Designing and Managing the Supply Chain using Fuzzy Logic Approach

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ABSTRACT
In broad sense the Supply Chain Management is concern in optimizing customer service level requirements along with optimizing the cost of steps involved in it. In this paper, we use fuzzy if - else constructs for deriving customer satisfaction and cutting the costs for increasing the supply chain management efficiency. The proposed scheme provides managerial insights on the impact of the decision making in all the Supply Chain elements including suppliers, manufacturers, warehouses, transporters, retailers, and customers. In particular, we focus on the way in which our agent purchases components using a mixed procurement strategy (combining long and short term planning) and how it sets its prices according to the prevailing market conditions.

Keywords
Supply Chain Management, Fuzzy Logic, Fuzzy Association Rules, Linguistic Terms.

1. INTRODUCTION

1.1 Supply Chain Management
The definition of Supply chain management given by Chopra and Meindl (2001) is Supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers, and customers themselves.

The best companies around the world are discovering a powerful new source of competitive advantage. It's called supply-chain management and it encompasses all of those integrated activities that bring product to market and create satisfied customers. The Supply Chain Management Program integrates topics from manufacturing operations, purchasing, transportation, and physical distribution into a unified program. Successful supply chain management, then, coordinates and integrates all of these activities into a seamless process. It embraces and links all of the partners in the chain. In addition to the departments within the organization, these partners include vendors, carriers, third party companies, and information systems providers.

Thus, we can say that Supply chain management is a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses, and customers so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time in order to minimize system wise costs while satisfying service- level requirements.

Supply chain management (SCM) is the task that moves in a process from supplier to manufacturer to wholesaler to retailer to consumer [1][2]. Supply chain management involves coordinating and integrating these flows both within and among companies [3][4]. It is said that the ultimate goal of any effective supply chain management system is to reduce inventory (with the assumption that products are available when needed).

2. RELATED WORK

2.1 Fuzzy Logic
Fuzzy logic is a derivative from classical Boolean logic and implements soft .linguistic variables on a continuous range of truth values to be defined between conventional binary. It can often be considered a suspect of conventional set theory. Since fuzzy logic handles approximate information in a systematic way, it is ideal for controlling non-linear systems and for modeling complex systems where an inexact model exists or systems where ambiguity or vagueness is common.

A typical fuzzy system consists of a rule base, membership functions and an inference procedure [5]. Fuzzy logic is a super set of conventional Boolean logic that has been extended to handle the concept of partial truth-truth-values between “completely true” and “completely false”.

2.2 Fuzzy Subsets
In classical set theory, a subset U of asset S can be defined as a mapping from the elements of S to the elements the subset [0, 1], U: S -> {0, 1}

The mapping may be represented as a set of ordered pairs, with exactly one ordered pair present for each element of S. The first element of the ordered pair is an element of the set S, and the second element is an element of the set (0, l). Value zero is used to represent non-membership, and the value one is used to represent complete membership. The truth or falsity of the statement. The 'X is in U' is determined by finding the ordered pair whose first element is X. The statement is true if the second element of the ordered pair is 1, and the statement is false if it is 0.

2.3 Merits of Fuzzy Logic
The reasons why fuzzy logic is used are as follows [6]:

An alternative design methodology, which is simpler and faster.

It reduces the design development cycle.

It simplifies design complexity.

A better alternative solution to non-linear control.

It improves control performance.

It is simple to implement.

It reduces hardware cost.

2.4 Structure of Fuzzy Rules

Examine fever on the basis of body temperature:

Conventional model:–

if temperature > X, take paracetamol

else, stop taking paracetamol

Fuzzy System :-

if temperature = hot, take paracetamol of high mg

if temperature = warm, take paracetamol of low mg

if temperature = normal, stop taking paracetamol

In fuzzy rules, the linguistic variable temperature also has the range (the universe of discourse) between 99 and 105, but this range includes fuzzy sets, such as hot, warm and normal. The universe of discourse of the linguistic variable take paracetamol can be between 150 and 500 mg and may include such fuzzy sets as high, low and stop.

A fuzzy rule can be defined as a conditional statement in the form:

A fuzzy rule can be defined as a conditional statement in the form:

IF x is A

THEN y is B

Where x and y are linguistic variables; and A and B are linguistic values determined by fuzzy sets on the universe of discourses X and Y, respectively.

3. PROPOSED MODEL

Here we are proposing SCM model for a particular product like Water Purifier with RO. In our model we are introducing the customer agent and Customer RRO (Request for RO). The customer agent receives customer RRO requesting a quantity of Water Purifier with RO delivery on a specified day. The customer agent is the key component while component agent is responsible for dealing with the component suppliers and aims to ensure that there are always sufficient components in stock to address the customers' changing demand for finished products.

3.1 Selecting Customer Request

We know that Water Purifier with RO is used for removing hardness from water. So the main task of Customer agent to find the areas where people are drinking hard water. As usual the demand for Water Purifier with RO in those areas will be more. If the demand is high then Customer agent may sell the product with high margin of profit and may increase the agent commission also. Customer agent commission depends on delivery date and hardness of water in the demanding areas.

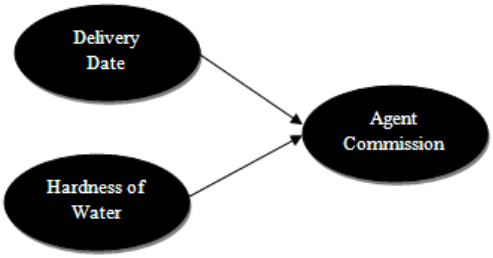

Fig 1: Agent Commission depends on Delivery Date and Hardness of Water

3.2 Measure Water Hardness - How is Water Hardness Measured?

Water hardness is measured in "grains" per gallon, in milligrams of calcium (Ca) per liter, or parts per million, and German Degrees of Hardness (dH) [which we drop here as this is for fish tanks]. we can take a water sample to a water test lab to have its hardness measures.

We can convert among water hardness measures. Water with hardness of 25 ppm = 25 mg. of hardness-causing minerals per liter of water.

Table 1. Degrees of Water Hardness [7]

Degrees of Water Hardness	
Soft water	0-17.1 mg/L of minerals
Slightly hard water	16.1-60 mg/L of minerals
Moderately hard water	61-120 mg/L of minerals
Hard water	121-180 mg/L of minerals
Very hard water	more than 180 mg/L of minerals

3.3 Methodology

We are applying the Fuzzy logic if-else algorithm using the following rules and simulated it using available data. Here we define fuzzy rules and then revisited the rules for our goal. Here we can define the membership function which can calculate the degree of hardness of water, then another membership function which can calculate the delivery date then on the basis of linguistic variables we can decide the agent commission. According to Table. 1. we assume the degree of hardness as given below

0.0 if the hardness of water is between (0 -17.1mg/L) of minerals (soft water)

0.25 if the hardness of water is between (16.1 – 60mg/L) of minerals (slightly hard water)

0.50 if the hardness of water is between (61-120 mg/L) of minerals (moderate hard water)

0.75 if the hardness of water is between (121-180 mg/L) of minerals (hard water)

1.0 if hardness >180 mg/L of minerals (very hard water)

Now we can decide the degree of delivery

0.0 if RO installed after seven days of request

0.20 if RO installed after six days of request

0.40 if RO installed after five days of request

0.50 if RO installed after four days of request

0.65 if RO installed after three days of request

0.75 if RO installed after two days of request

delivery > 0.85 if RO installed on the day of request.

Linguistics variables used in the rules

Table 2. Agent Commission on the basis of degree of membership

Hardness	Degree of Hardness	Degree of Delivery	Agent Commission	
200	1.0	1.0	A1	1.0
130	0.75	0.20	A2	0.75
67	0.50	0.60	A3	0.60
500	1.0	0.70	A4	1.0
700	1.0	0.80	A5	1.0

3.4 Fuzzy Intersection Operation

The membership function of the Intersection of two fuzzy sets A and B with membership functions μA and μB respectively is defined as the minimum of the two individual membership functions. This is called the minimum criterion.

$\mu A \cap B = \min(\mu A, \mu B)$.

3.5 Fuzzy Rules for Customer Agent Commission

So according to Rules given below, we can decide the agent commission on the basis of degree of hardness and delivery date.

Rule1: If the hardness of water is very high and Customer agent installing the Water Purifier with RO on the request date then the agent commission is very high.

Rule2: If the water is soft and Customer agent installing the Water Purifier with RO after seven days of request then the agent commission is very low

3.6 Data Analysis and Discussion

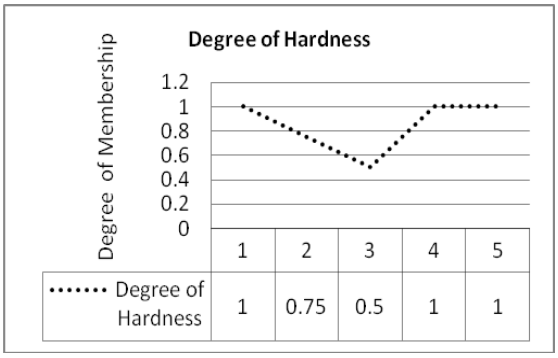

Fig 2: Degree of Hardness

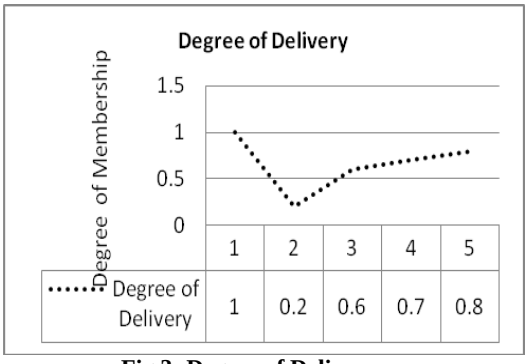

Fig 3: Degree of Delivery

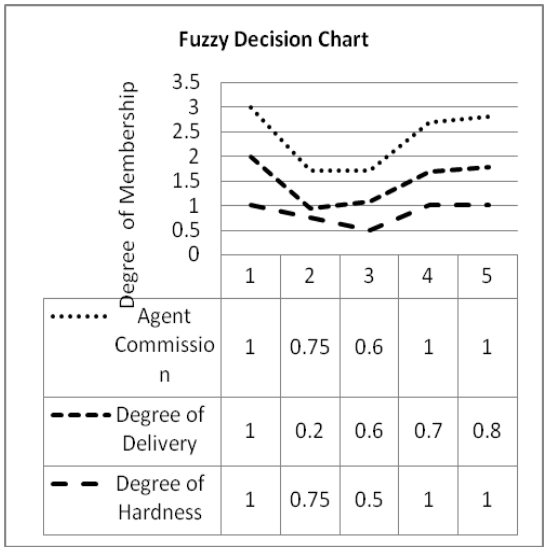

Fig 4: Fuzzy Decision

The aim of this research is to analyze the supply chain management on the basis of Customer Agent performance, the sale of water purifier with RO is depends on the Hardness of water and delivery time, as the sale of water purifier with RO increased the profit of manufacturer, suppliers, distributors and most important the agent commission also increased. Fig 2, Fig 3 and Fig 4 are justifying above thought.

4. SIMULATED RESULTS

Table 3. Simulated Result

Hardness	Delivery Date	Agent Commission	
Soft water	After seven Days	A1	Very low
Slightly hard water	After five days	A2	Low
Moderately hard water	After three days	A3	High
Very Hard Water	Same Day	A4	Very high

Fuzzy linguistic terms also showing the same result, as the result coming from crisp data. We are getting the crisp data in terms of degree after the fuzzification of crisp data. Then using the fuzzy if- else algorithm, it is giving the same results.

5. CONCLUSION

This paper, intended to use fuzzy logic in decision making for the supply chain management. Here we focused on agent commission in supply chain management. For achieving it we have used the fuzzy approach. In the proposed scheme, customer agent commission depends on the harness of water and delivery timings.

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