PRIORITIZATION & DECISION MAKING IN A SUPPLY CHAIN

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Abstract: The globalization of supply chains has forced organizations to focus on integrating supply chain processes with organizational decision levels. This require effective supply chain management strategies, with a broader sustainability perspective, that involve the simultaneous acquisition and coordination of the partners and technology, with an overall objective of customer satisfaction, while ensuring the improved quality with reduced costs. Keeping in view the above objectives, the robust supplier selection, being situated at the upstream of the chain becomes extremely critical for the organizations' competitive advantage and growth. The supplier selection process demands the evaluation of different candidate suppliers against a number of tangible and intangible strategic criteria, making it a multi criteria decision making (MCDM) problem. As the effective supplier selection and evaluation strategies directly impact supply chain performance, resulting in organizational productivity and profitability, therefore, supplier characteristics' has to be assessed rigorously before order placement. The present paper demonstrates the multi–disciplinary, multi–person, multi–objective, multi–level, futurologist decision ranking methodology, Multi-criteria Futuristic Decision Making (MCFDM) Methodology, which provides a comprehensive framework for solving the basic multi–criteria futuristic problems of decision making. The methodology chooses the best one in a set of competing futuristic alternatives that are evaluated under conflicting criteria. The methodology has been applied to prioritize and rank the decision indicators affecting supplier selection/evaluation, thereby, providing the Optimal Futuristic Decision Priority Scenarios and Action Plan for the Goal.

Keywords: Multi-criteria decision making, Multi-criteria futuristic decision making, Supplier selection and evaluation, Supply chain management.

Introduction: Managing supply chain networks effectively in today's vigorous and dynamic marketplace is a necessity for survival and growth of an organization and to remain competitive. A supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. The term supply chain conjures up images of product or service moving from suppliers to manufacturers to distributors to retailers to customers along a chain. Supply chains exist in both service and manufacturing organizations, although the complexity of the chain varies greatly from industry to industry and firm to firm. The globalization of supply chains have forced organizations to focus on integrating supply chain processes with organizational decision levels. The present trends of supply chain management require the need for integration of technical, economical, environmental, quality and social factors that supports the future decision making strategy. The effective supply chain management must involve the simultaneous acquisition and coordination of the partners, technology with an overall objective of customer satisfaction, while ensuring the improved quality with reduced costs.

To achieve these objectives simultaneously, the robust supplier selection, being situated at the upstream of the chain becomes extremely critical for the organizations' competitive advantage and growth. The supplier selection is a strategic decision making process which plays a significant role in the management of the activities of the entire chain resulting in cost reduction, quality improvement and timely delivery of products/services. The selection process necessitates the evaluation of different alternative suppliers against a number of factors/criteria, which can be both quantitative and qualitative, making supplier selection problem a multi criteria decision making problem and thus require tools that assist management in solving such important problems. A number of methods have been used in supplier evaluation and selection studies such as Multi-criteria Decision Making (MCDM) techniques that include Multi Attribute Utility methods such as Analytic Hierarchy Process (AHP) [1]-[4], Analytic Network Process(ANP) [5]-[7]; and Mathematical Programming (MP) techniques such as Linear programming(LP) [8] [9], Multi-objective programming (MOP) [10] [11], Data Envelopment analysis (DEA) [12] [13] and their hybrids [14]-[17] among others. The present paper demonstrates the Multi-criteria Futuristic Decision Making (MCFDM) Methodology which provides a comprehensive framework for solving the basic multi–criteria futuristic problems of decision making. The methodology chooses the best one in a set of competing futuristic alternatives that are evaluated under conflicting criteria. The rest of the paper is organized as follows. The next section discusses the

framework and algorithm of the methodology. In the section 3, an illustration showing the applicability of the methodology to a supplier selection problem is presented followed by results and discussion in section 4. Finally, the conclusions are addressed in the last section.

Multi-criteria Futuristic Decision Making (MCFDM) Methodology: Multi-criteria Futuristic Decision Making (MCFDM) Methodology is a multi–disciplinary, multi–person, multi–objective, multi–level, futurologist decision ranking methodology based on opinions of Multi Disciplinary Functional (MDF) Teams to simulate multi criteria futuristic decision problems. *Based on mathematics and human psychology,* the Methodology helps capture both subjective and objective futuristic evaluation measures, providing a useful mechanism for checking the consistency of the futuristic evaluation measures and alternatives suggested by the Multi Disciplinary Functional (MDF) Teams thus reducing bias in futuristic decision making. The Methodology also allows decision makers to model a complex futuristic decision problem in a hierarchical structure showing the relationships of the goal, objectives, criteria, sub–criteria, and alternatives.

It allows for the application of futuristic data, experience, insight, and intuition in a logical and thorough way. The Methodology not only supports futuristic decision–makers by enabling them to structure complexity and exercise judgment, but allows them to incorporate both objective and subjective considerations in the decision process.

The salient features of MCFDM Methodology are that it implicates multi–criteria approach for futurologist decision problems and consolidates information about tangible and intangible criteria and alternatives in decision making process. The Methodology also quantifies futuristic decision makers' subjective judgment by assigning corresponding numerical values based on the relative importance of indicators under consideration and the conclusion is reached by synthesizing futuristic judgments to determine the overall priorities of indicators. Therefore, the MCFDM Methodology enables one to cope with the intuitive, rational and the irrational, all at the same time, to make multi–criteria and multi–actor futuristic decisions. The feedback required for generating scenarios and action plans for multi–criteria futuristic decisions is based on the outputs of Multi Disciplinary Functional (MDF) Teams.

2.1 The Algorithm

Step 1: Goal and Problem Formulation by Decision Making Team (DM).

Step2: Selection of Interdisciplinary Futuristic (IF) Team and Expert (EP) Team from different related fields and areas by DM.

Step 3:Generation of Current Decisions Plan (CDP) by EP Team to meet the Goal.

Step 4: Cluster formation of CDP by DM into a responsible set of mutually exclusive and encompassing 'i' Multi Futuristic Decision Indicators (MFDI).

Step 5:Preparation of brief write–up about the Goal and Modified Delphi Technique for IF Team by DM.

Step 6: Design and development of Modified Delphi Questionnaire (MDPQ) for IF Team by DM.

Step 7:Rating and ranking of 'i' MFDI for different levels (L=1,2, ... ,l) by IF Team to derive Futuristic Feedback (FFB) Weights f_i^n (n = Modified Delphi rounds).

Step 8: Analysis of f_i^1 by DM for Modified Delphi II round.

Step 9: Rating and Ranking of MFDI by IF Team.

Step 10: Analysis of Modified Delphi n^{th} round weights f_i^n by DM. If the degree of stability is there, then go to Step 11, otherwise go to Step 9.

Step 11: Calculation of Futuristic Satisfaction (FSF) Weights s_i by DM.

Step 12: Arrangement of s_i in priorities to get Futuristic Priority (FP) Weights $p_{\hat{i}}$ for prioritized MFDI $\hat{i}$.

Step 13: Calculation of Futuristic Relative Comparison (FRC) Weights $w'_{\hat{i}j}$

$$w'_{\hat{i}j} = \begin{cases} 0 & if\ \hat{i} > j \\ \dfrac{p_j \times 100}{p_{\hat{i}}} & if\ \hat{i} \le j \end{cases} \quad \text{(i)}$$

Step 14: Formation of Relative Calibration (RC) Matrix, consisting of $[n_L(n_L\text{-}1)]/2$ futuristic judgments, by calibrating $w'_{\hat{i}j}$ from Futuristic Calibrating Chart.

Step 15: Preparation of Pairwise Comparison Questionnaire (PCQ) from $\hat{i}$ for EP Team by DM.

Step 16: Generation of Futuristic Pairwise Judgment (FPJ) Matrix, consisting of $[n_L(n_L\text{-}1)]/2$ futuristic judgments from PCQ using Futuristic Relative Importance Scale by EP Team.

Step 17: Generation of Average Futuristic Relative Judgment (AFRJ) Matrix for different L.

Step 18: Computation of Futuristic Eigen vectors (FEv), Futuristic Eigen Values (FEV), Futuristic Consistency Index (FCI) and Futuristic Consistency Ratio (FCR) by Eigen Vector

Method for all generated F.

Step 19: Computation of overall Futuristic Decision Priority (FDP) Weights $W_{\hat{i}}^{f_L}$ for all L of the problem and selection of the Optimal Futuristic Decision Priority Scenarios and Action Plan for the Goal.

3. Supplier Selection Problem: Supplier selection and evaluation is a strategic problem with the emerging trend to select suppliers where a long term relationship is desired and supplier involvement in product development is essential [18]. Supplier selection is a multi-criteria decision making problem requiring effective strategies for the selection of suitable criteria as the input of decision making model, which has a direct impact on the model efficiency.

3.1 Application of the MCFDM methodology for the Supplier selection problem

On the basis of literature review, expert (EP) team opinions; the Current Decisions Plan (CDP) to meet the Goal is generated and clustered into a responsible set of mutually exclusive and encompassing 'i' Multi Futuristic Decision Indicators (MFDI) by the Decision making team (DM). The MFDI identified for the supplier selection problem are decomposed in the form of a hierarchical tree (see Fig. 1).

A group of IF team comprising of representatives from purchasing and marketing departments were requested to rate and rank the MFDI at each level. After three Delphi rounds, Futuristic Satisfaction (FSF) Weights s_i were calculated. The Futuristic Satisfaction (FSF) Weights (s_i) were then arranged in priorities to have Futuristic Priority (FP) Weights $p_{\hat{i}}$ for prioritized MFDI $\hat{i}$. Futuristic Relative Comparison (FRC) Weights w'_{ij} were calculated using equation (i) and after calibration, the Relative Calibration (RC) Matrices were constructed.

The Futuristic Pairwise Judgment (FPJ) Matrices consisting of judgments, from Pairwise Comparison Questionnaire (PCQ) using Futuristic Relative Importance Scale by EP Team, were generated.

The Average Futuristic Relative Judgment (AFRJ) Matrices from RC and FPJ matrices were generated and Futuristic Eigen vectors (FEv) were calculated for different levels of the hierarchy (see Tables I-VII).

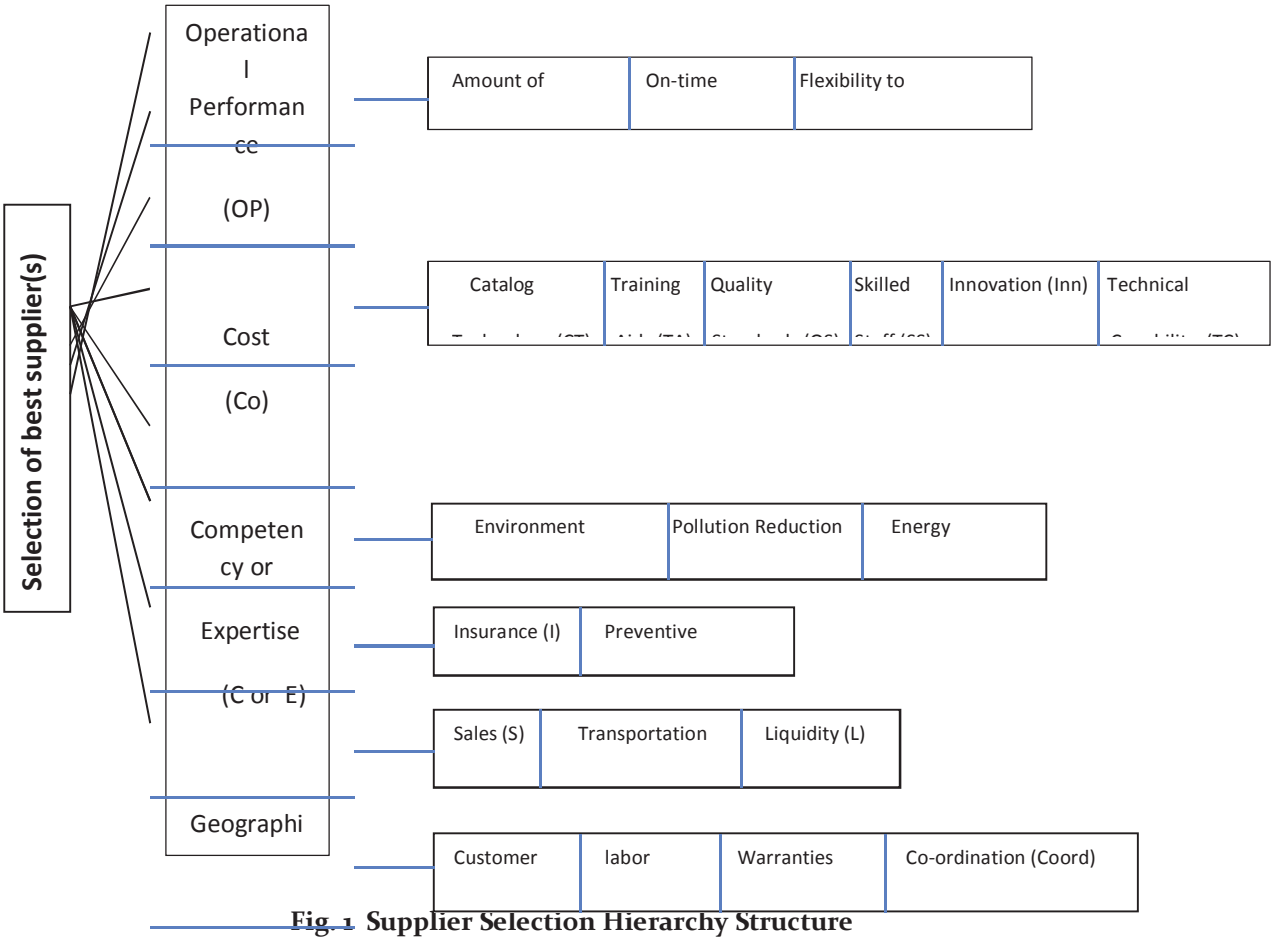

Fig. 1 Supplier Selection Hierarchy Structure

Table I: Average Futuristic Relative Judgment Matrix for MFDI at level 1

	OP	FH	C	Co	C or E	C&R	RF	GL	FEv
OP	x	3	3	4	4	5	6	6	**0.332**
FH		x	3	4	4	4	5	5	**0.235**
C			x	2	3	4	4	4	**0.143**
Co				x	2	3	4`	4	**0.103**
C or E					x	2	3	3	**0.072**
C&R						x	2	2	**0.049**
RF							x	1	**0.033**
GL								x	**0.033**

	S	TI	L	FEv
S	x	3	3	**0.594**
TI		x	2	**0.249**
L			x	**0.157**

Table II: Average Futuristic Relative Judgment Matrix for MFDI(FH) at level 2

	EFP	PRC	EC	FEv
EFP	x	4	3	**0.630**
PRC		x	2	**0.218**
EC			x	**0.152**

Table III: Average Futuristic Relative Judgment Matrix for MFDI(C) at level 2

	PM	I	FEv
PM	x	3	**0.75**
I		x	**0.25**

Table IV: Average Futuristic Relative Judgment Matrix for MFDI(RF) at level 2

	APB	OTD	FVC	FEv
APB	x	2	3	**0.527**
OTD		x	3	**0.333**
FVC			x	**0.140**

Table V: Average Futuristic Relative Judgment Matrix for MFDI(OP) at level 2

	CS	LR	W&C	Coord	FEv
CS	X	4	5	6	**0.598**
LR		x	3	2	**0.207**
W&C			x	2	**0.112**
Coord				x	**0.083**

Table VI: Average Futuristic Relative Judgment Matrix for MFDI(C&R) at level 2

	QS	TC	SS	Inn	TA	CT	FEv
QS	x	2	4	4	6	6	**0.401**
TC		x	2	3	5	5	**0.248**
SS			x	2	3	4	**0.148**
Inn				x	3	4	**0.111**
TA					x	1	**0.048**
CT						x	**0.044**

Table VII: Average Futuristic Relative Judgment Matrix for MFDI(C OR E) at level 2

Finally, overall Futuristic Decision Priority (FDP) Weights $W_i^{f_L}$ for all levels of the problem were calculated using Eigenvector method (see Table VIII).

Table VIII: Overall Futuristic Decision Priority (FDP) Weights for MFDI at Level 1 & 2			
MFDI (level 1)	$(W_i^{f_1})$	**MFDI (level 2)**	$(W_i^{f_2})$
Culture & Relationship	**0.049**	Customer Service	**0.0293**
		Labor Relations	**0.0101**
		Warranties & Claims	**0.0055**
		Co-ordination	**0.0041**
Financial Health	**0.235**	Sales	**0.1396**
		Transportation Infrastructure	**0.0585**
		Liquidity	**0.0369**
Risk Factors	**0.033**	Insurance	**0.0083**
		Preventive Maintenance	**0.0248**
Clean	**0.143**	Environment Friendly Products	**0.0901**
		Pollution Reduction Capability	**0.0312**
		Energy Consumption	**0.0217**
Geographical Location	**0.033**		
Competency or Expertise	**0.072**	Catalog Technology	**0.0032**
		Training Aids	**0.0035**
		Quality Standards	**0.0289**
		Skilled Staff	**0.0107**
		Innovation	**0.0080**
		Technical Capability	**0.0179**
Cost	**0.103**		
Operational Performance	**0.332**	Amount of Past Business	**0.1750**
		On-time Delivery	**0.1106**
		Flexibility to Volume Changes	**0.0465**

Results and Discussion: The MCFDM methodology is used to evaluate the decision process, as the identified criteria are both qualitative as well as quantitative. Based on expert (EP) and Interdisciplinary (IP) team subjective judgments, regarding the importance of MFDI for supplier selection, Operational performance and Financial Health are most favored and of utmost importance among other MFDI at level 1. As regards the relative importance of MFDI at level 2, Amount of past business, sales, on-time delivery and environment friendly products appeared to be the most significant ones. Keeping in mind the Futuristic Decision Priority Scenario (as shown in Table VIII), the DM may frame an optimal Action Plan for the selection and evaluation of suppliers. The plan suggests that DM must integrate the characteristics of the supplier like past experience, sales potential, delivery pattern and use of recyclable/bio-degradable products in the selection and evaluation process.

Conclusion: The present study is an application of the useful decision support tool for solving ranking and choice problems – the MCFDM Methodology, in analyzing the relative importance of MFDI at different levels in a hierarchy for supplier selection and evaluation. The MCFDM methodology facilitates the decision making process by prioritizing the MFDI from most important to least important one, by pulling together the decisions of Interdisciplinary team and experts' judgments, using the principle of hierarchic composition. This helps the DM in assessing suppliers' capabilities for designing Futuristic Decision Priority Scenarios and framing Action Plan for the Goal. The study has been presented without considering the alternatives i.e. the candidate suppliers and hence, the results may be applied to supplier selection process in any domain.

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