Strategic Goal Oriented Supplier Selection

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Abstract—**This paper develops a novel approach for selecting a strategic supplier that best meets both long-term strategic goals and short-term requirements of an auto parts manufacturing company in a supply chain. The relative importance value of the supplier selection criteria to the strategic goals is first assessed by identifying how the criteria contribute to the goals. Based on the relative importance value of the criteria to the goals, the criteria weights are obtained. This strategic goal oriented weighting method is incorporated into a Multi-criteria Decision Making (MCDM) model. The potential contribution of the suppliers to the strategic goals is evaluated by the MCDM model. An empirical study on the supplier selection problem of the auto parts company is conducted to demonstrate the applicability and effectiveness of the approach. The approach has general application in selecting a strategic supplier for a supply chain with various strategic goals and supplier selection criteria.**

Keywords-strategic suppliers; strategic goal oriented weighting method; Multi-criteria Decision Making.

I. INTRODUCTION

Supplier selection has become a crucial issue for the success of a company in a supply chain, since good suppliers can considerably help the company improve its price competitiveness [1] and enhance the quality of its products [2]. A conventional approach to supplier selection is that a company contacts many available suppliers, sends requests for quotations for a specific order, evaluates them in terms of their quote and performance, and selects the best-performing one for the given order [3].

Selecting the most suitable supplier among a large number of potential suppliers with different levels of performance is inherently a Multi-criteria Decision Making (MCDM) problem [4]. The supplier selection problem thus requires making trade-offs between conflicting quantitative and qualitative criteria in order to evaluate the performance of the suppliers. Various supplier selection approaches have been proposed to meet the short-term requirements of customer orders. To select top-performing suppliers that best meet the short-term customer orders, the selection criteria such as price, quality, delivery, service, and technical capability have long been used [5][6] [7][8].

To ensure long-term survival and growth, companies increasingly want to develop long-term relationships with competitive suppliers rather than dealing with many suppliers on an order-by-order basis. It is difficult and inefficient for the companies to maintain partnerships with all available suppliers, as it causes the excessive transaction and management costs, and difficulties for key supplier development. To develop the long-term relationships with suppliers, it is of strategic importance for a company to select the strategic supplier that can best meet long-term expectations of the company in addition to satisfying the short-term requirements of individual orders. No existing approaches, however, are available to choose a strategic supplier for meeting both long-term strategic goals and short-term requirements of companies. To fill this important gap, this paper presents a new approach for selecting the long-term strategic supplier that best contributes to both long-term strategic goals and short-term requirements of a company. To illustrate this approach, an MCDM model with a new weighting method is developed to evaluate the potential contribution of suppliers to the strategic goals by examining the relative importance value of the supplier selection criteria to the goals.

In Section 2, we first present the strategic supplier selection problem of an auto parts manufacturing company in South Korea (referred to as the KAP company). We then develop a new strategic supplier selection approach in the context of KAP in Section 3. In Section 4, we conduct an empirical study to illustrate the approach. Finally, we discuss key findings and practical implications of the study in Section 5.

II. THE SUPPLIER SELECTION PROBLEM IN AN AUTO PARTS MANUFACTURING COMPANY

The KAP company is a first-tier auto parts manufacturer in South Korea. KAP produces auto parts such as sun roof, rail roof, pedal, fuel tank, suspension, axle housing, wheel housing, frame parts, lamp parts, and FRT cowl parts. KAP receives materials and components from about 160 suppliers for manufacturing auto parts, and supplies the auto parts to four major Korean auto companies including Hyundai, Kia, Renault Samsung, and GM Daewoo as a first vendor. KAP has eight domestic factories located all over the country and the purchasing division of each KAP factory selects its suppliers close to the factory for transportation cost reduction. Thus, most of the 160 suppliers of KAP are small and spread allover the country. This creates many low quality suppliers and causes the excessive transaction expenses for KAP to deal with many minor suppliers. Very often a customer order is met by many suppliers with small quantities. This makes

the qualified suppliers have less opportunity to develop as a major supplier by constantly receiving many orders with large quantities. In this regard, KAP wants to develop a small number of long-term suppliers. In addition, developing long-term relationships with competitive suppliers gives KAP substantial benefits such as product cost reduction, quality insurance, product commonality and risk reduction of product liability. To address this issue, there is an urgent need for KAP to have a strategic plan for developing long-term strategic suppliers.

Table 1 shows the strategic goals G_k (k=1, 2, …, 10) and their weights w_k given by KAP in relation to its strategic plan for supplier selection. KAP considers achieving profitability (G_1), coercive power for supplier management (G_4) and long-term relationship between KAP and its suppliers (G_5) as the most important goals with regard to supplier selection. Development of large suppliers (G_2) and minimisation of product costs (G_3) are also important strategic goals, as they affect long-term profit and growth of KAP. KAP prefers to work with major suppliers for ease of communication (G_8), since they have advanced transaction systems and well-trained employees to make transaction processes easier for KAP.

The strategic goals are not directly used as criteria for evaluating the performance of suppliers, as it is difficult to assess and measure the performance of suppliers with respect to these goals. Thus, the supplier selection criteria C_j (j=1, 2,…, 14), which are measurable quantitatively or assessable qualitatively and are independent of each other, are used to achieve the strategic goals, as shown in Table 2. Each supplier selection criterion is linked to the different strategic goals in terms of its relative importance value to the goals, as shown in Fig. 1. The total turnover and profits criteria (C_1 and C_2) significantly affect the achievement of profitability (G_1), development of large suppliers (G_2), and minimisation of product cost (G_3). The types of equipment and number of equipment (C_3, and C_4) are used to achieve part commonality (G_7). C_1, C_2, C_3, and C_4 are quantitative criteria and their values are obtained from KAP.

To meet the strategic goals involving minimisation of product cost (G_3), long-term relationship (G_5), quality improvement (G_6), part commonality (G_7) and maximisation of return on investment (G_{10}), qualitative criteria C_5, C_6, C_7, and C_8 are used. These four qualitative criteria are assessed by KAP, based on its own assessment sheet with a score range of 0-100. For C_5, the lower the item price, the higher the score. Six selection criteria C_9, C_{10}, C_{11}, C_{12}, C_{13}, and C_{14} are related to the strategic goals including coercive power (G_4), long-term relationship (G_5), ease of communication (G_8), and mitigation of patent disputes (G_9). C_9 and C_{10} are measured in percentage and qualitative criteria C_{12}, C_{13}, and C_{14} are measured based on a 1-10 rating scale by KAP.

TABLE II. SUPPLIER SELECTION CRITERIA

	Criteria		Measure
C_1	The total turnover of the supplier		Dollar amount
C_2	The total profits of the supplier		Dollar amount
C_3	The number of types of equipment of the supplier to produce KAP item		Number
C_4	The total number of equipment of the supplier to produce KAP item		Number
C_5	Average item price		Score (0-100)
C_6	Average item quality (Error and shortage rate and late delivery rate history in previous transaction with KAP)		Score (0-100)
C_7	Quality management system (Quality, resource, facility, and process)		Score (0-100)
C_8	Technical skills		Score (0-100)
C_9	The proportion of turnover of the supplier made from KAP		Percentage
C_{10}	The proportion of profit of the supplier made from KAP		Percentage
C_{11}	The total partnership year between KAP and the supplier		Year
C_{12}	Personal connection, regionalism and kinship (blood relation) between KAP and the supplier		Rating scale (1-10)
C_{13}	Proactive manner for communication, and transaction		Rating scale (1-10)
C_{14}	Compatible strategic objectives of the supplier with KAP		Rating scale (1-10)

TABLE I. STRATEGIC GOALS AND THEIR WEIGHTS

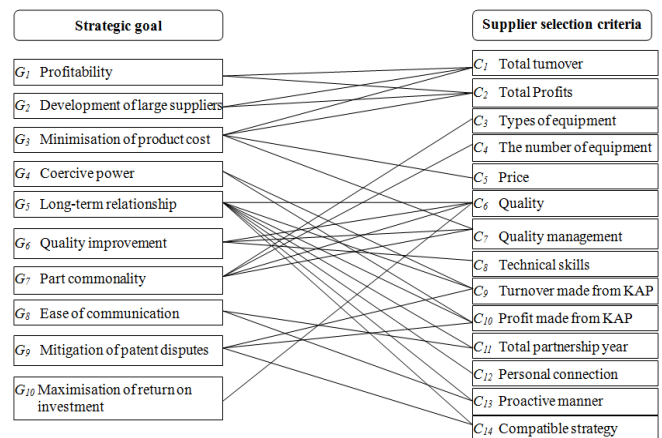|	Strategic goal	Weight
G_1	Profitability	0.2
G_2	Development of large suppliers	0.1
G_3	Minimisation of product costs	0.1
G_4	Coercive power for supplier management	0.2
G_5	Long-term relationship between KAP and its suppliers	0.2
G_6	Quality improvement of KAP and its suppliers	0.025
G_7	Part commonality	0.025
G_8	Ease of communication	0.1
G_9	Mitigation of patent disputes	0.025
G_{10}	Maximisation of return on investment	0.025
	Total	1

Figure 1. The relationship between the strategic goals and supplier selection criteria.

Based on the strategic goals and the supplier selection criteria, KAP wants to find which supplier can best perform for meeting its long-term strategic goals and short-term requirements. To address this important issue of KAP, we develop a strategic supplier selection approach.

III. THE STRATEGIC SUPPLIER SELECTION APPROACH

To evaluate the potential contribution of suppliers to the strategic goals, we develop an MCDM model with a strategic goals oriented weighting method. Evaluating suppliers can be formulated as an MCDM problem. The MCDM problem involves a finite set of I suppliers S_i (i=1, 2, …, I) with respect to a set of J supplier selection criteria C_j (j=1, 2, …, J). Assessments are conducted by decision makers to determine the weight vector W=(w_1, w_2, …, w_j) and the decision matrix X={x_{ij}, i=1, 2, …, I; j= 1, 2, …, J}. The weight vector W represents the weights of criteria C_j and the decision matrix X represents the performance ratings (x_{ij}) of suppliers S_i with respect to criteria C_j. The supplier selection problem has been solved by various MCDM methods [9][10][11][12][13]. Especially, the SAW method, also known as the weighted sum method, is the widely-used and well-known MCDM method [14]. The basic logic of SAW is to obtain a weighted sum of the performance ratings of each alternative with respect to criteria. This method is well justified theoretically and easily understood by a decision maker [14]. We use the SAW method to aggregate the performance ratings and criteria weights for evaluating suppliers.

In MCDM, different criteria weighting methods have been widely used to determine the importance of criteria [15][16][17]. We develop a new strategic goal oriented weighting method to determine the criteria weights by considering the strategic goals of KAP. To calculate the weights of the supplier selection criteria C_j (j=1, 2, …, J) (given in Table 2), the relative importance value r_{jk} (k=1, 2, …, K) of the supplier selection criteria C_j to the strategic goals G_k (k=1, 2, …, K) (given in Table 1) is assessed by investigating how the criteria contribute to the goals of KAP, as shown in Fig. 1. A point estimate measurement, such as a five-point Likert type scale [17] has been widely used for making subjective assessments, as it is intuitively easy for a decision maker to use in expressing the subjectiveness and imprecision of the decision maker's evaluation [18]. The relative importance value of the supplier selection criteria with respect to the strategic goals is assessed by using a set of five linguistic terms {Not Important (NI), Somewhat Important (SI), Moderate (M), Important (I), Very Important (VI)}, which is associated with a corresponding set of numerical values {1, 2, 3, 4, 5}. The assessment is made by KAP, based on its current strategic needs and operational settings.

With the linguistic terms, the relative importance value of the supplier selection criteria with respect to the strategic goals is given from the knowledge of experts in KAP. Table 3 shows the relative importance value for determining criteria weights under various strategic goals. For example, the total turnover of the supplier (C_1) is considered to be important (I) to achieve profitability (G_1) and reduction of

product cost (G_3). KAP considers that suppliers making high revenues can contribute more to profitability and cost reduction of KAP. Partnership year (C_{11}) is considered to be very important (VI) to achieve long-term relationship between KAP and its suppliers (G_5) and ease of transaction (G_8). Partnership year (C_{11}) that KAP has built with its suppliers can be a good indicator of buyer-supplier relationships. If KAP builds long-term relationships with its suppliers, transaction between KAP and its suppliers will become easier and more cost-effective to each other. The turnover and profits made from KAP criteria (C_9 and C_{10}) are the most important supplier selection criteria to achieve coercive power (G_4) and long-term relationship (G_5) of KAP. This coincides with KAP's opinions that they want to be suppliers' major customer taking most of their orders in order to hold a dominant position over a long-period of time. The types of equipment and number of equipment criteria (C_3 and C_4) are considered to be not important (NI) to achieve profitability (G_1), product cost reduction (G_3), quality improvement (G_6), ease of transaction (G_8), and mitigation of patent disputes (G_9), while it significantly contributes to expansion of the size of the supplier (G_2).

Based on the relative importance value of the supplier selection criteria with respect to the strategic goals, criteria weights w_j are calculated. The decision matrix X representing the performance ratings (x_{ij}) of each supplier S_i (i=1, 2, …, I) with respect to the supplier selection criteria C_j is assessed by KAP. These performance ratings are given based on both quantitative and qualitative assessments. The quantitative assessments are conducted based on objective data, while the qualitative assessments need the decision makers' subjective judgments to rate the performance of suppliers with respect to the supplier selection criteria.

TABLE III. THE RELATIVE IMPORTANCE VALUE OF THE SUPPLIER SELECTION CRITERIA TO THE STRATEGIC GOALS

Criteria	Strategic goal									
	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}
C_1	I	VI	I	SI	SI	M	NI	NI	NI	M
C_2	I	VI	I	SI	SI	M	NI	NI	NI	M
C_3	NI	I	NI	SI	SI	NI	M	NI	NI	SI
C_4	NI	I	NI	SI	SI	NI	M	NI	NI	SI
C_5	VI	SI	VI	NI	M	SI	NI	NI	NI	SI
C_6	SI	M	M	NI	M	VI	M	NI	SI	SI
C_7	SI	M	I	NI	SI	VI	M	NI	SI	SI
C_8	SI	M	SI	NI	SI	I	NI	NI	M	M
C_9	M	NI	NI	VI	VI	NI	NI	NI	I	I
C_{10}	M	NI	NI	VI	VI	NI	NI	NI	I	I
C_{11}	NI	NI	NI	M	VI	NI	NI	VI	SI	I
C_{12}	NI	NI	NI	M	I	NI	NI	M	SI	NI
C_{13}	NI	NI	NI	M	I	NI	NI	I	NI	NI
C_{14}	NI	NI	NI	M	I	NI	NI	SI	I	I

Given the relative importance value r_{jk} of the supplier selection criteria C_j and the decision matrix X, an MCDM model with a strategic goal oriented weighting and SAW method is developed to evaluate the potential contribution of suppliers to the strategic goals as follows:

Step 1: Calculate the strategic goal oriented criteria weights w_j (j=1, 2, …, J) of the supplier selection criteria C_j (j=1, 2, …, J) by aggregating the weight w_k of each strategic goal G_k (k=1, 2, …, K) and relative importance value r_{jk} of each selection criterion C_j to each goal G_k by

$$w_j = \frac{\sum_{k=1}^{K} w_k r_{jk}}{\sum_{j=1}^{J} \sum_{k=1}^{K} w_k r_{jk}}. \qquad (1)$$

Step 2: Normalise the performance ratings x_{ij} in the decision matrix X of supplier S_i for criteria C_j to make them compatible across the criteria by

$$y_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{I} x_{ij}^2}}. \qquad (2)$$

Step 3: Calculate the contribution scores T_i (i=1, 2, …, I) of supplier S_i by aggregating the strategic goal oriented criteria weights w_j and the normalised performance ratings y_{ij} by

$$T_i = \sum_{j=1}^{J} w_j y_{ij}. \qquad (3)$$

IV. THE EMPIRICAL STUDY

An empirical study is conducted to demonstrate how the strategic supplier selection approach works for KAP in order to meet its both long-term strategic goals and short-term requirements. To evaluate the potential contribution of suppliers to the strategic goals, an MCDM model with the strategic goal oriented weighting method is used. Ten suppliers are used as samples for the empirical study.

Based on the relative importance value criteria (given in Table 3) of the supplier selection criteria (given in Table 2) with respect to the strategic goals (given in Table 1), criteria weights w_j are calculated by Eq. (1). Table 4 shows the weights of the supplier selection criteria. The highest weight 0.094 is given for the proportion of turnover and profit of the supplier made from KAP (C_9 and C_{10}). KAP has assigned the highest weight 0.2 to coercive power for supplier management (G_4) and long-term relationship between KAP and its suppliers (G_5), and the proportion of turnover and profit of the supplier made from KAP (C_9 and C_{10}) are the most important selection criteria of suppliers to achieve coercive power for supplier management (G_4) and long-term relationship between KAP and its suppliers (G_5) of KAP. The number of types and total number of equipment of the supplier to produce KAP item (C_3 and C_4), on the other hand, gains the lowest weight 0.053.

TABLE IV. THE WEIGHTS OF THE SUPPLIER SELECTION CRITERIA

Criteria	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Weight	0.077	0.083	0.053	0.053	0.082	0.065	0.062
Criteria	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}
Weight	0.056	0.094	0.094	0.080	0.066	0.068	0.067

In the supplier selection problem, the performance ratings of ten suppliers with respect to the quantitative and qualitative selection criteria (given in Table 2) are assessed by KAP as shown in Table 5. The basic units of C_1 and C_2 are one million dollars. Average item price (C_5) and quality (C_6) criteria are adjusted by taking the reversal of the original data to make a consistent comparison across all criteria. The performance ratings of ten suppliers are then normalised by Eq. (2).

Given the criteria weights and normalised performance ratings of suppliers, the contribution scores of ten suppliers are calculated by Eq. (3). The highest and lowest contribution scores of the suppliers are 0.3164 and 0.2860 respectively. Table 6 shows the normalised performance ratings with respect to 14 selection criteria, and contribution scores (given in the last row) of the ten suppliers. Supplier S_2 is a highest rated supplier that best contributes to both long-term strategic goals and short-term requirements of KAP.

To help better illustrate how the strategic goals affect the strategic supplier selection, sensitivity analysis has been conducted by adjusting the strategic goal weights. Sensitivity analysis for strategic goals G_1, G_4, and G_5 has been used as an example. Figs. 2, 3, and 4 show how priorities of ten suppliers can change, based on the different weight of the strategic goals G_1, G_4, and G_5 by sensitivity analysis. The x-axis shows the weight of each strategic goal and y-axis displays the contribution score of ten suppliers.

TABLE V. THE PERFORMANCE RATINGS OF TEN SUPPLIERS

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
C_1	59	86	80	105	108.7	100	123	80	90	76
C_2	6	5	4.7	15	12	20	18	21.5	17	25
C_3	20	69	123	48	101	84	21	95	44	61
C_4	2500	5160	1800	2000	980	1200	400	980	912	1900
C_5	90	99	95	99	100	90	70	90	85	55
C_6	80	50	95	75	70	80	85	80	30	80
C_7	95	99	80	55	10	90	80	80	70	75
C_8	90	80	75	30	25	95	90	80	80	70
C_9	0.98	0.86	0.8	0.69	0.95	0.5	0.5	0.94	0.9	0.7
C_{10}	0.75	0.79	0.5	0.9	0.9	0.7	0.83	0.6	1	0.7
C_{11}	23	20	22	9	18	9	16	10	15	7
C_{12}	10	7	10	8	7	9	8	9	8	10
C_{13}	9	7	10	6	7	9	10	4	6	9
C_{14}	8	5	5	10	10	9	3	5	7	9

TABLE VI.   THE NORMALISED PERFORMANCE RATINGS,
CONTRIBUTION SCORES AND RANKINGS OF SUPPLIERS

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
C_1	0.202	0.294	0.274	0.359	0.372	0.342	0.421	0.274	0.308	0.260
C_2	0.119	0.099	0.093	0.297	0.238	0.396	0.356	0.426	0.336	0.495
C_3	0.085	0.294	0.525	0.205	0.431	0.358	0.090	0.405	0.188	0.260
C_4	0.361	0.744	0.260	0.288	0.141	0.173	0.058	0.141	0.132	0.274
C_5	0.322	0.354	0.340	0.354	0.358	0.322	0.251	0.322	0.304	0.197
C_6	0.339	0.212	0.402	0.318	0.296	0.339	0.360	0.339	0.127	0.339
C_7	0.389	0.405	0.327	0.225	0.041	0.368	0.327	0.327	0.286	0.307
C_8	0.379	0.337	0.316	0.126	0.105	0.400	0.379	0.337	0.337	0.295
C_9	0.387	0.340	0.316	0.273	0.375	0.198	0.198	0.372	0.356	0.277
C_{10}	0.304	0.320	0.203	0.365	0.365	0.284	0.336	0.243	0.405	0.284
C_{11}	0.457	0.398	0.437	0.179	0.358	0.179	0.318	0.199	0.298	0.139
C_{12}	0.365	0.255	0.365	0.292	0.255	0.328	0.292	0.328	0.292	0.365
C_{13}	0.359	0.279	0.399	0.239	0.279	0.359	0.399	0.159	0.239	0.359
C_{14}	0.338	0.211	0.211	0.423	0.423	0.381	0.127	0.211	0.296	0.381
Sco-re	0.3155	0.3164	0.3115	0.2872	0.2980	0.3122	0.2860	0.2933	0.2890	0.3009

Fig. 2 shows that S_6 is superior to suppliers S_2, S_1 and S_3 in terms of the contribution score when the weight of profitability (G_1) is higher than about 0.45, while suppliers S_2, S_1, and S_3 are preferable to S_6 when the weight of profitability (G_1) is less than about 0.16. Assigning the higher weight on profitability (G_1) increases the probabilities of S_6 to be selected. The contribution scores of suppliers S_6, S_2, S_1, and S_3 are always more dominant than suppliers S_{10}, S_5, S_8, S_9, S_4, and S_7, regardless of the weight of profitability (G_1) due to the fact that the performance ratings of suppliers S_6, S_2, S_1, and S_3 with respect to profitability (G_1) are much superior to suppliers S_{10}, S_5, S_8, S_9, S_4. This indicates that suppliers S_6, S_2, S_1, and S_3 contribute more to the profitability (G_1) strategic goal than suppliers S_{10}, S_5, S_8, S_9 and S_4. Fig. 3 shows that two suppliers S_2 and S_1 are always superior to others. This indicates that suppliers S_2 and S_1 contribute more to the coercive power (G_4) strategic goal than suppliers S_3, S_6, S_{10}, S_5, S_8, S_9, S_4 and S_7. Fig. 4 shows that S_1 is superior to supplier S_2 when the weight of G_5 is higher than about 0.25, while supplier S_2 or S_6 can be chosen when the weight of G_5 is less than about 0.25. Suppliers S_1, S_2, S_3, and S_6 are always more dominant than others. This indicates that they contribute more to the long-term relationship (G_5) strategic goal than others. It is noteworthy that depending on the different weights of the strategic goals, priorities of suppliers change. Thus, KAP will be able to use these different weighting combination results for its various strategic plans. The result of the sensitivity analysis demonstrates that determining the different weights of strategic goals changes criteria weights, thus affecting strategic supplier selection of KAP.
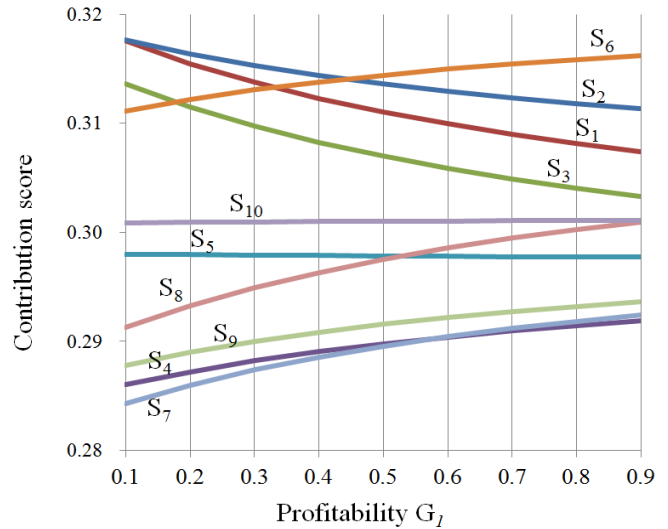

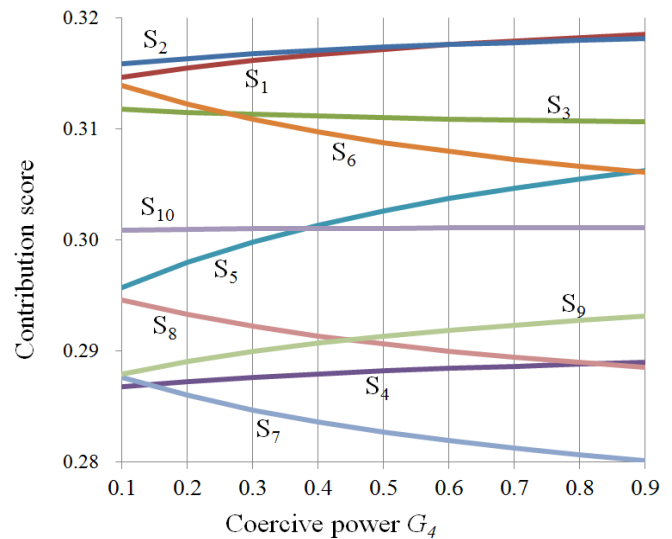Figure 2.   Sensitivity analysis based on profitability (G_1).

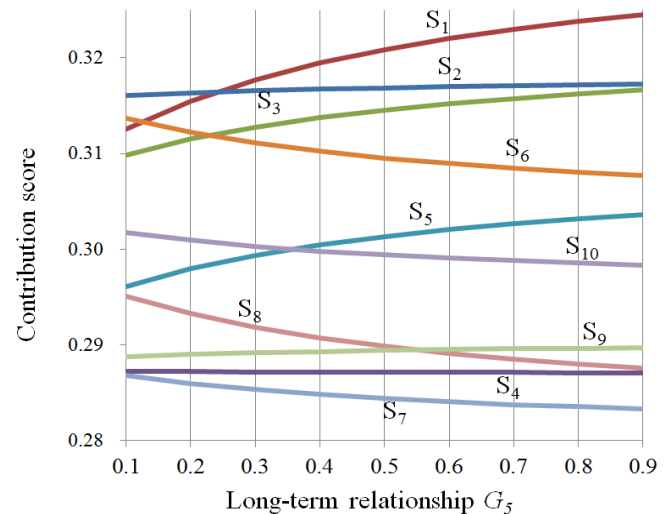Figure 3.   Sensitivity analysis based on coercive power (G_4).

Figure 4.   Sensitivity analysis based on long-term relationship (G_4).

V. CONCLUSION

Selecting the supplier that best meets both specific long-term expectations and short-term requirements of a company requires a comprehensive approach. To address this decision problem, we have developed a new strategic supplier selection approach for meeting both long-term strategic goals and short-term requirements of customer orders of a company. A new weighting method has been developed to evaluate the potential contribution of the suppliers to the strategic goals of a company by examining how the selection criteria contribute to the goals. The strategic supplier selection approach developed in this paper provides a structured approach for a company to choose the long-term strategic supplier most contributing to its long-term survival and growth, and short-term requirements. Although the approach is exemplified with the strategic supplier selection problem in the auto parts manufacturing company, it has general application in selecting a strategic supplier in different supply chains with various strategic goals and short-term requirements.

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