International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 3 | ISSN : 2456-3307

Survey on Fuzzy Logic and Subjective Performance Evaluation of Supply Chain Management

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ABSTRACT

Fuzzy logic can be a capable apparatus for directors to use rather than customary numerical models while assessing the execution of supply chains. The adaptability of the model enables the leader to present unclearness, vulnerability, and subjectivity into the assessment framework. In this paper we study an elective technique for the execution assessment framework rather than the conventional quantitative strategies. Execution assessments speak to a fundamentally critical choice that regularly includes subjective data. Models and heuristic systems that attention on the utilization of various kinds of data are accessible; in any case, with couple of special cases, the models are not sufficiently strong to be connected in a viable, authoritatively helpful way. Fuzzy logic models give a sensible answer for these basic choice circumstances. After broad investigation of the writing, we suggest a result of investigating Fuzzy logic approach in assessing subjective parts of execution of inventory network administration. In this paper we overview fuzzy logic as a powerful and simple understanding technique to assess subjective parts of execution of supply chains.

Keywords: Supply Chain, Performance Measurement, qualitative measures and fuzzy logic

I. INTRODUCTION

Many performance measures have been identified as appropriate for supply chain analysis, but have not yet been used in supply chain modeling research, although these measures may be important characteristics of a supply chain, their use in supply chain models is challenging, since the qualitative nature of such measures makes them difficult to incorporate into quantitative models [1]. Due to growing availability of qualitative information for performance measurement is more practical and easy to measure supply chain performance in linguistic terms, including vagueness concept [2]. Qualitative metrics do not possess quantitative values and cannot be measured by numerical numbers. In that case, linguistic terms are used to evaluate performance of qualitative metrics [2].

Fuzzy logic controller is useful when the problem is too complex to be solved with quantitative approachesConventional measures (such as: profit, percentage of products delivered on time etc.) had the drawbacks of tending to measure financial metrics, and failed to include intangible and lagging indicators [4]. Fuzzy is an appropriate modeling method to deal with intangible and qualitative measures which uses fuzzy set theory and linguistic values and has been applied widely in various areas of Supply Chain Management [2].

Fuzzy logic is a problem solving methodology that provides a simple way of definite conclusions from

vague and imprecise information. Fuzzy set theory was first introduced by Zadeh in 1965. He was motivated by observing that human reasoning can utilize concepts and knowledge that don't have well-defined boundaries [5]. Fuzzy set theory is a generalization of the ordinary set theory. A useful approach for examining many real-world problems is fuzzy approximate reasoning or fuzzy logic. This technique is based on the fuzzy set theory [6] that allows the elements of a set to have varying degrees of membership, from a non-membership grade of 0 to a full membership of 100 per cent or grade 1. This smooth gradation of values is what makes fuzzy logic match well with the vagueness and uncertainty typical of many real world problems. Given the preceding discussion, this literature review searched studies that relate to qualitative Supply chain performance Management evaluation to fuzzy logic. Therefore, we investigated how fuzzy logic has been applied in this field.

II. LITERATURE REVIEW

2.1 Fuzzy Logic

Fuzzy logic is very useful for various people who involved in research and development including several engineers like mechanical, electrical, civil, aerospace, chemical, agricultural, computer, biomedical, environmental, industrial, geological, and mechatronics. It also includes mathematicians, computer software developers, medical researchers, natural scientists, social scientists, business analysts, public policy analysts, and jurists. Actually, the applications of fuzzy logic, once supposed to be an ambiguous mathematical curiosity, can be establish in various engineering and scientific works. Fuzzy logic has been used in several applications such as air conditioners, facial pattern recognition, washing machines, antiskid braking systems, vacuum cleaners, transmission systems, knowledge-based systems for multi objective optimization of power systems, control of subway systems and unmanned helicopters, weather forecasting systems, medical diagnosis and treatment plans, models for new product pricing or project risk assessment, and stock trading. Fuzzy logic has been effectively used in various fields such as power engineering, control systems engineering, image processing, robotics, industrial automation, consumer electronics, and optimization.

Many researchers are working with fuzzy logic and making copyrights and research papers. Zadeh offered a report on the impression of fuzzy logic in March 2013 [6], According to this report there are 26 exploration journals on principle or applications of fuzzy logic, there are 22,657 publications or journals on principle or applications of fuzzy logic in the MathSci Net databank, there are 89,365 publications or journals on principle or applications of fuzzy logic in the INSPEC databank, there are 7149 copyright applications and copyrights issued interrelated to fuzzy logic in Japan and there are 16,898 copyright applications and copyrights issued interrelated to fuzzy logic in the USA. Many research contributions are increasing daily and are growing at an increasing rate. 89,365 publications or journals on principle or applications of fuzzy logic in the INSPEC databank, there are 7149 copyright applications and copyrights issued interrelated to fuzzy logic in Japan and there are 16,898 copyright applications and copyrights issued interrelated to fuzzy logic in the USA. Many research contributions are increasing daily and are growing at an increasing rate. 89,365 publications or journals on principle or applications of fuzzy logic in the INSPEC databank, there are 7149 copyright applications and copyrights issued interrelated to fuzzy logic in Japan and there are 16,898 copyright applications and copyrights issued interrelated to fuzzy logic in the USA. Many research contributions are increasing daily and are growing at an increasing rate.

2.2 Role of Fuzzy Logic in Qualitative Performance Evaluation of Supply Chain Management.

Conventional evaluation systems are representatives of structured systems that employ quantifiable and non-quantifiable measures of evaluation. It is often difficult to quantify performance dimensions. For example, "responsiveness" may be an important part of evaluating performance of supply chains. However, how exactly does one measure "responsiveness". Fuzzy approach can be effectively utilized to handle imprecision and uncertainty [15]. This approach to performance evaluation allows the organization to exercise professional judgment in evaluating its supply chains. In real problems, performance evaluation techniques engage in handling cases like subjectivity, fuzziness and imprecise information. It is often difficult to quantify performance dimensions because all critical parameters in a Supply Chain Management are indicated subjectively by linguistic terms and are characterized by ambiguity [14] .Fuzzy set theory is primarily concerned with quantifying and reasoning using natural language in which many words have ambiguous meanings. Application of the fuzzy set theory in evaluation systems can improve evaluation results [2]. The performance measurement process has evolved since the mid-eighties. Performance measures provide the necessary feedback for management which assists in business decisions [2]. Models in the past have only explored limited dimensions of supply chain performance such as cost [16], and flexibility [15]. Many performance measures have been identified as appropriate for supply chain analysis, but have not yet been used in supply chain modeling research, although these measures may be important characteristics of a supply chain, their use in supply chain models is challenging, since the qualitative nature of such measures makes them difficult to incorporate into quantitative models [1].

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Fuzzy set theory is primarily concerned with quantifying and reasoning using natural language in which many words have ambiguous meanings.

Supply chain performance extent can be attributed as a function of multiple criteria/attributes. Most of the criterions/attributes being intangible in nature; supply chain performance appraisement relies on the subjective judgment of the decision-makers [1]. Moreover, quantitative appraisement of supply chain performance appears very difficult due to involvement of ill defined (vague) performance measures as well as metrics [1].

A feature typical of the natural language, to be in no way circumvented, is the vagueness of its semantics. That is why a description delivered in the natural language cannot be translated directly into mathematical formulas

To be able to apply the classical mathematics, we have to have the task described in precise figures. This method, however, can return unsatisfactory results, as precise figures often do not properly reflect the reality. Fuzzy logic offers a solution to the problem, since it allows us to model the meanings of words used in the natural language [18].

Fuzzy logic is, however, not fuzzy. Basically, fuzzy logic is a precise logic of imprecision and approximate reasoning [17]. More specifically, fuzzy logic may be viewed as an attempt at formalization/mechanization of two remarkable human capabilities. First, the capability to converse, reason and make rational decisions in an environment of imprecision, uncertainty, incompleteness of information, conflicting information, partiality of truth and partiality of possibility; in short, in an environment of imperfect information. And second, the capability to perform a wide variety of physical and mental

tasks without any measurements and any computations [6].

Reality has almost always an aspect of randomness and an aspect of vagueness. The mathematical apparatus of the theory of fuzzy sets provides a natural basis for the theory of possibility, playing a role which is similar to that of measure theory in relation to the theory of probability [6]. Vagueness can be modeled using the theory of fuzzy sets, while the randomness is modeled with reliance on the probability theory and possibly other theories like the theory of possibility, different rates of veracity, etc. [18]. Viewed in this perspective, a fuzzy restriction may be interpreted as a possibility distribution, with its membership function playing the role of a possibility distribution function, and a fuzzy variable is associated with a possibility distribution in much the same manner as a random variable is associated with a probability distribution [6].

Fuzzy provides a remarkably simple way to draw definite conclusions from vague, ambiguous or imprecise information. In a sense, fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions. Marsili-Libelli (2004) set up the following steps which are necessary for successful application of modeling through a general fuzzy system: Fuzzification of the input and output variable by considering appropriate linguistic subsets, Construction of rules based on expert knowledge and/or the basis of available literature, The result appears as a fuzzy subset and therefore, it is necessary to defuzzify the output and obtain a crisp output.

H. Ramazi, and A. Amini [14] applied fuzzy logic in compiling multi geohazards macro-zone maps. L.A. Zadeh implemented it to find flexibility of protein motifs [15]. Y. Huang and Y. Li use fuzzy logic to outline differences between various poly nucleotides [16]. Z. Xiu-fen, P. Zi-shu, K. Le-shan and Z. Chu-yu Analyzed data for experimental expression [17] using fuzzy theory of adaptive resonance [15]. Some other researches applied fuzzy logic in aligning sequences for dynamic programming [18, 19], generating DNA sequencing [15], identifying the cluster genes from micro-array dataYQ Ren, XG Duan, HX Li, CLP Chen [21] proposed a multi-variable fuzzy logic control system for a class of distributed parameter systems. I. Pan and S. Das [22] enhanced PID Controller. M. Turkkan and N. Yagiz [22] developed active bus suspension system with help of fuzzy logic control system. A.M. Eltamaly and H. M. Farh [21] used fuzzy logic control to maximize power extraction from wind energy system. M. Togai and H. Watanabe [5] implemented for real time approximate reasoning. R. Kshirsagar et al. [2] developed an environment friendly air conditioner using fuzzy logic. B. Ganesh Kumar et al. [2] gives concept of induction control in diesel engine based on fuzzy logic and neural network. D. Petkovic et al. [8] proposed an adaptive neuro-fuzzy maximal power extraction of wind turbine with continuously variable transmission. A.I. Saleh [9] proposed a fuzzy matchmaking based system-oriented grid scheduler

2.2.1 Fuzzification of Supply Chain management performance input variables

Fuzzy algorithms execute in three major stages: fuzzification, inference, and defuzzification. In the fuzzification stage, real world sensory inputs in a given universe of discourse are characterized on the closed interval [0, 1] according to their levels of membership in fuzzy sets. These sets are given names which express qualities of the input variable using easily understood linguistic terms. Linguistic Variable means relating to language, (plain language words and statements). While variables in mathematics usually take numerical values, in fuzzy logic, the non-numeric linguistic variables are often used to facilitate the expression of rules and facts.

Numeric values for qualitative performance measures do not exist. Therefore the opinion of decision

makers (acting as measuring instruments) has to be transformed into numeric values.

Since human judgments and preference are often vague and can't estimate his preference with an exact numerical value. It is more realistic to use lingual expressions to describe the desired value, e.g. “very low”, “low”, “fair”, “high”, “very high”, “strongly”, “somewhat”, and “undecided”, "satisfied", "dissatisfied", etc. [2]. Due to this type of existing fuzziness in the survey process, fuzzy set theory is an appropriate method for dealing with uncertainty. For a fuzzy logic based supply chain performance parameters such as number of complaints, percentage of orders delivered on time, percentage of shipping errors etc. could be measured as high, very high, low, very low and medium for the numerical group and very good, good, average, poor and very poor for the proportional group.

2.2.2 Membership functions

Using fuzzy concepts, evaluators can use linguistic terms to assess the indicators in a natural language expression and each linguistic term can be associated with a membership function. A membership function

III. RELATED WORK

While fuzzy logic techniques have earned their place in a variety of field ranging from engineering to financial sector, to medicine, few efforts have been made to test the potential usefulness of these methods in the modeling supply performance evaluation. This section discusses the literature survey about the past and current research application of fuzzy logic. In his study, [1] , proposed a Fuzzy logic framework for quality as one of the important factors of qualitative performance is discussed to be measured by means of fuzzy logic controller in Malaysian rubber glove manufacturers. A suitable fuzzy inference mechanism and associated rule has been discussed. It introduces the principles behind fuzzy logic and illustrates how these principles could be applied by Supply chain managers to evaluate supply chain performance. This study only focused on one aspect of qualitative performance measurement of supply chain management.

In his study, [19] developed a fuzzy expert system approach to forward looking performance measurement system of delivery metric in two Thai textile companies. The developed system enables managers to develop systematic ways to predict future performance and identify potential problems in a company. Using the SCOR model delivery metric is only one of the factors of responsiveness and hence cannot be used to evaluate the complete supply chain performance management.

In his study, [1] Presented innovative fuzzy logic process based method for performance measurement in SCM. Their Qualitative category was divided into quality, flexibility, visibility, trust and innovativeness. This framework didn’t cover all the responsiveness and reliability factors which according to the SCOR model are two of the parameters that can be used to measure supply chain performance. Fuzzy rules applied to define qualitative terms. [20] proposed a methodology for monitoring the SC network with applying fuzzy logic for some reasons such as accuracy, reliability, compactness and lack of the concept of justification in rule-base system. This study focused on monitoring the supply chain network and not evaluating the performance of supply chain management.

IV. RECOMMENDATIONS

The review reveals that considerable amount of work has been carried out to identify performance measurement metrics of supply chains both qualitative and quantitative. Further exploration of both the theoretical and empirical literature review seems clear that there most of the performance measurement are qualitative in nature are complex, subjective and ambiguous, therefore conventional

evaluations are inappropriate and incompetent. However fuzzy logic is a very powerful tool to compensate this limitation and deal with vague and complex situations. This clearly reveals that there is an urgent need for an alternative approach for evaluating qualitative aspects of performance of supply chain management. The previous research focused on quality aspects of supply chains performance, delivery metrics, flexibility, so it seems clear that there an urgent need for implementation of qualitative performance measurement framework which looks into the other qualitative factors which are responsiveness and reliability. Hence, this survey recommends further research works on alternative framework for evaluating the other aspects of qualitative performance using Fuzzy Logic.

V. CONCLUSIONS

This study has addressed the questions of how to supply chain responsivess. One of the success keys for managers is selecting the most appropriate supply chain based on their performances. The evaluation of supply chain responsivess gains vital importance in modern scenario. Performance in nature is associated with complexity and ambiguity; therefore conventional evaluations are inappropriate and incompetent. However fuzzy logic is a very powerful tool to compensate this limitation and deal with vague and complex situations. Performance of any supply chain can be effectively evaluated using fuzzy inference system. Exploration of fuzzy logic helps in dealing with decision-makers' linguistic evaluation information efficiently, thereby eliminating ambiguity, imprecision and vagueness arising from subjective human judgment. Also for any industries to be survive in today competitive market they had to be truly performing and should periodically evaluate their supply chain performance. Performance of supply chain result in improving the response and service to the customer, therefore increasing the supply chain profitability.

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