AN APPLICATION OF THE ANALYTIC NETWORK PROCESS TO EVALUATE SUPPLY CHAIN LOGISTICS STRATEGIES

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ABSTRACT

The purpose of this work is to describe an application of the Analytic Network Process (ANP) method to model the influence of various factors on supply chain logistics strategic decision making in competitive business environment. Logistics plays an increasingly important strategic role for organizations that strive to keep pace with market changes and supply chain integration. Logistics and supply chain management are currently evolving due to external factors such as strategic alliances, technological changes, cycle time compression and an increasingly competitive environment. The present model is flexible enough to structure this complexity by evaluating logistics strategic strategies by utilizing a systemic multi-attribute analytical technique. This paper explores and illustrates an analytical framework in a real life environment to assess an organization's logistics strategy and challenges with varying levels of success.

Keywords: Multiple Criteria Decision Making, Analytical Network Process, Logistics Strategy, Supply Chain Management, e-procurement

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1. Introduction

SCM involves coordinating and managing all the activities from raw materials procurement to the delivery of the final product to customers by the efficient use of IT/IS. The aim of SCM is to globally optimize material and information flows in SC by horizontal integration between companies within SC and vertical integration of existing business processes in each company (Nakagawa and Sekitani, 2004). Supply chain logistics plays an increasingly important strategic role for organizations that strive to keep pace with market changes and supply chain integration. Traditionally, supply management and logistics have been delegated to operational level personnel in purchasing and distribution departments (Mead and Sarkis, 2001). Logistics and supply management are currently evolving due to external factors such as strategic alliances, technological changes, cycle time compression and an increasingly competitive environment. A framework for logistics research includes strategy, structure, and performance. Strategy can be defined as plans to meet relatively long-term organizational objectives that have broad corporate functional implications. (Begicevic et al.,2006), These developments explain how a successful logistics strategy has moved from an internal focus emphasizing integration with other enterprise functions, such as production and marketing, with a linkage to the overall corporate strategy, to an external focus of integrating supply chains and cycle time compression (Mead and Sarkis, 2001). The complexity of logistics strategic decisions and choices has increased with the number of dimensions that need to be considered.

In order to attain the aim of SCM, managers within SC need to make strategic decisions for supplier selection, buying strategies, capital equipment purchasing, supplier performance evaluation, long-term partnerships between buyers and suppliers, effective purchasing and distribution etc. These are usually ambiguous and unstructured problems that include both tangible and intangible factors involving complicated criteria with interdependent relationships (Korpelaa et al., 2001). A desirable methodology for such managerial issues is to allow for the synthesis of these factors and to help managers to structure the decision making problem. Analytic Hierarchy Process (AHP) and its extension, Analytic Network Process (ANP) are systematic approaches that can deal with both quantitative and qualitative factors under multiple criteria (Saaty, 1994). It is widely known that AHP and ANP are practical tools of multiple criteria decision analysis. Many applications and case-studies using AHP and ANP are reported in various fields of business and industry (Wind and Saaty, 1980 and Zahedi, 1986).

AHP in SCM has been a popular approach for supplier selection (Barbarosoglu et al., 1997 and Çebi et al., 2003**)**, the design of supply chain networks (Cakravastia et al., 2002 and Min et al., 1999**),** and supplier performance evaluation (Fung et al., 2001**)**. ANP is also applied to the same type of problems on SCM as AHP (Sarkis and Sundar Raj, 2002) because ANP allows for the network structure modeling including all AHP models. The network modeling capability adds ANP with new applications to SCM such as the strategic decision analysis of a long-term partnership within SC (Sarkis, 1997**)**. AHP, the origin of ANP, sometimes provides an irrational ranking of the details and this is called rank reversal phenomenon. By exploiting the network modeling effectively, ANP may mitigate the possibility of rank reversal phenomenon (Schenkerman, 1994).

The ANP model has been used in the exercise to structure this complexity by evaluating logistics strategic strategies by utilizing a systemic multi-attribute analytical technique. Part of the difficulty in analytically modeling strategic decisions is their basis in quantitative and qualitative information with multiple dimensions. A quantitative model that can be used to integrate qualitative information and quantitative values and analysis is the Analytic Hierarchy Process (AHP), but a primary limitation is that its basic relationships do not allow for an integrated dynamic modeling of the environment. AHP assumes the system elements are uncorrelated and are singly directionally influenced by a hierarchical relationship. A more general evaluation approach defined as the Analytic Network Process (ANP) or system- with- feedback approach may be used to assess a dynamic multi-directional relationship among decision attributes. The ANP approach is a non-linear, network relationship among various factors. (Saaty, 2001).

The present work is part of a consultancy project done by the authors for a telecom company of north India. In this project we provided support in the area of inbound logistics of the supply chain to the company. The company has a good number of overseas suppliers, and the lead time is very long. Therefore, a huge inventory is necessary to maintain product flow in the supply chain. We recommended to the company to utilize full e-procurement for essential raw materials. For ANP analysis a team was constituted including the following experts: Vice President (Marketing), Vice President (PPC), Vice President (SCM), and the authors. All the pairwise comparisons were done by this team. For decision modeling ANP is preferred due to interdependence of factors in the model. The chance for fraud is very high in-online procurement, so, the company wanted to make this strategic decision by considering all the aspects. Now, the company has developed a group of online purchasing suppliers. They have also sorted out the problem of high lead time, and developed long term, trusting relationships with suppliers and are doing business successfully. The main domain covered by this paper is inbound logistics of supply chain.

2. A logistics framework for supply chain coordination and integration

According to strategic alignment models, the success of organizational strategy is dependent upon the strategy and adopted technology, practices or systems. Understanding and measuring the dynamic nature of logistics will make an organization more competitive. As products advance through the cycle of integration, rapid growth, maturity, and decline, a different logistic configuration may be more economical. The framework for improving inbound logistics and good manufacturer supplier relationship is shown in Figure 1. The overall objective of the model is to determine the optimum strategic logistics system or alternative for XYZ Ltd. based on logistics strategy, and make the relationships flexible enough to meets the changing customer needs. In the end the various systems being considered will be weighted, and the one that ranks the highest will be suggested. The logistics system is evaluated on three different levels (or clusters); the supply chain/organizational relationship involved, the principles of logistics required, and the attributes of principles of logistics.

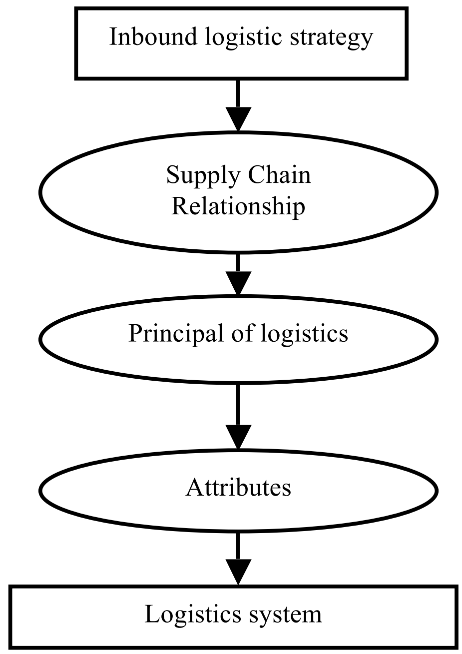

Figure 1 Framework for logistics strategic analysis (Jayant, 2002)

Figure 2 shows the framework in a representation conducive to ANP. As can be seen the current procurement system (C.P.S) is compared to two other alternatives i.e., partial e-procurement (P.E.P) system and full e-procurement (F.E.P), for maintaining competitive logistics strategy and good relations. The end result of the model indicates the system which best meets the needs of the decision maker based on interaction between the three different levels. Figure 3 represents a super matrix relationship for the ANP network model.

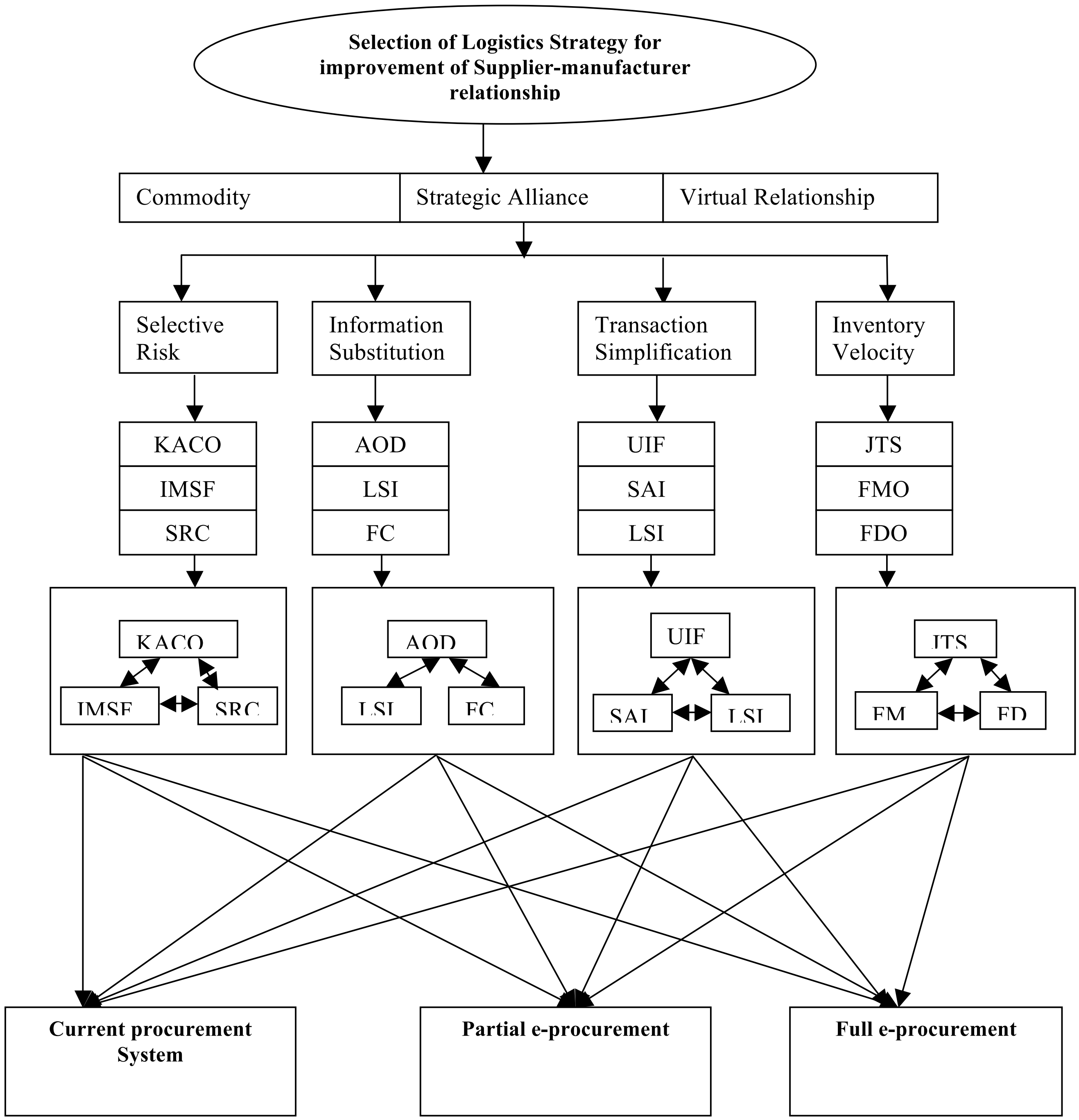

Figure 2.ANP Frame work for representations of relationships for the logistics strategic analysis

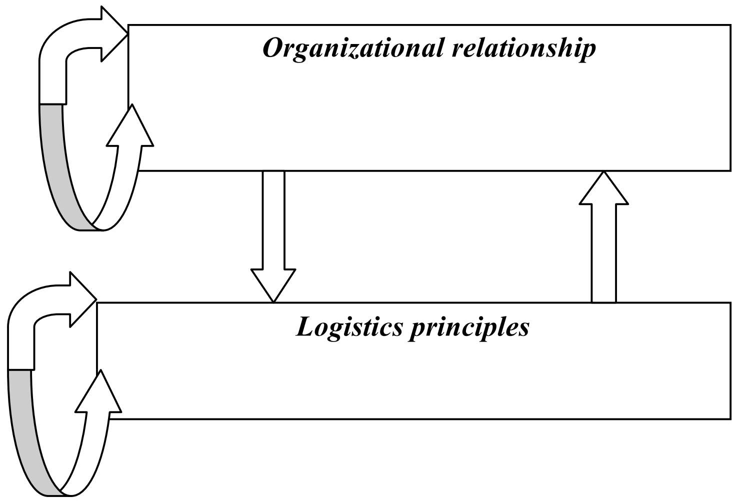

Figure 3 Network model for super matrix relationship

3. Reputation systems (differential alternatives)

3.1 Current procurement system

In the current procurement system transactions are analyzed as repeated games. When business entities engage in repeated transactions in a market, they need to be concerned about their reputation. The reputation ideally should serve as an effective enforcement measure for honest behavior. The enforcement comes from the idea that dishonest behavior against one agent causes sanctions or retaliations by other agents in the same market. At present, the company is using a traditional method of purchasing the materials from the different suppliers. They keep a list of multiple vendors for the same items because they do not want to risk that materials will be unavailable. In the current system the vendors are not connected through the Internet, rather information is shared on the phone or by courier services. The company simply places the order to the vendors by couriers and receives confirmation on the phone. Limitations of the current system include lack of collaborative planning, lack of flexibility, and the chance of fraud and poor service.

3.2 Partial e-procurement system

Partial e-procurement means the supplier and manufacturer are not connected through the Internet directly, but they can mail each other and access limited information about each other through opening the company's website. Neither party is connected through the cyber-mediary. The manufacturer cannot check the status of the pending order with the supplier, and the supplier cannot access the information related to the company's product demand, product type or the new product launch in advance so that he can plan production and schedule as needed. In this type of relationship the chance of fraud is greater because neither party is connected through any community or e-procurement portal.

3.3 Full e-procurement system

Web-based procurement is already becoming a must-do for companies with progressive approaches to maintenance, repair and operations (MRO) purchasing. The full e-procurement involves applying software technologies that have some of the highest return-on-investment. Full e-procurement systems identify supplier rationalization opportunity by analyzing supplier spending for a commodity. To purchase a product or service, an end user browses a web-based catalog. The user selects items, and these items along with company specific pricing are passed back to the e-procurement system "shopping cart". When the cart is checked out, any needed approvals are processed using web-based workflows, e-mails and extranet access. The approvals are based on user or cost-center limits, at the order level or in aggregate. Upon approval, the shopping cart is turned into a purchase requisition or PO in the back-office purchasing system. Vendors that are paid via terms usually receive an electronic funds transfer at pre-specified times (Gilbert, 2000).The most advanced MRO procurement solutions available today are Internet-based, and offer improved requisition-to-payment efficiencies, reduced maverick buying with electronic catalogs, sell-side system integration, Internet-based procurement holds the potential to dramatically reengineer and improve purchase-to-order processes for indirect goods and services.

4. Supply chain relationship/organizational relationships

The organization needs to determine what type of supply chain relationship strategy will help it achieve its greatest competitive advantage. Supply chain strategy level is a dynamic environment where various choices exist. Supply chain strategy includes a continuum extending from commodity providers to virtual enterprise membership. Commodity, strategic alliances and virtual enterprises from a spectrum of relationships that may exist among enterprises, with the relations of the inter-enterprise business processes become more unified and integrated along this spectrum. The strategic alignment of an organization's logistic network needs to be synchronized with the demands of the competitive environment. An enterprise that fails to respond to the environmental demands is placed at a disadvantage relative to competitive firms. We have chosen three types of relationships to discuss. These relationships are commodity relationships, strategic alliances and virtual relationships (Mead and Sarkis, 2001). Commodity relationships among enterprises focus on customers choosing suppliers based on price, quality, and reliability. The relevant business processes will be sparsely linked compared with the linkages to be found at the virtual relationship end of the spectrum, and financial/legal relationships will be less strongly coupled. The goal of a strategic alliance is to provide benefits to all sides of the relationship. The tangible benefits include cost and time reductions, whereas intangible benefits of partnering include flexibility and customer satisfaction.

5. The principles of logistics and principles of attributes

The principles of logistics provide a foundation for consistent evaluation of logistics activities and strategies. Logistics principles are defined with attributes for management of these principles. These attributes, which form the third level within the analysis framework, are based on expert opinion and literature. Table 1 is a summary of the four principles of logistics along with the supporting attributes for their effective management.

5.1 Principle of selective risk

With the growth and implementation of information systems, information is abundant. However, the logistics manager needs to determine how the logistics systems are designed, implemented and managed in order to provide the appropriate information at the appropriate time. The principle of selective risk's objective is to design logistics systems so that performance is directly related to the importance of the product or customer of the enterprise. Logistics strategies are based on the level of service desired for a specific customer. Detailed knowledge about the customer is necessary in order to implement this principle. Attributes of processes and systems for aiding in the management of selective risk, may include knowledge about customers (KACO) (e.g. sales, length of time as customer), knowledge about competition (KACO), and range of service capabilities of logistics system (SRC).

Table1
Principles of logistics and attributes of systems for management of logistics principles

Principles of logistics (Mead and Sarkis, 2001)	**Attributes for management of logistics principles** (Mead and Sarkis, 2001)
Selective Risk (S.R)	Knowledge about competition (KACO) Service range capabilities (SRC) Inventory management system flexibility (IMSF)
Information substitution (I.S.)	Accuracy of data (AOD) Level of system integration (LSI) Forecasting capabilities (FC)
Transaction simplification (T.S.)	User-interface friendliness (UIF) Level of system integration (LSI) Supplier access to information (SAI)
Inventory velocity (I.V.)	Just-in-time support (JTS) Flexible manufacturing operation (FMO) Flexible distribution options (FDO)

5.2 Principle of transactional simplification

Procurement logistics has been occupied with numerous operational transactions such as order entry, order fulfillment, and order delivery. The objective of the transaction simplification principle is to improve the efficiency and effectiveness of the transactional processes of the parties. This principle can be executed from both a technical and managerial perspective. Three attributes for effective management of the principles of transactional simplification have been selected. The first attribute is user-interface friendliness (UIF). This is created by a long term relationship, which helps to create mutual understanding hence simplification of the procedure. The second, attribute is the level of system integration (LSI), and the third is supplier access to operational information (SAI).

5.3 Principle of information substitution

The principle of information substitution is based on the fact that the cost of information is less than other resources. Some attributes that will aid in effectively managing information substitution include the amount of coverage of information linkages, accuracy of data (AOD), level of systems integration and forecasting capabilities (FC).

5.4 Principle of inventory velocity

The logistics role of facilitating the flow of inventory from raw materials to end-user serves as the basis of the principle of inventory velocity. Inventory velocity is not new to logistics. Quick Response (QR), a business strategy developed in1989 to shorten the time for production and distribution, and reduce inventory throughout the supply chain directly impacts the inventory velocity principle. Attributes of the processes and systems, which aid in managing the inventory velocity principal, include just-in –time (JTS) support mechanisms, flexible manufacturing operation (FMO), and flexible distribution option (FDO) (cross-docking capabilities).

6. ANP analysis and solution methodology

The framework is presented through a network of decision model relationships. The levels of the network framework include the supply chain relationships, the principles of logistic level, the attributes level, and alternative selection level. These levels impact the overall goal of maintaining a competitive logistics strategy. The components of the organizational relationship are commodity, strategic alliances and virtual relationship. The principles level contains the four principles of logistics discussed earlier. The attributes level is composed of the components, which help to monitor, deploy and manage the principle (Jayant, 2002). Three logistics systems (alternatives) are considered. They are the current procurement system (C.P.S.) i.e. current system, partial e-procurement (P.E.P) and full e-procurement (F.E.P). The goal of this model is to select the most appropriate logistics system for a given enterprise operating to improve inbound logistics, good relationships, reduce fraud and enhance competitive logistics strategy.

Step 1: Model construction and problem structuring: The first step is to construct a model to be evaluated. We will use the model that was summarized in Figure 2. The relevant criteria and alternatives are structured in the form of a hierarchy where the higher the level, the more 'strategic' the decision. The top-most elements are decomposed into sub-components and attributes. The model development requires the development of attributes at each level and a definition of their relationships.

Steps 2: Pairwise comparisons matrices between component and levels: The pairwise comparisons of the elements in each level are conducted with respect to their relative importance towards their control criterion. A scale of 1 to 9 have been used when comparing two components, with a score of 1 representing indifference between the two components, and 9 being overwhelming dominance of the component under consideration (raw component) over the comparison component (column component). If a component has some level of weaker impact the range of scores will be from 1 to 1/9, where 1 represents indifference, and 1/9 being an overwhelming dominance by a column element over the row element. When scoring is conducted for a pair, a reciprocal value is automatically assigned to the reverse comparison within the matrix. That is, if a_{ij} is a matrix value assigned to the relationship of component I to components j then a_{ij} are equal to $1/a_{ij}$. A pairwise comparison matrix is required for each of the organizational relationships for calculation of the impact of each of the logistics principles. After ircompleting the pairwise comparisons, the local priority vector w is calculated. Here a two-stage algorithm that involves forming a new $^{n}C_{n}$ matrix by dividing each element in a column by the sum of the column elements, and then summing the elements in each row of the resultant matrix and dividing by the n elements in the row. This is referred to as the process of averaging over normalized columns. This is represented as:

$$W_i = \sum_{I=1} \{a_{ij} / \sum_{i=1} a_{ij}\} / J \qquad (1)$$

Where:
W_i = the weighted priority for component I
J= index number of columns (components)
I = Index number of rows (components)

The first step includes the calculation of relative importance weights between principles of logistics for each relationship. We have to make one matrix each for the three relationships. The relative weights are expressed as P_{ij} (that is for i^{th} relationship and j^{th} principle of logistic). These have been calculated using Equation 1. This has been shown in the Table 2 where comparison has been done for commodity. The selective risk logistic gets 1 when compared with the same, and it has been allotted 3 when compared with transactional simplification because the selective risk knowledge information is more important i.e. if we go for a company with low transactional cost but a reputation that is not good in the market then the ultimate output will be that buyer will be cheated. So S.R. has been weighted higher than T.S. The comparisons have been done for all the three relationships in the same manner. (ii) For each proposed relationship, considering that relationship and one principle of logistics, the pairwise comparison has been done in all the attributes of that logistic. Thus for each relationship we have done four such comparisons as we have chosen four logistics, and over all we have done twelve such comparisons. After comparison, weights are calculated using Equation 1 for commodity, strategic alliance and virtual relationship. The relative importance weights are shown as Q_{ijk} in desirability index matrix i.e. weight for i^{th} relationship, j^{th} logistics and k^{th} attribute.

Steps 3: Pairwise comparison matrices of interdependencies: Here pairwise comparison for interdependencies between the attributes have been done considering the impact of one attribute over another for each particular relationship picking up one principle of logistics at a time. Thus for each relationship, three comparison matrices have to be calculated for each logistics principle. Therefore for each relationship we get twelve such matrices and over all thirty-six such matrices for the complete system. The weights are calculated using Equation 1. A sample matrix is shown in the Table number 2-6 for commodity; similar matrices are developed for strategic alliance and virtual relationship.

Step 4: Super matrix formulation and analysis: Table 19 shows a super matrix for commodity before convergence detailing the results of relative importance measures for each of the attribute enabler for commodity. Since there are twelve pairwise comparisons matrices, there will be twelve non-zero sub columns in the super matrix before convergence. Each of the non-zero values in the column in super matrix four is the relative importance weight associated with interdependency pairwise comparison matrix. Similar super matrices are developed for strategic alliance and virtual relationship. Thus, we get three such matrices before convergence for each relationship. The elements of ANP system may interact along many paths. For the measurement of priorities to be meaningful, uniformity is necessary when considering all paths of the network. The super matrix conversion helps to evaluate this framework and get stable values in the matrix to be used in calculation of the desirability index. The super matrix after convergence allows a resolution of the effects of interdependence that exists between the elements of the system. The super matrix before convergence is a portioned matrix, where each sub matrix is composed of a set of relationships between two levels. Therefore, super matrices before convergence are converged for getting long-term stable term of weight. For this, the power of super matrix before convergence is raised to an arbitrary large number. Here convergence has reached at 35^{th} power. Table 20 shows the values after convergence for commodity. Similar analyses are done for strategic alliance and virtual relationship. These values are shown in the desirability index table as R^{ijk} i.e. value of relative importance for i^{th} relationship j^{th} logistics and k^{th} attribute.

For Commodity

Table 2
Pairwise comparison matrix between principles of logistics for commodity

Commodity	S.R	I.S	T.S	I.V	Weight
S.R	1	5	3	4	0.45
I.S	0.2	1	2	4	0.20
T.S	0.33	0.5	1	2	0.13
I.V	0.25	0.25	0.5	1	0.22

Table 3
Pairwise comparison matrix between attributes for commodity and S.R

Commodity				
S.R	KACO	IMSF	SRC	Weight
KACO	1	0.25	0.25	0.12
IMSF	4	1	4	0.63
SRC	4	0.25	1	0.25

Table 4
Pairwise comparison matrix between attributes for commodity and I.S.

Commodity				
I.S	AOD	LSI	FC	Weight
AOD	1	4	2	0.54
LSI	0.25	1	0.25	0.12
FC	0.5	4	1	0.34

Table 5
Pairwise comparison matrix between attributes for commodity and T.S.

Commodity				
T.S	UIF	SAI	LSI	Weight
UIF	1	2	4	0.55
SAI	0.5	1	3	0.39
LSI	0.25	0.33	1	0.16

Table 6
Pairwise comparison matrix between attributes for commodity and I.V.

Commodity				
I.V	JTS	FMO	FDO	Weight
JTS	1	0.33	0.25	0.12
FMO	3	1	5	0.25
FDO	4	0.2	1	0.63

Attributes pairwise comparison

Table 7
Pairwise comparison matrix for interdependencies between the attributes for commodity and S.R.

Commodity and S.R			
KACO	IMSF	SRC	Weight
IMSF	1	4	0.8
SRC	0.25	1	0.2

Table.8
Pairwise comparison matrix for interdependencies between the attributes for commodity and S.R.

Commodity and S.R			
IMSF	KACO	SRC	Weight
KACO	1	4	0.75
SRC	0.25	1	0.25

Table 9
Pairwise comparison matrix for interdependencies between the attributes for commodity and S.R.

Commodity and S.R			
SRC	IMSF	KACO	Weight
IMSF	1	0.25	0.2
KACO	4	1	0.8

Table 10
Pairwise comparison matrix for interdependencies between the attributes for commodity and I.S.

Commodity and I.S			
AOD	LSI	FC	Weight
LSI	1	0.25	0.2
FC	4	1	0.8

Table 11
Pairwise comparison matrix for interdependencies between the attributes for commodity and I.S.

Commodity and I.S			
LSI	AOD	FC	Weight
AOD	1	7	0.85
FC	0.14	1	0.15

Table 12
Pairwise comparison matrix for interdependencies between the attributes for commodity and I.S.

Commodity and I.S			
FC	LSI	AOD	Weight
LSI	1	0.5	0.67
AOD	0.5	1	0.33

Table 13
Pairwise comparison matrix for interdependencies between the attributes for commodity and T.S.

Commodity and T.S			
UIF	SAI	LSI	Weight

SAI	1	0.25	0.2
LSI	4	1	0.8

Table 14
Pairwise comparison matrix for interdependencies between the attributes for commodity and T.S

Commodity and T.S			
SAI	LSI	UIF	Weight
LSI	1	3	0.75
UIF	0.33	1	0.25

Table 15
Pairwise comparison matrix for interdependencies between the attributes for commodity and T.S

Commodity and T.S			
LSI	UIF	SAI	Weight
UIF	1	5	0.84
SAI	0.2	1	0.16

Table 16
Pairwise comparison matrix for interdependencies between the attributes for commodity and I.V

Commodity and I.V			
JTS	FMO	FDO	Weight
FMO	1	0.2	0.16
FDO	5	1	0.84

Table 17
Pairwise comparison matrix for interdependencies between the attributes for commodity and I.V

Commodity and I.V			
FMO	JTS	FDO	Weight
JTS	1	4	0.8
FDO	0.25	1	0.2

Table 18
Pairwise comparison matrix for interdependencies between the attributes for commodity and I.V.

Commodity and I.V			
FDO	FMO	JTS	Weight

FMO	1	0.33	0.25
JTS	3	1	0.75

Table 19
Super matrix for commodity before conversion

Commodity	KACO	IMSF	SRC	AOD	LSI	FC	UIF	SAI	LSI	JTS	FMO	FDO
KACO	0	0.75	0.8	0	0	0	0	0	0	0	0	0
IMSF	0.8	0	0.2	0	0	0	0	0	0	0	0	0
SRC	0.2	0.25	0	0	0	0	0	0	0	0	0	0
AOD	0	0	0	0	0.85	0.33	0	0	0	0	0	0
LSI	0	0	0	0.2	0	0.67	0	0	0	0	0	0
FC	0	0	0	0.8	0.15	0	0	0	0	0	0	0
UIF	0	0	0	0	0	0	0	0.25	0.84	0	0	0
SAI	0	0	0	0	0	0	0.2	0	0.16	0	0	0
LSI	0	0	0	0	0	0	0.8	0.75	0	0	0	0
JTS	0	0	0	0	0	0	0	0	0	0	0.8	0.75
FMO	0	0	0	0	0	0	0	0	0	0.16	0	0.25
FDO	0	0	0	0	0	0	0	0	0	0.84	0.2	0

Table 20
Super matrix convergences to 'long term' weights at M^{35} for commodity

Commodity	KACO	IMSF	SRC	AOD	LSI	FC	UIF	SAI	LSI	JTS	FMO	FDO
KACO	0.43	0.43	0.43	0	0	0	0	0	0	0	0	0
IMSF	0.38	0.38	0.38	0	0	0	0	0	0	0	0	0
SRC	0.18	0.18	0.18	0	0	0	0	0	0	0	0	0
AOD	0	0	0	0.36	0.36	0.36	0	0	0	0	0	0
LSI	0	0	0	0.29	0.29	0.29	0	0	0	0	0	0
FC	0	0	0	0.33	0.33	0.33	0	0	0	0	0	0
UIF	0	0	0	0	0	0	0.4	0.4	0.4	0	0	0
SAI	0	0	0	0	0	0	0.15	0.15	0.15	0	0	0
LSI	0	0	0	0	0	0	0.44	0.44	0.44	0	0	0
JTS	0	0	0	0	0	0	0	0	0	0.43	0.43	0.43
FMO	0	0	0	0	0	0	0	0	0	0.16	0.16	0.16
FDO	0	0	0	0		0	0	0	0	0.39	0.39	0.39

Step 5: Pairwise comparison for different alternatives: In this step the pairwise comparison between different alternatives is done for each relationship considering each logistics principle at a time. In this we get four such matrices for each relationship and overall twelve matrices. Weights calculated are shown in a sample matrix in Table 21. The values being shown in the desirability index matrix as S_{ij1} i.e. Relative importance weight for i^{th} relationship j^{th} logistics and 1th alternative. The two-way arrow in the

Figure 3 shows an interdependence of organizational relationship and principles of logistics.

Table 21
The pairwise comparison between different alternatives for commodity and S.R

Commodity and S.R	C.P.S	P.E.P	F.E.P	Weight
C.P.S	1	0.33	0.166	0.09
P.E.P	3	1	0.5	0.25
F.E.P	6	2	1	0.66
	CR=0.675			

Step 6: Selection of best alternative: The selection of the best alternative depends on the calculation of the 'desirability index' for an alternative k^{th}. The equation for this is defined by:

$$\mathbf{D_{i1} = \sum_{j=1}^{3} \sum_{k=1}^{3} P_{ij} Q_{ijk} R_{ijk} S_{ij1}} \qquad (2)$$

Where,
D_{i1} = desirability index for i^{th} relationship considering 1^{st} alternative
P_{ij} = Relative importance weight for j^{th} principle of logistic considering i^{th} relationship
Q_{ijk} = relative importance weight between attributes for k^{th} attribute considering $i^{th.}$
R_{ijk} = Relative importance weight for k^{th} attribute considering i^{th} relationship j^{th} logistics & k^{th} attribute (For interdependencies)
S_{ij1} = Relative importance weight for 1^{st} alternative considering i^{th} relationship & j^{th} logistics and 1^{th} alternative

Table 22
Desirability index for different alternatives for commodity

Com-modity	Pij	Attri-butes	Qijk	Rijk		SijI	SijI	SijI	C.P.S	P.E.P	F.E.P
	1		2	3	4= 1x2x3	5	6	7	8=4x5	9=4x6	10=4x7
S.R	0.5	KACO	0.12	0.43	0.026	0.09	0.25	0.66	0.002	0.00645	0.017
S.R	0.5	IMSF	0.63	0.38	0.120	0.09	0.25	0.66	0.011	0.02993	0.079
S.R	0.5	SRC	0.25	0.18	0.023	0.09	0.25	0.66	0.002	0.00563	0.015
I.S	0.2	AOD	0.54	0.36	0.039	0.11	0.31	0.56	0.004	0.01205	0.022
I.S	0.2	LSI	0.12	0.29	0.007	0.11	0.31	0.56	0.001	0.00216	0.004
I.S	0.2	FC	0.34	0.33	0.022	0.11	0.31	0.56	0.002	0.00696	0.013
T.S	0.14	UIF	0.55	0.4	0.031	0.1	0.3	0.6	0.003	0.00924	0.018
T.S	0.14	SAI	0.39	0.15	0.008	0.1	0.3	0.6	0.001	0.00246	0.005
T.S	0.14	LSI	0.16	0.44	0.010	0.1	0.3	0.6	0.001	0.00296	0.006
I.V	0.16	JTS	0.12	0.43	0.008	0.16	0.24	0.6	0.001	0.00198	0.005
I.V	0.16	FMO	0.25	0.16	0.006	0.16	0.24	0.6	0.001	0.00154	0.004
I.V	0.16	FDO	0.63	0.39	0.039	0.16	0.24	0.6	0.006	0.00943	0.024
SUM									D11= 0.036	D12= 0.09077	D13= 0.211

Step 7: Relative importance weights for the relationship: The pairwise comparison matrix between relationships is calculated by the pairwise comparison between different relationships and the value calculated is shown in Table 23. The results show that commodity is most important relationship for supplier-manufacturer relationship with a value of 0.54.

Table 23
The pairwise comparison matrix between different supply chain relationships

	Commodity	Strategic alliance	Virtual relationship	Weight
Commodity	1	3	3	0.54
Strategic alliance	0.33	1	6	0.35
Virtual relationship	0.33	0.166	1	0.11
	CR=0.0373			

Step 8: Calculation of trust performance weighted index: Table 27 shows the values of trust performance weighted index. The values of the desirability index

calculated for different alternatives are given in the Appendix for different relationships (Tables 24, 25, 26). They are multiplied by respective weights for relationship, and total values are summed up for each alternative. The values are then normalized in Table 27. The value calculated is a performance-weighted index.

Table 27
Desirability index calculation for logistics systems alternatives

Relationship	Commodity	Strategic alliance	Virtual relationship	Performance Index	Normalized Index
Weight	0.54	0.35	0.11		
C.P.S	0.036	0.018	0.095	0.036	0.08
P.E.P	0.091	0.052	0.083	0.076	0.18
F.E.P	0.211	0.102	1.54	0.319	0.74

7. Results

The used Analytic Network Process (ANP) framework serves as a tool for making a strategic decision related to the selection of the best option out of finite set of alternatives with the feedback consideration. The analytic network process calculations for online procurement suggest shifting to full e-procurement from the current procurement system. The final values of trust performance weighted index for alternatives are 0.08 for CPS, 0.18 for PEP and 0.74 for FEP. Since the alternative with the maximum score is to be chosen the analysis suggests shifting to a full e-procurement system. The comparison scale may vary slightly from manager to manager and company to company, but the holistic view considered in the approach includes the feedback to minimize irregularities. If the analysis is applied with constant involvement of experienced managers then the present approach provides a sound strategy to choose the best alternative.

8. Conclusions and Discussions

The availed ANP model is capable of taking into consideration both qualitative, quantitative and multiple dimensions of information into the analysis, which is a powerful and necessary characteristic for any strategic evolution. The process becomes cumbersome if the number of logistic and system alternatives are increased to a large extent, but with the use of software and group decision support systems the barriers in calculation and implementation of this technique may be lessened. There is a strong move towards community as a social structure in the online world with applications such as e-bay and i-village. The implication for transaction is to take advantage of buy side solutions, and use social structure solutions to support interpersonal exchange. Thus the use of a full e-procurement system at full horizon will help to eliminate cheating, establish online trust, and provide flexibility to the company.

There are many vendors who provide buy-side solutions like Skyva, Index system and others. They provide all types of support and infrastructure to the company for e-procurement. This analysis framework can be used for selection or justification of various logistics strategies and systems for trust building e-markets. This approach is advantageous because it helps the management have more confidence in the buyer (manufacturer)-supplier relationship for online procurement. It also provides a structure for an organization to develop and enhance inbound logistics strategy.

For future studies, we suggest developing a more detailed model for supplier-manufacturer relationships by considering different factors. A comparative study may be performed on the basis of results obtained by ANP modeling in different business environments. Further recommendations include the application of others concepts such as group decision making to expand the results to a sector or to different companies.

APPENDIX

Table 24
Desirability index for different alternative for commodity

Com-modity	Pij	Attrib-utes	Qijk	Rijk		SijI	SijI	SijI	C.P.S	P.E.P	F.E.P
	1		2	3	4= 1x2x3	5	6	7	8= 4x5	9 =4x6	10= 4x7
S.R	0.5	KACO	0.12	0.43	0.026	0.09	0.25	0.66	0.002	0.00645	0.017
S.R	0.5	IMSF	0.63	0.38	0.120	0.09	0.25	0.66	0.011	0.02993	0.079
S.R	0.5	SRC	0.25	0.18	0.023	0.09	0.25	0.66	0.002	0.00563	0.015
I.S	0.2	AOD	0.54	0.36	0.039	0.11	0.31	0.56	0.004	0.01205	0.022
I.S	0.2	LSI	0.12	0.29	0.007	0.11	0.31	0.56	0.001	0.00216	0.004
I.S	0.2	FC	0.34	0.33	0.022	0.11	0.31	0.56	0.002	0.00696	0.013
T.S	0.14	UIF	0.55	0.4	0.031	0.1	0.3	0.6	0.003	0.00924	0.018
T.S	0.14	SAI	0.39	0.15	0.008	0.1	0.3	0.6	0.001	0.00246	0.005
T.S	0.14	LSI	0.16	0.44	0.010	0.1	0.3	0.6	0.001	0.00296	0.006
I.V	0.16	JTS	0.12	0.43	0.008	0.16	0.24	0.6	0.001	0.00198	0.005
I.V	0.16	FMO	0.25	0.16	0.006	0.16	0.24	0.6	0.001	0.00154	0.004
I.V	0.16	FDO	0.63	0.39	0.039	0.16	0.24	0.6	0.006	0.00943	0.024
SUM									D11= 0.036	D12= 0.09077	D13= 0.211

Table 25
Desirability index for different alternatives for strategic alliance

Strat-egic alliance	Pij	Attri-butes	Qijk	Rijk		SijI	SijI	SijI	C.P.S	P.E.P	F.E.P
	1		2	3	4= 1x2x3	5	6	7	8= 4x5	9= 4x6	10= 4x7
S.R	0.28	KACO	0.65	0.3	0.055	0.09	0.32	0.59	0.005	0.017	0.032
S.R	0.28	IMSF	0.2	0.18	0.010	0.09	0.32	0.59	0.001	0.003	0.006
S.R	0.28	SRC	0.15	0.39	0.016	0.09	0.32	0.59	0.001	0.005	0.010
I.S	0.47	AOD	0.56	0	0.000	0.13	0.27	0.6	0.000	0.000	0.000
I.S	0.47	LSI	0.24	0	0.000	0.13	0.27	0.6	0.000	0.000	0.000
I.S	0.47	FC	0.2	0	0.000	0.13	0.27	0.6	0.000	0.000	0.000
T.S	0.13	UIF	0.21	0.17	0.005	0.1	0.31	0.59	0.000	0.001	0.003
T.S	0.13	SAI	0.27	0.45	0.016	0.1	0.31	0.59	0.002	0.005	0.009
T.S	0.13	LSI	0.61	0.37	0.029	0.1	0.31	0.59	0.003	0.009	0.017
I.V	0.12	JTS	0.37	0.43	0.019	0.13	0.27	0.6	0.002	0.005	0.011
I.V	0.12	FMO	0.32	0.41	0.016	0.13	0.27	0.6	0.002	0.004	0.009
I.V	0.12	FDO	0.31	0.16	0.006	0.13	0.27	0.6	0.001	0.002	0.004
Sum									D21= 0.018	D22= 0.052	D23= 0.102

Table 26
Desirability index for different alternatives for virtual relationship

Virtual relationship	Pij	Attri-butes	Qijk	Rijk		SijI	SijI	SijI	C.P.S	P.E.P	F.E.P
	1		2	3	4= 1x2x3	5	6	7	8= 4x5	9= 4x6	10= 4x7
S.R	0.46	KACO	0.21	0.16	0.015	0.13	0.28	0.59	0.002	0.004	0.077
S.R	0.46	IMSF	0.69	0.43	0.136	0.13	0.28	0.59	0.018	0.038	0.077
S.R	0.46	SRC	0.12	0.39	0.022	0.13	0.28	0.59	0.003	0.006	0.077
I.S	0.13	AOD	0.14	0.43	0.008	0.2	0.12	0.68	0.002	0.001	0.136
I.S	0.13	LSI	0.63	0.37	0.030	0.2	0.12	0.68	0.006	0.004	0.136
I.S	0.13	FC	0.23	0.18	0.005	0.2	0.12	0.68	0.001	0.001	0.136
T.S	0.11	UIF	0.21	0.32	0.007	0.2	0.12	0.68	0.001	0.001	0.136
T.S	0.11	SAI	0.69	0.19	0.014	0.2	0.12	0.68	0.003	0.002	0.136
T.S	0.11	LSI	0.1	0.21	0.002	0.2	0.12	0.68	0.000	0.000	0.136
I.V	0.3	JTS	0.54	0.89	0.144	0.27	0.12	0.61	0.039	0.017	0.165
I.V	0.3	FMO	0.16	0.71	0.034	0.27	0.12	0.61	0.009	0.004	0.165
I.V	0.3	FDO	0.3	0.43	0.039	0.27	0.12	0.61	0.010	0.005	0.165
Sum									D31= 0.095	D32= 0.083	D33= 1.540

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