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## Application of operations research in supply chain management of Micro, Small, and Medium Enterprises

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### ABSTRACT

*Keeping in mind the complexity of the functioning of the Supply Chain Management of Small and Medium Enterprises, the authors of the paper have aimed at focusing on various methods that can be used to arrive at the best results with optimum utility of resources. The paper also depicts the functioning and procedures of the various methods and which one should be used under different circumstances that can obtain the best outcome for the enterprises. The aim is to show a way of improvement in supply chain management of micro, small and medium enterprises. Sustainability of small and medium sized enterprises (SMEs) is significant as SMEs contribute to GDP substantially in every economy. This research develops an innovative and sustainable supply chain performance measurement model for SMEs.*

**Keywords**—Supply Chain Management, SCOR, Bayesian SEM, MCDM, SWARA, MSMEs, SMEs

### 1. INTRODUCTION AND OVERVIEW

Supply chain management in SMEs is defined as a methodology that assists the association with working in a more dexterous and costs viable way by incorporating the cycles of different accomplices at all three levels – strategic, tactical, and operational. Despite of the way that SMEs are currently further taking an interest in the worldwide business organizations, store network failure is perhaps the most pivotal issue confronting the SMEs. SCM can work on the exhibition of a SME and furthermore increment its benefit by upgrading the capacity to acquire supplies in the right quality, at the ideal opportunity, and at the most preferred costs. Then again, most SMEs don't utilize SCM and view it as a single direction measure that applies a buyers' force. Supply chain management in SMEs has three levels that are supply chain integration, strategic planning and implementation respectively.

In this paper of Supply Chain Management of Micro, Small and Medium Enterprises, the OR techniques used are SCOR Method, Bayesian SEM Model, SWARA Method and Multiple criteria decision-making (MCDM). SCOR means Supply Chain Operation Reference Model. It's a method of managing processes in supply chain operations, in the form of a description of business processes from the supplier to the customer by the objectives of the Supply chain. The next technique used is Bayesian method which uses the Bayes' Theorem to compute and update the probabilities after obtaining the new data from the model. The statistics used in this method are based on the Bayesian interpretation of probability where probability expresses a degree of belief in an event. The next technique is SWARA method. Stepwise Weight Assessment Ratio Analysis (SWARA) is a Multi Criteria Decision Making (MCDM) tool and also a new methodology for supplier selection and the main motive to use this model is to minimize purchase risk and maximize the overall efficiency of supplier. The last technique used in this Research Paper is Multiple criteria decision-making (MCDM) which is considered as a complex decision-making (DM) tool involving both quantitative and qualitative factors. The main objective of this article is to systematically review the applications of MCDM techniques and methods. The methodologies followed in this study of the MCDM model are Analytic Hierarchy Process (AHP) and Analytical Network Process (ANP).

SCOR provides a chain of benefits. The SCOR model gives a company an idea of the level of advancement of its supply chain, helps to understand the complete cycle of the supply chain and is critical in getting a product successfully along each level. It enables full leverage of capital investment and helps to get a great return on investment. The Bayesian approach is typically more suitable for estimating random effects, because it is possible to produce rear distributions for a large number of unit-level parameters. It also avoids the drawbacks caused by the sparseness of individual-level data. SWARA Method's expert ability and mastery are the most vital and influencing points in determining the importance of each criterion because it includes both qualitative and quantitative factors. The SWARA method has logical perspective because it is determined by the Experts which makes it a powerful tool. In MCDM- AHP and ANP, both have their limitations that further result in a general method. The general, method follows the flow of initially allocating weights to all the criteria based on their relative importance. Even though AHP and ANP are very handy in addressing problems in specific situations, they are avoided by companies owing to their deficiencies.

The first and foremost question should be what is a supply chain and what is supply chain management. Supply chain is a system of converting raw material, manpower and all processes associated with production to finished goods. It is therefore called a "chain" of integrated processes that enables the product to reach from the supplier to the end consumer. Supply chain management is the process of integrating the supply and demand management, not only within the organization, but also across all the various members and channels in the supply chain so they work together most efficiently and effectively (Supply Chain Management: Here's What You Need to Know, 2020). Supply Chain Management is divided into six different components that are plan, source, make, deliver, return and enable. Supply chain management and its analysis is a necessity for large enterprises as their process can be complex and they need to make their production as efficient as possible. This is also important for small and medium enterprises as they constitute a large part of the economy. So SMEs or small and medium enterprises constitute of about most of the businesses in India. Small and Medium Enterprise (SMEs) are a pivotal part of every economy in the world and primary source of economic growth. Although they play a key role in the development of an economy, SMEs often lack finances, time, technology, high-end equipment and the knowledge to implement environmental improvement measures and also have low sustainability awareness. Eventually it will be this growth in supply chain that would convert them from small enterprises to large corporations. Supply chains in Indian businesses can be very dynamic considering the price competition in the country. Also Indian people consider doing a business rather than doing a job, therefore we have many small businesses in the country. Maintaining a constant supply chain is a challenge for all businesses. To have a good efficient system, the system needs to be analysed and improved over time. Small and medium-size enterprise (SME) owners need to understand that they have an untapped gold mine right in front of their eyes. (Vuolle, 2016) There are various models that can be used to evaluate supply chains but the problem is that SMEs usually don't have the financial resources and knowledge to use models. Further, the models can be complex at times and too time consuming for the objective or aim of the business to be achieved. Here we have explained and compared four models that can be useful in analysis of supply chains. The motivation behind this research is to educate the small and medium enterprises about supply chains and how essential they can be in the lifetime of an organization. Therefore they need to know about ways that can be useful to improve their product cycle with minimum time and maximum results. The models compared in this research are Bayesian SEM Model, Supply Chain Operation Reference Model (SCOR), Multiple criteria decision-making (MCDM) and Stepwise Weight Assessment Ratio Analysis (SWARA). The structure of the research is the review of existing literature and what can we learn from it. Then different models are introduced and compared, each with their pros and cons. We will finally conclude with our recommendation on the most appropriate model that should be used by SMEs.

## **2. LITERATURE REVIEW**

The impact of SMEs in the global economy is a very crucial role in the construction of a society which is free of poverty (iQualityUK, 2020). Although they play a key role in the development of an economy, SMEs often lack finances, time, technology, high-end equipment and the knowledge to implement environmental improvement measures. SMEs help in the regional and local development of undeveloped places by accelerating the industrialization in these areas by connecting them to the urban sector and global organizations. Indian businesses are dominated by SMEs most of which are family owned and therefore we will find out the relationship that family business characteristics have on supply chain management (Srinivasan, 2010). In family businesses the owners are the managers and take all the strategic decisions and hence, the success of the SME depends on many factors like trusting relationships with suppliers, on time delivery, communication, etc. A major challenge which SME industries face when it comes to supply chain management is that it is dynamic as it has to change according to the demand and coordination across multi location manufacturing units (Jayaram et al., 2014) In developing countries like India, information systems and advanced information technology infrastructure plays an important role in improving the SCM among the SME industries. One of the main reasons that large organizations outperform family-owned businesses is because they use advanced IT techniques that drastically reduces the interaction and transaction costs and also helps in vendor and customer relationship management. (Malesios et al., 2020) Owners of the SMEs are the ones, who make strategic decisions, control and manage operations and due to this, their attitude towards growth, risk level, objectives to be achieved, improving the IS capability, delivery lead time and cost of customer service and professionalism of the enterprise has a huge impact on the business and managing its SCM. SMEs should be better prepared when they are starting and applying for a loan, with getting the collateral, maintaining good relationships with financial institutions and having a good financial record. SMEs are unable to align their long-term Sustainability strategies with their short-term Profitability goal. (Jayaram et al., 2014;)

Supply chain management is the management of a product's or service's complete manufacturing flow, from the smallest raw materials to delivery of the end product to the customer that completes the process (Hazen et al., 2018) The primary sources for this research article were gathered through the use of big data. Analysis of past data patterns and trends using historical data and insights from the customers help forecasting what will happen in the future and hence many elements of a business, such as acquiring realistic goals, planning efficiently and avoiding risks. (Hazen et al., 2018).

SCOR is a management tool. It is a process reference model for supply-chain management, spanning from the supplier's supplier to the customer's customer. Through research, there have been found four cornerstones of the SCOR model that are Process, Performance, Practice and People (Ramadheena et al., 2020). The first pillar of the SCOR model comprises the five-process categories -plan, source, make, deliver and return. The entire channel of the raw materials being produced till the customer receiving the finished goods is made up of tens of different processes each with its standard operating procedures. Supply chain performance metrics that have been validated by respondents are referred to as KPI so that performance can be measured (Yuniaristanto, 2020). The second pillar in the SCOR model uses a unified system of more than 100 key performance indicators, which are hierarchical. This measures how well the process was carried out. The main objective of the model is to reach optimum utilization of resources and the most efficient real and monetary flow. (Ramadheena et al., 2020)

In general, eight types of Success factors can be identified which contribute to the successful implementation of Green Supply Chain Management, they are as follows, Environmental Perspectives, Social Perspectives, In-house Development, Green Practices, Customer Relations, Regulatory Norms, Green Strategic Factors, and Others. Each type of Success Factor includes a list of Drivers under it, for example, Environmental Perspectives Includes Eco-labelling, Pollution Control, Waste Reduction, Reduction of hazardous wastes, Environmentally Friendly Materials (Raja Ariffin, 2015). Social Perspectives includes Conservation of National Resources, Social Responsibility, environmental Related Training, and Seminar. In-House Development Includes the training of Employees & suppliers, Top management Commitment (Gandhi, Evaluating Factors in implementation of Successful Green Supply Chain Management using DEMATEL- A case study, 2015), adoption of clean Technology, Environmental management. Green Practices include Green Manufacturing, Green packaging, Green Purchasing, Green Transportation, Green design, green information, green innovation (Rostanzadeh, 2014). Customer Relation Includes Customer Requirement, Cooperation with Customer, Customer awareness regarding GSCM, competitiveness, Customer environmental Collaboration (Bey, 2013), supplier Environmental Collaboration. Regulatory Norms Include the ISO 14001, Government regulation standards, and hazardous and toxic Regulations (Bey, 2013). Green Strategic Factors include Reuse, Recycling, Reverse Logistic, Remanufacturing, Reduce and Others include green operation, Competitive pressure, Globalization, Green Procurement, Investment Recovery, Reuse of Packaging, Waste management, Minimization of Carbon Footprint.

MCDM (Multi-Criteria Decision Making) Model is used for identifying Success factors of GSCM. The AHP (The Analytic Hierarchy Process) approach (Gruels, 2015) comes under the MCDM umbrella, the merits of this approach are that it allows the Decision-makers to structure the decision making problem into a hierarchy tree making the problem easily comprehensible and understandable and the demerit of this method is that, Scoring and ranking in this method depends on the alternatives considered for evaluation and removal of any alternative may change the whole structure. Other methods that can be used to identify Drivers and collect information on them include Bayesian SEM, SWARA model etc. (Ali et al., 2020)

### **3. OBJECTIVE**

The objective of this research paper is to study the existing and the new models used in SCM and find out which model is best suited for SME industries as such businesses have many constraints like resources, finances, lack of knowledge and therefore our main aim is to check which model is the most efficient so that the SME industries can compete globally. We aim to use time efficient models for the SMEs.

### **4. METHODOLOGY**

Methodology of this research includes introducing various models of evaluation of supply chain management and showing their calculations. Weights are calculated in respective models. Their advantages and disadvantages are shown in analysis and findings.

### **5. ANALYSIS AND FINDINGS**

#### **5.1 SCOR Method**

In 1996 Supply chain consulting firm Pittiglio Rabin Todd & McGarh and AMR Research introduced the SCOR model. (Ramadheena et al., 2020) SCOR means Supply Chain Operation Reference Model. It's a method of managing processes in supply chain operations, in the form of a description of business processes from the supplier to the customer by the objectives of the Supply chain. SCOR method includes several processes in the supply chain, for example: Process Plan. Sources Process, make the Process, Delivery process, and Return process. The SCOR method consists of 3 levels of general to specific Procedures that contain metrics that must be done in stages or steps in determining the performance attributes.

The Steps that need to be taken in measuring Supply Chain Performance are to Firstly, Identify a level 1 Metric containing the overall process size or General Definition of the 5 core supply chain processes, which are: Plan, Make, Source, Deliver and Return. At level 2, Metrics can be called Dimensions, that contain indicators consisting of attributes to measure SCM performance. The Dimensions are Reliability, Responsiveness, Flexibility, Cost and Asset. Reliability is the assessment of Company Performance with regards to carrying out its tasks exactly as expected. Responsiveness is the Assessment of Supply Chain Speed Performance. Flexibility is the time taken to react to change in market conditions. Cost is the Evaluation of Company Expenses in a supply Chain. Assets is the assessment of the management of company property. At level 3, examine and determine indicators that affect level 2 Metrics, these are called Key Performance Indicators (KPI).

Next is the data Processing Stage. The value of each Key Performance Indicator metric along with the normalization (Snorm de Boer is used) is calculated. The objective is to adjust the KPIs metric value to be used as an indicator.

$$\begin{aligned} \text{For Larger is Better } S_{norm} (skor) &= (SI - S_{min}) / (S_{max} - S_{min}) \times 100 \\ \text{For Lower is Better } S_{norm} (skor) &= (S_{max} - SI) / (S_{max} - S_{min}) \times 100 \end{aligned}$$

SI is the indicator value achieved. Smin is the productive value of the worst performance indicators. Smax is the best performance value of a performance indicator

In the above calculation each weight of the indicator is converted into a range of values ranging from 0 to 100. From the results of the parameter values for each indicator, analysis and conclusions can be made later

Lastly we need to determine weights for each process, dimensions and the KPI indicators. Determination of the weight is done by distributing questionnaires to respondents listed in step 2. Each Process, size, and the Index has Different influences, the result of this survey are then normalized into a weighing Equation =  $W_i / \sum W_j$ , Where  $W_j$  is the value after conversion and  $\sum$  is the total number.

Calculating the final performance value, can be obtained by multiplying each normalized value by the weight value of each metric. Calculating the final cost performance consists of 3 stages. 1st step is estimating the value of the KPI indicator, 2nd stage is calculating the value of each dimension & 3rd step is calculating each process's value.

SCOR provides a myriad of benefits. The SCOR model gives a company an idea of the level of advancement of its supply chain, helps to understand the complete cycle of the 5 steps of SCOR and that each step is a link in the supply chain and is critical in getting a product successfully along each level. It enables full leverage of capital investment and helps to get an average return of 2 to 6 times on investment. It helps to examine key processes and supply chain management in detail. The method to calculate the final score is easy to understand and is a lesser time-consuming process. It helps in the creation of an efficient supply chain road map. The introduction of weights into the model helps giving importance to different parameters ethically.

Not every chain can be analysed effectively with this model. SCOR does not cover each aspect of the SCM. It does not cover information technology, training, research and development. Also, it does not include post-delivery customer support. In addition to these, companies have to think about environmental degradation too. No KPIs in this model includes sustainability of the supply chain. This model is difficult to integrate with other management information systems. Process involves ranking given by different people so it is subjective in nature. Not a cost friendly project.

This model can be improved by taking into account the sustainability of the supply chain by adding new KPIs in each of the 5 steps. Green SCOR should be used preferably instead of SCOR. The 5 step process misses a new step "enable". Enable refers to the processes which are integrating the Supply Chain management such as data resources, business policy, information technology etc. These are key facilitators of movement of information and goods.

## **5.2 Bayesian SEM Model**

*Bayesian statistics is a theory in the field of statistics based on the Bayesian interpretation of probability where probability expresses a degree of belief in an event.* Bayesian method uses the Bayes' Theorem to compute and update the probabilities after obtaining the new data from the model.

Structural equation modelling (SEM) is a technique which is used in scientific investigations to test and evaluate multivariate causal relationships.

The flexibility of the Bayesian approach makes it easy to be applied to a very broad class of SEM type modelling frameworks, allowing nonlinearity, interactions, missing data, mixed categorical, count, and continuous observed variables, etc.

Bayesian SEM should only be used with small samples when the information is available about the limited range of values for all the parameters given in the model.

The risks associated with default priors when Bayesian SEM is used are that when samples are small, priors have a relatively larger impact on the rear than when the samples are large. The rear is seen as a compromise between the prior and the likelihood. If there is a larger sample size, the likelihood dominates the rear. However, if there is a small sample size, the likelihood has relatively less weight on the rear. Accordingly, the prior has relatively more weight on the rear and also that most of the default priors have very wide distributions.

Bayesian estimation of Structural Equation Models has become more and more famous in the past decade and is being used more and more often as a solution to problems that are caused by small sample sizes. (Smid & Winter, 2020) The results show that the relationship between efficiency and size depends on the internal properties and the characteristics of the firm and the environment in which it is operating and that there is a lot of heterogeneity among the firms. The Bayesian approach is typically more suitable for estimating random effects, because it is possible to produce rear distributions for a large number of unit-level parameters. Moreover, it also avoids the drawbacks caused by the sparseness of individual-level data. (Majocchi et al., 2015) The drawbacks of the Bayesian SEM Method are that there is no specific way to select a prior in the method and the fact that it produces rear distributions that are heavily influenced by the priors. The Bayesian SEM Method is also a highly costly method with a lot of parameters.

## **5.3 Tools Of MCDM**

Multiple criteria decision-making (MCDM) is considered as a complex decision-making (DM) tool involving both quantitative and qualitative factors (Saaty, 1990, 1977, 1986). In recent years, various MCDM techniques and methods have been proposed to

select the best possible option. The main objective of this article is to systematically review the applications of MCDM techniques and methods.

The methodologies followed in this study of the MCDM model are Analytic Hierarchy Process (AHP) and Analytical Network Process (ANP).

Analytical Network Process (ANP) is an MCDM method, by Saaty which developers use to classify by pair comparison. This method is associated with the consistency relationship. Assuming there are many standards and alternatives, first use the Saaty's scale to calculate the weight of the standard by pairwise comparison. Then compare all the alternatives to each standard in pairs and use the scale to list them in a separate table. The sum of each row is calculated, normalized, and then placed in the last column and marked with local weights. This column is used to build a new table with the criteria set along the top row, while the alternatives build the left column. The value of each cell in each column is multiplied by the weight of the standard associated with the column, and the sum of each row is calculated. The calculated number is set in the last column of the final table, which represents the degree of attention to the overall alternative or weight. The final ranking is based on the overall weight and submitted to the decision maker.

If the number of columns are "i" and the number of columns are "j" then a perfectly consistent matrix will fulfil the condition

$$W_{ij} = 1/W_{ji}, \\ W_{ij} = W_{ik}/W_{jk}.$$

Since, AHP was inconsistent in determining how the elements were interrelated, therefore Analytical Network Process (ANP) was developed by Saaty and Takizawa. ANP is a version of AHP that considers the internal relationships between elements through additional steps. This MCDM method follows a process similar to AHP, but in addition, items in the same group are compared with each other, regardless of hierarchy. For example, use the Saaty scale to wisely compare standards with each other in separate tables. Although these types of comparisons of internal elements are meaningless and very confusing, except in limited circumstances, because the number of tables has increased significantly, the inconsistency problem has become more serious than AHP.

The elements are compiled in a supermatrix and are then compared in pairs using Saaty's scale. After comparing all the elements in the supermatrix, they are raised to an arbitrarily large limit power to obtain the cumulative effect of the elements on each other. Using a supermatrix ensures that all possible relationships between elements are considered.

However, AHP and ANP, both have their limitations that further result in a general method. The general method follows the flow of initially allocating weights to all the criteria based on their relative importance. Moving to the next step, these weights are then normalized. Furthermore, the normalised weights of the alternatives are obtained with respect to each criteria. In the next step, the normalised weights of the alternatives are transferred to a matrix in which the columns represent all the criterion and the alternatives are represented by the rows. Then, the weights of the criterion are multiplied by the respective values in the columns. In the last step, The summing of each row is done and the totals are ranked from the highest to the lowest.

Therefore, even though AHP and ANP are very handy in addressing problems in specific situations, they are avoided by companies owing to their deficiencies. Also, in many cases the general method outperforms AHP and ANP considering the fact that MCDM does not focus on pair wise comparisons.

#### **5.4 SWARA Method**

During these dynamic times, selecting the right supplier for a firm, which satisfies all the needs, has become an integral part of managing the business efficiently. Stepwise Weight Assessment Ratio Analysis (SWARA) is a Multi Criteria Decision Making (MCDM) tool and also a new methodology for supplier selection and the main motive to use this model is to minimize purchase risk and maximize the overall efficiency of supplier. (Tonekaboni, 2012) Weight assessment is the most important and critical part of MCDM and it includes both quantitative and qualitative factors. In SWARA model the experts determine the weights of the selected criteria and rank the suppliers according to their own knowledge. The main factor for the selection for each company depends upon the marketing strategies and the policies of those each company. (Tonekaboni, 2012)

The main advantage of this particular method under MCDM is that it has the ability to estimate and interpret the expert's opinion hired by the company about the importance ratio in the process of weight assessment. It is comparatively simpler and flexible than AHP and ANP because the conclusions on problems where the priorities to the weights can be varied according to the company's policy. The expert's ability and mastery are the most vital and influencing points in determining the importance of each criterion because it includes both qualitative and quantitative factors. The SWARA method has logical perspective because it is determined by the Experts which makes it a powerful tool. (Stanujkic, 2015)

#### **6. CONCLUSION**

Each Model has its Pros and Cons, in this study the SWARA model gains Victory over the other Models. SWARA Model which stands for Stepwise Weight Assessment Ratio Analysis (SWARA) is a Multi Criteria Decision Making (MCDM) tool, the main advantage of this method under MCDM is that, it has the ability to estimate and interpret the expert's opinion who has been hired by the company, about the importance ratio in the process of weight assessment. The SWARA model has a logical perspective as it has been determined by the Experts ,hence the SWARA model is a powerful tool .SCOR model on the other hand has its Limitations, because it cannot effectively analyse every supply chain ,it does not cover information technology ,training ,research and development and ignores sustainability of supply chain .SCOR model is difficult to integrate with other management

information systems .Bayesian SEM Model also has its shortcomings, because there is no specific way to select a prior in the method ,its highly expensive and comes with a lot of parameters. Through this paper we are helping SMEs, we are educating them about supply chain management, by this they can incorporate supply chain management in the enterprise. By increasing complexity, they can expand their business.

## 7. LIMITATIONS AND RECOMMENDATIONS

The objectives of this paper were to recommend what is the best model for supply chain analysis. The limitations for this research were that not all models were compared and this may not be the best model available. Also some small enterprises may still not be able to interpret these models. These models may not be universally applicable and is company specific. Further these models are subjective and does not do any qualitative analysis. There are new models coming up every single year by researchers across the globe. A universal model could be found in the future. Another objective not met in this research paper was that there is not a sustainable or environmentally friendly model to show how sustainable the supply chain is.

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