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A New Dynamic Supplier Selection and Supplier Evaluation Model in a Company for Decision-Making Process

Pınar AZİMLİ
Dokuz Eylül University
The Graduate School of Natural and Applied Sciences
Department of Computer Engineering
İzmir, Turkiye
pinar.azimli@ogr.deu.edu.tr
0000-0002-0824-2456

Yalçın ÇEBİ
Dokuz Eylül University
Faculty of Engineering
Department of Computer Engineering
İzmir, Turkiye
yalcin@cs.deu.edu.tr
0000-0002-2330-4440

***Abstract*— Supplier selection and evaluation processes are the companies' most critical decision-making processes. To achieve the desired customer satisfaction, selecting the most suitable supplier and evaluating the suppliers with objective criteria and scientific methods is essential. Supplier Selection (SS) is a strategic decision that a company implements when searching for a new supplier. In contrast, Supplier Evaluation (SE) refers to selecting suppliers among their existing suppliers. As criteria and weights are different in the supplier decision of the companies, a flexible and extensible model called the Dynamic Supplier Analysis Model (DSAM) is developed. This model enables the creation of criteria groups under SS and SE templates, assigning weights to criteria, and applying Multi-Criteria Decision-Making (MCDM) methods. A software program, Dynamic Application for Supplier Analysis Model (DAppSAM), is developed to implement the DSAM model in one of the world's leading chemical companies using an Enterprise Resource Planning System (ERP) as a case study. Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is applied to calculate criterion weight using dependencies and relationships between criteria. The Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) MCDM methods were applied using a quality advantage SE template to select materials. The confirmed results by experts show that this model allows companies to analyze their suppliers efficiently.**

Keywords*— *Supplier Selection, Supplier Evaluation, MCDM, AHP, TOPSIS

I. INTRODUCTION

Supplier defines any person, business, institution, or organization that supplies goods or services to companies. The term "supplier identification" is the process of determining which suppliers will supply goods and services to companies according to their fields of activity. Since customer satisfaction is at the center of business decisions, companies are trying to cooperate with suppliers to satisfy their customers. In today's competitive business environment, finding suitable suppliers has become more critical due to the increasing costs and low-profit figures. For this reason, businesses need a supplier determination system that enables them to establish long-term relationships with their suppliers by selecting the most suitable suppliers according to their expectations and goals, reviewing these relationships in specific periods, and managing their suppliers [1].

A purchasing expert is an individual who has a critical role during the supplier decision process. Purchasing experts manage all the purchasing processes of a business, negotiating with vendors to get the best price for goods and services. And also, it is important to communicate with other departments and company employees and take care not to exceed the budget limits while making their purchases.

Since a supplier can be chosen among new candidates or existing suppliers, the supplier determination can be classified into two processes: Supplier Selection (SS) and Supplier Evaluation (SE). The SS process is the process of identifying a supplier among candidate suppliers. Therefore, SS is the cornerstone for strategic sourcing and procurement advantage, and the decision-making process during this selection is accepted as strategic. In SS, data is obtained from suppliers through surveys and interviews, so collected data is unstructured. However, these unstructured data must be converted into structured data to be used in the evaluation process. And also, if the collected data format is unstructured, then the ability of the decision-maker to decide quickly with the required precision is hampered [2].

In contradistinction to the SS, the SE process is carried out on the current suppliers of the company. This process helps companies to evaluate their existing suppliers in order to decrease the purchasing risk and maximize the overall value to the buyer. The SE process is intended to guarantee that the best supplier is available. In the SE process, both the data obtained from the ERP of the company and the data collected from purchasing experts are used. Therefore, the SS process is accepted as a strategic decision-making process, the SE process is recognized as a tactical and operational decision process [3].

Criteria are the plural form of the word criterion, which describes a standard, rule, or test on which a judgment is based. In the past, companies used to make supplier decisions by considering price criteria, but with the increasing competition, different criteria, such as quality control certificates, customer complaints, capacity, and capability, were considered for evaluating alternatives. However, the companies may evaluate suppliers for different material and service purchases by defining the criteria and criterion weights according to their requirements. In this way, companies operating in different industry areas can evaluate

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existing suppliers and choose new suppliers according to their objectives.

In this study, a new model and software are developed to provide a solution to supplier decisions of companies in different industry areas by applying MCDM methods with a dynamic system structure. The supplier selection and evaluation processes can be distinguished by defining criteria and templates based on the requirements of a company. Decision-makers can define criteria and the calculation method to determine the criterion values of suppliers in this software. Moreover, criteria can be selected, and weights of criteria are assigned under template structures according to the requirements of the company. The weights of the criteria can be calculated after defining the effects and importance of the criteria. It is intended to integrate existing supplier data with an ERP system for the SE process. The suppliers are evaluated with more realistic data with this integration. Additionally, a structure is essential where different MCDM methods can be included and applied to supplier decisions. Therefore, a dynamic model should be established to identify and classify SS and SE criteria for selecting a supplier and to apply appropriate MCDM methods based on the industry domain.

II. Literature Review

Due to the importance and widespread use of Supplier Selection (SS) and Supplier Evaluation (SE) processes in many fields, numerous studies have been found in the literature. A novel grey decision model to evaluate suppliers for the process industry [4]. Analytic Network Process-Technique for Order of Preference by Similarity to Ideal Solution (ANP-TOPSIS) method is applied in the automotive industry for evaluating suppliers [5].

A multi-criteria intuitionistic fuzzy TOPSIS method sustainable supplier selection and determine the rank of suppliers through a real-world case study [6]. A model is constructed for integrated supplier selection by applying the ANP, Taguchi loss function, and PROMETHEE methods. In this study, various criteria were determined, such as price, delivery, financial status, and management capabilities. They used the ANP methods to determine criterion weights and relationships, Taguchi Loss Function, and PROMETHEE approaches to find the best supplier, rank the suppliers and apply in Tire Company. In conclusion, precise solutions were determined for complicated selection problems with traditional and non-traditional methods comparatively [7]. The generalized Choquet integral and the fuzzy TOPSIS approaches are applied to select the best supplier for purchasing steering gearbox products for the automotive industry in Turkey. The results showed that the fuzzy MCDM methods provided more reliable solutions instead of traditional MCDM methods [8].

Supplier decisions are made using the SS and SE criteria in conjunction with MCDM methods. The criteria are set by the companies based on their goals in selecting a product or service and applying MCDM methods [9]. Moreover, in the study of a company producing corrugated cardboard boxes in Turkey, the most frequently used criteria for supplier selection were price, quality, delivery, service, and sub-criteria. The weights of the criterion are determined by the Analytical Hierarchy Process (AHP) method, and alternative suppliers were selected with the TOPSIS method [10]. A literature review of supplier criteria selection and the research trends on criterion selection based on a review of related studies for selecting suppliers is presented. Also, the AHP method is applied in the business sector to gain optimal results [11]. The suppliers are selected, and supplier development status is found with the TOPSIS method [12].

The AHP and TOPSIS methods were used for housing selection [13], the measurement of corporate sustainability in the bank sector [14], and the evaluation of polyclinics [15]. A comprehensive evaluation model based on VIKOR and TOPSIS models is proposed to determine the security status of urban water supplies. The results indicate that Tianjin should develop water resources and focus on the construction of a water-saving society [16].

In a study, the rankings obtained by the TOPSIS and VIKOR methods, which are multi-criteria decision-making techniques, were compared in order to make the financial performance rankings of the enterprises. They examined whether there is a relationship between their financial performance and stock market performance by sequential correlation analysis [17].

The Grey Relational Analysis (GRA)-Best Worst Method (BWM-TOPSIS methods are integrated to propose a framework for resilient supplier selection with the presence of uncertain and incomplete data [18].

The decision-making trial and evaluation laboratory (DEMATEL) and Analytical Network Process (ANP) methods were used together for supplier selection in the health sector. The criteria are ranked as price, quality, sustainability, OHS, technique, and logistics with these methods. It is indicated that the proposed method may help managers with purchasing decisions [19]. They propose a methodology by using PROMETHEE II that identifies the best criteria first and calculates the preference indices according to these criteria. The PROMETHEE II algorithm is customized, and statistical analysis indicates that the proposed approach might be applied instead of PROMETHEE II and TOPSIS methods [20].

The effect of the criteria on supplier selection for bottleneck and strategic product groups is discussed. The bottleneck products have a particular design, while strategic product producers are limited. There are three candidate suppliers for each group. Criteria and sub-criteria with their weights were defined according to product groups. In this study, it was given that the criteria and weights used in supplier selection varied depending on the product group. Furthermore, it was noted that there might be dependencies between the criteria used for supplier selection, and ignoring these dependencies which would lead to erroneous results [21]. Additionally, the criterion “cost” is critical, but the criteria of “performance” and “ease of use” are also determined as essential when selecting a machine in the cable industry. The fuzzy structure enables the decision-makers to evaluate statements and create an objective decision structure [22]. In addition, Fuzzy logic is used to evaluate marble extraction methods [23]. MCDM methods combined with the fuzzy logic to deal with uncertainties by the Fuzzy TOPSIS

method [8] and [24]. Also, Fuzzy TOPSIS and Fuzzy DEMATEL were used by [25] to select the most suitable supplier. Similarly, the criteria weights and relationships are determined by using the Fuzzy DEMATEL technique [26] and [27]. Besides, the fuzzy AHP method is applied to determine the best alternative and the most suitable machine suppliers [28].

Also, another MCDM algorithm, namely Data Envelopment Analysis (DEA) is used to calculate relative importance and to monitor market performance by using many inputs and outputs without calculating weights [29]. The Analytical Network Process (ANP) to determine the weight in supplier selection criteria and the DEA method to handle hundreds of suppliers Reference [30]. Besides, supplier selection in the cable industry by employing the DEMATEL method for determining criteria relations, the ANP method for determining criteria weights, and the VIKOR method for supplier selection. In the cable industry, DEMATEL, Analytic Network Process, and VIKOR method are used to select polyethene suppliers [31,32]. As a result, "the suitability of the product price" is found as an essential criterion, and two companies are identified as the best suppliers. Additionally, the Delphi technique may also be used when individuals and groups need to solve complex problems without face-to-face meetings [33]. A comprehensive solution model is developed to select supplier in the Oil and Gas (O&G) industry to prevent delay problems during O&G operations resource extraction. They applied a Delphi technique to filter unnecessary factors and rank factors. Moreover, the best-worst method (BWM) is applied to calculate the weights of criteria and reduce pairwise comparisons. TOPSIS method is implemented to rank the suppliers. The applicability of this integrated MCDM model in the O&G industry reveals that this model can be used in other industrial sectors for SS [34].

Besides, Principal Component Analysis (PCA) is used to reduce the dimensionality of large datasets by computing low-dimensional representations of multivariate data [35] and [36]. Medium-sized bottling machine companies have used this method to evaluate the relative performance of suppliers with multiple outputs and inputs [37].

The fuzzy TOPSIS approach is applied to select hospital suppliers for ten main and twenty-four sub-criteria to evaluate three hospital supplies. Supplier one is selected as the best sustainable supplier but supplier two has the best performance based on economic criteria in the study. They indicate that this work can help hospital managers make decisions on candidate suppliers [38].

III. Problem Definition

Many other studies can be found which are carried out for different sectors in supplier decisions. The studies are sector-specific and inflexible with fixed criteria and methods. In the previous studies, it was seen that the concepts of SS and SE are intertwined. Besides, to the best of the authors' knowledge, no study exists that defines SS and SE processes separately and also has a flexible and extensible model depending on the company. Thus, companies can meet their expectations by defining their criteria within a model that provides e.g. financial, operational, and cost benefits. Also, another significant problem in evaluating criteria for SS and SE process is data collection methods. The companies are unclear about the required data, its format, the methods for collecting the data and collected data is unstructured form. In this model, an unstructured data should be converted into structured data. Regarding the mentioned problems, companies should determine the nature, definition, and use of data in the supplier selection and evaluation process.

IV. Methodology

A. Model Definition

In this paper, a novel, flexible and extensible model for both SS and SE called Dynamic Supplier Analysis Model (DSAM) is developed. DSAM model consists of four phases which are Data Collection and Preparation, Method Development, Evaluation, and Analysis shown in Fig. I.

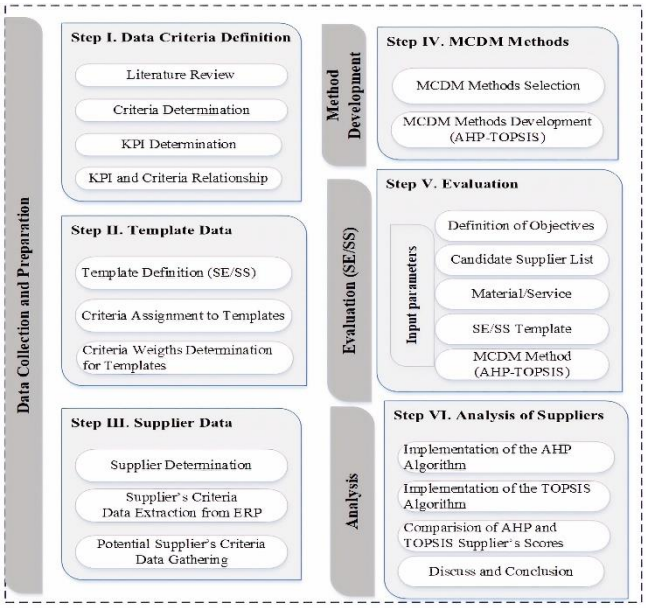

FIG I. DSAM MODEL

Data Collection and Preparation phase is the most important phase of this model. In the criteria creation step of this phase, literature analysis and workflow analysis of different firms were carried out, and criteria found after this research was analyzed by experts.

The criteria "Quality Control", "Product Control", "Delivery Performance", "Customer Complaints ", "Price and Payment Terms Control", "Accuracy" and "Quantity Control" were defined as follows;

Quality Control; Accepted ratio and Rejected products ratio

Product Control; the ratio of correct and incorrect product gives the result value of this criteria.

Delivery Performance; the performance of supplier for Order Delay Date, Packaging Capability and distance

Customer Complaint; the count of complaints gives the score for a supplier.

Price and Payment Terms Control; Ratio of Correct Price, correct payment term and Out of Tolerance criteria are used to calculate supplier value.

Accuracy; criteria value is calculated by the ratio of ontime delivery, correct product and amount of a material that is purchased.

Quantity Control; the ratio of correct and out of tolerance gives the value of the criteria for a supplier.

For each of the criteria, KPI's value definition methods were determined. After this step, different templates were defined to give flexibility and manageability to the user, and a hierarchical criteria tree, including weights for each criterion. In the Supplier Data step, different approaches were applied to the existing supplier or candidate supplier. For existing suppliers, data, criteria, and KPI values that exist in the ERP System of the company are imported. For candidate suppliers, their required data, criteria, and KPI values are obtained in digital form if possible or the required data is entered into the system manually.

The well-known and most used methods, AHP and TOPSIS, are developed in the Method Development phase. And also, depending on the requirements of the company, new methods can easily be applied and integrated into the system. Moreover, in the Evaluation phase of the model, the requirements of the company are determined, the materials and services are selected to be purchased, and SS and SE processes are carried out. In this phase, the user can select the suitable template for any desired situation, such as quality advantage, cost advantage, minimum price, and delivery time. The user also can define new templates according to their requirements. The Analysis is the last phase of the presented model, in which the results obtained from the applied methods are combined to make the final decision after the necessary analyses by the experts.

B. Data Collection and Analysis

The most important step in the data collection is determining the criteria. First, the criteria list is populated from the previous studies carried out by the different authors in the literature and the analysis carried out on different firms. Then each criterion was discussed with the purchasing experts, and then final criteria list was created. Values of the criteria can be determined by using two different ways depending on the situation of the current suppliers and candidates. For current suppliers, criteria values are determined depending on the data in the ERP system of the company. For candidates, the data used for the value determination is collected from surveys and interviews with the suppliers. Then, three data preparation techniques are performed together to extract meaningful information from the raw data, including (i) Criteria Determination Processes: New Criterion Adding Processes, Criterion Splitting Processes, Criteria Merging Processes, and Criterion Removal Processes. (ii) Segmentation: Criteria Characteristics Definition. (iii) Feature Extraction: Grouping Criteria as SS/SE and defining a related scale. Finally, the experts in the company finalize the criteria values and weights to be used during SS and SE processes.

C. The Relation between Criteria and KPI

KPI structure provides to define the method of obtaining the criteria values of the suppliers and the criterion scale ranges. The working methods of the criteria are determined by the KPI type and the calculation method. Also, KPI scales determine the actual value of the interval for scores and the direct effect of a criterion value. Some detailed examples of the KPI with scale and its intervals are given in Table I.

TABLE I. KPI DETAILS

KPI ID	KPI Name	Criterion Name	Method	Data	Scale	Unit	The effect	Interval	Score
69	Order Delay Time	Order Delay Time	Function	Transaction Values	15	Day	The negative effect Max Day=Min Score	-30 day -30/-10 -10/0 0/5 5/	5-Perfects 4-Good 3-Normal 2-Acceptabl 1-Bad
448	Distance	Distance	Objective Data Method	Data	95	Km	Negative Effect Max Distance=Min Score	Distance Min/Max Interval	1-Good, 2-Normal 0-Bad 3-Perfect
449	Packaging Capability	Packaging Capability	Subjective Data Method	Data	94	Bool	Exists Max Score	1-Exist 0-NotExist	1 0

D. Templates

Templates are criteria groups created to select or evaluate a supplier for a product or service. A template also gives the ability to users to define their requirements by using KPI and KPI weights in the system. While creating the templates, the Year, the Type (SE/SS), and the features of the template are selected. The features include "Cost", "Delivery", "Quality", and "Quantity", as given in Table II. These features enable to distinguish templates easily without reviewing KPI details. The user may also select one or more of these features depending on the requirements.

TABLE II. QUALITY ADVANTAGE TEMPLATE PROPERTIES

	Year	*Type*	*Cost*	*Delivery*	*Quality*	*Quantity*
Quality Advantage	2012	SE	☐	☐	■	☐

Each template has layers in which a sub-criteria is defined for each main criterion in a top layer. After adding criteria to the templates, weights are assigned to each criterion. These weights can be determined by experts or can be calculated using a method. In Table III, the Quality Advantage Template was created by experts; the first two layers of this template are given. As can be seen in Table III, the overall sum of the

weights defined in each layer is 100%, while each criterion has its weight. The weight of the criterion can be assigned under the template based on requirements. Besides, the weight of the criterion can be calculated by Decision-Making Trial and Evaluation Laboratory (DEMATEL) method in this model. The DEMATEL method determines the type of relations, the importance of the criteria, and their effects on each other [39] and is applied to determine criteria and criteria weights by using evaluation scales. These scales are linguistic terms as No influence, low influence, Medium influence, high influence and very high influence [40].

TABLE III. SE RESULTS OF THE AHP METHOD FOR QUALITY ADVANTAGE TEMPLATE OF TWO LAYERS

QUALITY ADVANTAGE TEMPLATE MAIN/SUB CRITERIA (LAYER I, LAYER II)			
LAYER I		**LAYER II**	
Criterion	**W%**	**Criterion**	**W%**
Quality Control	30%	Accepted Ratio	30%
		Condional Accepted Ratio	30%
		Environment Related Cerificates	20%
		QDMS System	20%
Product Control	15%	Ratio of Correct Product	40%
		Quality Control	60%
Delivery Performance	10%	Order Delay Date	50%
		Packaging Capability	20%
		Distance	30%
Price and Payment Terms Control	15%	Payment Control	50%
		Price Control	50%
Customer Complaints	5%	Quality Complaints	50%
		Delivery Complaints	10%
		Packaging Complaints	10%
		Handling of Complaints	20%
		Price Complaints	10%
Accuracy	10%	Ratio of Correct Price	13%
		Delivery On-Time Ratio	15%
		Delivery Correct Product	50%
		Delivery Amount Accuracy	12%
		Proper Packaging	10%
Quantity Control	15%	Ratio of Correct Quantity	80%
		Waste Rate	20%
Sum (Layer I)	**100%**		

The criteria to be used in the evaluation process are selected among the existing criteria in the system. In this selection process, the opinions of experts are taken, and the decision-makers can compare the relationships among the criteria by using criterion evaluation scales. Moreover, the DEMATEL method is applied to calculate criterion weight by using dependencies of criteria [41, 42]. In this study, Quality Control, Product Control, Delivery Performance, Price and Payment Terms Control, Customer Complaints, Accuracy, and Quantity Control criteria weights are calculated as 0.17814, 0.16888, 0.08867, 0.18084, 0.16676, 0.13601, 0.08071. These values indicate that price and payment terms control criteria are very important criteria. This template is created as a quality advantage, so the quality control criterion weight is assigned as 30%. However, the prerequisite of 100% total should always be preserved.

E. MCDM Methods

It is determined that different MCDM methods are used in supplier decision-making in the literature examined within the scope of this study. In this work, the Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods are used to calculate supplier score values. AHP method is a mathematical theory that is the most popular and widely used multicriteria method in decision-making developed by [38]. The criteria are compared according to their priorities, and criteria weights and supplier scores are calculated using the AHP method. On the other hand, the TOPSIS method is one of the MCDM methods frequently used in the selection of suppliers in literature [43]. The scores of the alternatives are considered by calculating the distances between the positive and negative ideal solutions in the TOPSIS method. The selected alternative is expected to be close to the positive ideal solution and away from the negative ideal solution [44].

An algorithm is developed using the analytic hierarchy process (AHP) method to evaluate suppliers. Supplier scores are calculated with the procedures developed for the application of this method. Moreover, the TOPSIS evaluation method is used in this study based on supplier data to evaluate suppliers. In this study, a flexible data structure was created, AHP and TOPSIS methods were applied by the prepared procedures, and the dependency on any ready-made library was eliminated with the development of the procedures within the scope of the study. These procedures allow flexible application of methods for different criteria and alternatives. The AHP method allows the evaluation of alternatives with paired comparison matrices created for the determined criteria. Simple mathematical operations are used in this evaluation process. In this study, the AHP method was used effectively by creating a dynamic data structure and pairwise comparison matrices for both criteria and alternatives. For the application of the method, the procedures developed in the study and the alternatives were evaluated by solving mathematical operations and pairwise comparison matrices. In addition, since the effect direction of the criteria can be positive or negative, the effect aspect of the criteria should also be taken into account in the evaluation of alternatives. If the cost criterion value of an alternative is large, this alternative should be evaluated negatively, and an alternative with minimal cost should be chosen as the best solution. If we consider another criterion, the quality criterion, it will have a positive effect if an alternative has a quality certificate. In other words, the cost criterion has a negative effect, but the quality certificate criterion has a positive effect. The TOPSIS method was used in this study because it calculates the distance of the alternatives from the positive and negative ideal solutions by taking into account the positive and negative effects of the criteria. In addition, to apply the TOPSIS method, a procedure was developed using the flexible data structure used in the AHP method, and mathematical operations were applied with matrix operations. In this way, the evaluation of alternatives was ensured by taking into account the positive and negative effects of the criteria.

In order to calculate supplier score values, the DAppSAM software user interface is shown in Fig. II. Industry field, template, material, and method are selected as parameters,

supplier evaluation and selection are selected, and scores are calculated.

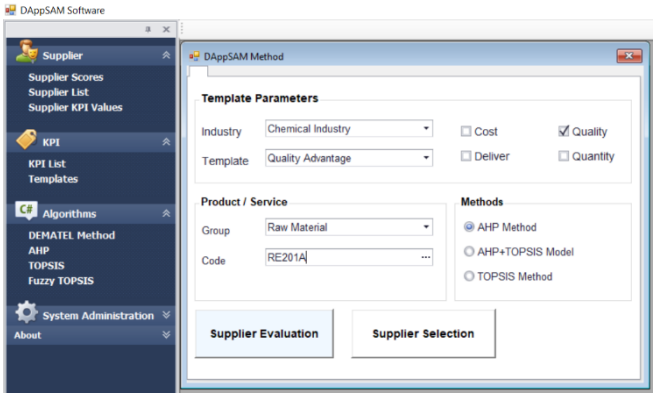

FIG II. DAPPSAM SOFTWARE USER INTERFACE

F. Supplier Score Calculation

AHP and TOPSIS methods are applied using a template, the supplier's data, and KPI value of each supplier is calculated. In order to calculate the supplier score, the criteria score values of suppliers are multiplied by criteria weights depending on the selected template, and a total score is calculated. In each layer, the score of a criterion and the total score of criteria are calculated by using formulas 1 and 2:

$$Score\ of\ criterion\ k = W\%(k) * AR \quad (1)$$

$$Total\ Score = \sum_{i=0}^{n} W\%(i) * AR(\mathrm{i}) \quad (2)$$

Where k= k_{th} criterion

- n: Count of a SS/SE template's main criteria
- W% (k): Weight of the kth criterion on a selected layer
- AR: Result value of a selected algorithm for kth criterion

Score: Multiplication of AR and W% values on a selected layer for kth criterion.

V. RESULTS AND DISCUSSION

The case study was carried out on the data of a chemical company that is among the top five companies worldwide and located in Turkey. The developed software DAppSAM was also integrated with the ERP system of the mentioned company to implement the DSAM model. As given above, the AHP and TOPSIS methods were selected and implemented in this study. Since the processes carried out for both SS and SE are similar, in order to see the effectiveness of the model and to compare with it the real-world data, only the SE was carried out. Also, the ERP data used in this study was related to the last five years. Depending on the purchase orders of the company in these years, 20 current and candidate suppliers were selected from the historical purchase order data at the same time for a product group. In this case study, the Quality Advantage Template was selected for SE. The name of the materials and the name of suppliers were coded to maintain data security. The suppliers have the ability to provide the materials coded as RE201A that were selected and used in the comparisons. The score of each supplier was calculated as given in formulas 1 and 2. The overall scores of the supplier evaluation process carried out by the AHP and TOPSIS methods are given in Tables IV and VI, respectively.

TABLE IV. SE RESULTS OF THE AHP METHOD

Supplier Code	Total Score	Quality Control	Quantity Control	Product Control	Price and Payment Terms Control	Delivery Performance	Accuracy	Customer Complaints
	100%	**30%**	**15%**	**15%**	**15%**	**10%**	**10%**	**5%**
S02	**6.4489**	1.7658	1.1251	1.1107	0.7399	0.5457	0.6724	0.4893
S12	**6.2040**	1.7658	1.1251	1.1107	0.9885	0.3624	0.7536	0.0979
S14	**6.1900**	1.5351	1.1251	1.1107	0.6992	0.5582	0.6724	0.4893
S05	**5.6099**	1.6482	1.1251	0.8494	0.8663	0.3523	0.5993	0.1693
S11	**5.2508**	1.5204	1.1251	0.6888	0.6181	0.4912	0.6788	0.1284
S20	**5.2366**	1.1250	1.0313	0.7943	0.6915	0.5573	0.5968	0.4404
S03	**5.1884**	1.9966	0.2812	0.6888	1.0910	0.4412	0.3176	0.3720
S10	**5.1866**	0.9412	1.1251	0.8494	0.7371	0.6694	0.6462	0.2182
S07	**5.1678**	1.2528	1.0313	0.8494	0.7346	0.5726	0.6507	0.0764
S13	**5.0671**	1.7658	1.1251	0.6888	0.6026	0.5629	0.1720	0.1499
S01	**5.0040**	0.7913	1.0313	0.5330	1.0868	0.4912	0.9011	0.1693
S09	**4.9499**	1.5204	0.1875	1.1107	0.6181	0.5499	0.5149	0.4484
S18	**4.6704**	1.2896	0.2812	1.1107	0.7821	0.4495	0.5880	0.1693
S04	**4.6364**	1.9966	0.2812	0.7943	0.6178	0.3652	0.4529	0.1284
S15	**4.4398**	1.5204	1.0313	0.3723	0.5521	0.3513	0.1720	0.4404
S06	**4.4119**	1.5204	0.1875	0.3723	0.9460	0.8110	0.4463	0.1284
S17	**4.3101**	1.5204	0.2812	0.7943	0.5405	0.5652	0.4392	0.1693
S08	**4.1648**	1.7511	0.2812	0.6888	0.6630	0.3944	0.2364	0.1499
S19	**3.9802**	1.7511	0.1875	0.3723	0.5566	0.5610	0.1633	0.3884
S16	**3.8849**	1.0220	1.0313	0.1110	0.8684	0.3485	0.3264	0.1773
Max. Score	**6.4489**	**1.9966**	**1.1251**	**1.1107**	**1.0910**	**0.8110**	**0.9011**	**0.4893**

Depending on the results obtained, it is observed that supplier S02 has the highest score while supplier S16 has the lowest. When details of the evaluation are examined, it is seen that the order of the suppliers is generally different. For example, suppliers S03 and S04 have the highest scores of 1.9966 from the Quality Control perspective. However, their scores are extremely low when compared to Quantity Control. Supplier S03 has the highest score from the "Price and Payment Control" perspective, but from other perspectives, it is located in the bottom section of the comparison list. Although supplier S02 was detected as the best in overall score, it was not the best in the "Price and Payment Control". In order to show the layer structure, the details of S02 are given in Table V.

After the TOPSIS implementation, it was revealed that supplier S02 is also the most advantageous supplier when the overall score is calculated. Although the supplier "S03" has the highest "Quality Control" score, other criteria scores are lower than it. By considering the overall results for both cases, it is observed that supplier S02 is the first and selected as the final supplier for the material RE201A.

TABLE V. DETAILED RESULTS OF "PRICE & PAYMENT CONTROL" CRITERION FOR SUPPLIER "S02"E RESULTS OF THE AHP METHOD

LAYER								
1		2		3				
Criterion	**W%**	**Criterion**	**W%**	**Criterion**	**W %**	**AR**	**WA% (*)**	**Score**
Price and Payment Terms Control	**15**	**Payment Control**	**50**	Supplier Payment Term	30	3.592	**2.25**	0.0808
				Correct Payment Term	40	4.167	**3.00**	0.1250
				Payment Delay Day	30	3.448	**2.25**	0.0776
				Total	**100**		**7.50**	**0.2834**
		Price Control	**50**	Ratio of Correct Price	40	6.25	**3.00**	0.1875
				Discount percentage by the Amount	40	5.556	**3.00**	0.1667
				Sectorial Price behavior Adjustment	20	6.818	**1.50**	0.1023
				Total	**100**		**7.50**	**0.4565**
		Total	**100**					**0.7399**

TABLE VI. SE RESULTS OF THE TOPSIS METHOD

Supplier Code	Total TOPSIS Score	Quality Control	Quantity Control	Product Control	Price and Payment Terms Control	Delivery Performance	Accuracy	Customer Complaints
	100%	**30%**	**15%**	**15%**	**15%**	**10%**	**10%**	**5%**
S02	24.6167	7.1024	4.2544	4.1810	2.9249	2.1157	2.4021	1.6362
S12	23.7252	7.0579	4.2544	4.1810	3.7676	1.4812	2.6616	0.3215
S14	23.5554	6.1589	4.2544	4.1810	2.7561	2.1667	2.4021	1.6362
S05	21.8870	6.6983	4.2544	3.1371	3.5359	1.4570	2.1686	0.6357
S11	20.2273	6.2084	4.2544	2.6273	2.6340	2.0236	1.9855	0.4941
S03	20.0508	8.0459	1.1470	2.6273	4.1306	1.8196	1.0561	1.2243
S20	19.9726	4.6352	3.8535	3.0158	2.7124	2.1455	2.1319	1.4783
S10	19.9369	3.9174	4.2544	3.1371	3.0002	2.6199	2.2143	0.7936
S13	19.8117	7.1468	4.2544	2.6273	2.4718	2.1682	0.6036	0.5396
S07	19.6309	5.0363	3.8535	3.1371	2.8941	2.2079	2.2260	0.2760
S09	19.3435	6.2972	0.7461	4.1810	2.6340	2.1327	1.8579	1.4946
S01	18.7184	3.1049	3.8535	1.9718	4.0870	2.0236	3.0419	0.6357
S04	18.3535	8.0459	1.1470	3.0158	2.5355	1.4925	1.6227	0.4941
S18	18.2954	5.3093	1.1470	4.1810	3.0774	1.8536	2.0914	0.6357
S15	17.4086	6.2528	3.8535	1.4621	2.3225	1.4358	0.6036	1.4783
S06	17.1779	6.2084	0.7461	1.4621	3.6436	3.3112	1.3124	0.4941
S17	17.1397	6.2528	1.1470	3.0158	2.3058	2.1950	1.5876	0.6357
S08	16.5210	7.1963	1.1470	2.6273	2.6027	1.6115	0.7966	0.5396
S19	15.7532	7.1963	0.7461	1.4621	2.3474	2.1780	0.5631	1.2602
S16	14.8529	4.0928	3.8535	0.4181	3.3154	1.4245	1.0966	0.6520
Max. Score	**24.6167**	**8.0459**	**4.2544**	**4.1810**	**4.1306**	**3.3112**	**3.0419**	**1.6362**

VI. CONCLUSION

In this study, for Supplier Selection and Supplier Evaluation processes a flexible and extensible model named Dynamic Supplier Analysis Model (DSAM) is developed. Moreover, in order to implement the DSAM Model to enable changes in templates and criteria, and to find the optimum solution with commonly used multi-criteria decision-making method TOPSIS and AHP algorithms, an application named Dynamic Supplier Analysis Model (DAppSAM) is also developed. The weights of criteria were calculated by the DEMATEL method and defined under a SE template for the product group in this chemical company. However, the criteria and their weights may differ based on the product group and requirements of a company. The templates structure is used to define the criteria group based on these requirements and revise the weights of crtieria. DSAM model is applied in one of the world's leading chemical companies to determine best supplier for a product group among twenty suppliers. In the DAppSAM software, the scores of these suppliers are calculated for AHP and TOPSIS method. Besides, the impact directions of the criteria is also investigated and it is seen that

the TOPSIS algorithm is also enabled to find the solutions closest to the positive solution and the farthest from the negative solution. Also, by changing the scales' sensitivity, the model can provide more effective solutions. The scores of these methods are consistent for Supplier Evaluation. The supplier S02 is the best supplier with AHP and TOPSIS score values with 6.4489, 24.6167 respectively.

The results are evaluated by experts, and the purchase amount of this product group is analyzed for the years between 2005 and 2011. The supplier "S02" purchase quantity is greater than other suppliers that are evaluated based on quality advantage. Finally, it was seen that DSAM allows companies to analyze their suppliers efficiently. The purchase quantity from all of these suppliers is compared and validated with the scores of suppliers.

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