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Development of Decision Support Systems towards Supply Chain Performance Appraisement

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ABSTRACT:

Purpose: : The purpose of this study is to build various Decision Support Systems (DSS) for supply chain (SC) performance evaluation and benchmarking. The goal of this project is to learn how to use a multi-level (measures and metrics) performance appraisal index system to assess overall supply chain performance, track continuing performance, and identify regions of the supply chain network that are underperforming.

Design/methodology/approach: A number of SC performance appraisal modules have been developed using fuzzy logic and grey theory (evaluation index systems). In order to address decision-makers' linguistic evaluation information towards meaningful and logical interpretation of procedural hierarchy incorporated to the abovementioned appraisement modules, generalized fuzzy numbers and generalized interval valued fuzzy numbers theory were used. The fuzzy-grey connection theory, the MULTIMOORA approach combined with fuzzy logic, and grey theory have all been developed to make overall SC performance evaluation, benchmarking, and decision-making easier.

Findings: The supply chain performance index was calculated in both a fuzzy and a grey context, indicating the current performance status of the mentioned organizational supply network. The SC's underperforming areas have also been recognized. According to the ongoing SC performance, fuzzy and grey based MULTIMOORA (MOORA: Multi-Objective Optimization by Ratio Analysis), fuzzy-grey relation analysis, as adapted, appeared to be useful in evaluating performance ranking order (and selecting the best) of various candidate alternatives (industries/enterprises) operating under similar supply chain architecture. The created decision support tools' application potential was demonstrated through empirical illustrations.

.**Practical implications**: Companies attempting to discover essential business success measures for their supply chains may find the decision support tools suggested useful. Ill-performing areas can be easily discovered, and firms can look for ways to improve those SC features in order to increase/better total SC performance. Benchmarking can aid in the identification of best practices in relation to the SC that is working optimally (benchmarked practices). The ideal organization's best practices must be passed on to others. Companies can learn from their peers to improve the overall performance of their supply chain. As a result, the research presented in this dissertation may be a valuable contribution to the successful management of organizational SC..

Research limitations: Although the methodology and presentation are conceptual, the tool can yield extremely useful interpretations for both academics and managers. The key constraints deciding which model will be used are data accessibility and availability. Empirical research has indicated procedural steps toward integrating the aforementioned decision assistance tools. The decision-making aids have not been validated through a real-world case study, nor have they been put to the test to determine their reliability.

.**Originality/value:** This paper outlines numerous ways for evaluating supply chain performance utilizing diverse assessment criteria (subjective evaluation indices), as well as the flexibility to change and analyze data sets gathered from a group of experts (decision-makers). Due to structure and fuzzy (as well as grey) sets, performance evaluation index system approaches are proposed. Operational researchers, engineers, and special managers will benefit from this work

Keywords: Decision Support Systems (DSS); supply chain (SC) performance appraisement; benchmarking; Fuzzy logic; grey theory; Fuzzy-grey relation theory; MOORA: Multi-Objective Optimization by Ratio Analysis.

1. Introduction:

Supply chain management (SCM) is a unique management concept and business operating method that is gaining increasing interest throughout the world. It is expected that in the future, company competition would be solely due to supply chain (SC) competition.

1.1 Supply Chain Performance Assessment: An Overview:

A supply chain is an integrated process in which raw materials are created and transformed into finished goods, which are then transported or dispersed to customers (via distribution, retail, or both). A typical supply chain has four echelons: supply, manufacturing, distribution, and consumers, with each level (or echelon) of the chain containing multiple facilities. The number of echelons in the supply chain, as well as the number of facilities in each echelon, determine the supply chain's complexity. Supply chain management (SCM) is being used by businesses in order to reduce costs, increase market share and sales, and retain strong customer relationships. Pioneers had already looked into supply chain management and written about it in the literature. While there are numerous current research projects on various elements of SCM, little attention has been paid to performance evaluation, and hence to supply chain measures and metrics. Stewart used taxonomy to discuss a framework for enhancing supply chain performance in a noteworthy work in this subject. The lack of supply chain measurements was also highlighted as a concern in managing supply chain inventory. SCM is a theory based on the belief that the performance of each firm/enterprise in the supply chain influences the performance of all other supply chain members, and ultimately, the entire supply chain performance extent. Functional and supply chain partner activities must be aligned with firm strategy and harmonized with organizational structure, procedures, culture, incentives, and people in order to effectively implement this philosophy. In order to deliver maximum advantage to its members, the chain-wide implementation of SCM methods accordance with the aforementioned concept is also required. A number of companies have grasped the potential benefits of incorporating supply chain management into day-to-day operations management in recent years. However, due to a lack of a balanced approach and a clear separation between metrics at the strategic, tactical, and operational levels, they frequently lack the information needed to build effective performance measures and metrics required to accomplish a fully integrated SCM. As a result, it is evident that measurement goals for effective SCM must take into account the whole scenario as well as the metrics to be investigated. These should take a balanced approach and be classified at the strategic, tactical, and operational levels, with financial and non-financial supply chain performance measurements included. The need for performance measuring systems at all levels of decision making, whether in industry or in service sectors (contexts), is unquestionably not new. However, there is a growing need to examine various measures and metrics in the context of SCM for two reasons: (a) A balanced approach is lacking; and (b) a clear separation between metrics at the strategic, tactical, and operational levels is lacking. A number of supply chain research themes and approaches have been articulated throughout the last decade. Cost, inventory levels, profit fill rate, stock out likelihood, product demand variance, and system capacity were all used as optimization criteria in supply chain models. The majority of deterministic and stochastic models focused on discrete components of the supply chain, such as supply production, production-distribution, or inventory-distribution systems. Some models focused on supply chain strategy concerns like the most cost-effective placement of plants and warehouses, flow of goods, and so on, while others focused on operational issues like order size, fill rate, inventory levels, and so on. Measuring supply chain performance, on the other hand, should be viewed as a valuable source of competitive intelligence. Given the inherent complexity of a normal supply chain, choosing proper performance metrics for supply chain analysis is extremely important, especially because the system of interest is typically huge and complicated. Individual supply chain echelon performance increase does not imply supply chain improvement as a whole. It is vital to evaluate the intricate multilayered internal linking activities across numerous businesses in order to adequately measure supply chain performance. The performance evaluation system and method of SC should be designed in order to analyze the efficiency and benefits of SC scientifically and objectively.

2. LITERATURE SURVEY

Gunasegaram et al. (2009) created a methodology for monitoring supply chain performance at the strategic, tactical, and operational levels. In an SCM, the focus was on performance measurements related to suppliers, delivery performance, customer service, inventory and logistics costs. The measures were created with the goal of aligning and relating them to customer satisfaction.

Gunasegaram et al. (2009) created a framework to help people comprehend the value of SCM performance metrics and measurement. The authors built the framework that spurred additional interest in this vital field by using existing research and the results of an empirical investigation of chosen British companies.

Shepherd and Gunter (2010) presented a taxonomy of performance metrics, followed by a critical assessment of measurement techniques for evaluating supply chain performance. The authors focused on the elements that influence the effective adoption of supply chain performance measurement systems, as well as the dynamics that shape their evolution over time and the difficulty of maintaining them.

For supply chain management (SCM) evaluation, Sharma and Bhagwat (2011) proposed an integrated balanced scorecard (BSC) analytical hierarchy process (AHP) approach. The goal of this study was to evaluate SCM effectiveness from four different angles: financial, customer, internal business process, and learning and growth.

An assessment framework was created by Thangavelu and Samavedham (2007) to review and improve the performance of an existing supply chain. The bottlenecks or badly performing nodes were identified using data from an existing network. Time-series data analysis techniques were used with the understanding of supply chain architecture. By lowering the supply chain cost, simulation-based optimization was extensively used to bring the performance of the inferior nodes closer to achievable benchmark levels.

At the process level of study, Field and Meile (2008) sought to empirically assess the relationship between supplier interactions and satisfaction with overall9supplier performance in a services context. Two hypotheses were developed: one predicting a positive relationship between a multi-dimensional construct of supplier relations and overall supplier performance satisfaction, and the other a five-part hypothesis predicting positive relationships between the underlying components of supplier relations and overall supplier performance satisfaction.

Mc Cormack et al. (2012) looked into the link between supply chain maturity and performance, using the business process orientation maturity mode and the supply chain operation reference model as examples. 478 Brazilian organizations participated in a quantitative, survey-based study. The use of descriptive statistics and structural equation modeling were merged in statistical analysis. According to empirical findings, supply chain maturity and performance have a substantial and positive statistical link. The findings also revealed that the maturity of the deliver process had a greater impact on overall performance than the maturity of the other supply chain processes.

Varma et al. (2012) evaluated the performance of the petroleum supply chain using a mix of the analytical hierarchy process (AHP) and the balanced scorecard (BSC). Customer, financial, internal business process, innovation, and learning were found to be the most important four viewpoints in terms of petroleum supply chain performance, in descending order of significance. Purity of product, market share, stable supply of raw material, and application of information technology appeared to be the most essential aspects in these viewpoints, respectively.

Fabbe-Costes and Jahre (2013) looked into the relationship between supply chain integration (SCI) and performance, as well as the empirical evidence around this crucial subject in logistics and supply chain management.

From a balanced scorecard (BSC) approach, Chiaet et al. (2009) experimentally investigated what senior supply chain executives measure and how they interpret performance measurement.

Thakkar et al. (2012) used a collection of qualitative and quantitative insights gathered throughout the case study research to present an integrated supply chain performance evaluation methodology for the instance of small and medium scale firms (SMEs). The facts disclosed through case study analysis, secondary data relevant to distinct SME clusters in India, and extensive contemporary studies reported on supply chain management in SMEs were used to build the supply chain performance evaluation framework in this paper. To provide a comprehensive performance measuring framework for SMEs, it combined the key aspects of the balanced scorecard (BSC) and supply chain operation reference (SCOR) models.

Chae (2011) presented a practical approach to measuring supply chain performance and a set of critical key performance indicators (KPIs). In terms of generating performance measures, the experience from, and their opinion of, industry standards and best practices in supply chain performance measurement10suggested that 'less is better.' Companies should concentrate on a small number of key performance indicators (KPIs) that are crucial to their operations management, customer service, and financial viability. Potential KPIs should be established for each of the four meta-processes in the supply chain operations-reference (SCOR) model (plan, source, make, and delivery) and organized hierarchically as primary and secondary metrics.

On the basis of a case study from the packaging sector, Hofmann and Locker (2009) studied the development of a value-based performance assessment concept in supply chains. The value-based approach provided a direct relationship between supply chain operations and shareholder value generation, as measured by economic value added (EVA).

Cai et al. (2009) suggested a paradigm for enhancing iterative key performance indicators (KPIs) in a supply chain setting using a systematic approach. The proposed approach investigated the interdependencies between a collection of KPIs quantitatively. It could identify critical KPI achievement expenses and provide performance improvement solutions for supply chain decision-makers.

Tsai and Hung (2009) suggested a fuzzy goal programming (FGP) technique for green supply chain (GSC) supplier selection and flow allocation that incorporated activity-based costing (ABC) and performance evaluation in a value-chain framework. Flexible goals, financial and non-financial indicators, quantitative and qualitative methodologies, multi-layer structure, various criteria, multiple objectives, and multiple tactics were found to be particularly suitable for the FGP approach.

Shaw et al. (2010) reviewed the literature and proposed a research agenda to determine whether environmental, i.e. green performance measures, could be integrated into an existing supply chain performance framework, to determine what a meaningful industry11recognized environmental measure should look like, and to determine the direct benefits of incorporating environmental measures into a supply chain performance framework.

Allesina et al. (2010) employed network analysis, which is commonly used to research natural ecosystems, to construct a quantitative measure of complexity for a supply network, concentrating in particular on the idea of entropy of information. To approach the problem of supply network optimization, the proposed strategy utilized a comprehensive approach.

According to Akyuz and Erkan (2010), performance measurement in the new supply age is still a work in progress. Framework development, empirical cross-industry research, and the adoption of performance measurement systems for the requirements of the new era, including the development of partnership, collaboration, agility, flexibility, information productivity, and business excellence metrics, could all be identified as areas where more research is needed.

In order to properly handle the dynamic behavior of the supply chain, Khilwani et al. (2011) suggested an effective modeling technique, the hybrid Petri-net. In deterministic and stochastic Petri-net for the modeling and performance evaluation of supply chain networks, this modeling framework included two attractive elements, namely cost and batch sizes. The approach was then used to risk management to look at the concerns of supply chain vulnerability and risk, which has become a hot topic in recent years. As a result, this study provided a comprehensive set of tools for industry practitioners to analyze, evaluate, and manage dangerous occurrences in supply chains.

When product, process, and environmental quality criteria were taken into account, Saadany et al. (2013) created an analytical decision model to assess the performance of the oaf supply chain.

El-Baz (2011) suggested a fuzzy decision-making approach based on fuzzy set theory and pair-wise comparison of Analytical Hierarchy Process to cope with performance monitoring in supply chain systems (AHP). Various input factors were chosen and treated as a linear membership function of fuzzy type in the suggested model. The method provided a useful decision tool for assessing the performance of a supply chain manufacturing environment.

3. PROBLEMS IDENTIFICATION & OBJECTIVES

- Exploration of multi-level (integrated) evaluation hierarchy, also called evaluation index system (consisting of SC performance measures and metrics/ main indices as well as sub-indices) towards estimation of overall SC performance extent.
- Exploration of fuzzy logic as well as grey theory to develop efficient as well as flexible decision support tools for systematic and logical appraisement of SC performance.
- Identification of ill (poor)-performing areas of SC.

OBJECTIVES

- To develop efficient as well as flexible decision support tools for systematic and logical appraisement of SC performance.

- Identification of ill (poor)-performing areas of SC.
- Ranking (and selection of the best) of alternative enterprises (running under similar SC architecture) in view of ongoing SC overall performance.

4. METHODOLOGY

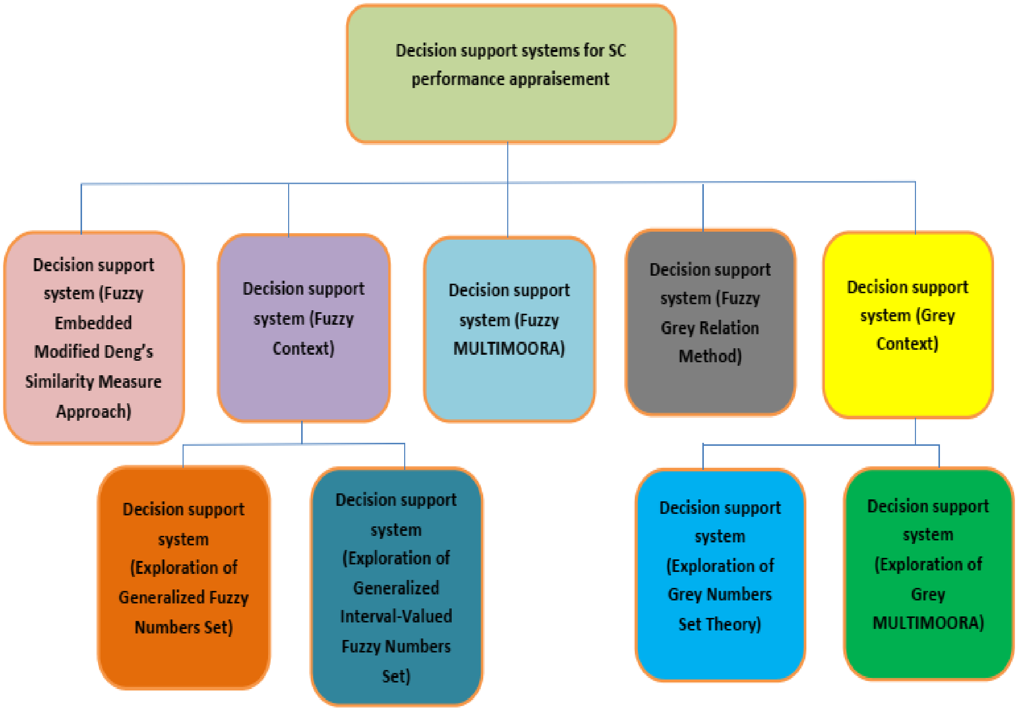

Fig: Outline of the work carried out in this dissertation

4.1 **Supply Chain Performance Assessment in Fuzzy Context**

4.1.1 Procedural Steps

The concept of generalized Interval-Valued Fuzzy Numbers (IVFNs) has been used to present a fuzzy based performance appraisal module in this part. Assume that the General Hierarchy Criteria (GHC) is a four-level index system that tries to achieve the goal of evaluating the overall appraisal index. Supply C1, Inbound Logistics C2, Core Manufacturing C3, Outbound Logistics C4, and Marketing & Sales C5, respectively, make up the first level. The evaluation of performance should begin at the fourth level and go to the first level before computing the overall performance extent. The procedural steps of performance appraisal have been more or less the same as previously mentioned, with the exception of the computational part of measuring overall performance extent and identifying supply chain network's ill-performing areas, as this model explores the generalized Interval-Valued Fuzzy Numbers (IVFNs) set, which is somewhat different from the theory of GTFNs set used in the empirical study reported in Section 3.4.
Step 1: Selecting linguistic variables in order to provide priority weights (to individual criteria/attributes and sub-attributes) and suitability ratings (performance extent) to each evaluation criterion (at highest level of the criteria hierarchy).
Step 2: Gather expert opinion (subjective judgment) from a specified decision-making group in order to express priority weight and appropriate ratings against each of the evaluation indices.
Step 3: Using appropriate fuzzy numbers to represent decision makers' language judgements.
Step 4: Estimate aggregated weight and aggregated rating (pulled opinion of the decision-makers) for each selection criterion using fuzzy operating rules.
Step 5: Calculation of the Fuzzy Performance Index, which is an overall SC performance index (FPI).
The computation should begin at the fourth level, then move backward (prior levels), and finally to the first level. The overall FPI for the supply chain under consideration is calculated using a fuzzy weighted average of individual 1st level indices' performance ratings.

5. RESULTS AND DISCUSSION

5.1 Empirical Data Analyses

Table 2.1 shows the evaluation index system (appraisal platform) (hierarchy of major SCM performance measures) platform used in this paper

(Gunasegaram et al.; Bhagwat and Sharma,). Level I and Level II performance indicators make up the two-level hierarchical model. Under each of the Level I indices, a variety of supply chain performance indicators have been analyzed, followed by Level II indices that comprise a number of strategic, tactical, and operational performance metrics. In Appendix A, the definitions of several SC performance indices (as shown in Table 2.1) are provided (at the end of the dissertation).

To evaluate an overall SC performance index in regard to each of the possible alternatives, a method based on the 'Modified Similarity Method' developed by (Safari et al.) was utilized. Due to the subjective nature of most assessment indices, the aforementioned decision-making issue has been adjusted to work in a fuzzy context. In this context, the decision-making team plays a critical role in delivering decision-making information in connection to several SC performance measures (their weight as well as rating). Individual SC performance indices' priority weights and related appropriateness ratings (performance estimates) were articulated in this study using linguistic characteristics obtained from a decision-making group (experts). Linguistic data has been translated into an appropriate fuzzy number using a predetermined fuzzy scale provided by the decision-makers. Fuzzy information (for appropriateness rating as well as priority weight for SC performance metrics) has been turned into a unique 'crisp score' based on the notion of 'Incentre of Centerior's' presented by (Thorny et al.) in fuzzy mathematics. Using the 'Modified Similarity Measure' approach, these precise data were used to quantify the total SC performance extent and, as a result, to simplify SC performance benchmarking. This strategy has been demonstrated to be extremely effective in solving multi-criteria decision making problems (MCDMs) in uncertain environments.

A decision-making dilemma has been created in this empirical study for SC performance evaluation and benchmarking. A number of candidate industries/enterprises (operating on comparable SC architecture) have been evaluated in this problem. The goal was to calculate the SC performance index of each industry/enterprise and determine their performance ranking order (Benchmarking).

SC performance benchmarking of alternative industries was done using an approach based on the 'fuzzy grey relation method' proposed by (Liao et al.). Due to the subjective nature of most assessment indices, the aforementioned decision-making issue has been adjusted to work in a fuzzy context. In this context, the decision-making team plays a critical role in delivering decision-making information in connection to several SC performance measures (their weight as well as rating). Individual SC performance indices' priority weights and related appropriateness ratings (performance estimates) were articulated in this study using linguistic characteristics obtained from a decision-making group (experts). Linguistic data has been translated into an appropriate fuzzy number using a predetermined fuzzy scale provided by the decision-makers.

The following is a summary of the procedural phases and their implementation outcomes:

Step 1: Using linguistic terms, collect information from the expert group about performance ratings and importance weights of various evaluation measures/metrics.

Step 2: Using IV trapezoidal fuzzy numbers to approximate the linguistic evaluation information

Normalization is the third step.

The Ratio System (Step 4)

Step 5: Using a Reference Point

Step 6: The Multiplicative Form in Its Entirety

Step 7: Using Dominance Theory, determine the final ranking order.

6. Scope for Future Research:

1. The decision support systems thus provided have not been validated (as an example of a real-world situation) or tested for reliability. Decision support systems may be used to test for reliability in the future.
2. Various appraisal systems have been investigated using various literature resources. It needs to be determined whether these criteria-hierarchies are industry-specific or vary depending on the industry/sectors. As a result, the criteria-hierarchy may require standardization.
3. The proposed fuzzy/grey-based appraisal modules are designed to identify areas of the supply chain that are underperforming. However, no suggestions for how to enhance such areas' performance have been made. The research may be expanded to uncover effective action plans for improving the performance of various underperforming SC areas and putting them into practice. After it's been implemented, the total supply chain performance must be reevaluated to see if the overall performance level has been increased or not.
4. When determining the best data collection for analysis, a compromise must be struck. A smaller data set may yield incorrect results.
5. In order to measure supply chain performance in a fuzzy (as well as grey) setting, the paper proposes various appraisal modules. The work's computational component is based on empirical data. The proposed appraisal models and procedural framework must be applied in real organizational supply chains in order to analyze existing performance scenarios across different industries, identify underperforming areas, and compare SC performance extents of different industries (following supply chains of similar type) in order to obtain a ranking order (benchmarking). This could aid industries in making various decisions more quickly.

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