TACKLING UNCERTAINTY WITH SUPPLY CHAIN EVENT MANAGEMENT, THROUGH FUZZY LOGIC

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ABSTRACT

Today's business environment is fraught with uncertainty. Without clear insight into imminent economic, political, and security development, many businesses fear how their supply chains will fare in the face of global disruptions and market change. In recent years, some enterprises have tried to simplify their command over their supply chains by outsourcing key business processes such as manufacturing and distribution. But while reducing their asset base, outsourcing adds business and communication complexity and risk due to the multiple entities involved. This complexity is increasing. Moreover, today's information flows and material flows are not sequential, linear chains. They represent complex networks with multiple paths and entities. In order to improve the planning and forecasting systems the companies spend lot of time, money and energy so as to minimize the uncertainties in the business problems. The proposed solution is to control the uncertainty by using fuzzy logic in supply chain event management. This is explained in detail.

Keywords: SCM, SCEM, Fuzzy Logic, Fuzzy Linear Programmimg

INTRODUCTION

In today's scenario the business environment is filled with uncertainty. Many businesses are not clear about economic, political and security developments and are not sure how their supply chains work in the disruptions and changes in the market globally. They feel it is necessary to maintain strong customer relationships and cut cost effectively especially when the customer is spending and his confidence is low.

Some companies recently tried outsourcing key business processes of manufacturing and distribution so as to simplify their supply chains. But it added to the complexity in communication and risk due to involvement of multiple entities. And this complexity is only increasing. Outsourced manufacturing and distribution, vendor-managed inventory, and continuous replenishments all increase a company's dependence on business partners. Today's business has certain barriers such as multiple suppliers, various modes of transportation, many outsourcing partners. Apart from this, companies should also be prepared to face other problems such as political and climatic, economic and political conditions.

INFORMATION FLOW FOR SUPPLY CHAINS

Today's information flows and material flows are not sequential, linear chains. They represent complex networks with multiple paths and entities. Due to this, there is a delay in execution and ontime deliveries through the supply chain among the different business processes, information systems and cultures. Therefore the companies are unable to react to the expectations and the changing conditions of the market and customer dissatisfaction.

In order to avoid delays in delivery, the issue is how companies can maintain the supply chains cost effectively and fulfill the expectations of the customers. The companies spend money and energy to avoid stock-outs, excess inventory and delay in deliveries by improving their forecasting systems. Due to uncertainty in the economic and political situations, their buying behavior is unpredictable; and it becomes difficult to plan the supply chain efficiently.

Further, since the market is dynamic, the market leaders are reducing the inventory as the demand reduces. The companies are not able to manage the market as the changes are unpredictable. There is always a certain amount of risk involved in these situations.

EXCEPTIONS IN SUPPLY CHAINS

There may be certain situations in every organization on a daily basis such as stock out due to delay in transportation, which may produce a heavy cost to the organization. These situations may occur due to various reasons, must be handled immediately and may dissatisfy the consumers thus involving heavy cost.

Many companies are now considering using offshore outsourcing, or lean approaches, or a just-in-time supply chain. But these processes are not that effective as they damage the inventory and involve high cost of storage and do not eliminate the exceptions in the supply chain completely.

SUPPLY CHAIN EVENT MANAGEMENT

Supply Chain Event Management which involves collaboration, integration and sharing of information address this situation within an organization and trading partners externally by supporting the measurement, monitoring, decision support and control the supply chain exceptions, but the uncertainty still remains. Some of the problems involved in this can be addressed using linear programming but thisis also affected by uncertainty. In this situation it is suggested that companies follow the concept of fuzzy linear programming in order to implement supply chain event management effectively.

THE NOTION OF FUZZY SETS

The members and non members can be discriminated by using a function of a crisp set which assigns a value, either 1 or 0, to each member in the set. This function can be generated in such a way that the values assigned to all the elements in the set fall in a specified range. If the values are large then it denotes that there exists a high degree of set membership. This function is known as the membership function and the set is defined as a fuzzy set.

Let X denote a universal set. Then, the membership function μA by which a fuzzy set A is usually defined, has the form

$$\mu A: X \rightarrow [0, 1]$$

where [0,1] denotes the interval of real numbers from 0 to 1, inclusive.

Although the range of values between 0 and 1, inclusive, it is the one most commonly used for representing membership grades: any arbitrary set with some natural full or partial ordering can in fact be used. Elements of this set are not required to be numbers as long as the ordering among them can be interpreted as representing various strengths of membership degree. This generalized membership function has the form

$$\mu A: X \rightarrow L$$

where L denotes any set that is at least partially ordered. Since L is most frequently a lattice, fuzzy sets defined by this generalized membership grade function are called *L-fuzzy* sets, where L is intended as an abbreviation for the *lattice*. L-fuzzy sets are important in certain applications, perhaps the most important being those in which $L = [0, 1]^n$. The symbol $[0, 1]^n$ is a shorthand notation of the Cartesian product

$$[0,1] \times [0,1] \times \ldots\ldots \times [0,1] \text{ - n times}$$

Although the set [0,1] is totally ordered, sets $[0,1]^n$ for any $n \geq 2$ are ordered only partially. For example, any two pairs (a1, b1) ε $[0,1]^2$ and (a_2, b_2) ε $[0,1]^2$ are not complete (ordered) whenever $a1 < a_2$ and $b1 > b_2$.

The fuzzy set provides us with an intuitively pleasing method of representing one form of uncertainty (Klir and Folger, 2002). Obviously, the usefulness of a fuzzy set for modeling a conceptual class or a linguistic label depends on the appropriateness of its membership function The methods proposed for accomplishing this have been largely empirical and usually involve the design of experiments on a test population to measure subjective perceptions of membership degrees for some particular conceptual class. There are various means for implementing such measurements. Subjects may assign actual membership grades, the statistical response pattern for the true or false question of set membership may be sampled, or the time of response to this question may be measured, where shorter response times are taken to indicate higher subjective degrees of membership. Once these data are collected, there are several ways in which a membership function reflecting the results can be derived.

FUZZY LINEAR PROGRAMMING

The classical linear programming problem is to find the minimum or maximum values of a linear function under constraints represented by linear inequalities or equations. The most typical linear programming problem is:

$$\begin{array}{ll}
\text{Minimize (or maximize)} & c_1x_1 + c_2x_2 + \ldots + c_nx_n \\
\text{Subject to} & a_{11}x_1 + a_{12}x_2 + \ldots + a_{1nxn} \geq b_1 \\
& a_{21}x_1 + a_{22}x_2 + \ldots + a_{2nxn} \geq b_2 \\
& \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
& a_{ml}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \geq b_m \\
& x_1, x_2, \ldots, x_n \geq 0
\end{array}$$

The objective function to be minimized (or maximized) is denoted by z. The numbers ci (i ε Nn) are called cost coefficients, and the vector $c = <c_1, c_2, \ldots, c_n>$ is called a cost vector. The matrix A $[a_{ij}]$, where i ε N_m and j ε N_n, is called a constraint matrix, and the vector $b = < b_1, b_2, \ldots, b_m >$ T is called a right-hand side vector. Using this notation, the formulation of the problem can be simplified as

$$\text{Min } z = cx$$
$$\text{s.t } Ax \geq b$$
$$x \geq 0,$$

where x = < x1, x2, ..., xn > T is a vector of variables, and s.t stands for "subject to". The set of vectors x that satisfy all given constraints is called a feasible set. As is well known, many practical problems can be formulated as linear programming problems.

In many practical problems, it is not reasonable to require that the constraints or the objective function in linear programming problems be specified in precise, crisp terms. In such situations, it is desirable to use some type of fuzzy linear programming. (Klir and Yuan, 2002).

The most general type of fuzzy linear programming can be formulated as follows:

$$\max \sum_{j=1}^{n} C_j X_j$$

$$\text{s.t } \sum_{j=1}^{n} A_{ij} X_j \geq \text{Bi (i ? Nm)}$$

$$X_j \geq 0 \; (j \varepsilon N_n)$$

where A_{ij}, B_i, C_j are fuzzy numbers, and X_j are variables whose states are fuzzy numbers ($i \varepsilon \dot{N}_m$, $j \varepsilon N_n$); the operations of addition and multiplication are operations of fuzzy arithmetic, and $\geq$ denotes the ordering of fuzzy numbers. There can be two special cases:

Case 1. Fuzzy linear programming problems in which only the right-hand-side numbers B_i are fuzzy numbers:

$$\max \sum_{j=1}^{n} c_j x_j$$

$$\text{s.t } \sum_{j=1}^{n} a_{ij} x_j \geq B_i \; (i \varepsilon N_m)$$

$$x_j \geq 0 \; (j \varepsilon N_n)$$

Case 2. Fuzzy linear programming problem in which the right-hand-side numbers B_i, and the coefficients A_{ij} of the constraint matrix are fuzzy numbers:

$$\max \sum_{j=1}^{n} c_j x_j$$

$$\text{s.t} \sum_{j=1}^{n} A_{ij} x_j \geq B_i \ (i \in N_m)$$

$$x_j \geq 0 \ (j \in N_n)$$

In general, fuzzy linear programming problems are first converted into equivalent crisp linear nonlinear problems, which are then solved by standard methods. The final results of a fuzzy linear programming problem are thus real numbers, which represent a compromise in terms of the fuzzy numbers involved.

Let us consider a fuzzy linear programming problems of the type Case 1. In this case fuzzy numbers B_i $(i \in N_m)$ typically have the form

$$B_i(x) = \begin{cases} 1 & \text{when } x \geq b_i \\ (b_i + p_i - x)/p_i & \text{when } bi < x < b_i + p_i \\ 0 & \text{when } b_i + p_i \geq x \end{cases}$$

where $x \in R$. For each vector $x = <x_1, x_2, \ldots, xn>$, we first calculate the degree, $D(x)$, to which x satisfies the ith constraint ($i \in Nm$) by the formula

$$Di(x) = Bi \left(\sum_{j=1}^{n} a_{ij} x_j\right)$$

These degrees are fuzzy sets on R^n, and their intersection, $\bigcap_{i=1}^{m} Di$, is a fuzzy feasible set.

Next, we determine the fuzzy set of optimal values. This is done by calculating the lower and upper bounds of the optimal values first. The lower bound of the optimal values, z_l, is obtained by solving the standard linear programming problem:

$$\max \ z = cx$$

$$\text{s.t} \sum_{j=1}^{n} a_{ij} x_j \geq b_i \ (i \ \varepsilon \ N_m)$$

$$x_j \geq 0 \ (j \ \varepsilon \ N_n)$$

the upper bound of the optimal values, zu, is obtained by a similar linear programming problem in which each bi is replaced with $b_i + p_i$:

$$\max \ z = cx$$

$$\text{s.t} \sum_{j=1}^{n} a_{ij} x_j \geq b_i + p_i \ (i \ \varepsilon \ N_m)$$

$$xj \geq 0 \ (j \ \varepsilon \ N_n)$$

Then, the fuzzy set of optimal values, G, which is a fuzzy subset of R^n, is defined by

$$G(x) = \begin{cases} 1 & \text{when } z_u \ ? \ cx \\ (cx-z_l)/(z_u-zl) & \text{when } z_l \geq cx \geq z_u \\ 1 & \text{when } cx \geq z_l \end{cases}$$

Now the problem becomes the following classical optimization problem:

$$\max \lambda$$

$$\text{s.t. } \lambda (z_u - z_l) - cx \geq -z_l$$

$$\lambda p_i + \sum a_{ij} x_j \ ? \ b_i + p_i (i \ \varepsilon \ N_m)$$

$$\lambda, x_j \geq 0 \quad (j \ \varepsilon \ N_n)$$

The above problem is actually a problem of finding $x \ \varepsilon \ R_n$ such that

$$[(\bigcap_{i=1}^{m} D_i) \cap G](x)$$

reaches the maximum value; that is, a problem of finding a point which satisfies the constraints and goal with the maximum degree.

CONCLUSION

Hence we can see that supply chain event management takes care of the problems of the enterprises as they arise. It is also seen that with the help of fuzzy linear programming the uncertainty is reduced and thereby optimization can be achieved. Therefore the companies can reduce their operational and administrative costs and improve their decision making capabilities, increase their revenue and enhance their investment in the supply chain.

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