Evidential Reasoning Approach for Logistics Collaboration in Supply Chain Coordination

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Abstract— **At present supply chains coordinate to bring together multiple organizations and functions effectively for achieving the performance. Logistic collaboration provides give new and innovative ways to improve supply chain coordination, reduce overall cost and improve social management of the supply process . In this paper a methodology to coordinate supply chains through logistic collaborations using evidential reasoning is being attempted.**

Keywords— supply chain coordination; evidential reasoning; logistics collaboration.

I. Introduction

Supply chain coordination aims at achieving global optimization within a defined supply chain network. Supply Chain consists of different functions: logistics, inventory, purchasing, and procurement, production, planning, intra-and inter-organizational relationships and performance measures. An efficient supply chain effectively integrates suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide cost while satisfying service requirements [8].

In the current economic context, logistics collaboration is emerging as a new opportunity for improving supply chain performance by emphasizing on key activities such as warehousing, transportation, and distribution. This is driven by heightened competitive pressure on a global scale, increased environmental concerns and new business models implementation. Collaboration between partners is a very popular subject in both logistics and decision support research. The essence of logistics collaboration lies in the process of resource sharing and collaborative decision making. The aim of this paper is to elaborate the different types of collaborations possible and to discuss the various decision making factors involved in logistics collaboration and to finally suggest a methodology using evidential reasoning for arriving at the best collaboration alternative for logistics.

II. Logistics Collaboration

Collaboration is one of the most promising areas of study in supply chain management. In logistics, a collaborative approach requires sharing common goals and resources throughout the life cycle of the collaboration [1].

A. Types of Collaboration

In general collaborations can be classified into vertical and horizontal collaborations. Vertical collaboration is defined as "a common process management in a supply chain by sharing complementary knowledge and resources in order to efficiently use synergies for planning, deployment, operation follow-up and control". In vertical collaboration the main approaches are:

- Efficient consumer response in which the consumer satisfaction is maximized by improving the economic performance of different actors within the supply chain.
- Vendor managed inventory in which the supplier is jointly responsible for warehouse resupply on the basis of sales forecast.
- The shared CPFR (Collaborative planning, forecasting and replenishment) extends the collaborative approach to a consortium of producers and/or grouped distribution stakeholders that pool their sales and logistics information to optimize their common resources .[1]

Horizontal collaboration is defined as the collaboration between a group of stakeholders of different supply chains acting at the same levels and having analogous needs. The main types of horizontal collaborations are:

- Bilateral collaboration is defined as the collaboration between two peers of the distribution supply chain, i.e. between two stakeholders belonging to the same echelon of the chain.
- Collaboration of logistics networks which involves the collaboration of two or more stakeholders
- Collaboration of open e-marketplace platforms: this form of collaboration is based on an electronic information exchange system by which potential customers for logistics services use to meet potential providers

B. Collaboration Phases

Collaboration process is based on group reasoning and information sharing. It takes place at different echelons of the supply chain. The collaboration process takes place in different phases. The first collaboration phase involves direct transactions. Next is the informational collaboration phase which forms the basis of cooperation between stake holders. The final is the decisional collaboration phase in which decision making takes place at different levels based on partnership or cooperative agreements [2].

According to Crainic and Laporte (1997) and Baglin (2009) the levels of interaction can be classified as follows:

- Transactional collaboration which involves common coordination and standardization of administrative practices and exchange techniques, requiring information and communication systems.
- Informational collaboration which concerns with mutual exchange of information such as sales forecasts, stock levels and delivery dates.
- Decisional collaboration which concerns the different collaboration possibilities in planning and management decisions within logistics and transportation. These can be further classified as:
  - Operational planning related to daily operations that can be coordinated or shared, like freight transportation or cross-docking.
  - Tactical planning which is a middle-term planning stage involves several tactical decisions, like sales forecasts, shipping operational decisions, stock and production management and quality control.
  - Strategic planning which is the highest collaboration stage is related to long term planning decisions such as network design, facility location, finance and production planning.

III. Decisions making in Collaborative logistics

In logistics collaboration decision making is the critical process on which the entire collaborative process depends upon. The decision concerns with the choice from a set of possible strategies or solutions implemented for short, middle and long-term strategies. According to Crainic and Laporte 1997 , in short-term or daily horizons individual reasoning assumptions prevail over group reasoning in real time operations whereas in middle or long-term horizon group decision making can have strong influence on the development of a common strategy. The process of decision involves the collaboration of decision makers to find a common organizational solution. These decision-making processes need to take into account not only individual but also the group viewpoint. This led to the formation of group decision making or reasoning communities. A reasoning community can be defined as a group or community of individuals that engage in dialogue with each other in order to reason toward action [9].The reasoning process involves three main stages:

- Individual reasoning where each individual seeks evidence organizes it and ultimately establishes claims that represent his or her preferred position or beliefs.
- Communication of reasoning which describes the transmission of all aspects of individual and coalesced reasoning to others.
- Coalesced reasoning: this phase seeks to obtain an acceptable solution for the entire community.

A. *Decision support tools for logistics collaboration*

There is a large number of decision support tools available for MCDM (Multi-Criteria Decision Making) is being used for decision making. Decision making tools should not become a substitute but it would rather be used to support human choice making. The best way is to analyze both system and individual visions while taking decisions about collaborations alternatives. Group decision making algorithms or models are better in strategic collaborative logistics. The decision support system is to be chosen based on the type of logistics sharing [1]. The logistics sharing can be broadly classified as:

- Non-collaborative sharing where the shared resources are managed by users independently and there is no collaboration between users
- Collaborative sharing with hierarchical decision making in which shared resources are commonly managed by their users but main decision processes are hierarchical.
- Collaborative sharing with non-hierarchical decision making in which different users take part in the decision process.

Hierarchical decision process is based on centralized approaches of decision making in which one partner possesses all the power, whereas non-hierarchical processes are characterized by the establishment of collaborative processes with decentralized decision making. The establishment of collaborative decision making in non hierarchical process implies that all the network partners are autonomous; all decisional independent units are collaboratively involved in the management of the network processes and integrated with different degrees of collaboration. Involved partners equally enjoy power sharing and status, and no individual partner leads the network. This method can be used in the logistics collaboration of SME’s that play a major role in the manufacturing sector supply chain. [7] . In this paper the main concern is with the development of a decision making methodology for the collaboration of logistics with non-hierarchical decision making.

B. *Evidential Reasoning (ER) approach in MCDM*

The Evidential Reasoning (ER) approach is a method used for MCDM in areas which includes hierarchical and non-hierarchical conditions [3]. It uses an evidence-based process to reach a conclusion which differs from traditional MCDA methods. ER uses the concept of ‘degree of belief’ to elicit a decision-makers preferences. The degree of belief can be described as the degree of expectation that an alternative will yield an anticipated outcome on a particular criterion. It uses an extended decision matrix, in which each attribute of an alternative is described by a distributed assessment using a belief structure. Each belief structure in the belief decision matrix can be transformed into a basic probability assignment (BPA) by combining the relative weight of the criterion and the degrees of belief. Each BPA is viewed as a piece of evidence [6].

Suppose there is a decision making problem with M alternatives, A_i where (i=1, …, M), to choose from and N criteria, C_j (j=1, …, N), to consider. The table-1 illustrates the extended decision matrix.

Table-1

	C_1	C_2	C_3	…………	C_n
A_1	$S(A_1(C_1))$				
A_2					
. . . .					
A_m					

The assessment of each alternative according to different criteria is to be conducted using K evaluation grades $G = \{G_1, G_2, G_3,…, G_K\}$. These grades are to be deployed in each cell of the decision matrix to provide the distributed assessments. Hence, the assessment of the alternative A_1 on a criterion C_1 can be represented using the following belief structure:

$$S (A_1(C_1)) = \{(b_{11},G_1), (b_{12},G_2), (b_{13},G_3),…, (b_{1K},G_K)\}$$

Where b_{11}, b_{12},b_{13},…, b_{1K} are the degrees of belief that the alternative A_1 is assessed to the evaluation grades G_1, G_2, G_3,…, G_K when considering the criterion C_1. These evaluation grades could be defined, for instance, as: Slightly preferred, moderately preferred, Preferred and greatly preferred. The degrees of belief are expressed by the decision maker and the value of each of them falls in the range between 0 and 1. The notion of extended decision matrix can be used for the purpose of deciding the collaborative criterion in logistics [3].

IV. Factors Influencing Collaborative logistics

Resource sharing is the major concern in logistics collaboration. The decision making process can be done successfully after listing the major resources of logistics. They can be broadly classified as:

- Information
- Infrastructure
- Planning and Management tools
- Transportation
- Human resources

Information resources are POS (Point of sale) data, order information, inventory information, forecast information, demand information and customer order information. Infrastructure resources include warehouse, Transport centers, Air cargo centers and Container depots. Planning and management tools commonly used are transport management system (TMS), Warehouse management system (WMS) ,Enterprise resource planning (ERP),Customer relationship management (CRM),Supplier Relationship management (SRM) and Supply chain planning integration and analysis (SCPIA). Transport facilities include vehicles on road, rail, water and air. Finally human resources involve truck drivers, supervisors, warehouse managers etc.

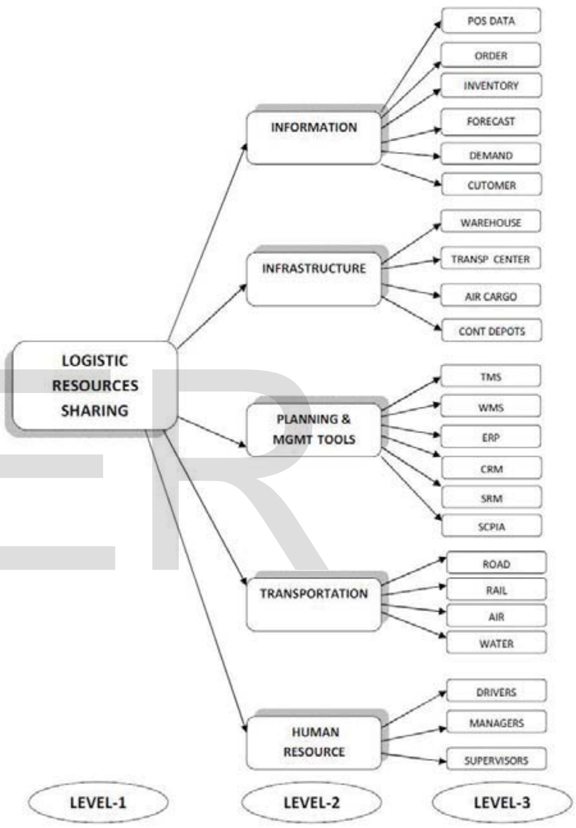

Fig -1 Evaluation criteria for decision

V. ER Methodology For Logistics Collaboration

The ER algorithm developed based on an evaluation analysis model and the evidence combination rule of the Dempster-Shafer (D-S) theory , which is well-suited for handling incomplete uncertainty [6]. The main strength of this approach is that it can handle uncertainties associated with quantitative and qualitative data, related to MCDM problems. The first step in a decision support system is to acquire information and to represent in the appropriate level. This approach employs belief structure to acquire knowledge and the appropriate information should be selected to feed the ER algorithm. Let 'logistic resource sharing' (S) be an attribute at level 1 as shown in fig 1 which is to be assessed for an alternative (A) (say decision on logistic sharing) and this assessment can be denoted as A(S). This is to be evaluated based on a set of w_i sub-attributes (such as information, infrastructure, planning tools, transport and human resource) at level 2, denoted by: $S = \{ w_1, w_2, w_3 \ldots \ldots . w_i, \ldots \ldots w_n\}$. Logistics resource sharing (S) can be assessed by using a set of evaluation grades such as: slightly preferred (H_1), moderately preferred (H_2), preferred (H_3) and greatly preferred (H_4) and this set can be written as: $H = \{H_{1,} H_{2\,,} H_{3\,,\ldots\ldots,} H_n, n = 1,2, \ldots \ldots N\}$. These evaluation grades are mutually exclusive and collectively exhaustive. A degree of belief is associated with each evaluation grade, which is denoted by $\{(H_{n,}, \beta_n), n = 1,2, \ldots \ldots N\}$, hence A(S)= $\{H_{n,}, \beta_n), n = 1,2, \ldots \ldots N\}$ denotes that the top attribute S is assessed to grade H_n with the degree of belief β_n. In this assessment, it is required that $\beta_n \geq 0$ and $\sum_{n=1}^{N} \beta_n \leq 1$. If $\sum_{n=1}^{N} \beta_n = 1$ the assessment is said to be complete and if it is less than one then the assessment is considered as incomplete. If $\sum_{n=1}^{N} \beta_n = 0$. then the assessment stands for complete ignorance. In the same way, sub-attribute w_i is assessed to grade H_n with the degree belief $\beta_{n,i}$ and this assessment can be represented as $\{A(w_i = (H_{n,}, \beta_{n,i}), n = 1,2, \ldots \ldots N \text{ and } i = 1,2, \ldots . . n\}$, such that $\beta_{n,i} \geq 0$ and $\sum_{n=1}^{N} \beta_n \leq 1$. The incompleteness as mentioned occurs due to ignorance, meaning that belief degree has not been assigned to any specific evaluation grade and this can be represented using the equation as given below :

$\beta_H = 1 - \sum_{n=1}^{N} \beta_n$. Where β_H is the belief degree unassigned to any specific grade. If the value of β_H is zero then it can argued that there is an of ignorance or incompleteness. If the value of β_H is is greater than zero then it can be inferred that there exists ignorance or incompleteness in the assessment. It is also necessary to distribute the degree of belief between evaluation grades for certain quantitative input data. It is important to know with what degree of belief an attribute is greatly preferred and with what degree of belief it is slightly preferred. This can be calculated with the following formula.

$$\beta_{n,i} = \frac{h_{n+1} - h}{h_{n+1,i} - h_{n,i}}, \beta_{n+1,i} = 1 - \beta_{n,i} \text{ if } h_{n,i} \leq h \leq h_{n+1,i}$$

Here, the degree of belief $\beta_{n,i}$ is associated with evaluation grade slightly preferred while β_{n+1} is associated with the upper level evaluation grade greatly preferred.

VI. Conclusion

The ER methodology used in this context gives a methodology for assessment of various factors influencing collaboration in logistics. Moreover this method of non hierarchical decision making is most suitable for SME's where nobody plays a leadership role and each of the members can enjoy the power sharing status and benefits equally. This is only the first phase of the work and the future work involves the actual study of these factors from the industry. Once the actual factors are found then the next phase includes weight normalization of the factors, basic probability assignment, attribute aggregation, combined degree of belief calculation, utility function and finally ranking of the factors for implementation.

References

[1] Jesus Gonzalez-Feliu , Joëlle Morana , Josep-Maria Salanova Grau , Tai-Yu Ma, "Design and scenario assessment for collaborative logistics and freight transport systems," International Journal of Transport Economics (2013) 207-240"

[2] Jesus Gonzalez-Feliu , Joëlle Morana , "Collaborative transportation sharing : from theory to practise via a case study from france," Technologies for Supporting Reasoning Communities and Collaborative Decision Making:Cooperative Approaches (2011) 252-271

[3] Dr. Ling Xu & Dr. Jian-Bo Yang, "Introduction to Multi-Criteria Decision Making and the Evidential Reasoning Approach" 2001

[4] Mark Velasquez1 and Patrick T. Hester , "An Analysis of Multi-Criteria Decision Making Methods," International Journal of Operations Research Vol. 10, No. 2, 56□66 (2013).

[5] Crainic, T.G., Laporte, G. (1997), Planning models for freight transportation, European Journal of Operational Research, Vol. 97, pp. 409-438.

[6] A. Taroun and J. B. Yang. "Dempster-Shafer theory of evidence: potential usage for decision making and risk analysis in construction project management." Journal of the Built and Human Environment Review 4, no. 1(2011) : 155-166 .

[7] Beatriz Andrés and Raul Poler. "Analysis of Collaborative Processes in Non-Hierarchical Business Networks" .5th International Conference on Industrial Engineering and Industrial Management September 7- 9, 2011

[8] Simchi-Levi, D., P. Kaminsky and E. Simchi-Levi. 2000. "Designing and Managing the Supply Chain", pp. 15–165.New Delhi: Irwin McGraw-Hill Companies.

[9] JL Yearwood, A Stranieri 2006, "The generic/actual argument model of practical reasoning."Decision Support Systems 41 (2), 358-379.