Evaluation of Supply Chain Collaboration: An AHP based Approach

Veepan Kumar
Assistant Professor (MED)
SLIET Longowal, Punjab

Ravi Kant
AssistantProfessor (MED)
Svnit Surat, Gujarat

Arvind Jayant
Associate Professor (MED)
SLIET Longowal, Punjab

Rakesh Malviya
Research Scholar (MED)
Svnit Surat, Gujarat

ABSTRACT
Supply chain collaboration (SCC) is the driving force to establish a collaborative relationship based on truly shared goal. 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 SC costs, to eliminate or reduce investments in physical assets, to transfer costs and risks to other parties in SC, to create a more flexible and responsive supply chain. 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.

Keywords
Analytical hierarchy process (AHP), Supply chain collaboration Enablers (SCCEs)

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).

A closer relationship enables the participating organisations to achieve cost reductions and revenue enhancements as well as flexibility in dealing with supply and demand uncertainties (Bowersox, 1990; Lee et al., 1997). SC collaboration has become a new imperative strategy for organizations to create competitive advantage (Horvath, 2001; Spekman et al., 1998). Hewlett-Packard (HP), for instance, initiated collaboration with one of its major resellers. 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. 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 organisation to alleviate inconsistencies in decision making problems. This study applies fuzzy linguistic preference relations to construct a pairwise comparison matrix. AHPis 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. LITERATURE REVIEW OF SC COLLABORATION
The organizations are aware of the importance of all the SCCEs but fall short of their practicing. Many authors have researched and written directly on these SCCEs. The various SC literatures have been reviewed to develop a framework for effective SC collaboration implementation.
Toni et al. (1994) discussed about co-operation with suppliers which may help the organizations to improve its time, costs and quality performances in the product flow management and design/product development. There are two areas namely information technology and warehouse and transport technologyin which technological advances are having a significant impact on the opportunities for SC collaboration improvement. The innovativeness and information sharing are major factor for SC collaboration (Fearne and Hughed, 1999). Akintoye et al. (2000) discussed that Collaboration has been recognized as a significant process that holds the value creation opportunity in SC also studied about SC collaboration and management in the top the UK construction industry contractors. Sridharan and Simatupang (2004) discussed a benchmarking study on SC collaboration between retailers and suppliers, which incorporates collaborative practices in information sharing, decision synchronization, and incentive alignment. An empirical study was carried out to benchmark the profile of collaborative practices and operational performance. Simatupang and Sridharan (2005) proposed an instrument to measure the extent of collaboration

in a SC consisting of two members, suppliers and retailers. The proposed model for collaboration incorporates collaborative practices in information sharing, decision synchronization and incentive alignment. A collaboration index is introduced to measure the level of collaborative practices. Collaboration index was positively associated with operational performance. Sheu et al. (2006) identify the necessary SC architecture for supplier-retailer collaboration, and demonstrate how it influences SC performance. A comprehensive supplier-retailer relationship model is developed with five specific research positions: supplier-retailer business relationship (interdependence, intensity, trust) affects long-term orientation, supplier-retailer business relationship affects SC architecture (information sharing, inventory system, information technology capabilities, coordination structure), long-term orientation affects SC architecture, SC architecture affects the level of supplier-retailer collaboration, and supplier-retailer collaboration enhances supplier-retailer performance. Overall, with the exception of duration, all variables are found to be critical to supplier-retailer collaboration. Manos et al. (2007) analysed the concept of SC collaboration and to provide an overall framework that can be used as a conceptual landmark for further empirical research. The concept is explored in the context of agri-food industry and particularities are identified. SC collaboration concept is of significant importance for the agri-food industry however, some constraints arise due to the nature of industry's products, and the specific structure of the sector. Lorentz (2008) investigated the level of SC collaboration in an uncertain cross-border context, and whether it improves SC performance. The moderating role of export experience and intensity to the collaboration-performance relationship is also investigated. It seems that experience in cross-border SC operations does not guarantee success in SC management. However, those organizations with large export volumes, implying frequency and leveraged resources in operations, seemed to be better able to collaborate for successful outcomes.Sridharan and Simatupang (2008) clarified the architecture of SC collaboration and to propose a design for SC collaboration (DfC), which enables participating members to create and develop key elements of the proposed architecture. The paper offers a concept for designing the five elements of the architecture of SC collaboration, namely collaborative performance system, decision synchronization, information sharing, incentive alignment, and innovative SC processes. A case study was carried out to illustrate the applicability of the framework. Fawcett et al. (2010) addressed how organizations mitigate existing forces to achieve the collaboration enabled SC. Seven key theories were used to provide insight into the theoretical framework for the creation of the collaboration-enabled SC: contingency theory, the resource-based view of the firm, the relational view of the firm, force field theory, constituency-based theory, social dilemma theory, and resource-advantage theory. The findings reveal that developing a collaboration-enabled business model is very difficult. Kant and Joshi (2012) presented an approach for effective SC collaboration by understanding the dynamics between various SCCEs that help to effective SC collaboration. The research presents a hierarchy-based model and the mutual relationships among the SCCEs using interpretive structural modeling. The research shows that there exists a group of enablers having a high driving power and low dependence requiring maximum attention and of strategic importance while another group consists of those variables which have high dependence and are the resultant actions.

3. METHODOLOGY

Supply Chain Collaboration Using AHP

Step1

Establish pairwise comparison matrix for priority weighting of attributes.

The attributes considered in SC collaboration implementationare shown in the table below

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	Flexiblity
SCCE18	Power sharing
SCCE19	Innovativeness
SCCE20	Customer Oriented Vision

Step2.

Normalize the pairwise 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.

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

Step3.
Derivation of the eigenvector and maximum eigen value.
The eigenvector represents the relative importance among the elements. Maximum eigenvalue (λ_{max}) can be used to determine the strength of consistency among comparisons.

Step4
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.

Step5
Establish a pairwise comparison matrix for weighting alternatives with respect to attributes.
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.

Step6
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.

Problem solving using AHP for supply chain collaboration implementation.
Step1
Establish pairwise comparison matrix for priority weighting of attributes (See TABLE 3 in appendix)

Step2
Normalize the pairwise comparison matrix and aggregate the priority weight for attributes(See TABLE 4in appendix)

Step3
Derivation of the eigenvector and maximum eigen value.

Maximum eigen value is 21.818
Step4. 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
Step5. Establish a pairwise comparison matrix for weighting alternatives with respect to attributes.

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

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

Step6. Priority weight for prediction. (SeeTABLE 7 in appendix)

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

Similarily, 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.(SeeTABLE 8 in appendix)

4. DISCUSSIONS

1. The ranks and priority weights obtained.

2. The pairwise 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 eigenvector, maximum eigenvalue, consistency index and consistency ratio, to ensure the consistency of a preference matrix.

5 All the enablers are ranked according to the priority weights.

5. CONCLUSION

In the 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 obtained consistency index for both the methods.The conventional AHP method uses reciprocal multiplicative preference relation with an interval scale [1/9, 9] to establish a pairwise comparison matrix based on a set of n (n-1)/2 preference ratios. The principal eigenvector, maximum eigenvalue, consistency index and consistency ratio then are calculated for assessing the consistency in a preference relation matrix. Consequently, paired comparison of the alternatives with respect to each attribute can be used to obtain the overall ranking of the feasible alternatives. Future studies will focus on the generalized analytic hierarchy process problems in linguistic terms without exporting the reciprocal additive transitivity property to reciprocal multiplicative decision models. 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.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.

6. REFERENCES

[1] Arvind Jayant, A.Singh, and V.Patel (2011), "*An AHP Based Approach for Supplier Evaluation and Selection in Supply Chain Management"* International Journal of Advanced Manufacturing Systems, Volume 2, No. 1, pp. 1-6

[2] Arvind Jayant, M.S.Dhillon (2014) "*Use of Analytic Hierarchy Process (AHP) to Select Welding Process in High Pressure Vessel Manufacturing Environment*" International Journal of Applied Engineering Research, Volume 10(8) 2015 pp.58695884, ISSN 0973-4562.

[3] Arvind Jayant, Vikram Singh (2014) "*An Application of Analytic Hierarchy Process (AHP) for Vendor Selection in Supply Chain Management"* accepted for publication in International Journal Enterprise Network Management (Indescience Publications)

[4] 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, 97, 2147-2156.

[5] Akintoye, A., McIntosh. G and Fitzgerald. E. 2000 'A survey of supply chain collaboration and management in the UK construction industry', European Journal of Purchasing and Supply Management, Vol. 6, pp. 159-168.

[6] Anbanandam, R., Banwet, D and Shankar, R. 2011 'Evaluation of supply chain collaboration: a case of apparel retail industry in India', International Journal of Productivity and Performance Management, Vol. 60, No. 2, pp. 82-98.

[7] Bowersox, D.J. 1990 'The strategic benefits of logistics alliances,' Harvard Business Review, Vol. 68, No. 4, pp. 36-43.

[8] Chang, T. H and Wang, T.C. 2009 'Measuring the success possibility of implementing advanced manufacturing technology by utilizing the consistent fuzzy preference relations,' Expert Systems with Applications, Vol.36, No.3, pp .4313–4320.

[9] De Toni, A., Nassimbeni, G and Tonchia, S. 1994 'New trend in the supply management', Logistics Information Management, Vol. 7, No.4, pp.41–50.

[10] Fawcett, S., Magnan, G and Fawcett, M. 2010 'Mitigating resisting forces to achieve the collaboration-enabled supply chain', Benchmarking: An International Journal, Vol. 17, No. 2, pp.269 – 293.

[11] Fearne, A and Hughes, D. 1999 'Success factors in the Fresh Produce Supply Chain: insights from the UK', Supply Chain Management, Vol. 4, No. 3, pp. 120-128.

[12] Hansen, M. T and Nohria, N. 2004 'How to build the collaborative advantage', slogan management review.

[13] Herrera–Viedma, E., Herrera, F., Chiclana, F and Luque, M. 2004 'Some issues on consistency of fuzzy preference relations', European Journal of Operational Research, Vol.154, pp.98–109.

[14] Horvath, L. 2001 'Collaboration: key to value creation in supply chain management', Supply Chain Management: An International Journal, Vol. 6 No. 5, pp. 205-7.

[15] Joshi, K. and Kant, R. 2012, 'Structuring the underlying relations among the enablers of supply chain collaboration', International journal of Collaborative Enterprise, Vol. 3, No. 1, pp.38–59.

[16] Lee, H.L., Padmanabhan, V. and Whang, S. 1997 'The bullwhip effect in supply chains,' Sloan Management Review, Vol. 38 No. 3, pp. 93-102.

[17] Lorentz, H. 2008 'Collaboration in Finnish-Russian supply chains: Effects on performance and the role of experience', Baltic Journal of Management, Vol. 3, No. 3, pp.246 – 265.

[18] Matopoulos, A., Vlachopoulou, M., Manthou .V and Manos, B. 2007 'A conceptual framework for supply chain collaboration: empirical evidence from the agri-food industry', Supply Chain Management: An International Journal, Vol. 12, No. 3, pp.177 – 186.

[19] Parks, L. 2001 'Wal-Mart gets on board early with collaborative planning', Drug Store News, Vol. 23, No. 2, pp. 14.

[20] Sheu, C., Yen, H.R and Chae, B. 2006 'Determinants of supplier retailer collaboration evidence from an international study', International journal of operations and production management, Vol. 26, No.1, pp.24-29.

[21] Simatupang, T and Sridharan, R. 2004 'A benchmarking scheme for supply chain collaboration', An International Journal, Vol.11, pp.9-30.

[22] Simatupang, T and Sridharan, R. 2005 'The collaborative supply chain', International Journal of Logistics Management, Vol. 13 No. 1, pp. 15-30.

[23] Simatupang, T. and Sridharan, R. 2008 'Design for supply chain collaboration', Business Process Management Journal Vol. 14, No.3, pp.401 – 418.

[24] Spekman, R.E., Kamauff, J.W. and Myhr, N. 1998 'An empirical investigation into supply chain management", International Journal of Physical Distribution and Logistics Management, Vol. 28, No. 8, pp. 630-50.