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Use of Analytic Hierarchy Process (AHP) to Evaluate Supply Chain Collaboration in Competitive Business Environment

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Abstract—*Supply chain collaboration (SCC) is the driving force to establish a collaborative relationship based on truly shared goal. The objective of this research is to evaluate SC collaboration using Analytical hierarchy process (AHP) by understanding the enablers for effective SC collaboration in the manufacturing organizations. To build awareness of the critical SCCEs and present an approach to make SC collaboration effective by understanding the dynamics between various SC Collaboration Enablers (SCCEs). The findings of the present research work reveal that three enablers of supply chain collaboration were statistically significant to organization performance. The empirical results demonstrate that top management support, common objectives and goals, communication SC strategic planning, Advance technology, Training Advancement and organization compatibility for SC collaboration are the seven main influential factors on the success of SC collaboration project. This study used subjective judgment and any biasing by the person who is judging the SCCEs might influence the final result. Here, 20SCCEs have been used to identify and rank the major SCCEs in relation to the success of SC Collaboration in the organization. The results offer insights to supply chain collaboration practitioners and policy makers for computing importance weights of SCCEs, which helps to identify and rank the important SCCEs for their needs and to reveal the direct and indirect effects of each SCCE for achieving the effective SC Collaboration in the organization by using AHP approach.*

1. INTRODUCTION

Supply chain collaboration is the driving force to establish a collaborative relationship based on truly shared goal between the partner organizations. The need of SC collaboration is to improve sales and/or profits of organization, to take market share away from competitors, to reduce organization's supply chain costs, to eliminate or reduce investments in physical assets, to transfer costs and risks to other parties in supply chain, to create a more flexible and responsive supply chains in competitive business environment. (Hansen and Nohira, 2004).

SC collaboration has become a new imperative strategy for organizations to create competitive advantage (Horvath, 2001; Spekman et al., 1998). A closer relationship enables the participating organizations to achieve cost reductions and revenue enhancements as well as flexibility in dealing with supply and demand uncertainties (Bowersox, 1990; Lee et al., 1997). Hewlett-Packard (HP), for instance, initiated collaboration with one of its major resellers (Callioni and Billington, 2001). These collaborative efforts, which focused on co-managed inventory by considering different levels of demand uncertainty, enabled both parties to improve fill rate, increase inventory turnover, and enhance sales. Similarly, Wal-Mart collaborated in demand planning and replenishment with its major suppliers to increase inventory turns, reduce inventory costs, reduce storage and handling costs, and improve retail sales (Parks, 2001).

AHP approach helps the organization to alleviate inconsistencies in decision making problems. This study applies fuzzy linguistic preference relations to construct a pair-wise comparison matrix. AHP is an easy and practical way to provide a mechanism for improving consistency in SC collaboration implementation.

Twenty SCCEs have been chosen on the basis of literature review and the opinions of experts from industry and academia. The main objectives of this paper are to measure the success/ failure possibility of implementing the supply chain collaboration using AHP approach.

2. METHODOLOGY

2.1 Supply chain Collaboration using AHP

Step 1. Establish pair-wise comparison matrix for priority weighting of attributes. The attributes considered in SC collaboration implementation are shown in the table 1 (Given in appendix).

Table 1: Shows list of enablers

SCCEs No	Enabler Name
SCCE1	Top management support
SCCE2	Common objectives and goals
SCCE3	Strategic planning

SCCE4	Communication
SCCE5	Training Advancement
SCCE6	Advance technology,
SCCE7	Information sharing
SCCE8	Trust and openness
SCCE9	Organizational compatibility
SCCE10	Cooperation
SCCE11	Benefit sharing
SCCE12	Decision synchronization
SCCE13	Motivation and rewards
SCCE14	Reliability
SCCE15	Mutual help and support
SCCE16	Lead Time
SCCE17	Flexibility
SCCE18	Power sharing
SCCE19	Innovativeness
SCCE20	Customer Oriented Vision

Table 2: Degree of preferences between two attributes

Preferences	Preferences number to be assigned
Equally important /preferred	1
Weakly more important/preferred	3
strongly more important/preferred	5
Very strongly more important	7
Absolutely more important /preferred	9
Intermediate values used to present compromise	2,4,6,8

Step 2. Normalize the pair-wise comparison matrix and aggregate the priority weight for attributes

The normalized value r_{ij} is calculated as

$$r_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \forall i, j = 1,2 \ldots., n.$$

Meanwhile, the aggregated priority weight of attribute W_i is

$$W_i = \frac{1}{n} \sum_{j=1}^{n} a_{ij} \ \forall i, j = 1,2, \ldots n$$

Where Wi denotes the priority weight of attribute (i) and n represents the number of the attributes.

Step 3. Derivation of the eigenvector and maximum eigen value. The eigenvector represents the relative importance among the elements. Maximum eigen value (λ_{max}) can be used to determine the strength of consistency among comparisons.

Step 4. Derive the consistency index and consistency ratio.

If matrix A is a consistent matrix, the maximum eigen value of A should equal its number of orders. Therefore, the consistency index(CI) = (λ_{max} –n)/ n-1 and consistency ratio (CR) = CI/RI can be used to assess the degree of consistency. If the consistency index < 0.1, then there is a satisfactory level of consistency. In addition, if the consistency ratio < 0.1, then the evaluation matrix is acceptable. In this case, CI is 0.09568.

Step 5. Establish a pair-wise comparison matrix for weighting alternatives with respect to attributes.

Yusuff et al. (2001**)** noted that the priority weights for alternatives are measured to show the preference of alternatives with respect to attributes. Restated, a stronger alternative preference indicates that the alternative in question is more likely to be successful. Five options, Extremely good (5), Good (3), Fair (1), Weak (1/3) and Poor (1/5) are provided to illustrate the change of success given different alternatives. The larger rating of an alternative indicates a higher chance of success.

Step 6. Priority weight for prediction.

The prediction weight is computed by multiplying the priority weights of the attributes and the evaluation ratings of the alternatives.

The prediction weight Ck is then obtained as

$C_k = \sum_{i=1}^{n} w_i k_i$

Where W_i denotes the aggregated weight of attribute i, and K_i represents the priority weight of possible outcome A_k with respect to attribute i.

The consistency ratio (C.R) for a comparison is calculated to determine the acceptance of the attribute priority weights. it is given by

Consistent ratio(C.R) = Consistency index / random index.

2.3 Problem Solving using AHP for Supply Chain Collaboration Implementation.

Step 1. Establish pair-wise comparison matrix for priority weighting of attributes (See TABLE 3 in appendix)

Table 3: illustrates Preference matrixes for pair wise comparison of attributes

	SCCE1	SCCE2	SCCE3	SCCE4	SCCE5	SCCE6	SCCE7	SCCE8	SCCE9	SCCE10	SCCE11	SCCE12	SCCE13	SCCE14	SCCE15	SCCE16	SCCE17	SCCE18	SCCE19	SCCE20
SCCE1	1.00	3.00	3.00	3.00	2.00	4.00	1.00	3.00	3.00	3.00	5.00	7.00	5.00	4.00	5.00	4.00	9.00	9.00	9.00	9.00
SCCE2	0.33	1.00	3.00	1.00	1.00	2.00	5.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	3.00	2.00	7.00	5.00	7.00	7.00
SCCE3	0.33	0.33	1.00	3.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	2.00	5.00	5.00	7.00	5.00
SCCE4	0.33	1.00	0.33	1.00	3.00	1.00	3.00	3.00	1.00	3.00	1.00	3.00	3.00	1.00	1.00	2.00	5.00	5.00	5.00	5.00

SCCE5	0.50	1.00	1.00	0.33	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	5.00	5.00	7.00	5.00
SCCE6	0.25	0.50	0.33	1.00	0.33	1.00	3.00	1.00	1.00	1.00	1.00	3.00	3.00	1.00	3.00	3.00	5.00	5.00	7.00	5.00
SCCE7	0.50	0.20	0.33	0.33	0.33	0.33	1.00	3.00	1.00	3.00	1.00	2.00	2.00	1.00	1.00	1.00	3.00	3.00	5.00	3.00
SCCE8	0.33	1.00	1.00	0.33	1.00	1.00	0.33	1.00	1.00	3.00	1.00	1.00	1.00	1.00	2.00	1.00	3.00	5.00	5.00	3.00
SCCE9	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	3.00	1.00	3.00	4.00	7.00	3.00
SCCE10	0.33	1.00	1.00	0.33	1.00	1.00	0.33	0.33	0.33	1.00	1.00	3.00	1.00	2.00	3.00	1.00	3.00	5.00	5.00	3.00
SCCE11	0.20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	3.00	3.00	3.00	4.00
SCCE12	0.14	1.00	1.00	0.33	1.00	0.33	0.50	1.00	1.00	0.33	1.00	1.00	1.00	2.00	1.00	2.00	7.00	3.00	3.00	3.00
SCCE13	0.20	1.00	0.50	0.33	1.00	0.33	0.50	1.00	1.00	1.00	0.33	1.00	1.00	1.00	1.00	1.00	3.00	3.00	3.00	3.00
SCCE14	0.25	0.33	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	0.50	1.00	1.00	1.00	2.00	3.00	3.00	3.00	3.00
SCCE15	0.20	0.33	1.00	1.00	1.00	0.33	1.00	0.50	0.33	0.33	1.00	1.00	1.00	1.00	1.00	1.00	3.00	1.00	3.00	3.00
SCCE16	0.25	0.50	0.50	0.50	1.00	0.33	1.00	1.00	1.00	1.00	1.00	0.50	1.00	0.50	1.00	1.00	3.00	3.00	3.00	3.00
SCCE17	0.11	0.14	0.20	0.20	0.20	0.20	0.33	0.33	0.33	0.33	0.33	0.14	0.33	0.33	0.33	0.33	1.00	1.00	1.00	1.00
SCCE18	0.11	0.20	0.20	0.20	0.20	0.20	0.33	0.20	0.25	0.20	0.33	0.33	0.33	0.33	1.00	0.33	1.00	1.00	3.00	1.00
SCCE19	0.11	0.14	0.14	0.20	0.14	0.14	0.20	0.20	0.14	0.20	0.33	0.33	0.33	0.33	0.33	0.33	1.00	0.33	1.00	1.00
SCCE20	0.11	0.14	0.20	0.20	0.20	0.20	0.33	0.33	0.33	0.33	0.25	0.33	0.33	0.33	0.33	0.33	1.00	1.00	1.00	1.00
SUM	5.94	14.83	17.74	16.30	18.41	21.41	26.87	21.90	17.73	25.23	20.58	29.14	29.33	23.83	31.00	27.33	74.00	70.33	88.00	71.00

Step 2. Normalize the pair-wise comparison matrix and aggregate the priority weight for attributes (See TABLE 4 in appendix)

Table 4: Illustrates normalized paired comparisons priority weights of attributes																						
	SCCE1	**SCCE2**	**SCCE3**	**SCCE4**	**SCCE5**	**SCCE6**	**SCCE7**	**SCCE8**	**SCCE9**	**SCCE10**	**SCCE11**	**SCCE12**	**SCCE13**	**SCCE14**	**SCCE15**	**SCCE16**	**SCCE17**	**SCCE18**	**SCCE19**	**SCCE20**	**Total**	**Average**
SCCE1	0.17	0.2	0.17	0.18	0.11	0.19	0.04	0.14	0.17	0.12	0.24	0.24	0.17	0.17	0.16	0.15	0.12	0.13	0.10	0.127	3.09	0.154
SCCE2	0.06	0.07	0.17	0.06	0.05	0.09	0.19	0.05	0.06	0.04	0.05	0.03	0.03	0.13	0.10	0.07	0.09	0.07	0.08	0.099	1.59	0.079
SCCE3	0.06	0.02	0.06	0.18	0.05	0.14	0.11	0.05	0.06	0.04	0.05	0.03	0.07	0.04	0.03	0.07	0.07	0.07	0.08	0.07	1.35	0.068
SCCE4	0.06	0.07	0.02	0.06	0.16	0.05	0.11	0.14	0.06	0.12	0.05	0.10	0.10	0.04	0.03	0.07	0.07	0.07	0.06	0.07	1.5	0.075
SCCE5	0.08	0.07	0.06	0.02	0.05	0.14	0.11	0.05	0.06	0.04	0.05	0.03	0.03	0.04	0.03	0.04	0.07	0.07	0.08	0.07	1.19	0.06
SCCE6	0.04	0.03	0.02	0.06	0.02	0.05	0.11	0.05	0.06	0.04	0.05	0.10	0.10	0.04	0.10	0.11	0.07	0.07	0.08	0.07	1.27	0.063
SCCE7	0.08	0.01	0.02	0.02	0.02	0.02	0.04	0.14	0.06	0.12	0.05	0.07	0.07	0.04	0.03	0.04	0.04	0.04	0.06	0.042	1	0.05
SCCE8	0.06	0.07	0.06	0.02	0.05	0.05	0.01	0.05	0.06	0.12	0.05	0.03	0.03	0.04	0.06	0.04	0.04	0.07	0.06	0.042	1.01	0.05
SCCE9	0.06	0.07	0.06	0.06	0.05	0.05	0.04	0.05	0.06	0.12	0.05	0.03	0.03	0.04	0.10	0.04	0.04	0.06	0.08	0.042	1.11	0.056

SCCE10	0.06	0.07	0.06	0.02	0.05	0.05	0.01	0.02	0.02	0.04	0.05	0.10	0.03	0.08	0.10	0.04	0.04	0.07	0.06	0.042	1	0.05
SCCE11	0.03	0.07	0.06	0.06	0.05	0.05	0.04	0.05	0.06	0.04	0.05	0.03	0.10	0.04	0.03	0.04	0.04	0.04	0.03	0.056	0.97	0.048
SCCE12	0.02	0.07	0.06	0.02	0.05	0.02	0.02	0.05	0.06	0.01	0.05	0.03	0.03	0.08	0.03	0.07	0.09	0.04	0.03	0.042	0.89	0.045
SCCE13	0.03	0.07	0.03	0.02	0.05	0.02	0.02	0.05	0.06	0.04	0.02	0.03	0.03	0.04	0.03	0.04	0.04	0.04	0.03	0.042	0.73	0.037
SCCE14	0.04	0.02	0.06	0.06	0.05	0.05	0.04	0.05	0.06	0.02	0.05	0.02	0.03	0.04	0.03	0.07	0.04	0.04	0.03	0.042	0.85	0.042
SCCE15	0.03	0.02	0.06	0.06	0.05	0.02	0.04	0.02	0.02	0.01	0.05	0.03	0.03	0.04	0.03	0.04	0.04	0.01	0.03	0.042	0.69	0.035
SCCE16	0.04	0.03	0.03	0.03	0.05	0.02	0.04	0.05	0.06	0.04	0.05	0.02	0.03	0.02	0.03	0.04	0.04	0.04	0.03	0.042	0.73	0.037
SCCE17	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.02	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014	0.25	0.013
SCCE18	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.03	0.014	0.29	0.015
SCCE19	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.014	0.22	0.011
SCCE20	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.014	0.26	0.013
SUM	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		

Step 3. Derivation of the eigenvector and maximum eigen value.

Maximum eigen value is 21.818

Step 4. Derive the consistency index and consistency ratio.

(CI) = (λ_{max} –n)/ (n-1) = (21.818- 20)/19= 0.09568 hence in our consistency is acceptable

Where CI is consistent index, λ_{max} is the maximum value of eigen value ., n is the number of variable

Consistency ratio (CR) = CI/RI

Random index (RI) For variable more than eight the random index is computed using empirical formula given by

$$RI\ (n) = -0.021n^2 + 0.1183\ n - 0.001$$

Where n is the order of the matrixes / variable considered in this SC Collaboration implementation

Table 5:(a). Paired comparison matrices for possible outcome in attribute SCCE2

Success			Failure
SCCE 2	Success	1	3
	Failure	0.33	1
	TOTAL	1.33	4

Table 5: (b) Normalized -matrix of priority weight for possible outcome in attribute SCCE2

		Success	Failure
SCCE 2	Success	0.75188	0.75
	Failure	0.24812	0.25

Step 5. Establish a pair-wise comparison matrix for weighting alternatives with respect to attributes.

Summary of Possible Outcome with Respect to Each attribute **(**See TABLE 6 in appendix)

Table 6: Summary of Possible Outcome with Respect to Each Attribute

SCCE NO.		Success	Failure	Priority Weight
SCCE 1	Success	1	3	0.75
	Failure	0.5	1	0.25
SCCE 2	Success	1	3	0.75
	Failure	0.33	1	0.25
SCCE 3	Success	5	1	0.167
	Failure	1	1	0.833
SCCE 4	Success	1	1	0.5
	Failure	1	1	0.5
SCCE 5	Success	1	5	0.833
	Failure	0.2	1	0.167
SCCE 6	Success	1	3	0.75
	Failure	0.33	1	0.25
SCCE 7	Success	1	5	0.833
	Failure	0.2	1	0.167
SCCE 8	Success	1	3	0.75
	Failure	0.5	1	0.25
SCCE 9	Success	1	3	0.75
	Failure	0.33	1	0.25
SCCE 10	Success	5	1	0.16
	Failure	1	1	0.833
SCCE 11	Success	1	1	0.5
	Failure	1	1	0.5
SCCE 12	Success	1	5	0.833
	Failure	0.2	1	0.167
SCCE 13	Success	1	3	0.75

	Failure	0.33	1	0.25
SCCE 14	Success	1	5	0.833
	Failure	0.2	1	0.167
SCCE 15	Success	1	3	0.75
	Failure	0.5	1	0.25
SCCE16	Success	0.5	0	0.167
	Failure	1	0.5	0.833
SCCE17	Success	0.5	0.5	0.5
	Failure	0.5	0.5	0.5
SCCE18	Success	0.5	1	0.8333
	Failure	0	0.5	0.167
SCCE19	Success	0.5	0.84	0.693
	Failure	0.16	0.5	0.307
SCCE20	Success	5	1	0.167

Step 6. Priority weight for prediction. (See TABLE 7 in appendix)

The prediction weights for Successful of SC Collaboration implementation **= 0.635**

Table 7: Illustrates Prediction weight for possible outcome

(AHP)																					Prediction weight
	SCCE1	SCCE2	SCCE3	SCCE4	SCCE5	SCCE6	SCCE7	SCCE8	SCCE9	SCCE10	SCCE11	SCCE12	SCCE13	SCCE14	SCCE15	SCCE16	SCCE17	SCCE18	SCCE19	SCCE20	
Attribute weight	0.155	0.079	0.068	0.075	0.060	0.063	0.050	0.050	0.055	0.050	0.048	0.045	0.037	0.043	0.035	0.037	0.013	0.015	0.011	0.013	
Success	0.750	0.750	0.167	0.500	0.833	0.750	0.833	0.750	0.750	0.167	0.500	0.833	0.750	0.833	0.750	0.167	0.500	0.833	0.693	0.167	0.635
Failure	0.250	0.250	0.833	0.500	0.167	0.250	0.167	0.250	0.250	0.833	0.500	0.167	0.250	0.167	0.250	0.833	0.500	0.167	0.307	0.833	0.365

Similarly, The prediction weights for Failure of SC Collaboration implementation = **0.365**

Table 8 illustrates the Rank of enablers of SC Collaboration according to priority weight. (See Table 8 in appendix)

3. DISCUSSION

1) The ranks and priority weights obtained
2) The pair-wise comparison times of the priority weight for possible outcome according to the twenty attributes are done.
3) The chances of successful and failure SSC implementation produced by AHP (0.635/0.365).
4) The AHP method performs complicated Mathematical operations to obtain indicators: for example eigen vector, maximum eigen value, consistency index and consistence ratio, to ensure the consistency of a preference matrix.
5) All the enablers are ranked according to the priority weights.

4. CONCLUSION

In present work, AHP approach has been used in the SC Collaboration implementation to obtain [possibility of success/failure implementation in SC Collaboration and obtain the prediction weights for success and failure of attribute. After that we obtain consistency index for the methods. The conventional AHP method uses reciprocal multiplicative preference relation with an interval scale [1/9, 9] to establish a pair-wise comparison matrix based on a set of n (n-1)/2 preference ratios. The principle eigen vector, maximum eigen value, consistency index and consistence ratio then are calculated for assessing the consistency in a preference relation matrix. Consequently, paired comparison of the alternatives with respect to each attributes can be used to obtain the ranking of the feasible alternatives. Future studies will focus on the generalized analytical hierarchy process problems in linguistic terms without exporting the reciprocal additive transitivity property to reciprocal multiplicative decision models that top management support, common objectives and goals, communication SC strategic planning, Advance technology, Training Advancement and organization compatibility for SC collaboration are the seven main influential factors on the success of SC collaboration project. Here, 20SCCEs have been used to identify and rank the important SCCEs for their needs and to reveal the direct and indirect effects of each SCCE for achieving the effective SC Collaboration in the organization by using AHP approach.

REFERENCE

[1] Arvind Jayant, P Gupta, S K Garg, M.Khan. 2014 'TOPSIS-AHP Based Approach for Selection of Reverse Logistics Service Provider: A Case Study of Mobile Phone Industry' Procedia Engineering, Vo.97 (2014), pp 2147-2156.

[2] Arvind Jayant, P Gupta, S K Garg. 2014. 'Reverse Logistics Network Design for Spent Batteries: A Simulation Study' International Journal of Logistics System and Management. Vol. 18, No. 3, pp.343–365.

[3] Arvind Jayant, P Gupta, S K Garg.2011. 'An Application of Analytic Network Process to Evaluate Supply Chain Logistics Strategies", International Journal of Analytic Hierarchy Process. Vol.4 (2011), Issue 1. Pp149-163.