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COMPARISON OF PERFORMANCE EVALUATION OF TRANSPORTATION SERVICE PROVIDING FIRMS USING HYBRID TOPSIS AND VIKOR

Mehandra Pal Damle [1]*, Revendra Kumar Deshmukh [2]

[1]*M. Tech. Student, Department of Mechanical Engineering, CSIT Durg, (C.G.), India.*

[2]*Assistant Professor, Department of Mechanical Engineering, CSIT Durg (C.G.), India.*

Abstract

Performance evaluation is a key activity of supply chain in the dynamic global competitive scenario for the improvement of productivity and profitability. As there is enough scope for improvement in productivity and profitability, supply chain managers need to strive for collection, analysis, and interpretation of qualitative and quantitative information to measure and compare in order to give the right direction to enhance supply chain performance. Then a comprehensive performance evaluation system needs to be developed and redefined to monitor, control, and direct total supply chain operations on a continuous basis by incorporating the entire supply chain process as an integrated system.

Service sector is becoming as a lifeline for the social and economic growth of any country. Evaluating service supply chains is essential to measure the growth. Very little attention has been paid to performance evaluation of service supply chains and hence there is a pressing need to direct research efforts in this direction. Since the output of service is intangible, heterogeneous and simultaneous, identifying suitable evaluation criteria is a crucial exercise.

In this work, a comprehensive listing of metrics suitable for performance evaluation of service supply chains was brought out. Performance evaluation of supply chains and the process of decision making based on the outcome of the evaluation is a multi criteria decision making (MCDM) process. As part of this research work, two hybrid multi criteria decision making approaches have been proposed for carrying out the evaluation of comparative performances of service supply chains. The fuzzy TOPSIS approach and the fuzzy VIKOR approach have been implemented for evaluating the performances of transportation service providing (TSP) firms. Comparison of ranking is been done in this paper. The approaches proposed here, once incorporated and institutionalized into the organizations can be very effective for practicing executives of organizations to evaluate and monitor the performances of supply chains employed by the organizations. The approaches are simple to learn and implement. The procedural steps are less time consuming both with or without the use of computers. The approaches are free from accusations of bias and they are very much suitable for standardization.

Keywords: SCM, DEA, MCDM, HYBRID TOPSIS, HYBRID VIKOR, KPI, SCOR, TSP.

* *Corresponding author*

1. INTRODUCTION

The transportation sector offers transportation via truck, rail, air, and water. warehousing and storage services are also available. Transportation services for pipeline, postal, courier, and messengers are also included. India's transport industry is largely reliant on the world economy. Manufacturing outputs, commodities trade, leisure trip activities, and consumer and corporate spending may all increase with a strong and stable economy. Some costs, like the price of fuel and labour, are constant. For the transportation industry to run smoothly, everyone must focus on the operations, which calls for a robust global economy. According to multiple criteria, including income, size, market presence, and reputation, following are the list of top 6 transport providing firm is been selected is as follows:

i) Transport Corporation of India (TCI)
ii) Blue Dart Express
iii) Gati
iv) DHL Supply Chain –
v) Safe Express –
vi) AEGIS LOGISTICS –

1.1 Supply Chain Management (SCM)

The objective of SCM is to satisfy the end customer requirements (Childerhouse & Towill 2000) and the focus is on how organizations utilise the processes, technology, and capabilities to enhance their own competitive advantage. SCM is defined as the control of supplier and customer connections upstream and downstream in order to provide better customer value at lower supply chain costs. Levy et al (2003) defined SCM is a collection of techniques used to effectively integrate suppliers, manufacturers, warehouses, and stores so that goods are produced and distributed in the appropriate quantities, at the appropriate times, and in the correct locations in order to reduce system costs and meet service level requirements. In the definition of Stadtler & Kilger (2008), SCM is "the process of connecting organisational units throughout a supply chain and coordinating material, information, and financial flows to meet (ultimate) consumer needs in an effort to increase the supply chain's overall competitiveness. SCM contributes in the value addition in the form of quality, costs, quick response, availability, and consistency of the system. In the supply chain process, each participant adds some value to the goods and services received from his preceding member before making delivery to the next party. The success or failure of each link in the supply chain network largely depends upon the real time contribution of its preceding link.

Information flow is as significant in the supply chain as blood is for human life (Colicchia & Strozzi 2012). The flow of information in the SCM network is in both directions for activation and improvement of the total supply chain system. The nature of backward information flow facilitates coordination activities consisting of quality feedback, customer order and specification, procurement quantity with specification and timing, strategic

capacity, processing and dispatch planning, etc. The forward information flow refers to operational activities that consist of availability of goods and services, order processing and management, order status, invoice, transportation and shipping systems, quality assurance, warranty card, operating manual etc. Any delay in the information flow costs to the firm, which ranges from higher transportation cost to lost sales and corporate image (Pereira 2009).

The role of supply chain management within an organization has changed considerably over the last few decades (Estampe et al 2013). It has evolved from an emphasis on integrating logistics and lowering of costs to provide better products and services to customers on real time basis in cost efficient manner. In the changing business dynamics, the challenge is to take supply chain management to a more strategic level within the firm. The foundations of overall business strategies of most of the proactive firms are moving around supply chain management. There is an alignment of SCM strategy with firm‟s overall business strategy (Roh et al 2014).

These changes in supply chain strategies are mainly aimed at achieving superior performance. Proactive firms are moving towards working more closely with their supply chain partners for the adaptation of rapidly changing market place scenario. This improved integration and collaboration is the essence of strategic supply chain management. Firms are reconsidering the linkages, not only between functions within their own enterprise, but also other firms up and down the supply chain (Kache & Seuring 2014).

In this process of transformation, there is significant thrust given to superior performance. The pursuit of functional excellence developed into a focus on business process excellence, with firms breaking down their systems and reorganizing around core supply chain related processes. This core of supply chain management philosophy is largely based on network excellence in the form of consumer response that links raw material providers, manufacturers, distributors, and retailers along a seamless supply chain (Gorane & Kant 2015). This strategic approach of supply chain emphasizes sharing of resources and information, eliminating duplication, enabling rapid information flows and, ultimately real time product and service flows.

1.2 Service Supply Chains

The size of service sector is increasing in virtually all countries around the world. Every industrialised country's economy has traditionally been driven by the service sector. (Giannakis 2011). It has been a persistent occurrence for industrialised economies to shift from a manufacturing foundation to a service focus. (Smith et al 2007). As a national economy expands, the relative share between agriculture, industry and services undergoes changes in favour of services. In most of the more highly developed nations, services account for between two-thirds and three-fourths of the gross domestic product (GDP). Even in emerging economies, the service output is growing rapidly and represents at least half of the GDP. Government policies, social changes, industry trends, advances in information technology and globalization are among the major factors contributing to the rapid growth of the service sector (Lovelock et al 2011).

Services are important, yet defining and classifying services is problematic (Ellram et al 2004). Services can be defined as economic activities between two parties, implying an exchange of value between the seller and

buyer in the market place (Lovelock et al 2011). Though services often include important tangible elements, such as, hotel beds, restaurant meals, and bank cards, it is the intangible elements that dominate the creation of value in services. One of the main challenges in classifying services is the fact that in service based industries, it can be very difficult to separate out generation and consumption from the operation management of final service. As such, services are often classified in numerous different ways. While some consider a service as an offering when it is complementary to goods or commodities, others regard services as a form of activity in itself.

1.3 Performance Evaluation of Service Supply Chains

Performance assessment has traditionally been described as the process of calculating the effectiveness and efficiency of activity. (Neely et al 1995). Performance measurement in modern corporate management encompasses much more than just quantification and accounting. It is anticipated that it would significantly boost corporate management and employee performance in the organisations. From a managerial standpoint, performance evaluation gives decision-makers and process managers the data they need for management feedback. It is essential for tracking progress, fostering motivation and communication, and identifying issues. (Rolstands 1995; Waggoner et al 1999). Additionally, performance evaluation offers a method for determining the efficacy and potential of management strategies as well as for facilitating situational understanding. It aids in focusing management efforts, updating corporate objectives, and reengineering business procedures. (Van Hoek 1998; Bourne et al 2000; Kuwaiti & Kay 2000).

Performance evaluation is a key activity of supply chain in the dynamic global competitive scenario for the improvement of productivity and profitability. Taking into consideration the present global competitive scenario, improvement of productivity and profitability on a continuous basis are the order of the day for survival. That is why, proactive and progressive enterprises need to be always concerned about performance evaluation. It can help them not only to improve productivity and profitability but also to ensure efficiency and effectiveness in utilization of resources for maximization of customer value. As there is enough scope for improvement in productivity and profitability, supply chain managers need to strive for collection, analysis, and interpretation of qualitative information to measure and compare in order to give the right direction to supply chain performance. Then a comprehensive performance evaluation system needs to be developed and redefined to monitor, control, and direct total supply chain operations on a continuous basis by incorporating the entire supply chain process as an integrated system.

Due to global competition and explosion of choices, the expectations of customers and end users are significantly increasing (Laosirihongthong & Dangayach 2005). Hence, to survive in such a situation, it is essential to take into consideration the perception of customers regarding supply chain performance so that improvements can be made in it. The leading edge enterprises conduct customer perception and satisfaction surveys on a regular basis. They have customer monitoring cells so that monitoring can be made on a regular basis. To win in the new environment, supply chains need continuous improvement. To achieve this we need performance metrics which support global

supply chain performance improvements rather than narrow company specific or function specific metrics which inhibit chain wide improvements.

Modern supply chains are highly complex and dynamic (Merschmann & Thonemann 2011). They are characterized by constantly changing relationships and configurations, they support a proliferation of stock keeping units, they use a mixture of operations to fulfill orders, and they involve multiple organizations. Additionally, as a new technology enabler, the internet has increased the quantity of customer interactions and product configurations, placing more demands on the management and effectiveness of the supply chain. The capacity to satisfy client requests for personalised goods and services quicker and more successfully than the competition is the ultimate aim and benchmark for success. Therefore, it is crucial to direct management attention towards the supply chain's performance as an integrated whole rather than as a collection of distinct processes or companies.

Although it is believed that services can benefit applying some best practices from manufacturing, the differences between service and manufacturing sectors create a need for specific constructs or scales reflecting service supply chain practices (Boonitt & Pongpanarat 2011). It is necessary to evaluate service supply chains' performance in order for them to develop into efficient and effective systems. However, there hasn't been much research on measuring the performance of the service supply chain. (Cho et al 2012).

Performance reviews of service supply chains can not only highlight areas for development, boost communication and motivation, and pinpoint issues, but they can also encourage cooperation and integration across chain participants. Overall levels of customer service, competitiveness, and profitability can all be raised as a consequence. Evaluation of the performance of the service supply chain is challenging due to the intangibility, inseparability, and heterogeneity of services. Therefore, it is necessary to identify and prioritise pertinent criteria as well as to develop appropriate and efficient methodologies for conducting a systematic evaluation of service supply chain performance.

2. LITERATURE REVIEW

2.1 Performance Evaluation of Supply Chains

Akyuz & Erkan (2010) conducted a critical review in the areas of supply chain, information technology, business process management, and performance management and identified the needs of performance measurement metrics in the modern era, allowing for the design of the metrics to address supply chain measure-related issues.

An integrated approach for supply chain performance monitoring was put out by Lin and Li (2010). In order to give a more thorough coverage of performance requirements, the framework utilises the six sigma metrics and consists of three components: team structure management, supply chain process management, and output measurement.

Internal benchmarking for assessment of supply chain performance was proposed by Soni et al (2010). An extensive use of performance value analysis (PVA) and strengths, weaknesses, opportunities, and threats (SWOT) analysis provided for diagnosis of supply chains. Internal benchmarking can be useful in leveraging the drivers of

various supply chains belonging to same focal organization and hence bring performance of all the supply chains at the same performance level.

Fabbe Costes et al. (2011) used a scanning framework that has six levels, including societal, network, chain, business, function, and people levels to explore the sustainability of supply chains. A method for analysing current supply chain performance evaluation systems across various supply chains and industries was presented by Cuthbertson and Piotrowicz (2011). The authors provided a chance for a standardised data gathering procedure to be used in a range of supply chain scenarios, producing data for future theory development.

To aid in decision-making from the viewpoint of a company involved in reverse logistics, Geethan et al. (2011) developed a performance evaluation analytic for reverse logistics. They also created some crucial performance indicators and business plans that may be used to operate reverse supply chains successfully.

In the Thai automotive sector, Vanichchinchai & Igel (2011) looked at the connections between supply chain management strategies and firms' supply chain performance. To ensure reliability and validity in structural equation modelling constructs, the assessment criteria were constructed based on a thorough literature research and validated by experts, pilot tests, and other statistical approaches. Through the use of a path analysis, the proposed model was evaluated. Qualitative case studies of two large first-tier automotive suppliers were conducted to obtain more in-depth information.

In order to assess the effectiveness of closed loop supply chains in the automotive sector, Olugu and Wong (2012) created an expert fuzzy rule based system using Visual Basic.Net and applied it in a car manufacturing firm.

In order to evaluate the performance of the hotel supply chain, Cho et al. (2012) conducted a literature analysis on the problems with performance assessment in service supply chains.

Estampe et al. (2013) examined multiple supply chain assessment models by highlighting their unique qualities and usefulness in diverse situations. They also provided an analytical grid that, by dissecting these models into seven levels, can assist managers in developing models that are more suited to their needs.

Chiu & Okudan (2014) investigated the supply chain performances of two module and three module design concepts in an effort to explore the impact of modularity level on supply chain performance and found that increased modularity is advantageous for the time based performance of a supply chain network, whereas decreased modularity yields superiority in terms of cost performance.

Shafiee et al (2014) proposed a hybrid method by combining the network data envelopment analysis with the balanced score card approach for performance evaluation of supply chains and applied the method in the Iranian food industry to evaluate the efficiency of supply chains.

Jakhar & Barua (2014) proposed a model that provides a salient notion of integrated supply chain performance evaluation approach for practicing managers by combining the structural equation modelling and the fuzzy analytic hierarchy process.

2.2 Metrics For Performance Evaluation of Supply Chains

The first analysis of supply chain performance most likely began with Chow et al. (1994), who also provided metrics for assessing supply chain performance. Additionally, they stated that compared to operations and specific processes, practitioners have given strategic level measures less weight and benefits.

The Supply Chain Operations Reference Model (SCOR) was created by the Supply Chain Council in 1996. It's critical in SCOR to measure the operational performance of comparable businesses and set internal goals based on "best in class" outcomes, such as supply chain operation performance analysis. The two analytical aspects that SCOR suggested were internal and customer-facing. Reliability, responsiveness, and adaptability are assessed in the customer-facing dimension. Delivery quality, fill rate, faultless order fulfilment, order fulfilment lead time, supply chain reaction time, and manufacturing flexibility are all examples of performance indicators. Measured in the internal-facing dimension are costs and assets. Cost of goods sold, value-added productivity, warranty or returns processing costs, cash-to-cash cycle time, inventory days of supply, and returns on assets are examples of performance measures.

Resources, output, and flexibility were recognised and analysed as separate supply chain performance metrics by Beamon (1999), who made the argument that these factors are essential to the success of the supply chain. Performance indicators including total cost, distribution cost, inventory cost, and return on investment are included in the resource measurements. Customer response, end product quality, and quantity are examples of output metrics. Volume flexibility, distribution flexibility, mix flexibility, and new product flexibility are all terms used to describe flexibility.

In the supply chain, Lapide (2000) placed emphasis on the balanced score card, process measurement, and restriction of total metrics. Limiting the quantity of measurements is said to be a significant difficulty for many businesses implementing measuring processes.

Gilmour (1999) described a group of benchmark measures for supply chain processes which are based on a set of capabilities which incorporate the extent of intention and use of technology in the logistics processes of an organization and the degree to which logistics is used as a key element of overall strategy formation and implementation. He proposed an integrated supply chain model, in which 11 processes, technology and organization capabilities are identified. Five dimensions for each of 11 capabilities were established in order to determine the logistics sophistication by the area of managerial activities. These dimensions are organization strategy, planning, business process and information, product flow and measurement.

Based on a literature review, Gunasekaran et al. (2001) created a methodology for assessing the strategic, tactical, and operational performance of a supply chain system. In addition to dividing the performance evaluation measures into financial and non-financial categories, they also divided them into strategic, tactical, and operational categories.

In order to generate supply chain performance measurements and identify those that convert into shareholder value, Lambert & Pohlen (2001) presented a framework. According to them, the rise in market value for each

business in the supply chain determines overall performance. They also emphasised the need for greater study to create supply chain metrics and get through implementation difficulties.

Chan (2003) brought about a listing of metrics for performance evaluation of supply chains. The listing comprised of seven performance criteria and forty sub criteria categorized into two separate groups.

A framework for measuring the performance of supply chains was created by Gunasekaran et al. in 2004. A survey was utilised to gauge importance within each metric category after they conducted a thorough measurement and metrics categorization.

Regarding the SCOR process phases, Shepherd & Gunter (2006) divided metrics into cost, quality, time, flexibility, and qualitative vs quantitative categories. Additionally, they emphasised that a number of crucial issues surrounding supply chain performance evaluation had not gotten enough attention, such as those influencing the effective implementation of supply chain performance measurement systems, the forces influencing their evolution over time, and the issue of their ongoing maintenance.

A thorough evaluation and classification of supply chain measurement and metrics was provided by Gunasekaran & Kobu in 2007. In their work, they emphasised a trend of rising focus on performance measurement and metrics in both literature and practise. They emphasised the ambiguity surrounding the literature's classification of metrics and the absence of comprehensive coverage of all performance indicators. The balanced scorecard approach, components of measurements, placement of measures, decision levels, type of measures, measurement base, and old vs modern measures were used to categorise the literature in their evaluation. They divided the indicators into five categories—order planning, supplier assessment, production level, delivery, and customer—and used an empirical study to rank the relevance of each category.

The bulk of supply chain metrics, according to Cuthbertson & Piotrowicz (2008), are economic and quantitative (cost, customer, responsiveness, and productivity), rather than qualitative. Additionally, they discovered from their research that current performance approaches are primarily focused on economic rather than sustainable aspects, and typically do not take social and environmental factors into account.

After conducting a thorough investigation of the Chinese retail market, Cai et al. (2009) determined that 20 supply chain performance criteria were pertinent for the sector. Resource, output, adaptability, and innovativeness are the four categories into which the discovered metrics were divided. The cause-and-effect connection between these metrics was also investigated.

Chae (2009) developed a new set of performance indicators for the SCOR model and offered instructions for building metrics. They also stated that organisations frequently discover a dearth of useful instructions for creating KPIs.

Three major categories of performance metrics by inventory, cycle time, and financials were examined by Martin & Patterson (2009). A survey-based research was used to explore the effects of supply relationships, organisational structure, partnerships, supplier agreements, and process changes on the performance metrics used.

Supply chain coordination, technology application, risk management, and reliability assurance are significant performance metrics to guarantee supply chain quality and continuous improvement, according to Zhang et al.

(2011). How these measurements are evaluated and followed up on determines how successful the supply chain will be.

Prasad (2012) used seven performance characteristics to quantify supply chain performance: cost, quality, time, productivity, flexibility, dependability, and customer service. By gathering empirical data from supply chain experts, the importance of performance factors from the perspective of the supply chain was investigated.

Irena Ali et al.'s (2021) main goal is to create a model for selecting the optimal business improvement plan for the transportation firm. The research is dependent on the harmonisation of methodologies and the validation of their findings since decision-making (DM) is not a simple series of actions. This methodology may be used in SMEs that make these kinds of judgements and others like it. Companies may use this model to improve their company outcomes by adapting their operational procedures to the model's findings. This study is the first to permit the use of such a model in strategic choice-making.

2.3 Metrics For Performance Evaluation of Service Supply Chains

Since service supply chains have peculiar characteristics of their own like intangibility, inseparability and heterogeneity, identifying suitable evaluation metrics for evaluating performance is a crucial exercise. The list of assessment metrics may be influenced by variables such as the service industry that the enterprises under examination are a part of, as well as the nation and location in which they operate. The measures chosen for measuring the performance of service supply chains are shown in Table 2.1.

Table 2.1 Supply chain performance metrics identified by various researchers

Performance Metrics and Identified by	
Accuracy Chan (2003)	Accuracy of forecasting techniques Harrington (1996), Fisher (1997)
Accuracy of scheduling Gunasekaran & Kobu (2007)	Bid management cycle time Gunasekaran & Kobu (2007)
Capacity utilisation Wild (1995)	Cash to cash cycle time SCOR (1996)
Compliance to regulations Gunasekaran & Kobu (2007)	Conformance to specifications Gunasekaran & Kobu (2007)
Consistency Chan (2003)	Cost of products SCOR (1996)
Cost per operation hour Gunasekaran et al (2001)	Customer query time Gunasekaran et al (2001)
Customer responsiveness Beamon (1999)	Customer satisfaction Chan (2003)
Delivery flexibility Beamon (1999), Chan (2003)	Delivery lead time Rushton & Oxley (1989)
Delivery performance SCOR (1996), Gunasekaran et al (2001)	Delivery reliability Gunasekaran et al (2001)
Distribution cost Beamon (1999), Chan (2003)	Driver reliability for performance Gunasekaran et al (2001)
Effectiveness of delivery invoice methods	Gunasekaran et al (2001)
Expansion flexibility Chan (2003)	Extent of cooperation to improve quality
Graham et al (1994)	Flexibility Beamon (1999)
Flexibility of service systems to meet particular customer needs Bower & Hout (1988),	Incentive cost and subsidies Chan (2003)
Information carrying cost Stewart (1995)	Innovativeness Chan (2003)
Intangible cost Chan (2003)	Labor efficiency Gunasekaran & Kobu (2007)

Labor flexibility Chan (2003)	Lead time SCOR (1996), Chan (2003)
Level of customer perceived value of product Gunasekaran et al (2001)	Mix flexibility Beamon (1999), Chan (2003)
Modification flexibility Chan (2003)	Net profit vs. productivity ratio Gunasekaran et al (2001)
Obsolescence cost Gunasekaran & Kobu (2007)	Operation flexibility Chan (2003)
Order lead time Gunasekaran et al (2001)	Order entry methods Gunasekaran et al (2001)
Overhead cost Chan (2003), Gunasekaran & Kobu (2007)	Price Gunasekaran & Kobu (2007)
Perfect order fulfillment SCOR (1996)	Process Innovation Klassen & McLaughtin (1996)
Quality Graham et al (1994)	Quality of delivery documentation Gunasekaran et al (2001)
Rate of return on investment Christopher (1992), Dobler & Burt (1996)	Range of services Gunasekaran et al (2001)
Resource utilization Chan (2003)	Responsiveness to urgent deliveries Gunasekaran et al (2001)
Return on assets SCOR (1996)	Routing flexibility Chan (2003)
Sensitivity to long term cost Chan (2003)	Supply chain response time SCOR (1996), Gunasekaran & Kobu (2007)
Total cash flow time Stewart (1995)	Total cost Beamon (1999)
Total supply chain cycle time Christopher (1992), Stewart (1995)	Trust Chan (2003)
Use of new technology Chan (2003)	Value added Gunasekaran & Kobu (2007)
Variations against budget Gunasekaran et al (2001)	Volume flexibility Beamon (1999), Chan (2003)

3. PROBLEM IDENTIFICATION

3.1 Problem Identification

The literature on the performance assessment of supply chains discussed methodologies and approaches for the performance assessment of supply chains, developed metrics for the performance assessment of manufacturing supply chains, and developed methodologies and metrics for the environmental performance assessment of manufacturing supply chains. The performance assessment of service supply chains in emerging economies, however, has received relatively little attention; this study fills this knowledge vacuum.

Qualitative type of research which is primarily exploratory research is the suitable type of research for the research problem chosen in this research work. Qualitative research which involves describing specific situation in details using research tools like interviews, surveys, and observations, is used to gain an understanding of underlying reasons, opinions, and motivations. Qualitative Research is used to uncover trends in thought and opinions, and dive deeper into the problem.

The sample size in qualitative type of research, which is used in this research work, is typically small, where respondents are selected to fulfill a given quota (Graziano & Raulin 1993; Welman & Kruger 2001; Creswell 2003). In the present work, from the complete list of transportation service providing (TSP) firms, employed by the textiles company for transporting the finished products to different parts of India, the six major TSPs are chosen for the performance evaluation exercise. Similarly, from the complete list of medical support service providing (MSSP) firms and the catering service providing (CSP) firms, the major four medical support service

providing (MSSP) firms and the major four catering service providing (CSP) firms are chosen for the performance evaluation exercise.

The research project used judgmental sampling, in which the sample was selected based on who would be a good candidate for the study. When there are few persons who are knowledgeable about the topic under study or when the research is focused on a narrow subject or a small group, judgmental sampling is frequently utilised. The progress of every nation's social and economic system is increasingly dependent on the service sector. To gauge expansion, service supply chains must be evaluated. Finding appropriate assessment criteria is an important task due to the intangible, varied, and simultaneous nature of service production. The current performance evaluation methodologies are hampered by a number of serious flaws that prevent them from significantly advancing the creation and growth of service supply chains. The following research is being done to address the stated research challenge. Problem Identified are as follows: -

1. Since identifying the essential performance metrics is the major problem in evaluating the performance of service supply chains, a list of performance metrics suited for doing so must be created.
2. It is necessary to identify and provide multi-criteria decision-making methods suitable for conducting performance evaluations of service supply chains. For the purpose of evaluating the performance of service supply chains, multi-criteria decision-making systems with desired characteristics including robustness, the capacity to capture holistic features, applicability at multiple levels, simplicity of use, and ease of implementation are appropriate.
3. By conducting service supply chain case studies in a developing country, the acceptability, efficacy, and application of the methodologies suggested for performance evaluation of service supply chains must be shown.

3.2 Objectives Of the Research Work

1. To Propose and Study various list of performance metrics applicable for evaluating service supply chains.
2. To Develop suitable performance evaluation framework need to evaluate the performance of various Transport Service Proving Firm.
3. To Evaluate the performance of various Transport Service Proving Firm using Hybrid Multi Criteria Decision Making methods need to.
4. To Rank best Transport Service Proving Firm on the basis of Hybrid multi criteria decision making methods

4. RESEARCH METHODOLOGY

4.1 Methodology Flow Chart

The present work is aimed to choose the most suitable TSP Firm for supply chain. In this context six TPSP firms as alternatives have been considered by utilising two hybrids MCDM technique: FUZZY TOPSIS approach and FUZZY VIKOR approach. A committee of five decision makers was formed, comprising of command in good expertise and experience in textile and logistic industries. Committee decided 12 criteria on basis of which they

evaluated six TSP firm. Weight of various criteria is given by these five decision makers and then these weights were normalised followed by other MCDM steps. The flow Chart is as follows.

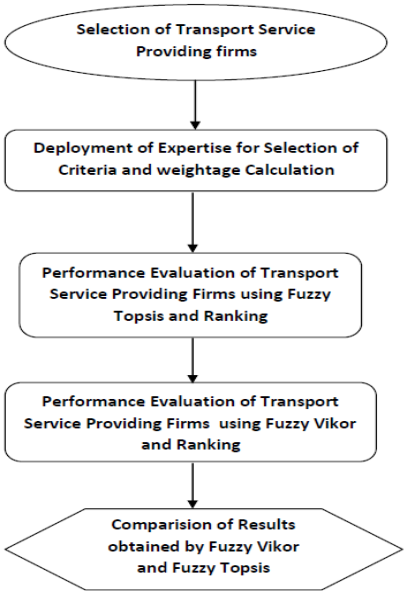

Figure 1. Flow Chart

4.2 Hybrid Approach – I: Fuzzy Topsis Approach

The weights of the criteria and the ratings of the alternatives are accurately known in the traditional TOPSIS technique, and crisp numbers are employed in the assessment process. The expansion of TOPSIS in a fuzzy environment, where the weights of criteria and ratings of alternatives are assessed by linguistic variables represented by fuzzy numbers, is advised since crisp data are insufficient to simulate organisational decision issues.

The fuzzy TOPSIS method's methodology is explained in the following steps:

Step 1: Create a list of all viable options as a first step.

Create a committee of decision-makers who are authorities in the area and have a wealth of knowledge and experience. The list of assessment criteria that will be taken into account when deciding the ranking of alternatives is created by the committee of decision-makers. Define linguistic variables and the fuzzy numbers that correspond to them for the ratings of alternatives and the weights of the criteria, respectively.

Step 2: Add up the weights assigned to each evaluation criterion.

If all decision-makers' fuzzy ratings are represented by triangle fuzzy numbers,

$\tilde{R}_k$ = (a_k,b_k,c_k), k= 1, 2,3,…….,K,

$$\text{Here } a = \min_k \{a_k\},\ b = \frac{1}{K}\sum_{k=1}^{K} b_k,\ c = \max_k\{c_k\} \tag{4.13}$$

If the fuzzy rating and importance weight of the k^{th} decision maker are $\tilde{x}_{ijk}$ = (a_{ijk}, b_{ijk}, c_{ijk}) and $\tilde{w}_{ijk}$ = (w_{jk3}, w_{jk2}, w_{jk3}) i = 1,2,.., m and j = 1,2,3,…….., n respectively, then the aggregated fuzzy ratings of alternatives with respect to each criterion can be found as $\tilde{x}_{ij}$ = (a_{ij}, b_{ij}, c_{ij}).

$$\text{Here, } a_{ij} = \min_k \{a_{ijk}\},\ b_{ij} = \frac{1}{k}\sum_{k=1}^{K} b_{ijk}, c_{ij} = \max_k\{c_{ijk}\} \tag{4.14}$$

Then the aggregated fuzzy weights of each criterion are calculated as $(\widetilde{w}_j)$ = (w_{j1}, w_{j2}, w_{j3})

$$\text{Here } w_{j1} = \min_k \{w_{jk1}\},\ w_{j2} = \frac{1}{k}\sum_{k=1}^{K} w_{jk2}, w_{j3} = \max_k\{w_{jk3}\} \tag{4.15}$$

Construction of fuzzy decision matrix ($\widetilde{D}$) and fuzzy weights matrix ($\widetilde{W}$) as

$$\widetilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mn} \end{bmatrix} \tag{4.16}$$

$$\widetilde{W} = [\widetilde{w}_1\ ,\ \widetilde{w}_2, \dots, \widetilde{w}_n] \tag{4.17}$$

Step 3: Obtain the normalised fuzzy decision matrix by normalising the built-in fuzzy decision matrix as

$$\widetilde{R} = [\tilde{r}_{ij}]m \times n \quad ; \text{i} = 1,2, \dots, \text{m};\ \text{j} = 1,2, .., \text{n}; \tag{4.18}$$

where $\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right)$ and $c_j^* = \max_i c_{ij}$

Step 4: Create a weighted, normalised fuzzy decision matrix like follows:

$$\tilde{V} = \left[\tilde{v}_{ij}\right]_{m\times n} \quad i = 1,2, \dots, m; \quad j = 1,2, \dots, n \tag{4.19}$$

$$\tilde{v}_{ij} = \widetilde{w}_j(.)\tilde{r}_{ij}$$

Step 5: The fuzzy positive ideal solution (FPIS, $\tilde{A}^*$) and fuzzy negative ideal solution (FNIS, $\tilde{A}^-$) should be determined.

$$\tilde{A}^* = (\tilde{v}_1^*,\ \tilde{v}_2^*, \dots\ \tilde{v}_n^*) \tag{4.20}$$

$$\tilde{A}^- = (\tilde{v}_1^-,\ \tilde{v}_2^-, \dots\ \tilde{v}_n^-) \tag{4.21}$$

where $\tilde{v}_j^* = \max_i \{v_{ij3}\}$ and $\tilde{v}_j^- = \min_i \{v_{ij1}\}$. I = 1,2, …m, j = 1,2, ..n.

Step 6: Determine each option's distance from FPIS and FNIS using the following formula:

$$d_i^* = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}\ ,\ \tilde{v}_j^*), \qquad i = 1,2, \dots m \tag{4.22}$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij}\ ,\ \tilde{v}_j^-), \qquad i = 1,2, \dots m \tag{4.23}$$

where d_v (.,.) is the measurement of the separation between two fuzzies.

Step 7: Each alternative's proximity coefficient may be computed as follows:

$$C_i = \frac{d_i^-}{d_i^* + d_i^-}, \qquad i = 1,2, \dots m \tag{4.24}$$

Step 8: According to the aforementioned equation, (4.24), an alternate Ai would move away from FNIS and towards FPIS as Ci gets closer to the value of 1. Based on the proximity coefficient values of the alternatives, the ranking of the alternatives may be decided.

4.3 Hybrid Approach – Ii: Fuzzy Vikor Approach

In order to provide a logical and systematic process to arrive at a ranking list of all possible alternatives in multi-criteria decision-making problems and to find the best solution and a compromise solution that can be used to resolve multi-criteria decision-making problems, the fuzzy VIKOR method is proposed. It is based on the idea of fuzzy logic and the VIKOR method.

The fuzzy VIKOR approach is composed of the following steps:

Step 1: Create a list of all viable options as a first step. Create a committee of decision-makers who are authorities in the area and have a wealth of knowledge and experience. The list of assessment criteria that will be taken into account when deciding the ranking of alternatives is created by the committee of decision-makers. Define linguistic variables and the fuzzy numbers that correspond to them for the ratings of alternatives and the weights of the criteria, respectively.

Step 2: Consider the preferences and viewpoints of the decision makers. Add up the fuzzily weighted criteria that n decision makers have indicated as

$$\tilde{w}_j = \frac{1}{n}\left[\sum_{e=1}^{n} \tilde{w}_j^e\right], \quad j = 1,2,\dots,k \tag{4.25}$$

Add the preferences and viewpoints of the n decision-makers for each alternative in relation to the j th criterion as well.

$$\tilde{x}_{ij} = \frac{1}{n}\left[\sum_{e=1}^{n} \tilde{x}_{ij}^e\right], \quad i = 1,2,\dots,m \tag{4.26}$$

Create the ormalized fuzzy decision matrix and compute the fuzzy weighted average.

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \cdots & \tilde{x}_{1k} \\ \tilde{x}_{21} & \tilde{x}_{22} & \cdots & \tilde{x}_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \cdots & \tilde{x}_{mk} \end{bmatrix} \tag{4.27}$$

i = 1,2, .., m; j = 1,2, .., k

$$\tilde{W} = [\tilde{w}_1,\ \tilde{w}_2,\ \dots, \tilde{w}_k,]\ ,\ \text{j} = 1,2,\dots,\text{k}\ ; \tag{4.28}$$

where $\tilde{x}_{ij}$ is the rating of alternative A_i with respect to criterion C_j and $\tilde{w}_j$ is the importance weight of the j th criterion.

Step 3: Determine the fuzzy best value ($\tilde{f}_j^*$) and fuzzy worst value ($\tilde{f}_j^-$)

$$\tilde{f}_j^* = \max_i \tilde{x}_{ij} \tag{4.29}$$

$$\tilde{f}_j^- = \min_i \tilde{x}_{ij} \tag{4.30}$$

Step 4: Calculate the value $\tilde{S}_i$, $\tilde{R}_i$ $\tilde{S}^*, \tilde{S}^-, \tilde{R}^*$ *and* $\tilde{R}^-$ and $\tilde{Q}_i$

$$\tilde{S}_i = \sum_{j=1}^{k} \tilde{w}_j (\tilde{f}_j^* - \tilde{x}_{ij}) / (\tilde{f}_j^* - \tilde{f}_j^-) \tag{4.31}$$

$$\tilde{R}_i = \max_j [\tilde{w}_j (\tilde{f}_j^* - \tilde{x}_{ij}) / (\tilde{f}_j^* - \tilde{f}_j^-)] \tag{4.32}$$

where $\tilde{S}_i$ is for A_i w.r.t. all evaluated criteria by the largest distance from the fuzzy best value (FBV), $\tilde{R}_i$ is for Ai with regard to the jth criterion, and the total of the distances from the FBV is the fuzzy best value.

$$\tilde{S}^* = \min_i \tilde{S}_i \tag{4.33}$$

$$\tilde{S}^- = \max_i \tilde{S}_i \tag{4.34}$$

$$\tilde{R}^* = \min_i \tilde{R}_i \tag{4.35}$$

$$\tilde{R}^- = \max_i \tilde{R}_i \tag{4.36}$$

$$\tilde{Q}_i = v(\tilde{S}_i - \tilde{S}^*)/(\tilde{S}^- - \tilde{S}^*) + (1-v)(\tilde{R}_i - \tilde{R}^*)/(\tilde{R}^- - \tilde{R}^*) \tag{4.37}$$

Here, $\tilde{S}^*$ is least value of $\tilde{S}_i$ which is the max rule of majority or max utilitization of group and $\tilde{R}^*$ is the minimum value of $\tilde{R}_i$, $\tilde{R}^*$ is the minimum value of $\tilde{R}_i$ which is the minimum individual regret of the opponent.

As a result, the index i is created, and it is based on the opponent's individual remorse as well as their value to the group. V is also the weight assigned to the strategy with the highest group utility.

Step 5: Defuzzifying triangular fuzzy numbers in step five Enter an equation here.and order the options by sorting them according to ascending Qi values. Therefore, the better the alternative, the lower the value of Qi.

Step 6: Choose a compromise solution in step six. Assume that the two requirements listed below are met. Then, as a single optimal solution, choose a compromise solution (a') using the index Qi.

[C1] Acceptance in favour:

$$Q(a'') - Q(a') \geq DQ \tag{4.38}$$

$$DQ = {}^{1}/_{m-1} \qquad (DQ = 0.25 \ \ if \ \ m \leq 4) \tag{4.39}$$

[C2] Acceptance of stability in decision making:

For this a condition Q (a') should satisfy S (a') or/and R (a').

If [C1] is not accepted and Q ($a^{(m)}$) – Q (a') < DQ, then $a^{(m)}$ and a' will result same compromise solution. Since a' do not have a compromising advantage, the solutions a', a", …, $a^{(m)}$ are the same compromise. If [C2] does not accept, the stabilization in decision making is of scarcity type, even though a' have comparable advantage. Thus, compromising solutions of a' and a" are identical.

Step 7: Choose the most suitable option. Select Q (a') as the best option that uses the least amount of Qi.

5. RESULTS AND DISCUSSIONS

5.1 RESULTS

In the present competitive scenario, improvement of productivity on a continuous basis is the order of the day for survival and growth of any enterprise. Due to global competition and explosion of choices, the expectations of customers and end users are significantly increasing. Proactive and progressive enterprises need to be always concerned about performance evaluation. It helps them not only to improve productivity and profitability but also ensures efficiency and effectiveness in utilization of resources for maximization of customer value. To keep customers satisfied and to maintain competitive conditions in the market, it is essential to track, comprehend, and sustain supply chain performance. In order to fulfil present and future demands, these measurements give management the ability to pinpoint existing gaps and spot variations in real performance in supply chain services.

5.1.1 Performance Evaluation of Transportation Service Providers by Fuzzy Topsis Approach

Five firm leaders with strong knowledge and experience in the logistics and textiles industries were assembled into a committee of five decision-makers. The five decision-makers' combined experience ranged from 20 to 35 years. The decision-makers carefully considered all pertinent elements and concerns while conducting a review of the current literature on supply chain performance evaluation. Twelve criteria were established by the decision-making committee to examine the six TSPs. Lead time, dependability, adaptability, defect-free delivery, experience, inventiveness, technology advancement, brand worth, tariff, capacity, market share, and growth capability were the twelve criteria.

Table 5.1 Rank by Fuzzy TOPSIS

	TSP1	TSP2	TSP3	TSP4	TSP5	TSP6
d_i^+	5.004	6.003	4.885	5.141	5.694	5.557
d_i^-	5.298	4.014	5.353	5.052	4.773	4.488
$d_i^+ + d_i^-$	10.3	10.02	10.24	10.19	10.47	10.05
Ci	0.514	0.401	0.523	0.496	0.456	0.447
Rank	2	6	1	3	4	5

TSP3 was the top-performing TSP out of the six companies that provided transport services (TSPs) and received impressive rankings for the three criteria of lead time, reliability, and defect-free delivery as well as very good rankings for the five criteria of flexibility, experience, innovativeness, tariff, and capacity. As the second and third best performing TSPs, respectively, TSP1 and TSP4 received very good rankings for five criteria each. The TSP2 was judged to perform badly across six parameters, including flexibility, defect-free delivery, innovativeness, technological upgradation, tariff, and growth capabilities, and as a result, was named the worst TSP.

5.1.2 Performance Evaluation of Transportation Service Providers by Fuzzy Vikor Approach

Lead time, dependability, flexibility, defect-free delivery, experience, inventiveness, technological upgradation, brand value, tariff, capacity, market share, and growth capabilities were the twelve criteria chosen by the committee of decision-makers for the performance evaluation. The evaluation of the comparative performances of the six TSPs was done using the fuzzy VIKOR approach, which was also applied to the evaluation data provided in the form of linguistic appraisals by the committee of decision makers.

TSP3 was the top-performing TSP out of the six TSPs evaluated for performance. TSP3 received impressive ratings for three criteria, including lead time, reliability, and defect-free delivery, and very good ratings for five criteria, including flexibility, experience, innovativeness, tariff, and capacity. A compromise solution was also advised by the fuzzy VIKOR technique since the best-performing business did not have a sufficient advantage. Three companies, TSP3, TSP1, and TSP4, made up the compromise solution.

Table 5.2 Rank by Fuzzy VIKOR

m	$\tilde{Q}_i$			Q_i	Rank
TSP1	0.039	0.095	0.195	0.11	2
TSP2	1	1	1	1	6
TSP3	0	0	0	0	1
TSP4	0.155	0.182	0.25	0.196	3
TSP5	0.613	0.617	0.678	0.636	5
TSP6	0.46	0.463	0.556	0.493	4

For their transportation requirements, textile industries hire the services of transportation service providers (TSP) companies. Six significant TSPs are selected from the whole list used by the textile firm to carry completed goods to various locations around India for the performance evaluation activity. The majority of the company's transport requirements are met by the six TSPs that were included in the experiment. The leading four medical support service providing (MSSP) organisations are selected for the performance evaluation exercise from the full list of medical support service providing (MSSP) businesses operating in Trivandrum. The big four catering service providing (CSP) organisations are picked for the performance evaluation exercise from the full list of CSP companies in the city of Trivandrum.

While the fuzzy TOPSIS approach produced the ranking order TSP3> TSP1> TSP4> TSP5> TSP6> TSP2, the fuzzy VIKOR approach produced the ranking order TSP3> TSP1> TSP4> TSP6> TSP5> TSP2. While both the approaches produced similar results for the three best performing TSPs and the worst performing TSP, the results were different in case of the fourth and fifth ranked TSPs.

Table 5.3 Comparison of Performance evaluation of TSPs

TSP	Fuzzy TOPSIS		Fuzzy VIKOR	
	Closeness Coefficient C_i	Rank	Decision Coefficient Q_i	Rank
TSP1	0.514	2	0.11	2
TSP2	0.401	6	1	6
TSP3	0.523	1	0	1
TSP4	0.496	3	0.196	3
TSP5	0.456	4	0.636	5
TSP6	0.447	5	0.493	4

5.2 DISCUSSION

The assessment goals must match organisational objectives and reflect a balance between financial and non-financial measurements that may be tied to strategic, tactical, and operational levels of decision making and control in order for performance evaluation and improvement to be effective. The effectiveness of supply chain participants is a key element in supply chain partnering and integration. A cooperative partnership that acknowledges some degree of reliance and collaboration is supply chain partnering. Such collaboration places an emphasis on direct, long-term relationship, which supports cooperative planning and problem-solving activities. Performance assessment and improvement studies must be conducted at every stage of the supply chain in order to enhance performance and get closer to the achievement of supply chain optimisation. All supply chain participants should be involved in and committed to shared objectives like increased customer satisfaction and supply chain competitiveness. A supply chain performance review programme should be comprehensive, address every individual participant, and be customised to meet those members' various demands.

5.2.1 COMPARATIVE ANALYSIS OF THE HYBRID MCDM APPROACHES

Practising executives used to be obsessed with a variety of tasks and obligations when managing and running supply chains for their firms. Therefore, it is important to make sure that the methodologies and approaches that are suggested for evaluating the performance of supply chains have a limited number of steps so that the performance evaluation exercises can be carried out without taking up a lot of the actual working time of practising executives. It can be seen from a comparison of the hybrid techniques suggested and used in the current work that the approaches based on fuzzy logic will take up more time from practising executives than those based on grey system theory. The TOPSIS technique includes benefits including being simple to grasp, having a straightforward conceptual foundation, and having a brief computing process. The ELECTRE method includes benefits including being rapid, using straightforward reasoning, and having the capacity to recognise the existence of incomparability. The VIKOR approach's main benefit is that it also suggests a compromise solution in the event that the best-ranked option does not have a favourable edge.

Table 5.4 Comparative analysis of the hybrid MCDM approaches

Parameter	Fuzzy TOPSIS	Fuzzy VIKOR
Conceptual Basis	Very easy to comprehend	Easy to comprehend
Computational Procedure	Short	Long
Level of Rigor	High	Very high
Ease of Calculation	High	High
Computational Time	Medium	Medium

Table 5.4 compares the four hybrid MCDM techniques that are suggested for assessing the performance of service supply chains. The fuzzy TOPSIS technique offers benefits including a conceptual foundation that is relatively simple to understand, a quick computing process, and a high calculation ease rating. The fuzzy VIKOR technique provides benefits including a conceptual foundation that is simple to understand, a very high level of rigour, and a high rating for computation simplicity. However, the computational process is lengthy.

6. CONCLUSION & FUTURE SCOPE

6.1 CONCLUSIONS

Supply chain managers must act rapidly in order to address competitive difficulties, customer complaints, erroneous order processing, and unpredictable transportation conditions. Businesses nowadays have been utilising cutting-edge technology and methods to gain and maintain competitive advantage in circumstances marked by ever-increasing rivalry and economic globalisation. Organisations are under increased pressure from customers demands for individualised products and services, quality enhancements, and demand responsiveness. To ensure profitability, they must, however, cut manufacturing costs, decrease lead times, and reduce inventory levels. More and more businesses are working to create long-term strategic alliances with a select group of capable supply chain partners and work with them to outsource non-core processes in order to thrive under these challenges.
The degree of performance efficiency of the supply chains that an organisation uses to both procure raw materials and services and to transport and distribute completed goods and services has a significant impact on how successfully and efficiently the organisation functions. Therefore, it is imperative that every organisation regularly assesses and tracks the performance of the various supply chains it employs for obtaining raw materials and dispersing finished goods.

Performance reviews may offer crucial feedback data that helps supply chain managers track implementation, identify advancements, improve communication, and identify issues. Additionally, it can offer information about how well established systems and procedures work, as well as point out successes and potential opportunities. The supply chain participants' integration and understanding of one another can be facilitated. It may offer a

crucial contribution to supply chain management decision-making, particularly when redefining corporate objectives and strategies and reengineering procedures.

Benchmarking initiatives inside the organisation might benefit from performance review. In order to maintain their competitiveness, organisations frequently copy the industry's best practises. This necessitates that businesses examine new technology and best practises as well as continuously monitor environmental developments. Benchmarking and performance assessment are viewed as complementary strategies, with performance evaluation serving as the information source for benchmarking operations.

The sharp facts are insufficient for organisational decision making since decision data, particularly for intangible components, is hazy. Decision-makers often have greater confidence making language judgements than precise value judgements because human judgements, including preferences, are frequently ambiguous and cannot be stated by precise number values. Due to its suitability for handling linguistic data, fuzzy logic and grey system theory are included in the job of evaluating the effectiveness of service supply chains.

Major flaws in the current supply chain performance evaluation methodologies include their failure to capture holistic features, unsuitability for various levels of measurement, complexity, need for minute details, and inadequacy to account for ambiguity in human judgement. Four hybrid multi-criteria decision-making (MCDM) techniques have been developed in this study for evaluating service supply chain performance. The applicability and viability of the suggested hybrid techniques have been proved through appropriate case studies that examined the performance of real-world supply chains by putting them into practise.

6.2 FUTURE SCOPE

The subject of SCM performance evaluation requires further study as well as practitioner-driven efforts. New metrics and procedures for assessing the performance of the supply chain as a whole as well as the performance of each organisation that is a component of the supply chain need to be designed creatively. The promotion of supply chain performance assessment generally, as well as the development of metrics and measuring methodologies specifically, require the assistance of industry consortiums, consultants, and researchers. It is necessary to conduct coordinated research on supply chains that belong to different service sectors in order to identify appropriate metrics that take into account the unique characteristics of each sector and to develop and implement suitable methodologies in businesses that belong to different service sectors.

The development of fresh, cutting-edge multi-criteria decision-making (MCDM) strategies that may be applicable to and efficient for the task of evaluating the performance of supply chains has to be promoted through research. It is necessary to investigate the applicability and significance of contemporary MCDM techniques like the multi objective optimisation on the basis of ratio analysis (MOORA) method.

Also Fuzzy Grey Vikor, Fuzzy Grey Electre and Fuzzy Grey Topsis can be used for comparison in various fields and it is very easy to analyse and compare and best process can be selected out using these methods

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