A Monitoring System to Assess Supplier Performance of A Passive Components Company in Taiwan by K-Means Method

Chao-Ching Tseng and Hsin-Hung Wu

***Abstract*—A case study of a passive components company in Taiwan is presented to assess the supplier performance evaluations in accordance with nine criteria. Except for coordination, the rest of eight criteria have the objective assessments. In order to establish a more objective assessment in supplier performance evaluations, a monitoring system is to be set up by considering the eight criteria to determine if a supplier performance is either underestimated or overestimated. K-means method is employed to classify all of the suppliers into three categories. The results based on the data from four quarters in 2017 and the first quarter in 2018 show that 4 of 43, 13 of 57, 24 of 58, 13 of 57, and 15 of 57 indicate the supplier performance seems to be abnormal, i.e., either underestimate or overestimate, for the first quarter, second quarter, third quarter, and fourth quarter of 2017, and the first quarter of 2018, respectively. Therefore, further investigations on coordination criterion can be conducted to understand if the judgment on coordination is reasonable.**

***Index Terms*—a passive components company, supplier performance evaluation, cluster analysis, underestimate, overestimate, K-means method**

I. Introduction

Wetzstein et al. [1] pointed out that the selection of the right suppliers is critically important to a company's business success with the rapid growth in outsourcing. Lee and Kang [2] also emphasized that selecting the right suppliers is an important decision-making process to improve corporate competitiveness in the supply chain management. Simić et al. [3] summarized that companies have become more dependent on suppliers than ever such that the supplier selection becomes an important aspect of competition and would determine the fate of a company. Kannan and Tan [4] considered the supplier selection and assessment as describing actual practices or modeling how suppliers should be selected when a set of criteria was given. That is, the supplier selection and assessment is typically viewed as a multiple criteria decision-making problem [3], [5].

Wu and Tsai [6] applied analytic hierarchy process (AHP) to identify the most essential criteria and sub-criteria in auto spare parts industry. Wu and Tsai [7] further integrated AHP and decision making trial and evaluation laboratory (DEMATEL) to identify essential criteria and sub-criteria in auto spare parts industry. The major advantage of integrating AHP and DEMATEL methods is that the decision maker can relentlessly improve suppliers' performance from both short-term and long-term viewpoints. Wu and Chang [8] utilized DEMATEL method to identify critical dimensions and factors in green supply chain management of electrical and electronic industries in Taiwan. In addition, Liu and Wu [9] applied DEMATEL method to identify both information and data management and sustainable index were two critical factors in the supplier management of Taiwan semiconductor industry in Industry 4.0. Further, Karsak and Dursun [10] proposed an integrated fuzzy multiple criteria decision-making approach in the supplier evaluation and selection. Moreover, Li and Wang [11] combined rough analytic network process and evidence theory to develop a green supplier assessment method for manufacturing companies. Obviously, the supplier assessment and selection (evaluation) in the previous studies has been viewed as a multiple criteria decision-making problem.

In practice, each company has its own scoring scheme or assessment method to evaluate the supplier performance based on a set of criteria. If the assessment for each criterion is objective, then the overall performance evaluation would become accountable in the supply chain management. In contrast, if the assessment for one or more criteria is subjective, then the overall performance evaluation might be somewhat in doubt. If the supplier assessment and evaluation cannot reflect the actual performance of suppliers, the risk such as the disruption of the production, customer dissatisfaction, financial losses, loss of sales, and damages to the corporate image would be drastically increased. The company and its entire supply chain networks could be significantly influenced negatively [12]. Therefore, it is essentially important to identify reliable suppliers in the long-term perspective.

A case study of assessing the supplier performance based on a set of given criteria in a passive components company in Taiwan is presented. There are nine criteria used to evaluate the supplier performance. Eight out of nine criteria are assessed objectively based on the guidelines for suppliers to follow. On the other hand, there is one criterion having a subjective assessment in the supplier evaluation. This study proposes a monitoring system by using K-means method to

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find if the assessment from coordination criterion on each supplier is objectively evaluated. If not, further investigations on coordination can be conducted to assess how coordination either underestimates or overestimates the supplier performance in this passive components company.

II. Clustering Approaches in Supplier Assessment And Selection

The supplier assessment and selection is a multiple criteria decision-making problem to evaluate suppliers based on a set of given criteria quantitatively or qualitatively [3], [5]. Zhang et al. [13] pointed out that large companies might work with hundreds of suppliers to provide raw materials, parts, sub-assemblies, and other components such that using supplier groups instead of selecting one supplier is recommended in practice [14]-[16].

Kara and Fırat [12] summarized that there are two types of researches to group suppliers in the literature, including cluster analysis and segmentation. The purpose of grouping suppliers is to identify a group of alternative suppliers or eliminate suppliers in accordance with given criteria. In doing so, the management can reduce the number of alternatives and increase the simplicity and flexibility of the supplier selection process in order to obtain manageable smaller and homogeneous supplier groups [14]. Cluster analysis which is an unsupervised method is one of the most popular data analysis tools in the field of data mining [17], [18]. The purpose of cluster analysis is to form homogeneous subgroups by partitioning observations in a data set based on the similarity in the characteristics typically measured by distance measures [19]. That is, the objects in the same cluster would have a higher degree of similarity while dissimilar objects are in separate clusters [20].

K-means method which is one of the most popular cluster analysis approaches is to categorize observations into k groups and then assign observations into clusters based on their distance using Euclidean distance to the mean of the clusters because of its simplicity of implementation and fast execution [21]. The major drawback of K-means method is that this method is very sensitive to the choice of a starting point to partition the items into k initial clusters [22], [23]. That is, it is very difficult to know in advance about k initial clusters for many real data sets [23]. Besides, when initial seeds are chosen randomly, K-means method often leads to different clustering results [23]. However, when the number of the cluster is determined, the clustering results generated by K-means method could outperform other cluster analysis approaches [24]. Moreover, K-means method has been applied to group core suppliers of the company [13]. In this study, the number of clusters can be determined in advance before the use of K-means method. In practice, this passive components company groups its supplier performance into three major categories. That is, the number of the cluster is set to three in terms of the needs of this case company. Therefore, this study employs K-means method to categorize the supplier performance.

III. Research Method

The passive components company in Taiwan uses nine criteria to assess the supplier performance in practice, including delivery on time, feed rejection rate, process rejection rate, corrective action response rate, correction effectivity, hazardous substance free system (HSF) testing compliance, sample pass rate, coordination, and excess freight cost with the respective weights of 10%, 10%, 15%, 10%, 10%, 15%, 10%, 10%, and 10%. The descriptions of nine criteria are summarized in Table I.

TABLE I
Descriptions of Nine Criteria

Criterion	Weight	Description	Score
Delivery on time	10%	Delivery rate	
		90% ~ 100%	10
		80% ~ 89%	8
		70% ~ 79%	6
		60% ~ 69%	4
		≤ 59%	0
Feed rejection rate	10%	Defective rate	
		0%	10
		0.01% ~ 1.0%	8
		1.01% ~ 2.0%	5
		2.01% ~ 3.0%	2
		≥ 3.01%	0
Process rejection rate	15%	Rejection rate	
		0%	15
		≤ 5%	10
		> 5% ~ ≤ 10%	5
		> 10% ~ ≤ 20%	2
		> 20%	0
Corrective action response rate	10%	Number of unfinished projects	
		0	10
		1 ~ 2	8
		3 ~ 4	4
		5 ~ 6	2
		≥ 7	0
Correction effectivity	10%	Results confirmation	
		No similarity	10
		Similarity: Once	5
		Similarity: More than once	0
HSF testing compliance	15%	Evaluation item	
		No abnormal in a month	15
		One batch over control in a month	0
Sample pass rate	10%	Evaluation item	
		No abnormal in a month	10
		One batch over control in a month	-2 per time; max: -10
		No sample proposed	8
Coordination	10%	Evaluation item	If one of the evaluation items: -2 per time; max: -10
		Deliveryman attitude and coordination	
		Abnormal quality handling and response	
		Proposed makeup	
Excess freight cost	10%	Evaluation item	
		No excess shipping cost	10
		Excess shipping cost ≤ 10,000 NTD	5
		Excess shipping cost > 10,000 NTD	0

Coordination is assessed by deliveryman attitude and coordination, abnormal quality handling and response, and proposed makeup. These three descriptions are difficult to be quantified in order to evaluate each supplier's performance in coordination objectively. Except for coordination which has a subjective judgement by procurement personnel, the rest of eight criteria have the objective assessments. For instance, the performance of delivery on time is based on delivery rate.

Each supplier's performance can be grouped into one of five categories, i.e., 90% ~ 100% with a value of 10, 80% ~ 89% with a value of 8, 70% ~ 79% with a value of 6, 60% ~ 69% with a value of 4, and ≤ 59% with a value of 0.

Though the scoring system for each criterion might not be reasonable for a long-term perspective, this study does not intend to address how the scoring schemes can be changed but mainly focuses on assessing the supplier performance in terms of grouping suppliers. A monitoring system is to be set up by considering eight criteria to determine if a particular supplier is to be either underestimated or overestimated compared with the original results based on nine criteria. That is, coordination criterion is removed in this monitoring system. The data are from four quarters of 2017 and the first quarter of 2018, i.e., 2017Q1, 2017Q2, 2017Q3, 2017Q4, and 2018Q1. In practice, the company classifies it suppliers by three major groups including A, B, and C and below. That is, the number of clusters is set to three to represent A, B, and C and below, respectively.

K-means method (based on IBM SPSS Modeler 14.1) is employed to classify all of the suppliers into three categories, i.e., A, B, and C, where A is classified as the best supplier group, followed by B and C. The raw scores in delivery on time, feed rejection rate, corrective action response rate, correction effectivity, sample pass rate, and excess freight cost range from zero to ten, while the raw scores in process rejection rate and HSF testing compliance range from zero to fifteen. There are eight input variables in K-means method including delivery on time, feed rejection rate, process rejection rate, corrective action response rate, correction effectivity, HSF testing compliance, sample pass rate, and excess freight cost. The input variables for each supplier are numerical values. If a particular supplier's assessment evaluated by nine criteria is higher than the suggested category by K-means method, the supplier's performance is classified as overestimated and vice versa.

IV. Results

Tables II-VI summarize the supplier evaluation results by the original evaluation method with nine criteria and K-means method with eight criteria in 2017Q1, 2017Q2, 2017Q3, 2017Q4, and 2018Q1, respectively. In order to keep the data to be confidential, suppliers' names are removed and presented by numbers in the first column. In addition, the same numbers in different tables do not represent the same suppliers. The original nine criteria along with the numerical performance for each supplier are documented from the second to tenth column. In the eleventh column, total score is to sum the numerical values of nine criteria, and the maximum score is 100. Classification in the twelfth column is based on the total score. That is, the classification results are determined by nine criteria including coordination. In contrast, suggested cluster in the thirteenth column represents the classification results generated by K-means method by using eight criteria. Finally, the column of "difference" is to examine the difference between classification in the twelfth column and suggested cluster in the thirteenth column. That is, if a supplier's performance is overestimated, i.e., classification is better than suggested cluster, an "O" (overestimated) is placed in difference (fourteenth column). On the contrary, if suggested cluster is better than classification, a "U" (underestimated) is placed in difference. However, if the performance evaluation is the same between classification and suggested cluster, a blank is placed in difference.

From Tables II-VI, 4 of 43, 13 of 57, 24 of 58, 13 of 57, and 15 of 57 from the data in the respective 2017Q1, 2017Q2, 2017Q3, 2017Q4, and 2018Q1 show the supplier assessment is abnormal, and the respective abnormal rates are 9.3%, 22.8%, 41.4%, 22.8%, and 26.3%. In 2017Q1, there are 2 overestimates and 2 underestimates. In 2017Q2, there is 1 overestimate but 12 underestimates. In 2017Q3, there are 9 overestimates and 15 underestimates. In 2017Q4, there are 2 overestimates but 11 underestimates. In 2018Q1, there are 10 overestimates but 5 underestimates. By cumulating the results from 2017Q1 to 2018Q1, the overall difference shows that there are 24 overestimates and 45 underestimates. Obviously, this passive components company has the tendency to underestimate the supplier performance. Because there are no clear guidelines to fairly judge the performance of coordination, further investigations on these abnormal cases particularly on underestimated suppliers can be conducted to understand if the judgement on coordination is reasonable.

In contrast to those underestimated suppliers, these 24 overestimated suppliers should be examined in terms of coordination since the scores in coordination are much higher than the actual performance. It would be of interest to know why procurement personnel provide much higher scores in coordination for these 24 overestimated suppliers. In addition, the abnormal rate in 2017Q3 is the highest among five quarters. There might be reasons to result in a higher abnormal rate in 2017Q3. Finally, it is worth to note that the supplier assessment in 2017 tend to be underestimated, i.e., 40 underestimated and 14 overestimated. However, the supplier assessment in 2018Q1 tend to be overestimated, i.e., 5 underestimates and 10 overestimates. Obviously, the trend is different. More data should be collected in 2018 to observe if the judgement of procurement personnel in coordination has been changed.

TABLE II
SUPPLIER EVALUATIONS BY ORIGINAL EVALUATION RESULT AND K-MEANS METHOD IN 2017Q1

Supplier Number	Delivery on time (10%)	Feed rejection rate (10%)	Process Rejection rate (15%)	Corrective action response rate (10%)	Corrective effectivity (10%)	HSF testing compliance (15%)	Sample pass rate (10%)	Coordination (10%)	Excess freight cost (10%)	Total Score	Classification	Suggested cluster	Difference
1	10	10	15	10	10	15	8	8	10	96	A	A	
2	10	10	15	10	10	15	8	8	10	96	A	A	
3	10	10	15	10	10	15	8	10	10	98	A	A	
4	10	10	5	8	10	15	8	10	10	86	C	C	
5	10	10	15	10	10	15	8	10	10	98	A	A	
6	10	10	15	10	10	15	8	10	10	98	A	A	
7	10	8	10	10	10	15	8	10	10	91	B	B	
8	10	10	15	10	10	15	8	10	10	98	A	A	
9	10	10	10	10	10	15	8	10	10	93	B	B	
10	10	8	10	10	10	15	10	10	10	93	B	B	
11	10	8	10	10	10	15	10	10	10	93	B	B	
12	10	10	15	10	10	15	10	10	10	100	A	A	
13	10	10	15	10	10	15	8	10	10	98	A	A	
14	10	10	15	10	10	15	8	10	10	98	A	A	
15	10	10	15	10	10	15	8	10	10	98	A	A	
16	10	10	15	10	10	15	8	10	10	98	A	A	
17	10	8	15	10	10	15	8	8	10	94	B	A	U
18	10	10	15	10	10	15	8	10	10	98	A	A	
19	10	10	15	10	10	15	8	10	10	98	A	A	
20	10	10	15	10	10	15	8	10	10	98	A	A	
21	10	8	10	10	10	15	8	10	10	91	B	B	
22	10	10	15	10	10	15	8	10	10	98	A	A	
23	10	10	15	10	10	15	8	10	10	98	A	A	
24	10	10	15	10	10	15	8	10	10	98	A	A	
25	10	10	15	10	10	15	8	10	10	98	A	A	
26	10	10	10	10	8	15	10	10	10	93	B	B	
27	10	10	15	10	10	15	8	10	10	98	A	A	
28	10	10	15	10	10	15	8	10	10	98	A	A	
29	10	10	15	10	10	15	10	10	10	100	A	A	
30	10	10	15	10	10	15	8	10	10	98	A	A	
31	10	10	15	10	10	15	8	10	10	98	A	A	
32	10	10	15	10	10	15	10	8	10	98	A	A	
33	10	10	10	10	10	15	8	10	10	93	B	B	
34	10	10	15	10	10	15	8	10	10	98	A	A	
35	10	10	15	10	10	15	8	10	10	98	A	A	
36	10	10	15	10	10	15	8	10	10	98	A	A	
37	10	10	15	10	10	15	10	8	10	98	A	A	
38	10	10	10	10	10	15	10	10	10	95	A	B	O
39	10	10	10	10	10	15	10	8	10	93	B	B	
40	10	10	10	10	10	15	10	10	10	95	A	B	O
41	10	10	10	10	10	15	10	6	10	91	B	B	
42	10	8	10	10	10	15	8	4	10	85	C	B	U
43	10	10	10	10	10	15	10	6	10	91	B	B	

TABLE III
SUPPLIER EVALUATIONS BY ORIGINAL EVALUATION RESULT AND K-MEANS METHOD IN 2017Q2

Supplier Number	Delivery on time (10%)	Feed rejection rate (10%)	Process Rejection rate (15%)	Corrective action response rate (10%)	Corrective effectivity (10%)	HSF testing compliance (15%)	Sample pass rate (10%)	Coordination (10%)	Excess freight cost (10%)	Total Score	Classification	Suggested cluster	Difference
1	10	10	15	10	10	15	8	8	10	96	A	A	
2	10	8	15	10	10	15	8	10	10	96	A	A	
3	10	10	15	10	10	15	8	10	10	98	A	A	
4	10	10	15	10	10	15	6	10	10	96	A	A	
5	10	10	15	10	10	15	8	10	10	98	A	A	
6	10	10	15	10	10	15	8	10	10	98	A	A	
7	8	10	10	10	10	15	8	10	10	91	B	A	U
8	10	10	15	10	10	15	8	10	10	98	A	A	
9	10	10	10	10	10	15	6	10	10	91	B	A	U
10	10	10	15	10	0	15	4	10	10	84	C	A	U
11	10	10	10	10	10	15	4	10	10	89	C	A	U
12	10	10	15	10	15	8	10	10	10	98	A	C	O
13	10	10	15	10	10	15	8	10	10	98	A	A	
14	10	10	15	10	10	15	8	10	10	98	A	A	
15	10	10	15	10	10	15	10	10	10	100	A	A	
16	10	10	15	10	10	15	10	10	10	100	A	A	
17	10	10	10	10	10	15	8	10	10	93	B	A	U
18	10	10	15	10	10	15	8	10	10	98	A	A	
19	10	10	15	10	10	15	10	8	10	98	A	A	
20	10	10	15	10	0	15	8	10	10	88	C	A	U
21	10	10	15	10	10	15	10	10	10	100	A	A	
22	10	10	15	10	10	15	10	10	10	100	A	A	
23	10	10	15	10	10	15	8	10	10	98	A	A	
24	10	10	15	10	10	15	8	10	10	98	A	A	
25	10	10	15	10	10	15	8	10	10	98	A	A	
26	10	10	10	10	10	15	6	10	10	91	B	A	U
27	10	10	15	10	10	15	8	10	10	98	A	A	
28	10	10	15	10	10	15	8	10	10	98	A	A	
29	10	10	15	10	10	15	8	10	10	98	A	A	
30	10	10	15	10	10	15	8	10	10	98	A	A	
31	10	10	15	10	10	15	8	10	10	98	A	A	
32	10	10	15	10	10	15	8	10	10	98	A	A	
33	10	10	15	10	10	15	8	10	10	98	A	A	
34	10	8	15	10	10	15	8	10	10	96	A	A	
35	10	10	15	10	10	15	8	10	10	98	A	A	
36	10	10	15	10	10	15	8	10	10	98	A	A	
37	10	10	15	10	10	15	8	10	10	98	A	A	
38	10	10	15	10	10	15	8	10	10	98	A	A	
39	10	10	15	10	10	15	8	10	10	98	A	A	
40	10	10	15	10	10	15	8	10	10	98	A	A	
41	10	10	15	10	10	15	8	10	10	98	A	A	
42	10	10	15	10	10	15	8	10	10	98	A	A	
43	10	10	15	10	10	15	8	10	10	98	A	A	
44	10	10	15	10	10	15	8	10	10	98	A	A	
45	10	10	15	10	10	15	8	10	10	98	A	A	
46	10	8	15	10	10	15	8	10	10	96	A	A	
47	10	10	15	10	10	15	8	10	10	98	A	A	
48	10	10	15	10	10	15	8	8	10	96	A	A	
49	10	8	15	10	10	15	8	8	10	94	B	A	U
50	10	8	15	10	10	15	10	10	10	98	A	A	
51	10	8	15	4	5	15	10	10	10	87	C	B	U
52	10	8	15	10	5	15	8	10	10	91	B	A	U
53	10	10	15	10	10	15	8	8	10	96	A	A	
54	10	10	15	10	10	15	8	10	10	98	A	A	
55	10	10	15	10	10	15	8	10	10	98	A	A	
56	10	10	15	10	10	10	8	10	10	93	B	A	U
57	10	10	15	10	10	10	8	10	10	93	B	A	U

TABLE IV
SUPPLIER EVALUATIONS BY ORIGINAL EVALUATION RESULT AND K-MEANS METHOD IN 2017Q3

Supplier Number	Delivery on time (10%)	Feed rejection rate (10%)	Process Rejection rate (15%)	Corrective action response rate (10%)	Corrective effectivity (10%)	HSF testing compliance (15%)	Sample pass rate (10%)	Coordination (10%)	Excess freight cost (10%)	Total Score	Classification	Suggested cluster	Difference
1	10	10	10	8	10	15	8	8	10	89	C	A	U
2	10	10	15	10	10	15	8	10	10	98	A	A	
3	10	10	15	10	10	15	8	10	10	98	A	A	
4	10	10	15	10	10	15	8	10	10	98	A	A	
5	10	10	15	10	10	15	8	10	10	98	A	A	
6	10	10	10	10	10	15	10	10	10	95	A	B	O
7	10	8	10	10	10	15	8	10	10	91	B	A	U
8	10	10	10	10	10	15	8	10	10	93	B	A	U
9	10	0	10	10	10	15	10	10	10	85	C	B	U
10	10	10	10	10	0	15	10	10	10	85	C	B	U
11	10	10	15	10	10	15	8	10	10	98	A	A	
12	10	10	15	10	10	15	10	10	10	100	A	C	O
13	10	10	15	10	10	15	8	10	10	98	A	A	
14	10	5	10	10	10	15	10	10	10	90	B	B	
15	10	10	15	10	10	15	8	10	10	98	A	A	
16	10	10	15	10	10	15	10	10	10	100	A	B	O
17	10	10	15	10	10	15	8	10	10	98	A	A	
18	10	10	15	10	10	15	10	8	10	98	A	B	O
19	10	5	15	10	0	15	10	8	10	83	C	B	U
20	10	10	15	10	10	15	8	10	10	98	A	A	
21	10	10	15	10	10	15	10	10	10	100	A	B	O
22	10	10	15	10	10	15	10	10	10	100	A	B	O
23	10	10	15	10	10	15	8	10	10	98	A	A	
24	10	10	15	10	10	15	6	10	10	96	A	A	
25	10	10	15	10	10	10	8	10	10	93	B	A	U
26	10	10	15	10	10	15	8	10	10	98	A	A	
27	10	10	15	10	10	15	8	10	10	98	A	A	
28	10	10	15	10	15	8	10	10	10	98	A	C	O
29	10	10	15	10	10	15	8	10	10	98	A	A	
30	10	10	15	10	10	15	8	10	10	98	A	A	
31	10	10	15	10	10	15	8	10	10	98	A	A	
32	10	10	15	10	10	15	8	10	10	98	A	A	
33	10	10	15	10	10	15	8	10	10	98	A	A	
34	10	10	15	10	10	15	8	10	10	98	A	A	
35	10	10	15	10	10	15	8	10	10	98	A	A	
36	10	10	10	10	10	15	8	8	10	91	B	A	U
37	10	10	15	10	10	15	8	10	10	98	A	A	
38	10	10	15	10	10	15	8	10	10	98	A	A	
39	10	10	15	10	10	15	8	10	10	98	A	A	
40	10	10	15	10	10	15	8	10	10	98	A	A	
41	10	10	15	10	10	15	8	8	10	96	A	A	
42	10	10	15	10	10	15	8	10	10	98	A	A	
43	10	10	15	10	10	15	8	10	10	98	A	A	
44	10	10	15	10	10	15	10	10	10	100	A	B	O
45	10	10	15	10	10	15	10	10	10	100	A	B	O
46	10	10	15	10	10	15	8	10	10	98	A	A	
47	10	10	15	10	10	15	8	10	10	98	A	A	
48	10	10	15	10	10	15	8	10	10	98	A	A	
49	10	10	10	4	5	15	8	10	10	82	C	A	U
50	10	10	10	10	10	15	8	10	10	93	B	A	U
51	10	10	10	10	10	15	8	8	10	91	B	A	U
52	10	10	10	10	10	15	8	10	10	93	B	A	U
53	10	10	10	10	10	15	8	10	10	93	B	A	U
54	10	10	15	10	10	15	8	10	10	98	A	A	
55	10	10	10	10	5	15	6	10	10	86	C	B	U
56	10	10	10	10	10	15	8	10	10	93	B	A	U
57	10	10	15	10	10	15	8	10	10	98	A	A	
58	10	10	15	10	10	15	8	10	10	98	A	A	

TABLE V
SUPPLIER EVALUATIONS BY ORIGINAL EVALUATION RESULT AND K-MEANS METHOD IN 2017Q4

Supplier Number	Delivery on time (10%)	Feed rejection rate (10%)	Process Rejection rate (15%)	Corrective action response rate (10%)	Corrective effectivity (10%)	HSF testing compliance (15%)	Sample pass rate (10%)	Coordination (10%)	Excess freight cost (10%)	Total Score	Classification	Suggested cluster	Difference
1	10	10	15	10	10	15	8	8	10	96	A	A	
2	10	8	15	10	10	15	8	10	10	96	A	A	
3	10	10	15	10	10	15	8	10	10	98	A	A	
4	10	10	15	10	10	15	6	10	10	96	A	A	
5	10	10	15	10	10	15	8	10	10	98	A	A	
6	10	10	15	10	10	15	8	10	10	98	A	B	O
7	8	10	10	10	10	15	8	10	10	91	B	A	U
8	10	10	15	10	10	15	8	10	10	98	A	A	
9	10	10	10	10	10	15	6	10	10	91	B	B	
10	10	10	15	10	0	15	4	10	10	84	C	B	U
11	10	10	10	10	10	15	4	10	10	89	C	A	U
12	10	10	15	10	15	8	10	10	10	98	A	C	O
13	10	10	15	10	10	15	8	10	10	98	A	A	
14	10	10	15	10	10	15	8	10	10	98	A	A	
15	10	10	15	10	10	15	10	10	10	100	A	A	
16	10	10	15	10	10	15	10	10	10	100	A	A	
17	10	10	10	10	10	15	8	10	10	93	B	A	U
18	10	10	15	10	10	15	8	10	10	98	A	A	
19	10	10	15	10	10	15	10	8	10	98	A	A	
20	10	10	15	10	0	15	8	10	10	88	C	A	U
21	10	10	15	10	10	15	10	10	10	100	A	A	
22	10	10	15	10	10	15	10	10	10	100	A	A	
23	10	10	15	10	10	15	8	10	10	98	A	A	
24	10	10	15	10	10	15	8	10	10	98	A	A	
25	10	10	15	10	10	15	8	10	10	98	A	A	
26	10	10	10	10	10	15	6	10	10	91	B	A	U
27	10	10	15	10	10	15	8	10	10	98	A	A	
28	10	10	15	10	10	15	8	10	10	98	A	A	
29	10	10	15	10	10	15	8	10	10	98	A	A	
30	10	10	15	10	10	15	8	10	10	98	A	A	
31	10	10	15	10	10	15	8	10	10	98	A	A	
32	10	10	15	10	10	15	8	10	10	98	A	A	
33	10	10	15	10	10	15	8	10	10	98	A	A	
34	10	8	15	10	10	15	8	10	10	96	A	A	
35	10	10	15	10	10	15	8	10	10	98	A	A	
36	10	10	15	10	10	15	8	10	10	98	A	A	
37	10	10	15	10	10	15	8	10	10	98	A	A	
38	10	10	15	10	10	15	8	10	10	98	A	A	
39	10	10	15	10	10	15	8	10	10	98	A	A	
40	10	10	15	10	10	15	8	10	10	98	A	A	
41	10	10	15	10	10	15	8	10	10	98	A	A	
42	10	10	15	10	10	15	8	10	10	98	A	A	
43	10	10	15	10	10	15	8	10	10	98	A	A	
44	10	10	15	10	10	15	8	10	10	98	A	A	
45	10	10	15	10	10	15	8	10	10	98	A	A	
46	10	8	15	10	10	15	8	10	10	96	A	A	
47	10	10	15	10	10	15	8	10	10	98	A	A	
48	10	10	15	10	10	15	8	8	10	96	A	A	
49	10	8	15	10	10	15	8	8	10	94	B	A	U
50	10	8	15	10	10	15	10	10	10	98	A	A	
51	10	8	15	4	5	15	10	10	10	87	C	B	U
52	10	8	15	10	5	15	8	10	10	91	B	A	U
53	10	10	15	10	10	15	8	8	10	96	A	A	
54	10	10	15	10	10	15	8	10	10	98	A	A	
55	10	10	15	10	10	15	8	10	10	98	A	A	
56	10	10	15	10	10	10	8	10	10	93	B	A	U
57	10	10	15	10	10	10	8	10	10	93	B	A	U

TABLE VI
SUPPLIER EVALUATIONS BY ORIGINAL EVALUATION RESULT AND K-MEANS METHOD IN 2018Q1

Supplier Number	Delivery on time (10%)	Feed rejection rate (10%)	Process Rejection rate (15%)	Corrective action response rate (10%)	Corrective effectivity (10%)	HSF testing compliance (15%)	Sample pass rate (10%)	Coordination (10%)	Excess freight cost (10%)	Total Score	Classification	Suggested cluster	Difference
1	10	10	15	10	10	15	8	10	10	98	A	A	
2	10	10	15	10	10	15	8	10	10	98	A	A	
3	10	10	15	10	10	15	8	10	10	98	A	A	
4	10	10	10	10	10	15	8	10	10	93	B	C	O
5	10	10	15	10	10	15	8	10	10	98	A	A	
6	10	10	10	10	10	15	8	10	10	93	B	C	O
7	10	10	10	10	10	15	10	10	10	95	C	B	U
8	10	10	10	10	10	15	10	10	10	95	C	B	U
9	10	10	15	10	10	15	8	10	10	98	A	A	
10	10	10	10	10	10	15	8	6	10	89	C	C	
11	10	10	10	10	10	15	10	10	10	95	A	B	O
12	10	10	15	10	10	15	8	10	10	98	A	A	
13	10	10	15	10	10	15	8	10	10	98	A	A	
14	10	10	15	10	10	15	8	10	10	98	A	A	
15	10	10	15	10	10	15	8	10	10	98	A	A	
16	10	10	10	10	10	15	10	10	10	95	A	B	O
17	10	10	10	10	10	15	10	10	10	95	A	B	O
18	10	10	15	10	10	15	8	10	10	98	A	A	
19	10	10	15	10	10	15	8	10	10	98	A	A	
20	10	10	15	10	10	15	8	10	10	98	A	A	
21	10	10	15	10	10	15	6	10	10	96	A	A	
22	10	10	15	10	10	15	8	10	10	98	A	A	
23	10	10	15	10	10	15	6	10	10	96	A	A	
24	10	10	15	10	10	15	8	10	10	98	A	A	
25	10	0	10	10	10	15	8	10	10	83	C	C	
26	10	10	15	10	10	15	8	10	10	98	A	A	
27	10	10	15	10	10	15	8	10	10	98	A	A	
28	10	10	10	10	10	15	10	8	10	93	B	B	
29	10	2	10	10	10	15	8	10	10	85	C	C	
30	10	10	10	10	10	15	8	10	10	93	B	C	O
31	10	10	10	10	10	15	8	6	10	89	C	A	U
32	10	10	15	10	10	15	8	10	10	98	A	A	
33	10	8	10	10	10	15	10	10	10	93	B	A	U
34	10	8	10	10	10	15	8	10	10	91	B	C	O
35	10	10	15	10	10	15	8	10	10	98	A	A	
36	10	10	10	10	10	15	8	10	10	93	B	C	O
37	10	10	5	10	10	15	10	8	10	88	C	B	U
38	10	10	15	10	10	15	8	10	10	98	A	A	
39	10	10	15	10	10	15	8	10	10	98	A	A	
40	10	10	15	10	10	15	8	10	10	98	A	A	
41	10	10	15	10	10	15	8	10	10	98	A	A	
42	10	10	15	10	10	15	8	10	10	98	A	A	
43	10	10	15	10	10	15	8	10	10	98	A	A	
44	10	10	15	10	10	15	8	10	10	98	A	A	
45	10	10	15	10	10	15	8	10	10	98	A	A	
46	10	10	15	10	10	15	8	8	10	96	A	A	
47	10	10	15	10	10	15	8	10	10	98	A	A	
48	10	10	15	10	10	15	8	10	10	98	A	A	
49	10	10	15	10	10	15	8	10	10	98	A	A	
50	10	10	15	10	10	15	8	10	10	98	A	A	
51	10	10	15	10	10	15	8	10	10	98	A	B	O
52	10	10	15	10	10	15	8	10	10	98	A	A	
53	10	10	15	10	10	15	8	10	10	98	A	A	
54	10	10	10	10	10	15	8	10	10	93	B	C	O
55	10	10	15	10	10	15	8	10	10	98	A	A	
56	10	10	15	10	10	15	8	8	10	96	A	A	
57	10	10	15	10	10	15	8	10	10	98	A	A	

V. Conclusions

Fairly assessing the supplier performance for each company is critically important. In practice, suppliers with better performance should be encouraged, whereas suppliers with poor performance should be penalized in order to reduce the risk in the supply chain management. In this case study from a passive components company in Taiwan, nine criteria are used to assess the supplier performance. Eight out of nine criteria have objective guidelines for suppliers to follow while coordination is subjective solely based on the score from procurement personnel. In order to identify if coordination criterion plays an important role in assessing the supplier performance, this study proposes a monitoring system with the use of K-means method based on eight objective criteria to group suppliers into three major categories. Based on the findings, nine to forty-one percent of the suppliers from 2017Q1 to 2018Q1 might be incorrectly categorized into either underestimated or overestimated supplier assessment groups. Moreover, this passive components company in Taiwan has the tendency to underestimate the supplier performance when coordination criterion which is a more subjective criterion is taken into account. Therefore, this study suggests this company to conduct investigations to understand if the scores in coordination are fair to those either underestimated or overestimated suppliers. In the long-term perspective, detailed guidelines or scoring schemes should be developed in coordination to reduce the biases of the supplier assessment.

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