. For this reason, it is possible to observe changes in the results depending on the qualitative data obtained from different experts. For this reason, special attention should be paid to ensure that the experts from whom qualitative data will be obtained from the supplier have sufficient knowledge of the requirements of the relevant job. AHP's work with qualitative and quantitative methods; makes this method effective among supplier selection methods. In this study, the supply problem of the fasteners of X Company has been solved. The Company wants to rank the alternative suppliers according to various criteria.

Within the scope of the study, the integration of BPM and AHP was carried out in X Company. Using the AHP method, an effective supplier selection was made among the existing suppliers in the market. The criteria and sub-criteria of the products to be supplied were determined and scored. The pairwise comparison method determined the importance levels of these criteria and sub-criteria against each other. Afterward, calculations were made based on the supplier options, criteria, and sub-criteria that can supply the products of X Company. Consistency analyses of all data were made, calculations exceeding 10% inconsistency rate were reviewed, and final results were reached. The fastener supplier was determined as “A-Company” with an inconsistency value of 2%. Thanks to BPM, the supplier selection problem and SCM has been solved systematically.

The actions taken in supplier selection were mapped and analyzed in detail. In particular, the accurate definition of the process steps and the relevant positions responsible for the steps prevented the formation of management gaps.

6. Discussion and Implication

Many studies have been carried out in the automotive industry using the AHP technique. These studies are limited to supplier selection and contain inadequacies in the process management perspective and generation of responsibility assignment matrix. This study eliminated these inadequacies in supply chain management from end to end. For future studies to yield more effective results, sector and product classifications and supplier and supplier criteria pools are generated nationally; these databases can be turned into a platform that all businesses can use jointly. This platform will increase our quality and effectiveness on a national and international basis, along with the level of competition. In future studies, the real-time and autonomous feature will be brought to supply chain management by increasing the Industry 4.0 integration level and artificial intelligence-based processes. Thus, optimum resource utilization will be ensured when needed. Process variability will be provided autonomously. As a result, costs will be reduced, and operational excellence will be achieved. While adapting this study to different sectors, a scenario should be prepared in line with the needs of the relevant field. In addition, with technological developments such as IoT and artificial intelligence, the quality of this work will be raised to a better level.

Author's Contributions

Mahmut Sayar: Drafted and wrote the manuscript, performed the experiment, result analysis and interpretation.

Ethics

There are no ethical issues after the publication of this manuscript.

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