



# A CONCEPTUAL FRAMEWORK FOR SUPPLY CHAIN COORDINATION IN FUZZY ENVIRONMENT

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## ABSTRACT

Supply chain management is concerned with the coordination of material, information and financial flows within and across often legally separated organizational units. With the recent advances in information technology, real time data exchange has become feasible and affordable. As a result, an equally (if not more) important issue for supply chain coordination is to incorporate information into a coordination policy. In this paper, we have studied a vast literature on coordination problem for supply chains with suppliers, manufacturers, retailers, and customers. In this research we have developed a framework for: (1) information sharing within supply chain members, (2) improving decision making process, and finally (3) strategic management of the whole supply chain. The information sharing within supply chain members is considered in two dimensions. First dimension is the quantitative information on demand, inventory, and backlog, which will decrease bullwhip effect, and improve efficiency of production planning and inventory control. Second dimension is the qualitative information on customer preference which can be used in decision making and planning that will lead to customer satisfaction. In this model the decision making process is based on four prominent aspects of customer satisfaction namely: price, lead time, quality, and service level. This framework can be used by strategic decision makers who need comprehensive models to guide them in efficient decision making that increases the profitability of the entire chain.

**Keywords:** *Supply Chain Coordination, Information Sharing, Fuzzy Analytical Network Process (FANP), Balanced Scorecard (BSC)*

## 1. INTRODUCTION

Coordination in supply chain management has gained much more attention than ever before. A supply chain refers to the production and distribution process from raw materials to finished goods. A supply chain includes of raw material suppliers through end users. Every party in a supply chain is usually an independent business. Those businesses have their own objectives, interest and perspectives of demand forecast. They try to gain competitive advantages, to maximize their profit. However, the individual objectives and interest may conflict with those of others. The conflicts limit the competitiveness of every company and worsen the performance of supply chain. Therefore, when companies face intense competition, companies can't fully use their

competitive advantage. To avoid such situations, many companies have realized the importance of coordination.

In general, increased coordination improves information flow along the supply chain and enhances the ability of industries to identify and adjust to changing consumer demands (Boehlje et al., 1999). Increased coordination also typically results in the ability to gain enhanced control over the production and processing of products to ensure a certain standard of quality and consistency. Coordination results in the alignment and control of various factors including price, quantity, quality, and terms of exchange (Peterson and Wysocki, 1998).

There are many driving forces for coordination in supply chains. For example, the innovative nature of products, the length of the life cycle and the



duration of retail trends in the industries, the longer more complex supply chains and the general movement to offshore production are only some of the associations that move supply chains into that direction. Global markets and more competition is likely to move supply chains towards a more universal participation where final retailers and upstream suppliers will be more willing to coordinate in an effort to cut costs (Polychronakis and Syntetos, 2007; Flidner, 2003). According to Udin et al. (2006), collaborative SCM can be defined as a condition in which all parties in the supply chain are dynamically working together, towards objectives by sharing information, knowledge, risk and profits, which possibly involve consideration of how other partners operate and make decisions.

As outsourcing has increased, the scale of supply chains has become larger, and each member in the supply chain needs more information to improve their efficiency and effectiveness (Parrish et al., 2004). Nowadays, companies are looking to apply Enterprise Resource Planning (ERP) systems and business intelligence systems to supply chain management. When implementing ERP systems, sharing information among trade partners is an important issue to be concerned with (Hodge, 2002). Therefore, studying information sharing in supply chains is important in order to satisfy the needs of the members of the chain and the customer. However, sharing information among members of a chain is a less researched area within the general supply chain management literature. Sharing information among members of a supply chain can reduce not only the Bullwhip Effect but also the costs of the whole chain (Park et al., 2003). In this paper, we consider customers' desired priorities for selecting retailers as information to be shared throughout the chain. The process of selecting upstream partners in a supply chain is based on various attributes which has been investigated by many scholars (Ha and Hong, 2005; Biehl, 2005; Shui-ying and Rong-qiu, 2001). Sharing priority weights of mentioned attributes, will lead to formation of coordination among upstream partners. This coordination is directed towards maximizing profitability of all participants while gaining customers satisfaction.

According to the vast literature (Boer et al., 1998; Choi and Hartley, 1996; Weber et al., 1991), it could be concluded that some properties are worth considering for upstream partner selection in a supply chain. First, the criteria may consider quantitative as well as qualitative dimensions (Choi and Hartley, 1996; Dowlatshahi, 2000; Verma and Pullman, 1998; Weber et al., 1991, 1998). In general, these objectives among these criteria are conflicted. A strategic approach towards supplier selection may further emphasize the need to consider multiple criteria (Donaldson, 1994; Ellram, 1992; Swift, 1995). Second, several decision-makers are very often involved in the decision process for upstream partner selection (Boer et al., 1998). Third, decision-making is often influenced by uncertainty in practice. An increasing number of decisions can be characterized as dynamic and unstructured. Situations are changing rapidly or are uncertain and decision variables are difficult or impossible to quantify (Cook, 1992).

There is a need for a systematic approach to elicit customers' preferences based on their strategic perspectives. Supply chain members often select their upstream partners based on their strategic priorities. Strategic priorities of customers for selecting retailers can be categorized in four perspectives, namely financial, Customer, Internal process, and learning and growth, as defined in balanced scorecard. Balanced Scorecard is a carefully selected set of measures derived from an organization's strategy (Niven, 2002). Perspectives of balanced scorecard and attributes for selecting upstream partners in a supply chain are interrelated (Moser, 2007).

Therefore, in the addressed supply chain network, we faced a multiple criteria decision making problem with BSC perspectives as criteria for obtaining priority weights of upstream partner selection attributes.

Unlike many traditional multiple criteria decision making methods that are based on the independent assumption; the analytic network process (ANP) which incorporates interdependence relationships between perspectives and attributes is a new approach for multi-criteria decision making. The analytical network process (ANP) provides an effective tool for solving complex decision-making



problems. Due to its consideration of interdependence between the elements of the decision problems, the ANP method establishes a better understanding of the complex relationships between the elements in decision making, and at the same time improves the reliability of decision making (Jharkharia and Shankar, 2007). Saaty and Vargas (2006) suggested that ANP can be used in many disciplines such as political, economic, social, technological, etc. Thus, we develop an effective model based on BSC and ANP to help customers in supply chains to evaluate the priority weights of attributes for selecting upstream partners.

In the other hand, managing a supply chain (SC) is very difficult, since various sources of uncertainty and complex interrelationships between various entities exist in the SC. In general, a supply chain is defined as follows (Mabert and Venkataraman, 1998):

“A supply chain is the network of facilities and activities that performs the functions of product development, procurement of material from vendors, the movement of materials between facilities, the manufacturing products, the distribution of finished goods to customers, and after-market support for sustainment.”

Based on this definition, such a network in a system contains a high degree of imprecision. This is mainly due to its real-world character and its imprecise interfaces among its factors, where uncertainties in activities from raw material procurement to the end user make the SC imprecise. Thus, it is summarized that fuzzy set theory is a suitable tool to come up with such a complicated system (Zarandi et al., 2002).

Therefore, in this paper Fuzzy Analytical Network Process (FANP) method is used in order to increase the reliability of customers' priorities for selecting upstream partner in a supply chain since in many cases decision makers could be uncertain about their own level of preference, due to incomplete information or knowledge, complexity and uncertainty within the decision environment, or a lack of an appropriate measurement units and scale. In addition, the preference model of the human decision maker is uncertain, and it is relatively difficult for the decision maker to provide exact

numerical values for the comparison ratios. Duran and Aguilo (2008) argued that by adopting fuzzy numbers decision makers will be able to achieve a better flexibility in estimating the overall importance of attributes in developing real alternatives to assess problems with greater confidence. Consequently, since fuzzy set theory can give a much better representation of the linguistic data (Cheng et al., 1999), this research used a FANP base to calculate customers' priorities for selecting upstream partner in supply chain.

Hence, the four main objectives pursued in this paper are as follows:

1. Introducing an efficient set of factors as information to be shared throughout a supply chain for enhancing coordination and subsequently increasing benefits of all the chain members by using upstream partner selection attributes.
2. Linking financial and non-financial, tangible and intangible, inward and outward factors as customers' objectives for prioritizing the attributes that affect selection of upstream partners in a supply chain by using balanced scorecard perspectives.
3. Consideration of interdependence between the elements of the decision problems including BSC perspectives and upstream partner selection attributes by using ANP method as an effective tool for solving complex decision-making problems.
4. Providing the ability of achieving a better flexibility in estimating the overall importance of upstream partner selection attributes and giving a much better representation of the linguistic data by adopting fuzzy numbers in decision making

The paper is organized as follows. The results of a literature review on related subjects including information shared in a supply chain; Fuzzy Analytical Network Process (FANP) Method and Balanced Scorecard (BSC) are presented in the next Section. In Section 3, the proposed framework for Supply Chain Coordination in Fuzzy Environment is depicted, and this is followed by concluding the paper with a discussion of the implications of this study, research directions, and concluding remarks.



## 2. LITERATURE REVIEW

### 2.1. Information shared in a supply chain

The supply chain members coordinate by sharing information regarding demand, orders, inventory etc. Information sharing between downstream and upstream partners in a supply chain is considered to be a major indicator of the use of SCM. Information sharing is used, in effect, to integrate the entire value chain into one longer chain (Shapiro et al., 1993; Rayport and Sviokla, 1995; Bhattacharya et al., 1995; Towill, 1997). Timely information or advanced commitments from downstream customers helps in reducing the inventory costs by offering price discounts and this information can be a substitute for lead time and inventory (Reddy and Rajendran, 2005). The value of information sharing increases as the service level at the supplier, supplier-holding costs, demand variability and offset time increase, and as the length of the order cycle decrease (Bourland et al., 1996; Chen et al., 2000). Some comparative studies have been conducted in which no information sharing policy is compared with full information sharing policy. Information sharing policy results in inventory reductions and cost savings (Yu et al., 2001). On the other words, sharing information in a supply chain is important not only to reduce the Bullwhip effect but also to reduce the cost of entire chain (Gavirneni et al., 1999).

Most of the models assume that a supply chain partner has complete information (including cost, demand, lead time, etc.) about the other partner. This is considered to be major limitations of these models. In a decentralized supply chain, hardly will be the situation where complete information will be available with the parties. Coordination under limited information sharing is an important issue of concern to be studied for the decentralized supply chain (Sarmaha et al., 2006).

In terms of the information content classification, Chopra and Meindl (2001) classified supply chain information into supplier information, manufacturer information, distribution and retailer information, and demand information. Handfield and Nichols (1999) classified supply chain information into 10 categories. Customer information includes customer forecast, sales

history, point of sale, and promotional plan; Supplier information includes product line, product lead time, capacity, and production plan; Inventory information includes inventory level, and inventory cost. Bensaou (1997) measured IT use by the information exchanged in electronic forms in the following six areas: purchasing, production control, quality, engineering, transportation and payment. Chen and Chen (1997) found that the JIT environment requires the exchange of information between supplier and manufacturer in the following items: schedules, schedule changes, design data, engineering changes, quality or delivery issues, cost, etc. Lummus and Vokurka (1999) described the requirements of sharing information among supply chain partners. The information includes supplier information (e.g. finished goods inventory, MPS, delivery information), consumer information (e.g. promotion plan, and demand forecast), retailer information (e.g. inventory and POS), and distributor information (e.g. delivery schedule). Chen (2002) provided a comprehensive literature review about information sharing in supply chains. Several studies discuss the upstream passing of various types of information: costs (Chen, 2001), lead-times (Chen and Yu, 2001a) and uncommitted production capacity (Chen and Yu, 2001b). Other studies involve passing information downstream. In Chen (2002), upstream information refers to the information exchanged between upstream members of supply chains, while downstream information refers to the information exchanged between downstream members of supply chains. Fulkerson (2000) suggested that sharing bill of materials with distributors could help implement postponement strategy in the supply chain. A postponement strategy delays the final assembly of products until customer demand is known. Lee and Whang (2000) studied the PC industry, in which manufacturers share information (e.g. capacity, demand forecasts, production plan, promotion plan, POS, customer's forecast, sales data) with their suppliers. They suggested five types of information to share: inventory level, sales data, order status for tracking, sales forecast, and production/delivery information. Huang et al. (2003) classified information in the supply chain into six categories: product, process,



planning, inventory, order, and resource. The classification of information is shown in Table 1.

Table 1: Classification of production information model (PIM) (Huang et al, 2003)

Category	PIM
Product	Product structure
Process	Material lead-time, Variance of lead-time, Order transfer lead-time, Process costs, Quality, Shipment, Set-up cost
Planning	Demand forecast, Order schedule, Forecasting model, Time fence
Inventory	Inventory level, Holding cost, Backlog cost, Service level
Order	Demand, Demand variance, Order batch size, Order due date, Demand correlation
Resource	Capacity, Capacity variance, Supply

Upstream partner selection in a supply chain is based on the four most important factors – price, quality, service level and lead time.

In this paper, the scope of information shared throughout the chain has been restricted to these factors as upstream partner selection criteria. These are actually the four most important criteria in similar studies (Dickson, 1966; Weber et al. 1993; Talluri, 2002).

Most organizations mainly concern the partner selection decision because the cost of procuring is paramount to their profits. In industrial companies, the cost of raw materials and component parts purchased from external partners typically ranged between 50-90% of the total production cost (Burton, 1988). The other factor that leads to customer satisfaction is quality. Consumers have heterogeneous willingness to pay for quality. Based on a distinct engineering principle, for a given production technology, the unit production cost tends to rise more rapidly as quality increases (Chen, 2006). As changing customer preferences requires a broader and faster demand of products and service, the companies urge for a more systematic and transparent approach to purchasing decision-making, especially regarding the area of partner selection (Carter et al. 1998).

The efficient information flow between partners is identified as the key to improving the time, quality, service and cost factors. Meeting the customer objectives satisfactorily depends on coordination of

information that helps produce highest quality, low cost and minimum time to service (Titus and Bröchner, 2005).

## 2.2. Fuzzy Analytical Network Process (FANP) Method

The FANP is a generalization of the FAHP as a widely used multi criteria decision-making tool by replacing hierarchies with network. More recently, a more general form of FAHP approach, which incorporates feedback and interdependent relationships among decision criteria and alternatives, has been proposed as a more accurate approach for modeling complex decision environments. While FAHP is a well-known technique that decomposes a problem into several levels in such a way that they form a hierarchy, FANP enables interrelationships among the decision levels and criteria to be taken into consideration in a more general form. Thus, the FANP can be used as an effective tool in those cases where the interactions among the elements of a system form a network structure (Saaty, 1996). Since nature of decision making usually includes uncertainty so it is sufficient to apply fuzzy concepts in problems which human has a role in them (Zadeh, 1965). Further to the fuzzy set theory introduced by Zadeh, it has been applied in various contexts (Zimmermann, 1994).

Fuzzy ANP is investigated by several researches. Kahraman et al. (2006) used fuzzy FANP for QFD planning process in which the coefficients of the objective function are obtained from a fuzzy ANP approach. Lin and Hsu (2008) consider performance measurement systems by fuzzy ANP. The essential point is existence of inner dependence between objectives and criteria. For this purpose, super matrix method is applied as follow (Kahraman et al. 2006):

If  $W_1$  represents weight vector of the objectives in respect to goal,  $W_2$  is a matrix that denotes the impact of the objectives on each of the criteria.  $W_3$  and  $W_4$  are the matrices that represent the inner dependence of the objectives and the inner dependence of the criteria, respectively, then the super matrix of the problem is as follows:



$$W = \begin{bmatrix} 0 & 0 & 0 \\ W_1 & W_3 & 0 \\ 0 & W_2 & W_4 \end{bmatrix} \quad (1)$$

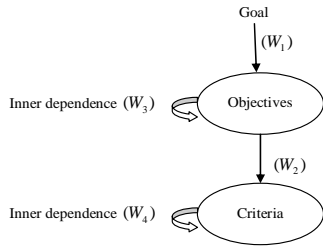


Figure 1: Configuration of the problem

In this phase experts conduct pair wise comparisons. Since there is uncertainty in decisions, they asked to express their opinions with linguistics data. We use Chang's extent analysis method to obtain weights (Chang, 1996).

If  $\tilde{M}_1 = (l_1, m_1, u_1)$  and  $\tilde{M}_2 = (l_2, m_2, u_2)$  represent two triangle fuzzy numbers (Figure 2).

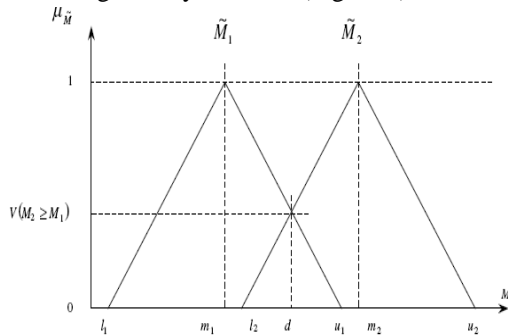


Figure 2: Comparison of two triangular fuzzy numbers

In this phase experts do pair wise comparisons. Since there is uncertainty in decisions, they asked to express their opinions with linguistics data.

Where d is the ordinate of the highest intersection point d between two membership function. The value of  $\tilde{M}_k$  relate to row k and is calculated as follows:

$$\tilde{M}_k = \sum_{j=1}^m M_{kj} \left[ \sum_{i=1}^m \sum_{j=1}^m M_{ij} \right]^{-1} \quad (2)$$

$\tilde{M}_{ij}$  is the element in row i and column j.

The degree of possibility of  $\tilde{M}_2 \geq \tilde{M}_1$  is defined as

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \text{hgt}(\tilde{M}_1 \cap \tilde{M}_2) = \begin{cases} 1, & \text{if } m_2 \geq m_1, \\ 0, & \text{if } l_1 \geq u_2, \\ \frac{l_1 - u_1}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases} \quad (3)$$

In this method for each matrix  $j=1, \dots, n$ .

$$w_i = \text{Min}(V(\tilde{M}_i \geq \tilde{M}_k)), k = 1, \dots, m, k \neq i \quad (4)$$

Via normalization, the normalized weight vectors are

$$w_i^* = \frac{w_i}{\sum w_i}, i = 1, \dots, m \quad (5)$$

Having defined the above addressed parameters, the experts are asked to use their pair wise comparisons based on Table 2.

Table 2: Linguistic scales for and importance

Triangular fuzzy reciprocal scale	Triangular fuzzy scale	Linguistic scale for importance
(1, 1, 1)	(1, 1, 1)	Just Equal (JE)
(2/3, 1, 2)	(1/2, 1, 3/2)	Equally important (EI)
(1/2, 2/3, 1)	(1, 3/2, 2)	Weakly more important (WMI)
(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	Strongly more important (SMI)
(1/3, 2/5, 1/2)	(2, 5/2, 3)	Very strongly more important (VSMI)
(2/7, 1/3, 2/5)	(5/2, 3, 7/2)	Absolutely more important (AMI)

Now we do following algorithm:

Step 1: Determining importance degrees of objectives by assuming that there is no dependence among objectives: Calculation of  $W_1$

Step 2: Determining the importance degrees of criteria with respect to each objective by assuming that there is no dependence among the criteria: Calculation of  $W_2$

Step 3: Determining the inner dependency matrix of the objectives with respect to each objective: Calculation of  $W_3$

Step 4: Determining the inner dependency matrix of the criteria with respect to each criterion: Calculation of  $W_4$

Step 5: Determining the interdependent priorities of the objectives: Calculation of  $W^A = W_3 \times W_1$

Step 6: Determining the interdependent priorities of the criteria: Calculation of  $W^B = W_4 \times W_2$

Step 7: Determining the overall priorities of the criteria: Calculation of  $W^{ANP} = W^B \times W^A$



### 2.3. Balanced scorecard in a Supply Chain

Recently, an increasing number of the literature focus on the adaptation of BSC to fit the needs of SCM (Brewer and Speh, 2000; Bullinger et al., 2002). Balanced scorecard (BSC) receives broad attention not only in scientific literature but also in practical applications. In addition to financial criteria, the BSC comprises a customer perspective, a learning and growth perspective as well as an internal business perspective. These perspectives can integrate a set of attributes that provides a deeper insight for decision making (Stadtler and Kilger, 2005). Every attribute selected for a scorecard should be part of a link of cause-and-effect relationships, ending in financial objectives that represent a strategic theme for the business. The attributes are designed to pull organization toward the overall vision. This methodology is consistent with the approach of supply chain management by helping organizations to overcome traditional functional barriers and ultimately lead to improved decision making and problem solving (Waters, 2007). In this paper, we apply the concept of balanced scorecard (BSC) perspectives which links financial and non-financial, tangible and intangible, inward and outward factors as customers' objectives for prioritizing the attributes that affect selection of upstream partners in a supply chain.

There are three types of relations among the factors: first, direct relations including subordinate relations, feedback relations and dominating relations; secondly, indirect relations, in which the subordinate relations are ambiguous and the mutual influences between each two are transferred by another index; finally, self feedback or self-associated relations. These three relations embrace all the ways in which BSC indexes interact (Yu and Wang, 2007).

Kaplan and Norton (1993, 2004) articulated four perspectives that can guide companies as they translate strategy into actionable terms:

**Financial Perspective:** The revenues, profit margins, and expenses are very important to an organization seeking to achieve its goals. A common mistake with organizations is that they normally do not link the financial goals with the non-financial strategic objectives of the company.

The financial perspective gives respect to the relationship between stated financial goals and other goals that feed the machine to create the result.

**Customer Perspective:** The customer perspective is viewed as the set of objectives the organization must achieve to gain customer acquisition, acceptance, and perpetuation. Objectives are an outgrowth of assumptions made about the customers and their attitudes, the markets they represent, and the value they perceive in a relationship with the organization.

**Internal Perspective:** The internal perspective reminds us that the background works, driven by objectives and goals, must be in place to ensure that the customer and financial objectives are achieved. Internal processes, cultures and procedures in all departments and business units support the value proposition to the target market segments.

**Learning and Growth Perspective:** This perspective is the basis for all other perspectives and serves to remind the practitioner that the basis for all other results in the internal, customer, and financial perspectives are found in the learning and growth of the people. Learning dictates how people absorb new ideas, improve their skills and turn them into action.

Chiang (2005) proposed a dynamic decision approach for long-term vendor selection based on AHP and BSC. Ravi et al. (2005) combined analytic network process and balanced scorecard for conducting reverse logistics operations for EOL computers. Leung et al. (2006) apply the analytic hierarchy process and analytic network process to facilitate the implementation of the balanced scorecard. Leem et al. (2007) proposed modeling the metrics for measuring the performance on logistics centers by BSC and ANP in Korean context. Xue-zhen (2007) proposed a dynamic model based on AHP and BSC for long-term strategic vendor selection problems.

### 3. CONCEPTUAL FRAMEWORK

Supply network has a multilevel structure so that each level is influenced by various entities' decisions in the network. Here, the typical network consists of four layers, customer, retailer, manufacturer and supplier. The aim of this paper is

to develop a method to manage a multi layers supply chain architecture in a collaborative manner. Each of the players in the supply network is an actor who makes independent decisions based on information gathered from the upstream and downstream levels.

In addition, there exists more than one member in each layer. All members in each echelon are performing the same activities, rivaling with each other, trying to increase demand for their products. Consequently each member in this network should select one, two or more counterpart from its upstream trading partners. Briefly the buyers in a market fundamentally are faced with the supplier selection. Moreover, the presence of multiple suppliers will require the buyer to set up a

competitive mechanism for capacity allocation among the selected suppliers. Thus, an evaluation of each potential supplier, who responds to a call for proposal from a customer according to rules and criteria that are impartial and common to all, can be quantified. Hence, procurement generally involves many criteria other than price. For example, product quality, payment terms, and delivery conditions are also commonly treated as negotiable criteria. In the model among various criteria investigated by scholars, four attributes namely price (P), lead time (LT), quality (Q), and service level (SL) are assumed. These attributes will cover approximately, all the needs and priorities of customers.

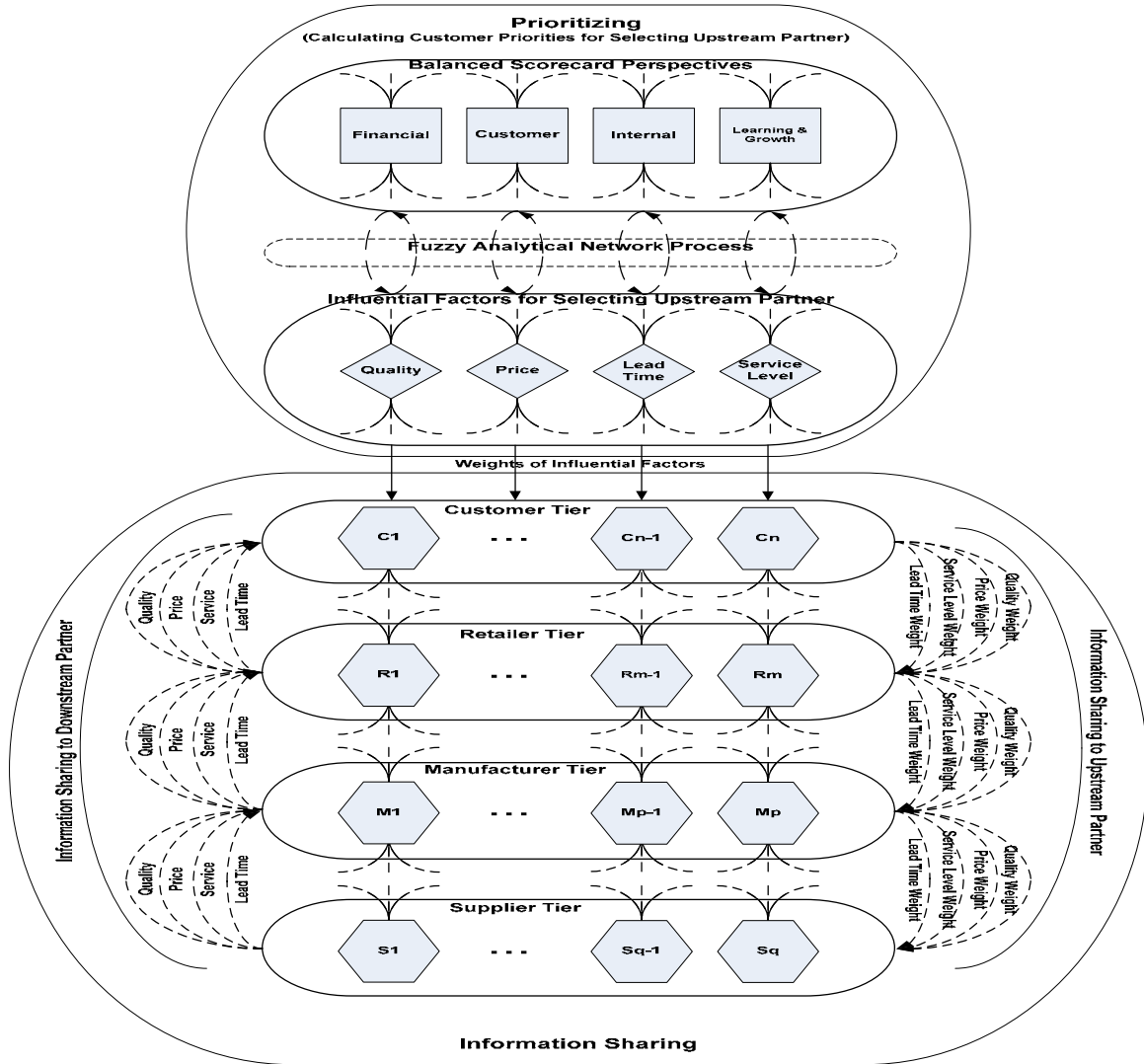


Figure 3: Conceptual framework for supply chain coordination





Service level  $C_i$ , lead time weight  $C_i$ , price  $C_i$ , and quality  $C_i$  are the priority weights of the first tier customers for selecting its upstream partners. These weights are obtained based on BSC perspectives as objectives. In order to obtain priority weights of upstream partner selection attributes, FANP method based on table 2 is applied in a 3 steps procedure as follows:

*Step 1: Acquiring the decision makers' assessments of comparing BSC perspectives.* At first, by assuming that there is no dependence among perspectives, the importance degrees of perspectives ( $W_1$ ) are determined. Then, the decision makers are asked to define the relation network among the BSC perspectives and based on the network, the importance degrees of BSC perspectives with respect to each perspective ( $W_3$ ) are determined.

*Step 2: Acquiring the decision makers' assessments of comparing upstream partner selection attributes.* In this step, the importance degree of influential upstream partner selection attributes ( $W_2$ ) is determined. Then, by defining the relation network among selection attributes, the importance degrees of upstream partner selection attributes with respect to each selection attribute ( $W_4$ ) is determined.

*Step 3: Calculating and analyzing interdependent priorities.* According to FANP method, the interdependent priorities of the BSC perspectives ( $W^A$ ), the interdependent priorities of influential criteria in each BSC perspective ( $W^B$ ) and overall weights of upstream partner selection attributes ( $W^{ANP}$ ) are calculated.

For the purpose of supplier selection process, a variable is created, both using some variables related to performance of the supply network actors, and some variables regarding customers priorities. This variable is called desirability ratio which can be calculated for all retailers related to customers' perspectives. The desirability ratio is calculated through the following formula which contains indexes and weights.

$$DR_{Ci Rj} = \frac{SL_{Ci} \times SL_{Rj} + LT_{weight} \times \frac{LT_{Ci}}{LT_{Rj}} + P_{Ci} \times P_{Rj} + Q_{Ci} \times Q_{Rj}}{SL_{Ci} + LT_{weight} + P_{Ci} + Q_{Ci}}$$

Where these indexes and weights are calculated and normalized as follow:

**Service Level (SL):** Service level is used in supply chain management and in inventory management to

measure the performance of inventory systems. In this model,  $SL_{Rj}$  is defined as the ratio of retailer's backlogs to its total incoming orders.

**Lead Time (LT):** Lead time is the period of time between the initiation of any process of production and the completion of that process. A more conventional definition of lead time in the supply chain management realms is the time from the moment the supplier receives an order to the moment it is shipped. In this model lead time of retailers is calculated through summation of lead times of upstream partners and their share of retailer's demand. The value of calculated lead time should be compared to desired lead time proposed by customers. For this purpose lead time of retailer is divided by lead time of customer.

**Price (P):** Price is the final amount that customer has to pay for products; this includes profit of the seller and costs. Whereas cost is the total amount spent on the final product such as raw material, production and transportation costs.

**Quality (Q):** Quality is a perceptual, conditional and somewhat subjective attribute and may be understood differently by different people. Consumers may focus on the specification quality of a product/service, or how it compares to competitors in the marketplace. Manufacturers are spending more and more money on quality control to provide a quality product and avoid customer returns. Quality of  $R_j$  addresses the quality of products which will be delivered to customers and is obtained through aggregation of upstream partners' quality and their share of retailer's demand.

When the desirability ratio of all customers and retailers is obtained, market share of retailers from customers' demand which is called purchase ratio (PR) can be calculated as follows:

$$PR_{Ci Rj} = \frac{D.R._{Ci} \times Rj \times Demand_{Ci}}{\sum_j D.R._{Ci} \times Rj}$$

After calculating all ratios, we sum up ratios associated with each retailer, the result of this summation for each retailer is considered as its demand from upstream partners. Now the selection process should be repeated for retailers and also for manufacturers. For this purpose, required information regarding customers' priorities should be collected and shared throughout the chain



among its partners. This kind of information sharing will be an important tool for ensuring customer satisfaction. Consequently retailers' priorities are obtained through aggregation of customers' priorities and their purchase ratios. With this regard, by calculating retailers' demand and priority weights, the selection process can be done for retailers again.

#### 4. CONCLUSION

Supply chain coordination is truly a transformational business strategy that has a profound effect on competitive success. Many companies exchange an increasing amount of supply chain information with their business partners, but still are far from applying a structured Collaborative process. Information sharing increases the efficiency of Supply chain operations, especially when the supply chain is complex. In this paper, we proposed a framework for modeling the flow of customers' priorities for selecting upstream partner as information to be shared within the supply chain. In addition, the balanced scorecard perspective is used for linking financial and non-financial, tangible and intangible, inward and outward factors as objectives for prioritizing the attributes that affect selection of upstream partners in a supply chain. A fuzzy based analytical network process is also used to consider interdependencies between the elements of the decision problems including BSC perspectives and upstream partner selection attributes. This gives a much better representation of the linguistic data by adopting fuzzy numbers in decision making. Consequently, this framework can help actors of the network, to strengthen their strategic relations with upstream and downstream partners.

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