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CAN FUZZY MULTI-CRITERIA DECISION MAKING IMPROVE STRATEGIC PLANNING BY BALANCED SCORECARD?

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Abstract

Strategic management is momentous for organizational success and competitive advantage in an increasingly turbulent business environment. Balanced scorecard (BSC) is a framework for evaluating strategic management performance which translates strategy into action via various sets of performance measurement indicators. The main objective of this research is to develop a new fuzzy group Multi-Criteria Decision Making (MCDM) model for strategic plans selection process in the BSC. For this to happen, the current study has implemented linguistic extension of MCDM model for robust selection of strategic plans. The new linguistic reasoning for group decision making is able to aggregate subjective evaluation of the decision makers and hence create an opportunity to perform more robust strategic plans, despite of the vagueness and uncertainty of strategic plans selection process. A numerical example demonstrates possibilities for the improvement of BSC through applying the proposed model.

Keywords: Strategic Management, Balanced Scorecard (BSC), Performance Management, Fuzzy Logic, Fuzzy Multi Criteria Decision Making

1 INTRODUCTION

The BSC is a conceptual framework and its function is to translate strategic objectives of a company into a set of operational attributes. These indices are usually selected from four perspectives including financial, customer, internal processes and learning and development perspectives (Kaplan and Norton 1992 ; Najmi et al. 2001). Many attributes are used for the advancement of a company in the direction of its perspective. Some other attributes are used for the evaluation of comp any development in accessing long-term objectives. Moreover, the BSC helps the managers to identify the lagging and leading attributes in their companies.

Furthermore, the BSC has rapidly got to be prevailing in another aspect of management research, such as organization studies, operations management and information systems. The causes for this quick increase to prevalence are clear; there is the request of simpleness. No longer do managers have to work their way through heaps of statistics, but they can keep track of a few key indicators instead (Lee et al. 2008; Leung et al. 2005).

Since the BSC model has some drawbacks, like their inability to prioritise strategic plans, some other models have been suggested including MCDM. In crisp MCDM model, usually utility of alternatives is assumed a real number, however; in the real world value of strategic plans is expressed linguistically and associated with vagueness. Regarding the vagueness and uncertainty of strategic plans selection process, it requires the linguistic extension of MCDM methods for robust decision making. As a result of ambiguous attributes linked to assessment in BSC, most measures are described subjectively using linguistic terms, and cannot be effectively described using conventional assessment approaches. The usage of fuzzy linguistic variables to conduct evaluation will enhance the efficiency of decision making by reducing error in utility values in strategic plans selection. The main objective of this research is to develop a fuzzy MCDM model for linguistic reasoning under new fuzzy group decision making for strategic plans selection process in BSC. Since the modelling of fuzzy linguistic extension of MCDM for group strategic plans selection problem is in essence non-existent, this study has aimed to fulfil the following contributions:

1. determining the explicit criteria and sub-criteria in BSC regarding the strategic plans selection problem;
2. employing fuzzy linguistic extension of group MCDM for the strategic plans selection problem under uncertainty. The new linguistic reasoning for group decision making is able to aggregate subjective evaluation of the decision makers and hence create an opportunity to perform more robust strategic planning procedures.

This paper proceeds as follows. In Section 2, the literature of BSC and MCDM is reviewed. The proposed model and numerical example are discussed in Sections 3 and 4, respectively. Finally, Section 5 provides discussion, conclusion and future work.

2 LITERATURE REVIEW

BSC is a new tool for designing operative strategies (translate strategy into action), The BSC model offers a way for a corporation to gain a wider perspective on its strategic decisions by considering the impact on finances, customers, internal processes and employee learning. The analysis takes into account financial and no financial measures, short-and long-term goals, external goals, internal improvements, past outcomes and ongoing requirements as indications of future performance (Goodspeed 2003; Kaplan and Norton 1992 ; Lee and Seo 2016). The four perspectives are described concisely as follows:

- Financial: This aspect usually contains the traditional financial performance measures, which are typically related to profitability. The measurement criteria are usually profit, cash flow, ROI, economic value added (EVA) and return on invested capital (ROIC).
- Customer: Customers are the source of business profits; therefore, customer satisfaction needs is the objective continued by companies. In this aspect management identifies the expected target customers and market segments for operational units and monitors the performance of operational

units in these target segments. Some illustrations of the core or genetic measures are customer satisfaction, customer retention, new customer acquisition, market position and market share in targeted segments.

- Internal business process: The aim of this perspective is to fulfill shareholders and customers via excelling at some business processes that have the greatest impact. In determining the objectives and measures, the first step should be corporate value-chain analysis. A traditional operating process ought to be tuned to recognize the financial and customer perspective objectives. A comprehensive internal business-process value chain that can meet current and future needs then would be constructed. A common enterprise internal value chain consists of three main business processes: operation, after-sale services and innovation.
- Learning and growth: The initial objective of this aspect is to make the infrastructure for obtaining the objectives of the other three perspectives and for developing long-term growth and improvement through people, systems and organizational procedures. This perspective emphasizes employee performance measurement, like employee satisfaction, continuity, training and skills, since employee growth is an intangible asset to enterprises that will contribute to business growth. In the other three aspects, there is often a gap between the actual and target human, system and procedure capabilities. Through learning and growth, enterprises can reduce this gap. The criteria include turnover rate of workers, expenses on training, expenditures on new technologies and lead time for introducing innovation to a market (Lee et al. 2008; Lee and Seo 2016).

2.1 Multi criteria decision making (MCDM)

MCDM provides an effective framework for comparison based on the evaluation of multiple conflicting criteria. It has been one of the fastest growing areas of operational research. MCDM was described as the most well known branch of decision making (Triantaphyllou 2000). The decision makers' viewpoints and tastes always involve and involved in decision making. Psychologist George Miller found that the number of information that a human being is able to deal with simultaneously is seven plus or minus two (Doyle and Green 1994; Saaty 2004). It is one of the most widely used decision methodologies in the sciences, business, and government and engineering worlds. MCDM methods can help to improve the quality of decisions by making the decision-making process more explicit, rational, and efficient. Some applications of MCDM in engineering include the use on flexible manufacturing systems (Wabalickis 1988), layout design (Cambron and Evans 1991), integrated manufacturing systems (Putrus 1990), and the evaluation of technology investment decisions (Boucher and MacStravic 1991).

2.2 Fuzzy logic

Fuzzy logic involves fuzzy sets and logical links for designing the human-like reasoning issues of the real world. A fuzzy set, in contrast to conventional sets, covers all components of the universal set of the domain but with different membership values in the interval [0, 1]. It should be considered that a conventional set includes its members with a value of membership equal to one and ignores other components of the universal set, for they have zero membership. The most general operators used to fuzzy sets are AND (minimum), OR (maximum) and negation (complementation), while AND and OR have binary arguments, negation has unary argument. The logic of fuzzy sets was suggested by Zadeh, who presented the concept in systems theory for the first time, and subsequently widened it for approximate reasoning in expert systems (Wah and Li 2002). Among the pioneering contributors on fuzzy logic, the work of Tanaka in stability analysis of control systems (2002), Mamdani in cement kiln control (1977), Kosko (1998) and Pedrycz (1995) in fuzzy neural nets, Bezdek in pattern classification (1981) and Zimmerman (1996) and Yager (1983) in fuzzy tools and techniques requires particular acknowledgement (Konar 2000).
Table 1 summarizes the recent reviewed research papers in the area of the BSC and FMCDM.

Research title	Purpose
Performance Measurement of Project Management By Using FANP Balanced Scorecard (Hermawan et al. 2016)	This study used Fuzzy Analytical Network Processing (FANP) to measure qualitative and quantitave by comparing weighting priority between many KPI's in BSC.
A Hybrid Multi-Criteria Decision-Making Model for a Cloud Service Selection Problem Using BSC, Fuzzy Delphi Method (FDM) and Fuzzy fuzzy analytical hierarchy process AHP (FAHP) (Lee and Seo 2016)	This study proposed a hybrid multi-criteria decision-making model for a cloud service selection problem using BSC, FDM and FAHP.
Strategic business unit ranking based on innovation performance: a case study of a steel manufacturing company (Noori 2015)	In this study, a fuzzy AHP method was used to select the most innovative SBU.
A hybrid fuzzy MCDM method for measuring the performance of publicly held pharmaceutical companies (Tavana et al. 2014)	This study proposed a hybrid fuzzy multi-criteria decision making method for measuring the performance of publicly held companies in the Pharmaceutical industry.
A fuzzy-QFD approach to balanced scorecard using an analytic network process (Tavana et al. 2013)	This research used the quality function deployment technique to create a linkage between the BSC perspectives applying fuzzy AHP.
Multidimensional assessment of organizational performance: Integrating BSC and AHP (Bentes et al. 2011)	This study integrated two tools, BSC and AHP, to provide a better assessment of the (relative) performance of three organizational units within a Brazilian telecommunications company.
A FAHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan (Lee et al. 2008)	This study proposed an approach based on the FAHP and BSC for evaluating the performance of IT department in the manufacturing industry in Taiwan.
Applying fuzzy BSC for evaluating the CRM performance	This research aimed to provide a framework for evaluating the impact of implementing CRM based on the BSC using fuzzy TOPSIS and SAW.
The Assessment of Military Project Alternatives between Dry Dock and Slipway in Taiwan's Navy (Hai and Wei 2011)	This study proposed a new "Vote-Ranking" method to BSC analytic process to assess MCDM combined with DEA, BSC and AHP.
The comprehensive evaluation of railway freight enterprises' performance based on the BSC and AHP (Guo and Yu 2011)	This research proposed a methodology for railway freight business' performance assessment based on BSC using AHP and TOPSIS.
Using Topsis Method with Goal Programming (GP) for Best selection of Strategic Plans in BSC Model (Dodangeh et al. 2010)	This study proposed a methodology for selecting of strategic plans in BSC using TOPSIS and GP.
Using Multi-Attribute Decision Making For Designing Revised Balanced Scorecard In National Iranian Oil Products Distribution Company (Arya Nezhad et al. 2011)	This study proposed an approach for evaluating oil company using AHP and SAW.
Multi-criteria quality assessment of products by integrated DEA-PCA approach (Azadeh et al. 2007)	The objective of this study was to analyse and assess multi- criteria quality of products by an integrated multivariate approach. The

	integrated multivariate method was based on DEA, principle component analysis (PCA) and numerical taxonomy (NT).
Ranking of Strategic Plans in Balanced Scorecard by Using Electre Method (Dodangeh et al. 2010a)	This research proposed a method for selection of strategic plans in BSC using Electre which is one of the MCDM model.
A fuzzy multi-objective balanced scorecard approach for selecting an optimal electronic business process management best practice (e-BPMBP) (Zandi and Tavana 2011)	The article proposed a novel fuzzy group multi-objective method for e-BPMBP evaluation and selection.
Priority of strategic plans in BSC model by using Borda method (Dodangeh et al. 2008)	This study proposed a method for selecting strategic plans in BSC using Borda.
R&D project evaluation: An integrated DEA and balanced scorecard approach (Eilat et al. 2008)	This research proposed a methodology for R&D project evaluation based on BSC using DEA.

Table1. A summary of studies in the area of BSC and MCDM

Some mathematical programming approaches based on AHP have been used for BSC in the past (Al-Hedaithy 2000; Bentes et al. 2011; Guo and Yu 2011; Huang ; Ishizaka et al. 2010; Lee et al. 2008; Talaei-Khoei et al. 2011; Talaei-Khoei et al. 2012; Umayal Karpagam and Suganthi 2013; Yuan and Chiu). However, AHP has two main weaknesses. First subjectivity of AHP is a weakness. Second AHP could not include interrelationship within the criteria in the model. Because of the complexity of the decision-making process involved in BSC, several aforementioned literatures relied on some form of procedures that assigns weights to various performance measures. The primary problem associated with arbitrary weights is that they are subjective, and it is often a difficult task for the decision maker to accurately assign numbers to preferences. Dodangeh et al. (2010) presented an integrated GP with TOPSIS for selecting strategic plans in BSC. However, one of the GP problems arises from a specific technical requirement. After the decision maker specify the goals for each selected criterion, they must decide on a preemptive priority order of these goals, i.e., determining in which order the goals will be attained. Frequently such a priori input might not produce an acceptable solution and the priority structure may be altered to resolve the problem once more. In this fashion, it may be possible to generate a solution iteratively that finally satisfies the decision maker. Therefore, it would be costly and inefficient. Most researches on developing BSC have been done by certain and crisp data; however, in the real world managers make a decision by imprecise and uncertain data and information due to the complexity (Lee et al. 2008). The key point is that usually the managers use their own personal experience and imprecise data for modeling of BSC. In this essense, the artificial inteligence (AI) models such as fuzzy logic have been gone through lots of advancement for facing the uncertainties and complexity. Indeed, it could be a suitable tool toward modeling of Balanced Scorecard.

3 PROPOSED MODEL

3.1 Fuzzy Multi Criteria Decision Making (FMCDM)

Decision making is a most important scientific, social, and economic endeavor. To be able to make consistent and correct choices which is the essence of any decision process imbued with uncertainty, Fuzzy logic provides a useful way to approach a MCDM problem (Ross 2004). MCDM is one of the well-known topics of decision making. Very often in MCDM problems, data are imprecise and fuzzy. In a real-world decision situation, the application of the classic MCDM method may face serious practical constraints, due to the criteria containing imprecision or vagueness inherent in the information. For these cases, FMCDM method have been developed (Kahraman 2008). Applications of FMCDM are used in engineering and management in several studies (Bi and Wei 2008; Cheng et al. 2009; Grabisch

1996; Jassbi et al. 2009; Kahraman 2008; Liginlal and Ow 2006; Ross 2004; Sugeno 1985; Zimmermann 1996). In general, FMCDM matrix is illustrated in table 2.

Criteria ⇨ ⇩ Alternatives	C1={fuzzy set}	C2={fuzzy set}	C3={fuzzy set}	Cm={fuzzy set}
A1	A11={fuzzy set}	A12={fuzzy set}	A13={fuzzy set}	A1m={fuzzy set}
A2	A21={fuzzy set}	A21={fuzzy set}	A23={fuzzy set}	A2m={fuzzy set}
…	…	…	…	…
An	An1={fuzzy set}	An2={fuzzy set}	An3={fuzzy set}	Anm={fuzzy set}

Table2. Fuzzy MCDM Matrix

MCDM problem has some objective that should be recognized by decision makers. All MCDM methods require information that should be gained based on relative importance of the objective. Objective weights can be allocated directly to objective by a decision maker group or by scientific methods. These weights specify relative importance of every objective.

Usually groups are classified based on their different levels in social status, knowledge and work experience. So every factor in special subject that causes increase or decrease of an idea's weight should be considered. In this regard allocating different weights to opinions regarding their knowledge and experience in relation to that subject seems necessary. Our study uses hierarchical objectives for identifying of strategic plans weights as can be seen in figure 1.

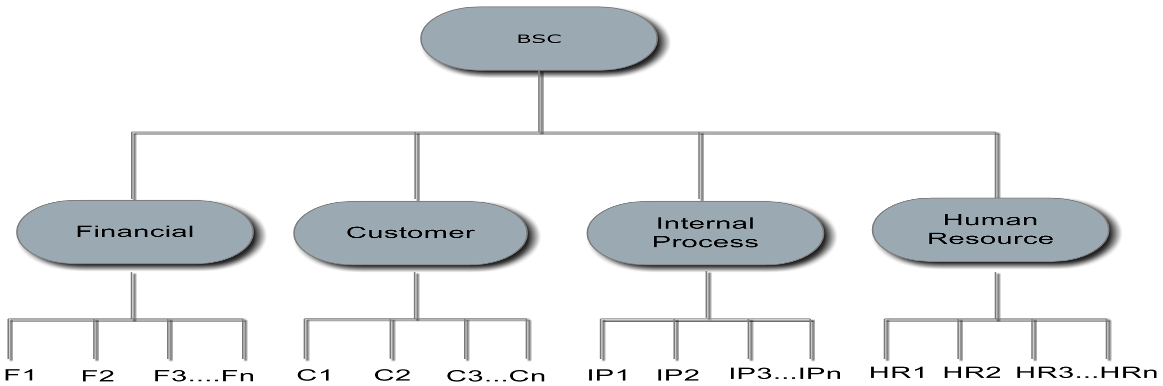

Figure 1. Hierarchical Objectives

For this process, the study has to determine the weights of perspectives and sub perspectives using expert opinions. The final weights of sub-perspectives (financial, customer, internal processes and learning and growth) are determined using the geometric average method. The method for calculation is shown as follows.

$$TW_{Cij} = \sqrt{W_{Ci}.W_{Cij}} \qquad (1)$$

TW_{Cij} : Final weights of objective

W_{Ci} : Weights of perspective

W_{Cij} : Weights of objective

TW_{Cij} : Final weights of objective are equal the strategic plan weights (Dodangeh 2006b).

3.2 Algorithm of strategic plans selection in BSC

In this section, model inputs, processes and output which selection of strategic plans are systematically outlined. In the subsequent flowchart (Figure 2), the components of accomplished algorithm have been depicted. On the basis of algorithm of modelling process for selecting strategic plans in BSC, different phases are explained as follows.

3.2.1 Phase 1. Forming BSC Model

Based on data and information experts panel are formed the BSC model including objectives, measures, targets and strategic plans (initiatives) in the four perspectives comprising financial, customer, internal business process and learning and growth. Members of the experts' panel who have been significant information about strategic direction of a company are chosen. There are several methods such as Delphi or Nominal Group Technique (NGT) which can be used to identify the strategic plans based on experts opinions.

3.2.2 Phase 2. Calculating the importance weight of strategic plans

In terms of experts' opinions, the importance weights of four perspectives are calculated. Then the importance weights of strategic plans are computed based on equation 1.

3.2.3 Phase 3. Establishing criteria and forming decision making matrix

Expert panel by NGT method determine the strategic plans. They have consensus for establishing criteria and forming decision making matrix with regards to table 2. The four criteria are defined by expert panel and based on their knowledge and experience as follows.
1- Importance criterion: importance criterion is the degree of the weight or importance of each strategic plan for the organization and this importance (weight) is defined by expert opinions and their knowledge and experience.
2- Gap criterion: the concept of gap is distance between the present situation and desirable situation. In this sense, the bigger gap between the present and the desirable situation in an organization, the higher importance and priority for the organization to execute the strategic plans. Indeed, gap is the distance between measure and target in BSC model.
3- Cost criterion: generally, organizations have limitations in budgetary and financial resources; consequently, we are looking for cost of strategic plans and whether the organization can perform them with regards to these limitations.
4- Time criterion: the execution time of each strategic plan is different and the quicker execution time of a strategic plan leads to faster achievement of the organizational objectives.

3.2.4 Phase 4. Modelling of FMCDM

Modelling procedures of FMCDM are described as follows.
4.1: The first step to construct a FMCDM is defining universe set which is the element of universe U= {1 2 3 4 5 6 7}
4.2: Then select a membership function for each criteria and alternatives (table 2). A "membership function" is a curve that defines how the value of fuzzy variable is mapped to a degree of membership between 0-1. Membership functions are used to calculate the degree of FMCDM in different values expressed by linguistic term. The verbal values defined as shown in table 2.

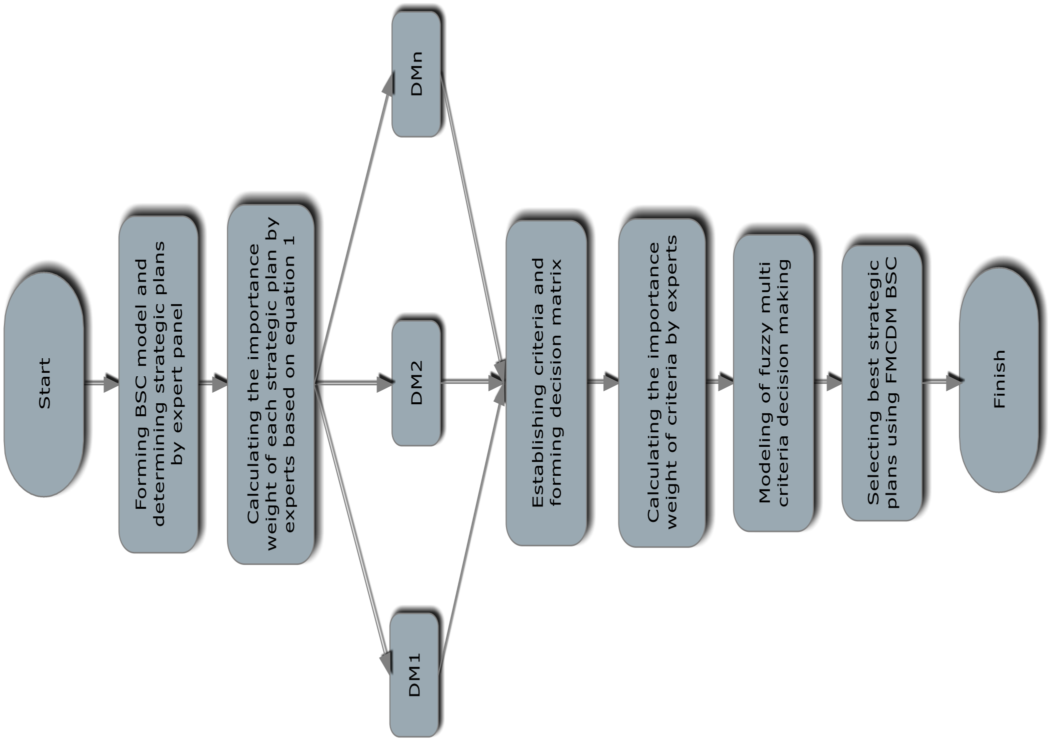

Figure 2. Modelling Process

Verbal Values	Definition	Degree
EL	Extremely Low	1
VL	Very Low	2
L	Low	3
M	Medium	4
H	High	5
VH	Very High	6
EH	Extremely High	7

Table3. Definition of verbal values

4.3: Considering bell shape membership function, the decision matrix (fuzzy sets of criteria and alternatives) is formed regarding table 1(Fuzzy MCDM matrix) and equation 4.1.

$$\mu_A(x) = \frac{1}{1+ d \ (x-c)^2} \quad 4.1$$

Where XЄ [0, 1] is the element of universe U= {1 2 3 4 5 6 7 8 9}, c indicates the standard score for determining verbal (linguistic) value of the criteria and strategic plans in BSC and d determines the shape of the membership function (here d = 0.2).

In the meanwhile, we determine fuzzy degree of gap from intersection of measure and target in BSC model, using equation 4.2.

$$\mu_{A \cap B}(x)=\min(\mu_{A(x)}, \mu_{B(x)}) \qquad x \in U \qquad 4.2$$

4.4: By applying subsequent formula, the utility of decisions (strategic plans) is calculated using equation 4.3.

$$Ai = \{(\overline{C1} \cup ai1) \cap (\overline{C2} \cup ai2) \cap ....(\overline{Cm} \cup aim)\} \qquad 4.3$$

$$Ai = \bigcap_{i=1}^{n} (\overline{Cj} \cup aim)$$

3.2.5 Phase 5. Selecting best strategic plans

By employing centre of gravity method, fuzzy outputs of strategic plans are transformed to crisp utility with regards to equation 5.1 (Dodangeh 2006a; Dodangeh et al. 2008; Dodangeh et al. 2010; Dodangeh et al. 2010b).

$$Z^* = \frac{\sum_{j=1}^{n} \mu_A(x_j).x_j}{\sum_{j=1}^{n} \mu_A(x_j)} \qquad 5.1$$

Ultimately, with regards to last step which determined crisp utility of strategic plans, the strategic plans in BSC are ranked.

4 NUMERICAL EXAMPLE

The four perspectives of BSC were considered as the framework for formulating strategic plans in this study. The NGT is a method for making decision for applying among different group sizes, in order to facilitate making decision, as by a vote, but everyone's opinions are considered and taken into account. The BSC framework was genereted hypothetically to demonstrate the proposed method and come up with strategic plans (initiative) for all perspectives including financial, internal processes, customer and learning and growth as illustrated in table 4. Then we completed the FMCDM matrix based on four criteria including importance, gap, cost and time as shown in table 5.

Financial			
Objectives	**Measures**	**Target**	**Initiatives**
Increasing income	0.797	0.817	I1-Marketing Research
Increasing Profit	0.133	0.153	I2- Marketing
Maximizing Investment Utilization	0.004	0.004	I3- Inventory Control
Cost reduction	0.066	0.026	I4- ABC
Customer			
Increasing customer satisfaction	0.27	0.236	I5-After sales Services
Increasing Market share	0.027	0.024	I6- Marketing Research
Supporting Customers	0.541	0.505	I7-CRM
Increasing added value for customers	0.162	0.236	I8-Value Engineering

Internal Processes			
Objectives	**Measures**	**Target**	**Initiatives**
On time delivery	0.07	0.06	I9- Time & Motion Study
Product development	0.873	0.886	I10- QFD
Products Quality	0.004	0.001	I11- ISO 9000
Continues Improvement	0.052	0.054	I12- TQM
Learning & Growth			
Increasing employees satisfaction	0.209	0.244	I13- Increasing personnel salary
Increasing employees productivity	0.049	0.031	I14- personnel evaluation system
Personnel's Motivation	0.697	0.698	I15- Reward System
Increasing informational skills	0.045	0.028	I16- MIS

Table4. Balanced Scorecard model for electronic and computer research center

Based on Phase 3 experts have consensus for establishing criteria and forming decision making matrix by NGT method as shown in table 2. The fuzzy multi criteria decision making is illustrated in table 5.

Criteria → Strategic plans ↓	Importance	Gap Min{M,T}	Cost	Time
I1	EH	Min{M,T}	VH	H
I2	VH	Min{M,T}	H	M
I3	H	Min{M,T}	L	L
I4	VH	Min{M,T}	M	M
I5	H	Min{M,T}	L	M
I6	EH	Min{M,T}	VH	H
I7	H	Min{M,T}	M	L
I8	M	Min{M,T}	H	VL
I9	L	Min{M,T}	L	L
I10	M	Min{M,T}	L	M
I11	VL	Min{M,T}	VL	EL
I12	M	Min{M,T}	VH	VH
I13	L	Min{M,T}	EL	M
I14	H	Min{M,T}	M	L
I15	M	Min{M,T}	L	VL
I16	H	Min{M,T}	H	VH

Table5. Fuzzy multi-criteria decision matrix

Indeed, gap is calculated using fuzzy "AND" operation which intersection between fuzzy measuring and fuzzy target of BSC model. In other words, gap is the distance between measure and target in the

BSC model. Fuzzy weighting of criteria which is illustrated in table 6, are created using consensus of expert panels and taking into consideration table 2 and step 3.

Criteria	Importance	Gap	Cost	Time
Fuzzy weighting	Very High	Medium	Extremely High	High

Table6. Fuzzy weighting of criteria

The membership function of criteria weighting under fuzzy space is depicted in figure 3.

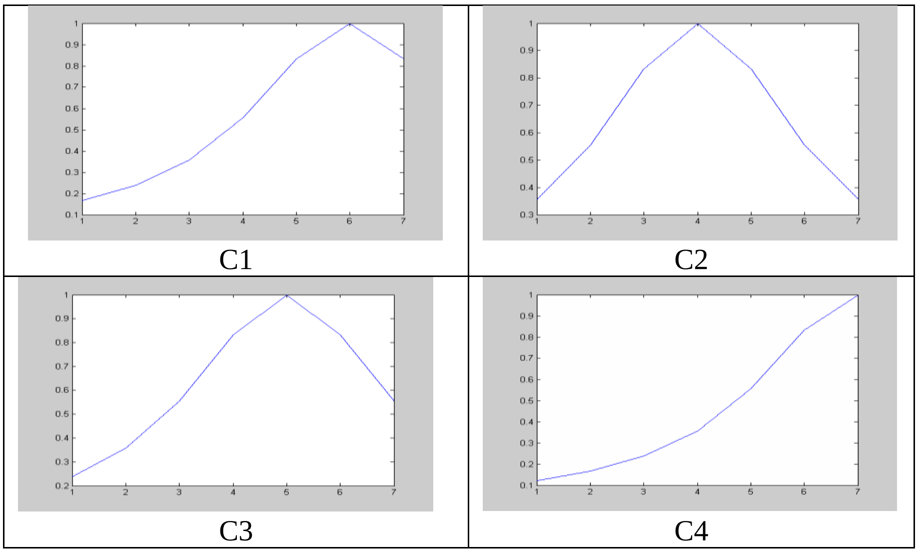

Figure3. Membership function for weighting of criteria

The fuzzy utility of each strategic plans are calculated by steps 4.3 and 4.4 and equations 4.1, 4.2 and 4.3. Therefater, by employing centre of gravity method, fuzzy outputs of strategic plans are converted to crisp utility reagrding equation 5.1. The values are shown in table 7.

I1	I2	I3	I4	I5	I6	I7	I8
0.4972	0.4629	0.4328	0.4613	0.4324	0.4771	0.4463	0.4281
I9	**I10**	**I11**	**I12**	**I13**	**I14**	**I15**	**I16**
0.4763	0.4707	0.4753	0.4709	0.5162	0.4795	0.4710	0.5038

Table7. Utility of strategic plans

Ultimately, considering previous step, which determined crisp utility of strategic plans, the strategic plans in BSC are ranked as illustared in table 8.

No. of Strategic Plans	Strategic Plans	Utility	Rank
I1	Marketing Research	0.5529	16
I2	Marketing	0.5450	13
I3	Inventory Control	0.5436	5
I4	ABC	0.5387	15
I5	After sales service	0.5243	12
I6	Marketing Research	0.5230	14
I7	Customer relationship Management(CRM)	0.5216	11
I8	Value Engineering	0.5172	3
I9	Time & Motion Study	0.5040	2
I10	QFD	0.5013	8
I11	ISO 9000	0.4977	4
I12	TQM	0.4938	1
I13	Increasing personnel salary	0.4809	9
I14	Personnel evaluation system	0.4475	7
I15	Reward system	0.4434	10
I16	MIS	0.3796	6

Table8. Strategic plans ranking

5 DISCUSSION, CONCLUSION AND FUTURE WORK

Balanced scorecard is a tool for translating strategy into action via various sets of performance measurement indicators. Numerous studies and publications have designed procedures for evaluating performance measurement (Jiang and Liu 2013; Lee and Seo 2016; Noori 2015; Xian et al. 2014). However, selecting the best strategic plans is a complex task which requires intelligence analytical methods to deal with this important issue. For organizations with limitations of time, budget and resources, in which they cannot implement all the strategic plans, there should be an intelligent model for choosing the best strategic plans (Hermawan et al. 2016). The proposed model solved these problems by developing a decision making methodology that integrates group decision making and fuzzy linguistic evaluation. This study has clearly demonstrated that strategic plans selection can be improved in several ways by implementing proposed model which was shown through the numerical example. In this sense, strategic plans can be assessed based on decision makers' verbal terms and applying linguistic variables with less emphasis on data collection in fuzzy environment seems more comfortable during the evaluation stage. In this methodology, the new linguistic reasoning for group decision making under uncertainty has been employed for evaluating strategic plans. The proposed model is able to aggregate subjective evaluation of the decision makers and offer an opportunity to perform more robust strategic plans selection procedures. The proposed model seems logical regarding to ”cause and effect” strategy mapping. For instance, TQM and value engineering from cause group have the highest execution priorities. Applying fuzzy linguistic extension of MCDM for group strategic plans selection problem in this study has several particular contributions including 1) Determining the explicit criteria and sub-criteria in BSC regarding the strategic plans selection problem, 2) Employing fuzzy linguistic extension of group MCDM for the strategic plans selection problem under uncertainty.

5.1 Implications for Practitioners

In order to evaluate the strategic plans in an effective way, several implications for managers can be derived from the results. Valuable information can also be drawn from the ranking strategic plans (Table 8) to identify insightful decisions.

First, decision makers are able to assess strategic plans based on their own verbal terms. Applying linguistic variables in fuzzy environment is often comfortable for decision makers during the evaluation stage. In addition, using linguistic variables places less emphasis on detailed data collection.

Second, in the proposed model, the strategic plans including TQM and ISO 9000 from the internal process criteria are ranked within “cause group” which shows their importance and priority to achieve high performance. In fact, if a company aims to achieve high performance in the “effect criteria,” it would be required to attend and monitor “cause criteria” in advance, since the cause criteria imply the meaning of the effect criteria (Govindan et al. 2016). In other words, the cause criteria can be considered as the critical criteria in directing the right benchmark for other organizations.

Third, it is found that TQM (I12) is the most important strategic plans among the 16, as it has the highest rank in relation to other strategic plans. Actually, it is related to the cause criteria and it makes sense to be the first rank of strategic plans. In the broader sense, the model can be used as an analytical and monitoring tool to develop strategic planning and performance evaluation. FMCDM is sufficient for the management to greatly understand the evaluation aspects and criteria. Moreover, managers may apply the proposed FMCDM model for ranking strategic plans and performance evaluation.

5.2 Limitations and Future Work

Ranking of strategic plans with FMCDM model is performed using only one MCDM method. However, for constructing a solid model, future studies should include a network base data envelopment analysis model. Although, some methods have been developed with a variety of formal modeling techniques, they may be limited due to different reasons. MCDM methods and decision support tools and methodologies can assist organizations and managers make more effective decisions. To promote this area of research and to help further integrate strategic planning discussion into the decision making modeling area, future research may apply several other methods to assess the casual relationships among evaluation criteria of the BSC to objectively construct strategy maps. While numerical examples are a common way to demonstrate a proposed method in practices, we admit the simpilistic nature of this demonstration for further generaliability and we recommend future emprical studies, productions and real-world experimentations of the proposed method.

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