*Research Inventy: International Journal Of Engineering And Science*
*Vol.2, Issue 10 (April 2013), Pp 48-52*
*Issn(e): 2278-4721, Issn(p):2319-6483, Www.Researchinventy.Com*

# Tackling Rationing and Shortage Gaming Reason of Bullwhip Effect With Fuzzy Logic Approach

[1]Manoj Kumar, [2]Dr. S. Srinivasan, [3]Dr. Gundeep Tanwar
[1]*(Research Scholar Suresh Gyan Vihar University Rajasthan*
[2]*(Professor & Head of Department PDM College of Engineering Haryana*
[3]*(Associate Professor BRCM College of Engineering & Technology Haryana*

***Abstract –*** *The supply chain is major part of business activities. In the supply chain, every organization orders from its instantaneous upstream collaborators. Usually, the retailer's order do not match with the authentic retail sales. The bullwhip effect refers to the incident where orders to the supplier tend to have bigger variance than sales to the buyer (i.e. demand misrepresentation), and the alteration propagates upstream in an enlarged form (i.e. variance amplification). It is verified that if the members of the supply chain allocate information with intellectual support technology, and concur on enhanced and superior fuzzy estimates on future sales for the upcoming period, then the bullwhip effect can be significantly reduced.*

***Keywords*** *– Supply chain management system, Bullwhip effect, Fuzzy Logic, Rationing & Shortage gaming.*

## I. INTRODUCTION

When every member of the grouping in a supply chain tries to exploit his or her own benefit without regard to the impact of other members of the group, the overall effectiveness may suffer. Such inefficiencies often creep in when rational members of supply optimize individually instead of coordinating their efforts. A well known example of such inefficiency in staged supply chains is the bullwhip effect. This effect refers to the tendency of replenishment orders to increase in variability as one moves up the supply chain from retailer to manufacturer. A lack of coordination may even outweigh the benefits from specialization and economics of scale. Therefore it can be said that the bullwhip effect is the key example for supply chain inefficiency. So the bullwhip effect is near-hand term for a dynamical phenomenon in supply chains.

The rationing and shortage gaming is the fourth cause for Bullwhip effect. It is characterized by large swings in perceived demand at upstream components of supply chain. To counter this reason following measures are useful.

- Allocate product depend on past sales not on current orders
- Share information regarding capacity
- Long term contracting to permit vendors to adjust capacity
- Eliminate generous return and order cancellation policies

Generally, Bullwhip effect is a main cause of worry in a supply chain as these results in inventory pile-up while there is no demand and huge shortages while there is demand. Both result in loss of profitability. Moreover, this phenomenon is more serious whenever one go away from the customer end of a supply chain. The possible approaches to counter this influence have been mentioned above.

It is more effectively countered with information sharing among channel alignment, supply chain partners, and better operational efficiencies.Internally also, this behavior is present seriously throughout the chain. The typical case is the "marketing-manufacturing conflict". The demand forecast is inflated by marketing so as to achieve longer allocation from the manufacturing units. It saves them from being caught in short-supply situation under an upward market swing. Manufacturing and distribution people make a second guess apparently to nullify it that creates further distortion in demand. Likewise way, other elements of the chain contribute to the inventory building measures. Decisions about required-capacity of the enterprise lag behind the modification in demand. This causes further building-up of a safety net for inventories or lost sales because of under-production

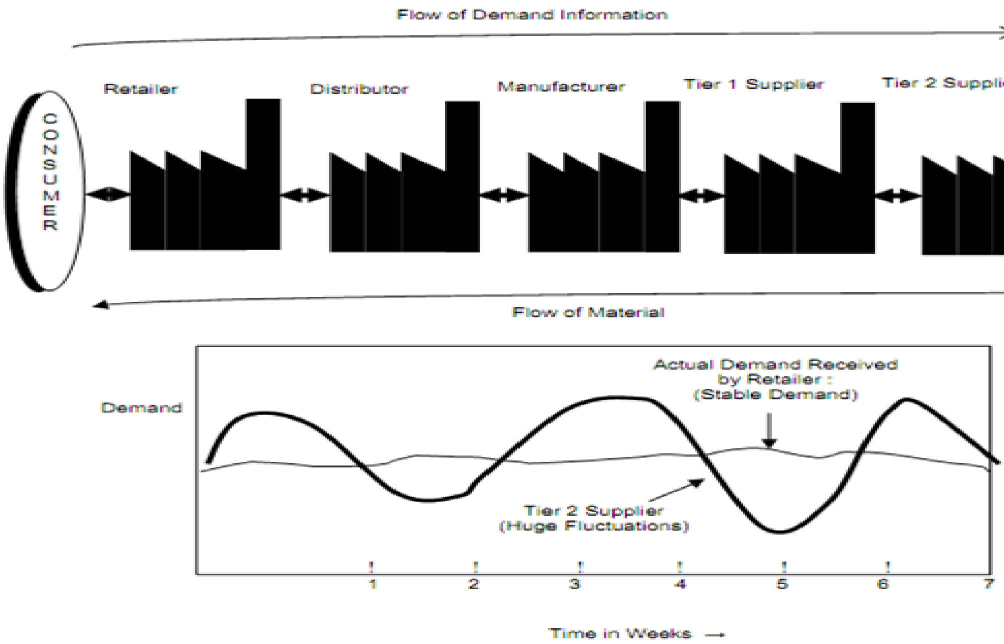


Figure 1: Bullwhip effect

They both reflect the responses of individual stakeholders to market dynamics (Lee et al. 1997a). As with price fluctuations, the effect of shortage gaming is also that the customer's orders do not reflect the real demand pattern, albeit for different reasons. "Gaming" occurs when customers order more than they really need, because they know that the supplier will have to ration his product quantities in times of capacity shortages. Customers may even place orders with multiple suppliers, buy from the first one that can satisfy their needs and subsequently cancel all other orders.An effective counter-measure is to apply different rules for allocating scarce capacity across customers in (genuine) shortage situations. For instance, the introduction of allocation mechanisms based on past sales records rather than on actual orders eliminates the incentive for customers to exaggerate their order sizes.

## II. RELATED WORK

Lee et al. (1997) stated that the bullwhip effect occured when the demand order variabilities in the supply chain were amplified as they moved up the supply chain. Distorted information from one end of a supply chain to the other leaded to tremendous inefficiencies. Companies effectively counteracted the bullwhip effect by thoroughly understanding its underlying causes. Industry leaders were implementing innovative strategies that pose new challenges: 1. integrating new information systems, 2. defining new organizational relationships, and 3. implementing new incentive and measurement systems.Akkermans et al. (2000) highlighted an additional root cause: interactions of high workloads and reduced process quality that started reinforcing each other in a vicious cycle once workloads pass a certain threshold. In this particular case, many of the known counter-measures to eliminate amplification did not apply given the nature of the service process or could only yield limited results. A potentially very powerful counter-measure is to implement quality improvements throughout the service chain. This quality dimension links our research to the literature on service management in general, where service quality is on top of the research agenda.

Zarandi et al. (2005) presented a fuzzy multiple objective supplier selection's model in multiple products and supplier environment. In their model, all goals, constraints, variables and coefficients are fuzzy. They showed that with the application of fuzzy methodology, the multi-objective problem is converted to a single one.Saghiri et al. (2006) presented a fuzzy expert system model for SC complex problems. They compared the results of their proposed expert system model with fuzzy linear programming and showed its superiority. Ismail et al. (2008) simulated a four-stage supply chain that is based on the Stock-to-Demand inventory type. The aim of the simulation was to investigate the well-known phenomenon of the bullwhip effect, and identify the parameters that affect it. To investigate and measure this impact, a simulation model was developed using Arena 12.0 software package for a four-stage supply chain, consisting of a single retailer, wholesaler, distributor and a factory. Since the bullwhip effect was based on an interrelated network of parameters, the model will be changed to reflect the change in these parameters on the variance amplification of orders. The experiments with the developed model were described and the results are analyzed.

Collins et al. (2010) discussed its significance in the context of today's global market economy as well as AI research, the ways in which it broken away from limiting assumptions made in prior work, and some of the advances it had engendered over the past six years. TAC SCM required autonomous supply chain entities, modeled as agents, to coordinate their internal operations while concurrently trading in multiple dynamic and highly competitive markets. Since its introduction in 2003, the competition had attracted more than 150 entries and brought together researchers from AI and beyond in the form of 75 competing teams from 25 different countries.Behzad et al. (2010) modeled and simulated the internal service supply chains of a healthcare system to study the effects of different parameters on the outputs and capability measures of the processes. The specific objectives were to analyze medication delivery errors in a community hospital based on the results of the models and to explore the presence of bullwhip effect in the internal service supply chains of the hospital.

## III. IMPACT OF RATIONING AND SHORTAGE GAMING

The rationing and shortage gaming occurs when demand exceeds supply. If the paper mills once have met shortages with a rationing of customer deliveries, the customers will start to exaggerate their real needs when there is a fear that supply will not cover demand. The shortage of DRAM chips and the following strong fluctuations in demand was a historic case of the rationing and shortage game. The bullwhip effect will amplify even further if customers are allowed to cancel orders when their real demand is satisfied. The gaming leaves little information on real demand and will confuse the demand patterns of customers. On the other hand, there have not been any cases of shortage of production capacity of the paper products in the last decade; there is normally excess capacity. Thus we have excluded this possible cause from further study.

The bullwhip effect occurs due to rational decision making by the units within the supply chain's infrastructure. The problem lies in the chain's infrastructure and processes. It is therefore necessary that it is designed and developed in a manner that will counter the bullwhip effect. We can see this through the major causes of the bullwhip effect such as demand forecast updating, order batching, and rationing. In demand forecasting, suppliers rationally forecast demand by their previous orders which they assume will remain constant therefore trying to keep inventory as well as costs low. Order batching in the supply chain is also rational though it is affected by transport costs which can be very high. Therefore if ordering frequently the suppliers try to order for a full truck load. Rationing can be seen as rational because when customers over react because they anticipating shortages, the supplier then has to ration the products to avoid complete shortages in the market. Proportional rationing schemes are countered by allocating units based on past sales. Ignorance of supply chain conditions can be addressed by sharing capacity and supply information. Unrestricted ordering capability can be addressed by reducing the order size flexibility and implementing capacity reservations. For example, one can reserve a fixed quantity for a given year and specify the quantity of each order shortly before it is needed, as long as the sum of the order quantities equals to the reserved quantity. Countermeasures to fluctuating prices - High-low pricing can be replaced with everyday low prices (EDLP). Special purchase contracts can be implemented in order to specify ordering at regular intervals to better synchronize delivery and purchase. However, just because the decision making is rational does not mean that there will be no bullwhip effect. It is only an improved supply chain structure plus rational decision making that will effectively reduce the bullwhip effect.

Cyclical industries face alternating periods of oversupply and undersupply. When buyers know that a shortage is imminent and rationing will occur, they will often increase the size of their orders to insure they get the amounts they really need. To counteract this behavior, Lee and his colleagues advocate allocation of demand among customers based on past usage, not on present orders. Furthermore, they encourage more open sharing of sales, capacity, and inventory data so that buyers are not surprised by shortages.

## IV. FUZZY LOGIC

Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth -- truth values between "completely true" and "completely false". It was introduced by Dr. Lotfi Zadeh of UC/Berkeley in the 1960's as a means to model the uncertainty of natural language. Zadeh says that rather than regarding fuzzy theory as a single theory, we should regard the process of ``fuzzification" as a methodology to generalize ANY specific theory from a crisp (discrete) to a continuous (fuzzy) form. Thus recently researchers have also introduced "fuzzy calculus", "fuzzy differential equations", and so on In classical set theory, a subset U of a set S can be defined as a mapping from the elements of S to the elements of the set {0, 1},

U: S --> {0, 1}

This 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, 1}. The value zero is used to represent non-membership, and the value one is used to represent membership. The truth or falsity of the statement

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.Similarly, a fuzzy subset F of a set S can be defined as a set of ordered pairs, each with the first element from S, and the second element from the interval [0,1], with exactly one ordered pair present for each element of S. This defines a mapping between elements of the set S and values in the interval [0,1]. The value zero is used to represent complete non-membership, the value one is used to represent complete membership, and values in between are used to represent intermediate DEGREES OF MEMBERSHIP. The set S is referred to as the UNIVERSE OF DISCOURSE for the fuzzy subset F. Frequently, the mapping is described as a function, the MEMBERSHIP FUNCTION of F. The degree to which the statement

x is in F

is true is determined by finding the ordered pair whose first element is x. The DEGREE OF TRUTH of the statement is the second element of the ordered pair. In practice, the terms "membership function" and fuzzy subset get used interchangeably.

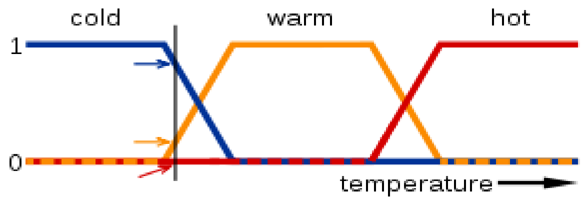


Figure 2: Degree of Membership

That's a lot of mathematical baggage, so here's an example. Let's talk about people and "tallness". In this case the set S (the universe of discourse) is the set of people. Let's define a fuzzy subset TALL, which will answer the question "to what degree is person x tall?" Zadeh describes TALL as a LINGUISTIC VARIABLE, which represents our cognitive category of "tallness". To each person in the universe of discourse, we have to assign a degree of membership in the fuzzy subset TALL. The easiest way to do this is with a membership function based on the person's height.

tall(x) = { 0, if height(x) < 5 ft.,

(height(x)-5ft.)/2ft., if 5 ft. <= height (x) <= 7 ft.,

1, if height(x) > 7 ft. }

Fuzzy logic is used directly in very few applications. The Sony PalmTop apparently uses a fuzzy logic decision tree algorithm to perform handwritten (well, computer lightpen) Kanji character recognition. Most applications of fuzzy logic use it as the underlying logic system for fuzzy expert systems.

## V. FUZZY LOGIC BASED RATIONING AND STORAGE GAMING RESOLVING MODEL

As uncertainty in the environment of supply chain is usually unavoidable, an appropriate system is needed to handle it. Fuzzy system modeling has shown its capability to address uncertainty in supply chain. It can be used in an agent-based supply chain management system by development of fuzzy agents and fuzzy knowledge-base; Fuzzy agents use fuzzy knowledge bases, fuzzy inference and fuzzy negotiation approaches to handle the problems in the environment and take into consideration uncertainty. Using fuzzy concepts leads to more flexible, responsive and robust environment in supply chain which can handle changes more easily and cope with them naturally. This paper focuses on the architecture of information agent in ISCM. For this purpose, we explain its functions, inputs and outputs. Then, by considering the basics of a modular architecture for agents and also supply chain properties, a new modular architecture for the information agent in ISCM is proposed. We develop the knowledge-base in the architecture and define required fuzzy rules and database. Moreover, we evaluate and test the knowledge base and compare the method in which fuzzy rules has been used with the one with non-fuzzy rules.

Finally, we introduce an approach for dynamic updating the forecasted cost and time in every stage of supply chain. We have used Mamdani type operators to fuzzify the variables and aggregation of the rules, stated in (Cordon 2001). Mamdani fuzzy reasoning takes the minimum of the antecedent conditions in each rule and assumes the fuzzy truth of the rule to be 1. We use minimum operator for rule implications and AND operator in antecedent of rules. From a functional point of view, a Mamdani fuzzy inference system is a nonlinear mapping from an input domain X □ Rn to an output domain Y □ Rm. This input/output mapping is realized by means of R rules of the following form

IF $_{x}$isr $_{A(r)}$THEN $_{y}$ is $_{b(r)}$

Rule-base contains both fuzzy and crisp rules. As mentioned before, every order has its related total time and total cost which can be obtained respectively by adding time and cost of each stage in the order route. We introduce an approach for updating the forecasted values of total time and cost of each order and directing the supply chain to the committed cost and time. for the costumer. Before an order flows in the supply chain, there is forecasted total time and total cost for order fulfillment. As the order moves in the chain and goes through the stages, the actual cost and time for each stage are emerged. Consequently, we can define new total time and total cost for the order. Thus, if order needs m stages to be fulfilled, we have: For implementing the proposed model, The MATLAB is used. It contains the Fuzzy Logic Toolbox™ having functions, apps, and a Simulink® block for analyzing, designing, and simulating systems based on fuzzy logic.

## VI. CONCLUSION

This chapter proposes a proper modular architecture for the supply chain management system having the inputs, functions, and outputs. The proposed architecture is concerned regarding the rationing & shortage gaming. Then, we explored the occurrence of bullwhip effect in supply chains, in a fuzzy environment. We built an agent-based system which can operate in a fuzzy environment and is capable of managing the supply chain in a completely uncertain environment. They are able to track demands, remove the bullwhip effect almost completely, and discover policies under complex scenarios, where analytical solutions are not available. Such an automated supply chain is adaptable to an ever-changing business environment.

## REFERENCES


[1] Baganha M, Cohen M., “The stabilizing effect of inventory in supply chains”. Operations Research; 46:572–83, 1998.

[2] Barbuceabu, M., Fox, M.S., “The Information Agent: An Infrastructure Agent Supporting Collaborative Enterprise Architectures”, report of Enterprise Integration, University of Toronto, 19995.

[3] Cachon GP, Lariviere MA., “Capacity choice and allocation: strategic behavior and supply chain performance”. Management Science; 45(8):1091–108, 1999.

[4] Cachon GP., “Managing supply chain demand variability with scheduled ordering policies”, Management Science, Vol. 45, No. 6, pp. 843–56, 1999.

[5] Caglayan, A., Harrison, C., “Agent Sourcebook”, John Willey & Sons, 19997.

[6] Carlsson C., Fuller R., Reducing the bullwhip effects by means of intelligent, soft computing methods. Proceeding of the 34th Hawaii International Conference on System Science, 2001.

[7] Carlsson C., Fuller R. On possibilistic mean value and variance of fuzzy numbers, Fuzzy Sets and Systems, (122), 315-326, 2001.

[8] Chauhan, D., “JAFMAS: A Java_based Agent Framework for Multi-Agent Systems Development and Implementation”, Technical Report, ECECS Department, University of Cincinnati, 1997.

[9] Chen F, Drezner Z, Ryan J, Simchi-Levi D, Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead-times, and information. Management Science; 46(3):436–43, 2000.

[10] Chen F, Decentralized Supply Chains Subject to Information Delays, Management Science, Vol. 45, No. 8, 1076-1090, 1999.

[11] Chen, Y., Peng, Y., Labrou, Y., A negotiation-based multi-agent system for supply chain management. Working Notes of the gents’99 Workshop on Agents for Electronic Commerce and Managing the Internet-Enabled Supply Chain, Seattle, WA, April, 15–20, 1999.

[12] Chen F, Drezner Z, Ryan J, Simchi-Levi D., “Quantifying the bullwhip effect in a simple supply chain: the impact of forecasting, lead-times, and information”, Management Science; Vol. 46, No. 3 pp. 436–43, 2000.

[13] Cebi F., Bayraktar D., “An integrated approach for supplier selection”, Logistics Information Management, Vol. 16, No. 6, pp. 395-400, 2003.

[14] Cordon, O., Herrera, F., Hoffman, F., “Genetic fuzzy Systems: Evolutionary Tuning of Learning of Fuzzy Knowledge-Bases”, Advanced in Fuzzy Systems-Applications and Theory, Vol. 19, World Scientific, 2001.

[15] Dasgupta, P., Narasimhan, N., Moser, L., Melliar-Smith P., ”MAgNET: Mobile Agents for Networked Electronic Trading”, IEEE Transactions on Knowledge and Data Engineering, Vol. 11, No. 4, 1999.

[16] Drezner Z, Ryan J, Simchi-Levi D. Quantifying the bullwhip effect: the impact of forecasting, lead-time, and information; Management Science, 46(3); 436-443, 2000.

[17] Erol E., Ferrel W.G., “A method for selection problems with multiple conflicting objectives and both qualitative and quantitative criteria”, International Journal of Production Economics, Vol. 86, pp. 187-199, 2003.

[18] Fazel Zarandi M.H., Saghiri S., “Developing fuzzy expert systems models for supply chain complex problem: A comparison with linear programming”, IEEE World Congress on Computational intelligence, Vancouver, Canada, pp. 6935-6939, 2006

[19] Fazlollahi, B., “Soft Computing Agent-Based Distributed Intelligent Systems”, IOSPress, 2002.

[20] Feng Y., Hu L., Shu H., The variance and covariance of fuzzy random variablesand their application. Fuzzy Sets and Systems.120, 487-497, 2001.