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Designing a Hybrid MCDM Model for Risk Management of Supply Chain

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Abstract:- With the rapid process of global expansion and attention to creating various uncertainties in supply chain operations, supply chain risk management has become a very important topic today. Given that supply chain, risk management has a significant impact on the stability of relationships between supply chain partners; it is useful to develop a supply chain risk management decision model. This article introduced decision-making models based on product life cycles, operational process cycles, and organizational operational factors. Of course, the decision-making options in this model are various combinations of risk or. Exposure strategies. We used Fuzzy Hierarchical Analysis and Fuzzy TOPSIS to design appropriate decision paths and dynamic relationships in supply chain risk management.

Keywords:- *Risk Management, Supply Chain, Fuzzy Hierarchy Analysis, Fuzzy TOPSIS.*

I. INTRODUCTION

Supply chain management enables many companies, to achieve many benefits by integrating all activities related to the flow of materials, information and capital, starting with suppliers and ending with end consumers. These competitive advantages are achieved by improving supply chain relationships and creating strong, links between chain partners, i.eween suppliers, manufacturers, distribution centers, warehouses and final consumers. Therefore, that today, the supply chain itself has become an important competitive advantage that can lead to cost reduction and an increase in the quality of products and services. On the other hand, the supply chain inherits risks in various dimensions and types from our lives, and therefore we should seek to make appropriate decisions and manage these risks efficiently.

Here we have developed an analysis path based on product life cycle, operational processes as well as supply chain or, supply chain organizational performance factors,es.

Different factors play a role in the complexity and risk of a supply chain system (Copra & Sin production). Having many suppliers makes it challenging to keep a solid connection. Supply chain managers must decide on a practical approach to applying risk management to production processes.

To reduce disruptions related to various types of risks in the supply chain (uncertain economic cycles, uncertain customer demands, and unpredictable human and natural disasters), many reaches have developed different strategy models for managing supply chain risks (Tang, 2006).

Brass Caster, Anant Raman Karegaru (2011) He developed an integrated system for supply chain risk management and identified techniques to lessen the effects of supply chain risk factors in his research on supply chain risk management. They used phase 1 of the network analytical process approach in their research to weigh the supply chain risk factors and phase 2 of TOPSIS to rank supply chain participants in order to identify supply chain risk. Thon and Honig Have researched supply chain risk management techniques that are scientific and empirical. They looked at 67 manufacturing facilities.

In the German automotive industry, and after looking at the major factors that influence supply chain risks, they assessed the risks that had been found by examining the likelihood of failures and potential effects on the supply chain. The outcomes have also been presented as an "effect probability" matrix. They then determined the tools needed to address them and looked at how supply chain risk management affected the performance of the company (Thun and Hoenig, 2011). Liu, Zhao, and Zhou (2011) highlighted the research on supply chain risk management’s vendor selection section. They divided the most recent research into categories for supply chain management, vendor selection, and vendor selection under supply chain risk circumstances. They also provided a conceptual framework with three dimensions for summarizing research Zhao and Liu(2011).

II. THE LITERATURE OF THE SUBJECT

➢ *Risk Management*

Risk management is a process in which managers identify measures, make decisions and monitor various risks for the organization (Hendi, 2006). In other words, the goal of risk management is to recognize, assess, and develop a plan to lower the likelihood of risky situations.

➢ *Supply Chain Management*

The supply chain has been given many different definitions. a market's supply of goods or services being

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established by businesses in that order (Douglas and James, 1998). The entire process that directly or indirectly contributes to meeting customer needs is referred to as the supply chain, and it includes not only the manufacturer and supplier but also the retailers, warehouses, and customers themselves (as well as other parties (Chopra & So Meindel, 2007).

III. SUPPLY CHAIN RISK MANAGEMENT

Given that domestic chains cannot be satisfied with a single objective, such as profitability, and that global supply chains are more vulnerable than domestic chains, a thorough definition of global supply chain risk management is required. Recertifying and global supply chain risk.

Assessing supply chain risks and ensuing losses with the goal of lowering one or more of the following one or more of the following:

Losses, probability speed of loss time to investigate events , sequence and exposure for the supply chain, which in turn results in compliance and increased savings and profitability. Currently existing demands are hierarchical. (Manuj & Mentzer, 2008).

IV. FUZZY HIERARCH-DECISION-MAKING PROCESS

One of Saati's most well-known methods for multi-criteria decision making is the hierarchical analysis process. When there are numerous options and decision-making indicators, this method may be helpful (Saaty, 1998). The use of fuzzy sets is more compatible with human linguistic and somewhat hazy explanations, so it is preferable to use fuzzy sets (using fuzzy numbers) for long-term forecasting and real-world decision-making. This is because the traditional hierarchical analysis process is not able to fully reflect the human thinking style.

Chang (1996) introduced a technique called the developmental analysis method in 1996.

Fuzzy triangular numbers are used in this method. The value of Sk Which itself in this approach, or each row of the pairwise comparisons matrix is a triangular number that is derived using the equation

$$S_k = \sum_{j=1}^{n} M_{ij} \times \left[\sum_{i=1}^{m}\sum_{j=1}^{n} M_{ij}\right]^{-1} \qquad (1)$$

In order to calculate the total fuzzy number for the judgment matrix table, they are added together as well as the fuzzy numbers for each row of the judgment matrix.

After calculating Si, their magnitude relative to each other should be obtained so that (1,u1,m1=(l1M) and (2,u2,m2=(l2M) are two triangular fuzzy numbers, the magnitude of 2M by 1M which is 1>=M2V(M is shown and defined as follows:

$$V(M_2 > M_1) = hgr(M_1 \cap M_2) = \mu_{M2}(d) \begin{cases} 1 & if\ m_2 \gg m_1 \\ 0 & if\ l_1 \gg u_2 \\ \dfrac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)} & o.w \end{cases}$$

The size of convex fuzzy number M derived from convex number N. Mi,...,k(2,1(i=) is defined as follows:

$$V(M_1 \geq M_2, \cdots, M_k) = V(M_1 \geq M_2) \cdots and\ V(M_1 \geq M_k)$$

CALCULATE THE WEIGHT OF THE INDICATORS IN THE PAIRWISE COMPARISON MATRIX, IT IS DONE IN THE FORM OF EQUATION (4):

$$W'(x_{ij}) = \min\{V(S_1 \geq S_k)\}$$

Therefore, the index weight vector will be in the form of equation (5):

$$W' = \{W'(x_1), W'(x_2), \cdots, W'(x_n)\}$$

Which is the fuzzy hierarchical analysis process's vector of non-normalized coefficients.The non-normalized outcomes of equation (4) are normalized using equation (5).

$$W(X_k) = \frac{W'(x_k)}{\sum(W'(x_k))}$$

All above steps will be done for all the research judgment matrices so that the weights based on the obtained normalized vectors are also obtained for their normalized criteria and sub-criteria and the final priority is determined.

➢ *Fuzzy TOPSIS method*

This section provides a step-by-step explanation of Chen and Huang's fuzzy TOPSIS technique for a multi-criteria decision-making problem with m criteria and n options (Chen & Hwang,2000)

- Step1&2) creating the decision matrix is establishing the weighting matrix for the criteria.
- Step 3) The fuzzy decision matrix is de-scaled in Step3

In this method, linear scaling is used to convert rigorous criteria into a comparable scale in order to descale the values of the fuzzy decision matrix. Given that the Xijs are fuzzy in this instance, the rijs will also be fuzzy. The positive and negative criteria are derived, respectively, from the following relationships, if trigsuzzy numbers appear triangular in the rows of the decision matrix.

$$r_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \qquad a_j^- = MIN\ a_{ij}$$

$$r_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \qquad c_j^* = MAX\ C_{ij}$$

- Step 4) Choosing the weighted fuzzy decision matrix in step four:

To create the weighted fuzzy decision matrix based on the relative importance of the various criteria, the importance coefficients of each criterion in the unscaled fuzzy matrix are multiplied as shown below.

$$V_{ij} = r_{ij} \times w_{ij}$$

In this regard, Wj emphasizes the significance of the Cj criterion. The weighted fuzzy decision matrix will therefore look like this:.

$$V = \begin{bmatrix} v_{11} & \cdots & v_{1j} & \cdots & v_{1n} \\ \vdots & & \vdots & & \vdots \\ v_{i1} & \cdots & v_{ij} & \cdots & v_{in} \\ \vdots & & \vdots & & \vdots \\ v_{m1} & \cdots & v_{mj} & \cdots & v_{mn} \end{bmatrix}$$

For positive and negative criteria, we have if the fuzzy numbers are triangular.

$$v_{ij} = r_{ij} \times w_j = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \times (w_{j1}, w_{j2}, w_{j3}) = \left(\frac{a_{ij}}{c_j^*} \times w_{j1}, \frac{b_{ij}}{c_j^*} \times w_{j2}, \frac{c_{ij}}{c_j^*} \times w_{j3}\right)$$

$$v_{ij} = r_{ij} \times w_j = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \times (w_{j1}, w_{j2}, w_{j3}) = \left(\frac{a_j^-}{c_{ij}} \times w_{j1}, \frac{a_j^-}{b_{ij}} \times w_{j2}, \frac{a_j^-}{a_{ij}} \times w_{j3}\right)$$

- Step 5) Finding fuzzy ideal option and the fuzzy anti-ideal option

$$A^+ = (v_1^*, v_2^*, \cdots \cdots \cdots, v_n^*)$$
$$A^- = (v_1^-, v_2^-, \cdots \cdots \cdots, v_n^-)$$

Due to the fact that it offered the following constant values to calculate the values of the fuzzy ideal option and the fuzzy anti-ideal option:

So that the options that have a higher similarity index get a higher rank.

The main weakness of TOPSIS is not providing weights and also not checking judgmental consistency. Because of this,the AHP technique offers an effective procedure to ascertain the relative importance of various indicators to the goal. (Roa & Davim, 2 P., 2008). The hierarchica analysis is also us. Hierarchically the limited human capacity in information processing, it is considerably limited and the ceiling of comparisons is considered to be seven plus or minus two (Kandakoglu, Celik, & Akgun, 2009). As a result, the capacity limit is not included in the process (Shih, et.al., 2007). On the other hand, the TOPSIS approach assumes that certain variables are accurate and are treated as numerical data. It is certain that most of the eCertainly,and knowledge of the real world is not only not accurate, but also inaccurate. These inaccuracies and ambiguities, which come from various sources sucareas non-measurable.

Information, incomplete information, and also unobtainable information, is one of the disadvantages of the TOPSIS technique. Due to a lack of access to the precise requirements of decision-makers, the decision-makers in the traditional AHP technique accurately reflect human thought. So, when describing how fuzzy numbers are used, decision-makers are mentioned.

TOPSIS inputs and meeting the needs of the decision-makers approved decision-makers used model 1- Determining the efficient supply chain risk management indicators. the factors affecting the probands of works of literature are identified and placed in a hierarchical structure. In this research, after reviewing 30 literatures, a list of effective indikinds of the literature identified signs of the model.

The operational process cycle of the supply chain (OPC), which includes 5 value-added activities from purchase to service; organizational performance factors (OPF), which include the organization's strategic orientation; and each of these clusters have their own risk management components, all of which have an impact on the performance of supply chain risk management. These factors can be grouped into three categories. For example, the product life cycle has four stages, and the supply chain operational process cycle has five value-added activities. Figure (1) depicts the decision-making system used in risk management, with the improvement of supply chain risk management as its overall goal. Acceptance, transfer, attenuation, and avoidance are some of the risk reduction strategies that are available to us. There are also various combinations (double, triple, quadruple, and single combinations).

- *Product Life, Cycle*

It is learn how risk takes different forms at different points in the supply chain PLC. In other words, each PLC stage has specific risk characteristics. PLC is typically broken down into four stages and is one of the most significant elements of strategic supply chain risk management.

$$A^- = (0,0,0)$$
$$A^+ = (1,1,1)$$

- Step 6: Measuring the separation from the fuzzy ideal. An option that is not ideal:

The distance between each choice and the hazy ideal is measured in this step. And the anti-ideal is produced.:

$$S_i^* = \sum_{j=1}^{n} d(v_{ij}, v_j^*) \qquad i = 1,2,\cdots\cdots\cdots m$$

$$S_i^- = \sum_{j=1}^{n} d(v_{ij}, v_j^-) \qquad j = 1,2,\cdots\cdots\cdots,n$$

The product introduction stage begins with the product entering the market. When the product is in the introduction stage, the sales l evelsalesbe low until the customers know about the existence of this product and its benefits. At this stage, the primary goal is to find the market and create initial demand for the product, and a large amount number active are spent on advertising and promoting the product. Pricing policies are of particular importance and prices are generally considered high in or to the Company's profitability goals. Of course, in some cases, the prices are considered low for quickly acquiring the market. This stage includes demand analysis, standardization, and environmentally friendly attitudes in product design.

- 1-2-2 *Cycle Of Operational Processes of the Supply Chain*

When PLC is an important factor in supply chain risk management, OPC plays an important role. The OPC supports the strategic objectives of the various stages of the PLC. The cycle of operational processes in the supply chain usually includes purchasing, production, distribution, logistics and, service.

Prices are typically regarded as high in orto the, and pricing policies are of particular importance. financial objectives of the company. The prices are, of course, sometimes thought to be low in order to capture the market quickly.

Demand analysis, standardization, and considerations for the environment in product design are all part of this stage. The supply chain's operational processes follow a 1-2-2 cycle.

OPC plays a significant role when PLC is a key component of supply chain risk management.

The OPC assists. the PLC's various stages in achieving its strategic goals. Purchasing, production, distribution, logistics, and service are typically included in the supply chain's operational cycle

The choice to buy has an impact on both the ability to continue production and the caliber of the goods produced. There are numerous potential risk management components in manufacturing, such as process competence, machine stability, playability, and employee quality. Purchasing techniques have a significant impact on the performance of new products in many ways, including quality consistency and price competitiveness. These factors may have an impact on the supply chain's product quality and the accuracy of receipts.

Continuously improving the internal .production system used throughout the supply chain and appropriately outsourcing soma business sub-processes are two methods for reducing and transferring

The choice of distribution nodes and transportation options, on-time delivery, and product protection are just a few of the general risk components that are included in logistics and distribution. Designing policies relating to distribution and transportation methods in accordance with the life cycle characteristics and the characteristics of the regional market is necessary to avoid potential risks in these processes.

The system in procuremen entails a sizable investment and has a protracted return period. Distribution and procurement are two distinct operational areas where there is numerous operational models to accomplish objectives with various cost-benefit ratios, including self-support, cooperative support, and third-party procurement; All of them have various future risks.

The entire supply chain is impacted by quantity uncertainty. There are shortages of parts and raw materials because of inaccurate safety stock forecasting. Production is restricted by shortages, which causes bottlenecks and an accumulation of excess inventory.

Errors in the demand forecasting process could effectiveness buildup or lost opportunities. the excess of the finished product.

Supply chain operations may be impacted by quality in many different ways. Customer satisfaction is impacted by the effectivensess of the after–sales services system.The output of the production process as well as the consumer's taste will be diminished by the low quality of the components and parts used. (Graves and Tomlin, 2003) The last low-level causes of product obsolescence.

The supply chain is affected in numerous ways by cost as well. Variations in the cost of goods may make the new scale of revenue and profit worse. Production costs are always increased by long staff shifts and long lead times. According to Ray, Li, and Song (2005), making an irrational price decision causes a market share to decline and inventory to rise.

Time as a form of risk has many effects on the supply chain. On-time delivery seriously affects the fluctuations of the production cycle. Time is very important in planning a Product, even if the company f may lag behind the competition (Kleindorfer & Partovi, 1999).

- *Strategies For Facing the Risk*

The factors pertaining to the lowest level, i.e. Strategies for managing risk are also included in the fourth level. Given that acceptance is one of the four operational risks., transmission, weakening, and avoidance, as a res depending on the situation, a combination of them can be used, all of which are 25-1=15, in which all combinations of Four, triple, double, and single, are considered. Risk acceptance:

Risk transfer: insurance - guarantee - guarantee Avoiding risk: through changes to the project plan (reduction) Weakening risk: preventive programs. Active acceptance: proactively addressing risky events. Passive acceptance: withholding and accepting changes to the budget, timeline, and execution quality.

➢ *A Breakdown of the Calculations*

To start, we calculate each matrix's inconsistency rate. For the matrices whose inconsistency rate was higher than 0.1, D.M is applied was requested to complete that matrix once more. Then, we need to combine the expert opinions into a single matrix in order to determine the weights. The definite numbers entered by the experts in the questionnaire are first converted into the corresponding triangular fuzzy numbers, and then the counts of the fuzzy numbers for each of the items were individually geometrically averaged, creating a new matrix of triangular fuzzy numbers, which is used to combine the opinions of various experts into a single opinion. Following that, the weights of the criteria and sub-criteria were obtained using the fuzzy hierarchical analysis algorithm, yielding a total of 10 matrices (one for each).There are nine matrices for the pairwise comparisons of the sub-criteria to the criteria. The pairwise comparisons of the main criteria to the objective. The fuzzy TOPSIS method was used because there were 15 options at the top level and the pairwise comparison matrix and hierarchical analysis method were ineffective. As a result, the fuzzy TOPSIS method needed a decision matrix, which was made up of 7 matrices obtained from 7 experts.

Options for consolidation, matrix conversion, and fuzzy TOPSIS methods were ranked, and their weights were determined.

For the outcomes we obtain a single matrix, which is their weighting by computing the incompatibility rate for all the matrices, converting them all into triangular fuzzy numbers, and using the geometric mean of all the matrices. A fuzzy hierarchy technical analysis algorithm called we do is used for this. The pairwise comparison matrix of the criteria for the target is provided in table (1).

Table 1 The matrix of pairwise comparisons of the criteria to relative to the target

Goal	Introduction Stage			Introduction Stage			Maturity Stage			Descent Stage		
Introduction stage	1	1	2	78%	100%	25%	27%	1.19%	365	0.75	0.88	1.13
Growth stage	1.73	2.14	1	1	2	3.00	5.00	2.00	1.18	1.67	1.72	2.00
Maturity stage	.22	0.85	0.14	0.22	1	1	2	3	3	0.65	1.00	1.53
Descent stage	0.88	1.23	0.33	0.85	0.65	1.00	1.15	1.00	`1	1	1	2

For each row of the matrix of pairwise comparisons, the value of Sk, which is a triangular number, is calculated from equation (1). And finally we get ,th,e weights

Table 2 normale and unnormalized of matrix

Goal	Introduction	Growth	Maturity	Deacent
Unnormalized Weight	0.53	1	0.30	0.27
Normalized Weight	0.251	0.447	0.141	0.130

In the first line (product life cycle), each life stage was valued according to the goal (improvement of supply chain risk management competence); In this line, the growth stage has the highest weight;

Using the matrix of pairwise comparisons, we get the weight of the second level criteria, as diagram (2) shows, it is clear at each stage which operational process is more important.

After that, we obtain the weight of the final forms of risk in relation taboutprocesses. In the diagram (it is well known which form of risk is more preferab each stage of the operational process.

At the last level, where the options are located, the fuzzy TOPSIS method is used, in which we need the decision matrix and the final weight of the criteria of the last level. Table (3) shows the final weight of the criteria.

Table 3 The weight criteria

Option	Time	Cost	Value	Quality
weight	9	8	1	2

V. CONCLUSION

The decision-making model for risk management must account for the interaction and relationships between risk management factors and elements due to the dynamic nature of the supply chain risk system. Here, we introduced a strategic model for supply chain risk management, where the operational process's life cycle and supply chain were used as the foundation for the decision-making process. Additionally, we proposed that various configurations of operational risk performance result in performance.

Risk associated with the supply chain is unique. All modeling outcomes demonstrate that this model offers a clear understanding of supply chain risk management, which not only has a strategy but also has an operational Perspective and aids in fundamentally addressing crucial relationships in the supply chain risk system. We anticipate that this literature will provide managers with more knowledge about risk management.

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