International Journal of Computer and Communication Technology

Volume 4 | Issue 4 Article 10

October 2013

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Abstract: An unmanaged supply chain is not inherently stable. The bullwhip effect occurs when the demand order variability's in the supply chain are amplified as they moved up the supply chain. Distorted information from one end of a supply chain to the other can lead to tremendous inefficiencies. In this paper it is shown that if the members of the supply chain share information with intelligent support technology, and agree on better and better soft computing technique on future sales for the upcoming period, then the bullwhip effect can be significantly reduced. This paper emphasizes on fuzzy logic technique and discusses its effect on reducing bullwhip effect. It is shown that with the application of the fuzzy logic, the multi-objective problems converted to a single one, which can be easily solved with the proposed methodology. It is also shown that linguistic values can be determined to assess vendors' characteristics, in order to address, in an accurate way.

Keywords: Supply Chain Management (SCM), Bullwhip Effect, Digital Signal Processing, Fuzzy logic ,Soft computing.

1. INTRODUCTION

A supply chain is, "a web of autonomous enterprises collectively responsible for satisfying the customer by creating an extended enterprise that conducts all phases of design, procurement, manufacturing, and distribution of products". This involves a complex group of companies that move goods from raw materials to suppliers to finished goods retailers. The team work together when meeting consumer demand for a product ;supply chain allow companies to focus on other specific process to maintain maximum stability. The main objective of a supply chain is to synchronize the requirements of the customer with the flow of material from suppliers in order to get a balance between the conflicting goals of a supply chain such as high service level, low inventory investment and low unit cost.

Figure 1 illustrates a simple six-stage general supply chain: consumer, retailer, wholesaler, distributor, manufacturer and a supplier. The retailer observes consumer demand and places orders to the wholesaler. The wholesaler receives product from the distributor who places orders to the manufacturer. . The manufacturer places an order for raw materials, to the supplier.

Thus, the demand information flows from the consumer through various supply chain links to the supplier.

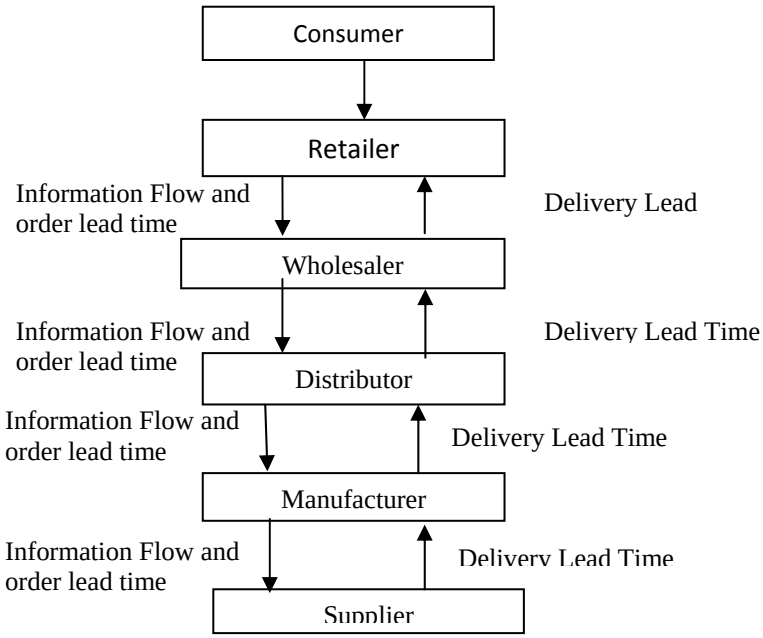


Fig 1: Generic supply chain model

2. BULLWHIP EFFECT

The prime responsibility of a supply chain is to move the raw material from the point of procurement to the point of

consumption with minimum lead-time. Unfortunately, supply chain may stumble when market condition changes and consumer demand shifts .Demand variability increases as one moves up the supply chain away from retail customer , and small changes in customer demand can result in large variation in order to place upstream. As a result the network oscillates in very large swing and different organizations adopt different methods to overcome and solve the problem. By their own perspective. This phenomenon is known as Bullwhip Effect.

It can be said that the Bullwhip Effect is due to the rational behavior of the decision-makers of a supply chain under a given structure. There are several factors that contribute to the Bullwhip Effect. The factors that contribute significantly are

1) The inaccurate forecasts of demand called “demand signal processing”.
2) Rationing of the products by the manufacturer to retailers due to some limitations in production called the“ rationing game”.
3) The ordering policy used by retailers called “order batching”.
4) Discounts and seasonal price variations.

Each of the four forces in concert with the chain's making create the bullwhip effect infrastructure and the order managers' rational decision

2.1 Demand signal processing

Demand signal processing is a major contributor to the bullwhip effect. Generally demand for goods in supply chain is based on demand forecast from companies rather than a actual consumer demand. Every company in a supply chain usually does product forecasting for its production scheduling, capacity planning, inventory control, and material requirements planning. Forecasting is often based on the order history from the company's immediate customers An important factor is each player's thought process in projecting the demand pattern based on what he or she observes and mentally prepares own strategy which is subjected to change with situation variation. When every downstream member places an order, the upstream member readjusts the demand forecast and then places an order to the upstream partner in the supply chain. These orders get processed and then finally reach the manufacturer as overall demand for the product. Forecasting is always subjective, as each firm uses different techniques, and the order quantity for a future period very often includes a very subjective 'hunch' on the part of the planner. These variables are sources of bias and noise in the demand signal.

Apart from the error due to the forecasting technique chosen, it is also the practice of sales personnel to amend the forecast demand figures according to their gut feelings before the close of the planning period (Reddy 2002). This causes an even greater variance in the demand information as it travels upstream.

2.2 ***Rationing and shortage gaming.***

Shortage gaming occurs in an environment of tight supply and when the manufacturer is expected to ration its products. The customers, wholesalers and retailers may order in large quantities with the expectation that they will receive a greater allocation of products that are in short supply

The impact on the supply chain is significant as the forecasted demand is greatly, and unrealistically, increased with these inflated orders. Eventually orders disappear and cancellations pour in, making it impossible for the manufacturer to determine the real demand for its products.

2.3 ***Order Batching****:*

In a supply chain, each supply chain member places orders on an upstream member using some inventory replenishment mechanism .The demands from customers may be small and frequent which deplete the inventory gradually; firms would wait until the inventory level reaches a predetermined minimum level (the reorder point) before order is initiated. This requires firms to order periodically in batches. This order size is large compared to the regular demand faced by the firm. The supplier receives a large, highly erratic stream of orders with a spike during one cycle, but no orders for the rest of the period. This variability is much larger than the demand faced by the downstream firm. As order cycles of disparate customers tend to randomly overlap, the result is a more erratic demand pattern than the actual demand seen by the customers - hence the *Bullwhip Effect.*

Batch order can also occur for other reasons, such as orders being held until a greater shipment size is reached, as this will result in better transport rates. Reddy (2002) points out that one way an artificial demand signal is often generated is by sales and marketing department personnel creating an artificial lower price for a product by foregoing a percentage of their own sales commission. Sales made in this way distort demand information and contribute to uncertainty.

2.4 ***Price Fluctuation***

Distributors periodically have various schemes and promotions like rebates and coupons to increase customer demand for the product. The buying pattern of the customer during such periods This variation in buying pattern is much higher than the variation in the consumption rate does not reflect buying needs, but is a seasonal condition Just as sales prompt consumers to buy an item in greater numbers compared with their usual buying patterns, special promotions and price discounts from manufacturers or suppliers result in retailers and wholesalers buying in large quantities and stocking them up. The manufacturers or suppliers often offer these to raise sales volume and to meet sales targets for a period. This is commonly known as 'meeting the quarter' in industry circles. The retailer takes advantage of these promotions to maximize profit. There is a similar buying spree when a price hike is expected. Commonly referred to as 'forwarding buying', the retailers and wholesalers make calculated decisions regarding likely future profits from such a move.

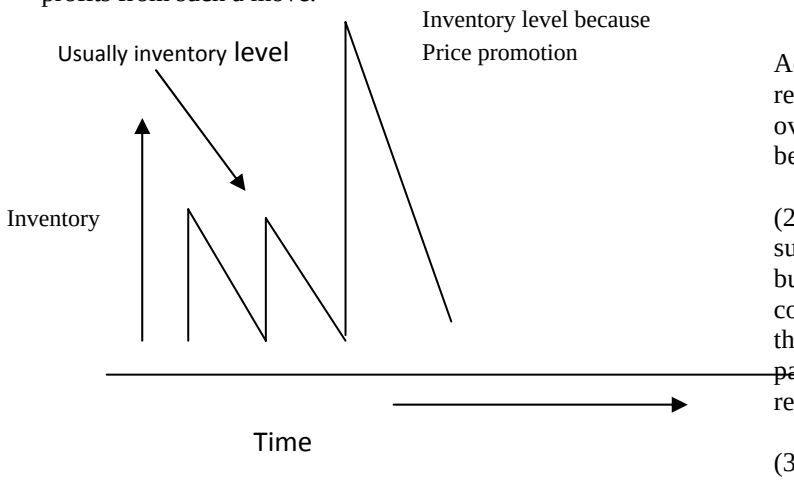


Fig 2 Price fluctuation

3. CONSEQUENCES AND POSSIBLE REMEDIES

In addition to greater safety stocks, the described effect can lead to either inefficient production or excessive inventory as the producer needs to fulfill the demand of its predecessor in the supply chain. This also leads to a low utilization of the distribution channel. In spite of having safety stocks there is still the hazard of stock-outs which result in poor customer service. Furthermore, the *Bullwhip effect* leads to a row of financial costs. Next to the (financially) hard measurable consequences of poor customer services and the damage of public image and loyalty an organization has to cope with the ramifications of failed fulfillment which can lead to contract penalties. Moreover the hiring and dismissals of employees to manage the demand variability induce further costs due to training and possible pay-offs

Possible Remedies

Measuring the total bullwhip effect does not tell which of the different causes contributes most and which solutions are most relevant. However, for each of the above causes, several possible remedies are suggested in literature. Some of them are

(1) Reducing Variability- Reducing the variability in the demand can reduce the *Bullwhip Effect* considerably. Frequent variation in product prices results in a pseudo increase or decrease in demand thereby introducing the variation into the system. If a product is offered for a consistent price as in EDLP (everyday low pricing), the *Bullwhip Effect* can be reduced to a considerable extent.

Lack of demand visibility can be addressed by providing Access to point of sale(POS) data. Single Control of replenishment or vendor management Inventory (VMI) can overcome exaggerated demand forecast .Long lead time should be reduced where economically advantageous.

(2) Reducing Uncertainty It is also true that even if all the supply chain partners use the same forecasting technique and buying policy the *Bullwhip Effect* cannot be eliminated completely. Data needs to be made available to all the links in the chain. This simple change in demand data transfer allows parallel forecasting and avoids the amplification that results from a multi-stage forecasting process .

(3) Planning to overcome fluctuating price. High low pricing can be replaced with every day low price (EDLP). Special purchase contents can be implemented in order to specify ordering at regular intervals to better synchronies delivery and purchase.

(4) Reducing lead time :Reducing both order lead-time and information lead-time will reduce a significant amount of variation in the system. In forecasting, safety stock levels and reorder points are a function of lead-time; reduction in lead-time reduces the variation. Systems such as cross docking and EDI (Electronic Date Interchange) can reduce both the ordering lead-time and the information lead-time

(5)Strategic Partnering and Buying – Strategic partnering reduces the lead-time to a great extent. Information sharing in strategic partnering reduces variation in the system. This can be

achieved by the use of a concept called VMI (Vendor Managed Inventory). This requires the manufacturer to maintain the inventory at the point of use thus reducing the variation in the system. The strategic buying policies adopted by the buyer and the manufacturer reduce the variation caused due to quantity discounts offered by the manufacturer.

(6)Adjusting Shortage gaming; Ignorance of supply chain conditions can de addressed by sharing capacity and supply information. Unrestricted ordering capacity can be addressed by reducing order size flexibility and implementing capacity reservation.

(7)Advanced Information Technology-Commerce eliminates the intermediaries such as the retailer from the system and gives the point-of-sale demand to all the supply chain partners. Elimination of the intermediaries, called disintermediation reduces the variation in the system to a large extent. This makes the demand information dynamically available to all the participants of the supply chain.

4. INTRODUCTION TO FUZZYLOGIC

A type of logic that recognizes more than simple true and false values. With fuzzy logic, propositions can be represented with degrees of truthfulness and falsehood. Fuzzy logic is a superset of conventional(Boolean) logic that has been extended to handle the concept of partial truth –the truth values between "completely true" and "completely **false".** The extent of uncertainty may make computation intractable. Fuzzy logic seeks to estimate a solution or neighborhood of a solution.

Crisp set: membership of element X of set A is defined by

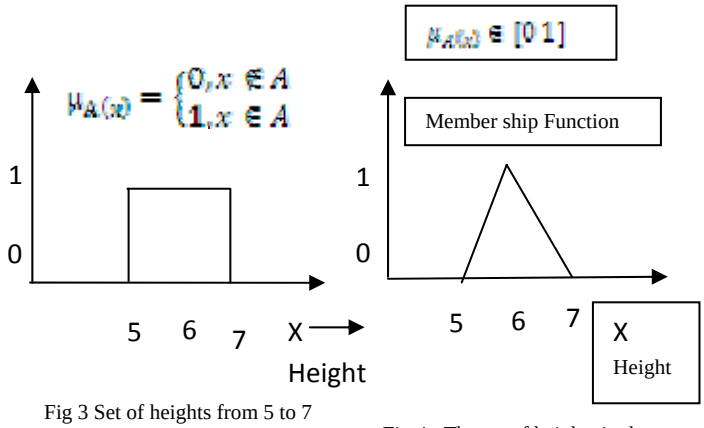


Fig 3 Set of heights from 5 to 7 feets

Fig 4 : The set of heights in the region around 6 feet.

Fuzzy set: Contain objects that satisfy imprecise properties of membership

The membership function is a graphical representation of the magnitude of participation of each input. It associates a weighting with each of the inputs that are processed, define functional overlap between inputs, and ultimately determines an output response.

2.21 *Triangular curve:* The triangular curve is a function of a vector, x, and depends on three scalar parameters *a*, *b*, and *c*, as given by

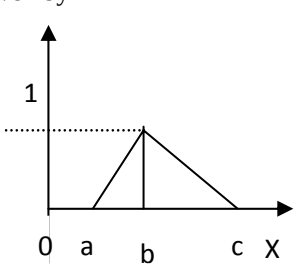


Fig: 5 Triangular fuzzy Asymmetrical

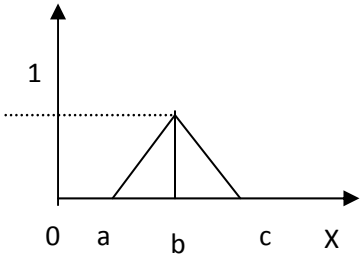


Fig: 6 Triangular fuzzy Symmetrical

$$f(x, a, b, c) = \begin{cases} \frac{x-a}{b-a}, & a \le x \le b \\ \frac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{cases}$$

Or more compactly by

$$f(x, a, b, c) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right)$$

The parameters *a* and *c* locate the "feet" of the triangle and the parameter *b* locates the peak.

2.2.2 The *trapezoidal curve*: The trapezoidal curve is a function of a vector, x, and depends on four scalar parameters *a*, *b*, *c*, and *d*, as given by

$$f(x, a, b, c, d) = \begin{cases} 0, & x \le a \\ \frac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \frac{d-x}{d-c}, & c \le x \le d \\ 0, & d \le x \end{cases}$$

Or more compactly by

$$f(x, ab, c, d) = max\left(min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right)$$

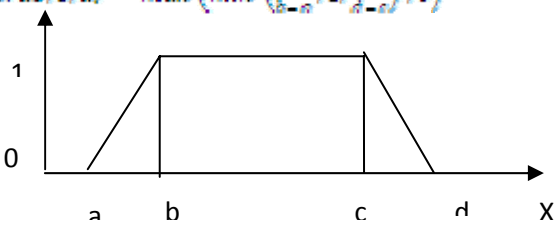


Fig 7 T*rapezoidal fuzzy* d and th

2.2.3Gaussian function: The symmetric Gaussian function depends on two parameters and *c* as given by the parameters for gaussmf represent the parameters and *c* listed in order in the vector.

$$f(x, \sigma, c) = e^{-\frac{(x-c)^2}{2\sigma^2}}$$

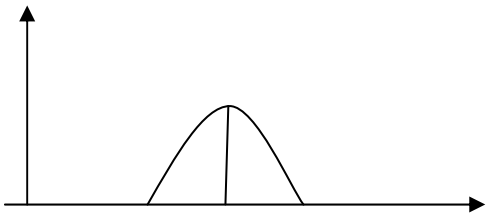


Fig:5 Gaussian Curve

5. FUZZY LOGIC APPROACH IN SUPPLY CHAIN MANAGEMENT

All facilities, functions, activities, associated with flow and transformation of goods and services from raw materials customer, as well as the associated information flows are considered as linguistic variables and all are combined with fuzzy (and) operation and Gaussian membership function is used. Mamdani fuzzy inference system is used to implement the rules.

This paper discusses three different attributes i e. Supplier performance , supplier characteristics and project..

Rules for strategic decision

characteristics which includes the sub characteristics described above and according to it the lower stream members can rank the supplier according to the requirement .

This paper discusses three different attributes i e. Supplier performance, supplier characteristics and project characteristics which includes the sub characteristics described above and according to it the lower stream members can rank the supplier according to the requirement .

Technological level: This aspect refers to the supplier development programs to implement new available technologies available by customer. It varies from worse to better through average.

Economical Situation:- It is "under risk" when is financial status does not satisfy customer's need medium when the financial condition of the vender is not optional but in moderate condition and can be modified and no risk when customer's expectation have been achieved.

Production capacity:- It is defined as overload when an investment is required to manufacture a new product due to lack of capacity. And available when there is manufacturing process and machine resources ready to be used by the new project.

Market share Similarly parameters market share of supplier characteristics can be put into linguistic variables. little participation, some participation, lot participation.

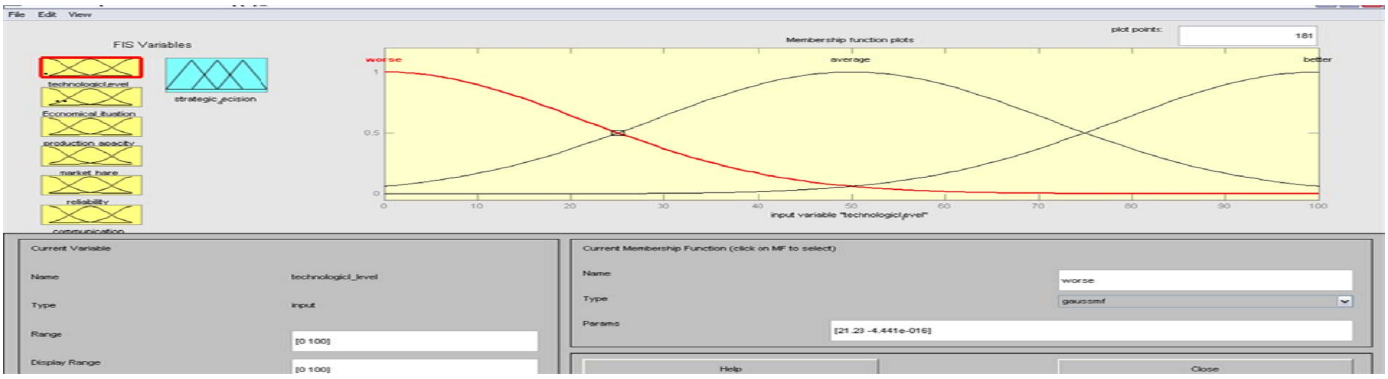
Reliability:- The reliability of the lower stream member to the supplier can be categorized to four linguistic variables i.e. poor, good, average, excellent .

Here some if then fuzzy inference rules are described basing on supplier characteristic and based on which strategic decision will be taken in the lower stream.

Fuzzy Inference Rules TABLE I

Rule no.	**Technogical level**	Economic situation	Production capacity	Market share (participation)	Reliability	Communication (information)	Strategic decision
1	**Worse**	Under risk	Over load	Little	Poor	Poor	Not recommended
2	**Worse**	Under risk	Available	Little	Poor	Poor	Not recommended

3	**Worse**	Moderate	Available	Some	Average	Poor	To-develop
4	**Average**	Moderate	Available	Some	Good	Good	To-develop
5	**Better**	Moderate	Overload	Lot	Good	Excellent	Convenient
6	**Average**	No risk	available	Little	Average	Average	Convenient
7	**Better**	Average	Available	Some	Average	Excellent	Recommended
8	**Better**	Average	Available	Lot	Good	Good	Recommended
9	**Better**	No risk	Available	Lot	Good	Good	Recommended
10	**Excellent**	No risk	Available	Lot	Excellent	Excellent	Recommended

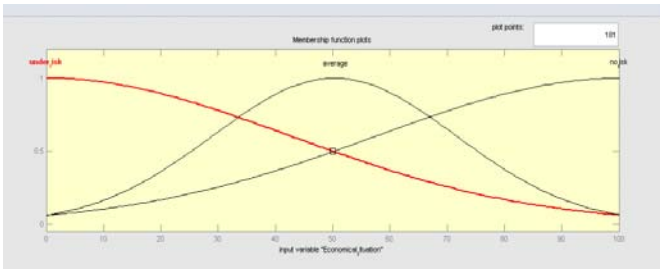


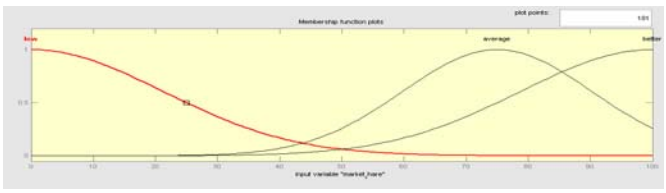
Rules for supplier performance TABLE II

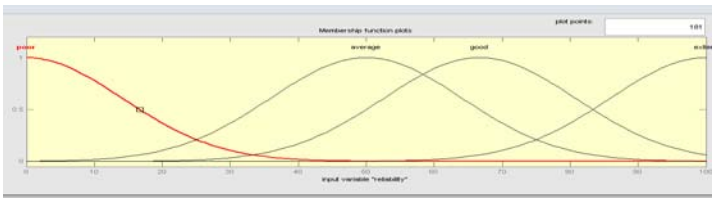
INPUTS				OUTPUT
Quality level	Delivery Rate	Price fluctuation	Safety stock level	Supplier performance
poor	poor	no	Poor	critical
good	poor	no	Poor	Critical
poor	good	little	Average	Critical
better	good	often	Average	Reliable
better	best	often	Good	Reliable
Excellent	best	little	Good	Perfect
Excellent	best	often	Good	Perfect

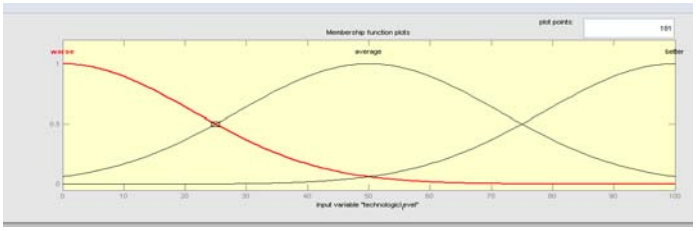
Rules for project characteristics TABLE III

INPUTS				OUTPUT
Project Partners' \Reputation	Investment cost	Project complexity (Time)	Demand of the project	Possibility of completion
low	high	high	low	10-20
low	high	high	medium	20-30
medium	high	medium	medium	30-40
medium	medium	medium	medium	40-60
high	medium	medium	medium	40-70
High	medium	medium	high	70-80
High	low	medium	high	80-90
High	low	low	high	90-100









Above two table describe the supplier performance and project characteristic in their linguistic forms and fuzzy inference rules. Following three tables give s the results for strategic decision, supplier performance, and project characteristics. .

Rules for Strategic Decision TABLE IV

Technological level	Economic situation	Production capacity	Market share (participation)	Reliability	Communication (information)	Strategic decision
30(worse)	50(moderate)	20(Available)	20 little	10(poor)	30(poor)	Not recommended(15)
40(worse	20(Under risk)	90(Overload	95lot	75(excellent)	80(excellent	Not recommended(33.5)
60(Better)	70(Norilsk)	30(Available)	40some	60(good)	50(average)	To-develop(3)
80(Excellent)	90(Norilsk)	50 Available)	80ot	50(average)	50(average)	Recommended(92)
80(Excellent	90 (Norilsk)	50 Available)	40some	90(excellent	30 (poor)	To-develop(50)
80(Excellent	90 (Norilsk)	90(Overload	70lot	90(excellent	50 average)	Convenient (78)

Rules for supplier Performance TABLE V

Quality level	Delivery Rate	Price fluctuation	Safety stock level	Supplier performance
10	10	10	10	Critical(17.7)
50	10	10	10	Critical(20)
90	50	20	40	Reliable (66)
100	80	90	90	Perfect (74.9)
90	80	90	90	Reliable(63.4)

Rules for Project characteristics TABLE VI

INPUTS				OUTPUT
Strategic decision	Supplier performance	Project complexity (Time)	Completion possibility	Final Decision
Not Recommended	Critical	10-20		Rejected
To Develop	Reliable	10-30		Rejected
Not Recommended	Critical	90-100		Rejected
To develop	Reliable	30-70		Second choice
Convenient	Reliable	60-80		Second choice
Convenient	Perfect	50-70		Under Consideration
Convenient	Perfect	70-90		First choice
Convenient	Perfect	90-100		First choice

TABLE VII

[Again the characteristics Supplier performance, strategic decision and project characteristic is fuzzified and converted to some if then rule to decide the rank of the supplier.]

Final Decision TABLE VIII

INPUTS			OUTPUT
Strategic decision	Supplier Performance	Completion possibility	Final Decision
10	30	1	15.4
60	30	.8	18.8
90	90	.6	88.3
80	70	.5	46.7
70	50	.9	58.2

Partners \Reputation	Investment cost	Project complexity (Time)	Demand of the project	Possibility of completion
5	5	5	5	45.2
1	5	5	9	35.2
4	8	7	9	48
10	10	9	9	82.4
10	7	9	8	72.6

6. CONCLUSION AND FUTURE WORK

In this paper fuzzy inference system is proposed for supplies selection. It has been observed that fuzzy theory provides a proper language by which indefinite and imprecise factors can be handled and is more realistic model than non fuzzy model. This study has proved that the bullwhip effect can be reduced significantly

by applying fuzzy set theory. It has shown that the fuzzy logic has the capabilities to determine the optimal ordering policy for each member of the SC. Further work can be carried out to investigate whether the GA, SVM can determine the optimal ordering policy for an online mode.

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