

Using Interpretive Structural Modeling to Determine the Relationships among Knowledge Management Criteria inside Malaysian Organizations

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Abstract—This paper is concerned with the establishment of relationships among knowledge management (KM) criteria that will ensure an essential foundation to evaluate KM outcomes. The major issue under investigation is to assess the popularity of criteria within organizations and to establish a structure of criteria for measuring KM results. An empirical survey was conducted among Malaysian organizations to investigate KM criteria for measuring success of KM initiatives. Therefore, knowledge workers as the respondents were targeted to establish a structure of criteria for evaluating KM outcomes. An established structure of criteria based on the Interpretive Structural Modeling (ISM) is used to map criteria relationships inside organizations. This structure is portrayed to identify that how these set of criteria are related. This network schema should be investigated and implemented to promote innovation and improve enterprise performance. To the researchers, this survey has significant insights into relationship between KM programs and business success.

Keywords—Knowledge Management, Knowledge Management Outcomes, KM Criteria, Innovation, Interpretive Structural Modeling

I. INTRODUCTION

ASIDE from being imperative role of knowledge management, a comprehensive set of criteria for measuring knowledge management outcomes was not developed yet. To a considerable degree, commentators reported this issue. Observing a few refers of these researchers help us evade certain types of wordiness. According to [1], a set of criteria to measure success of quality management, and project management programs have been established clearly. Reference [2] reported that there is no sufficient attempt to establish a widely accepted list of criteria or outcomes associated with KM programs. In this regard, [3] stated; without structuring such methods to measure knowledge management successes, many organizations may not recognize its full potential. Indeed, without measuring KM efforts there is no way to manage organization's intellectual capital

properly. Hence, in order to realize knowledge management's full capability, to emphasize on establishing criteria to measure knowledge management outcomes is vital and imperative. For the sake of filling the gap, this paper mainly focuses on determining criteria of measuring KM programs and furthermore, looks forward to develop widely-accepted criteria to evaluate success of knowledge management efforts for Malaysian organizations. Based on this set of criteria, efforts were done to understand the structure of inter-relationships among these criteria.

II. BACKGROUND

Considering a capital investment in knowledge management is an essential prerequisite to live up to expectations. In order to maximize return on KM investments, companies must realize the results and outcomes of KM initiatives [2]. Reference [1] has mentioned the perspectives of [4] on measuring outcomes of knowledge management systems. These perspectives included developing an assessment structure, encouraging top management's attention on what is important, and evaluating investments [1]. The evaluation process is performed by paying serious attention on intangible attribute of such KM outcomes. The organizations' balance sheets and financial statements do not convey inherent intangible attributes of intellectual capitals [5]. Hence, the significant obstacle to evaluate KM success is unfolded [5]. Reference [3] has also indicated the shortage of insights on how to investigate the intangible dimension of intellectual capital. This is the main barrier faced by managers to translate investments on intellectual capitals, which are the main source of core competencies [3]. According to [3], the second significant obstacle is flowered by evaluation of KM performance.

This problem solves through evaluating KM participation to business performance [6]. The most prestigious consulting companies supported this solution [1]. During the last two decades, numerous studies have investigated the linkage between balance scorecard and measuring KM performance. A summary of studies' results are available in [1]. Reference [7] indicated that integration between KM efforts, organizational activities, and business processes that may help turn knowledge into competitive advantage. As such,

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understanding business enterprise processes and activities is an essential prerequisite due to increase the KM's contribution to business strategy [8]. Nevertheless, organizations need to establish an appropriate structure of measurement. This is because measuring success of KM programs is not easy, and in order to perform so some types of measurement frameworks must to be established. Similar to a project, the criteria play an essential role to the success or failure of any KM project and therefore demand serious attention [8]. Hence, an appropriate trade-off between metrics and criteria for assessment of KM programs are proposed to assist the executives in picking a best-fitted project. In order to bridging the gap, this study paid serious attention to develop widely-accepted criteria to evaluate success of knowledge management programs and analyze a structure of inter-relationships among these criteria.

III. RESEARCH METHODOLOGY

The knowledge management literature emphasize on KM criteria as an essential prerequisite. Although KM criteria have been studied from several perspectives, this paper highlights two different objectives:

1. To discover the most favored criteria for measuring KM success.
2. To establish a structure of inter-relationships among these criteria.

Building on the two above-mentioned objectives, this article proposes the following research questions:

1. What criteria are the most favored for measuring KM success?
2. What is the structural modeling to KM criteria due to represent inter-relations among these criteria?

A. Data Analysis

In this research study, the MS Excel and SPSS software were used to analyze the questionnaire data. In order to respond to the research questions, the Descriptive Analysis and Interpretive Structural Modeling (ISM) were employed to extract patterns from data.

B. Participants

Participants to the survey included KM professionals, Malaysian executives, and Expats executives who activated in Malaysia. The study found widespread respondents were working in different types of companies included Governmental, For-profit, and Non-profit sectors.

C. Data Collection Method

For the purpose of this preliminary study, following data collection method was used. This research study employed mixed-mode sampling approach with internet-based option in order of data collection. Hence, the sampling method is based on probability [9]. Through the Internet channel, we could access to knowledge workers, executives, and individuals who would not be easy to contact via other channels. Hence, the first step of data collection was to choose a population to be sampled. The population framework was limited to virtual communities and email lists, which comprised a concentrated

number of Malaysian executives, knowledge workers, knowledge management experts, and expats. Hence, generalizability across all Malaysian organizations is limited because of inherent constraints of the sample. Subsequently, the online questionnaire was developed on Google Document platform and shared among all participants (virtual communities and email lists). Finally, 79 of respondents answered to the shared questionnaires. As expected, questionnaires were received with no missing data.

D. Questionnaire

The study depends on a survey's instrument of [1] with questions designed to identify the criteria for measuring knowledge management success. We surveyed the questionnaire in which 19 questions were presented in a closed-ended or open-ended format. The entire questionnaire consisted of three parts: (1) KM Criteria, (2) Individual Background, and (3) Organizational Background. There were 26 criteria, which were portrayed on one page of the questionnaire. This may help respondents to browse the questions easily. Respondents were requested to assign three different scores to each criterion. A nominal question (Yes=1, No=2) was asked from respondents in order to clarify whether they have utilized any of 26 criteria to measure knowledge management efforts. Respondents were also requested to assign a Likert Scale score (5=Very High to Very Low=1) to importance and effectiveness of each criterion. The list of KM criteria was shown in Table I. The outcomes included in Table I were adopted from [1] and [10].

IV. INTERPRETIVE STRUCTURAL MODELING FOR KM CRITERIA

The concept of Interpretive Structural Modeling (ISM) was primary introduced by J. Warfield in 1973 [11]. Warfield proposed ISM due to evaluate the complex socioeconomic systems [11]. Reference [12] stated that ISM approach facilitates to compel classification and direction on the complex relationships among components of a complexity of relationships among elements of a socioeconomic system. Reference [13] interpreted the words of Interpretive Structural Modeling. According to [13], ISM is interpretive as based on group's judgment and decision whether and how the system's elements are linked. It is structural as constructed on the relationship's foundation and final structure is exploited from complex set of system's variables [13]. It is also a modeling as the final relationship is illustrated in a directed graphical model [13]. The different steps, which are relevant to the development of ISM approach were stated in [13], and [8]. Following steps were exploited from [13], in order to develop ISM model to KM criteria.

V. STRUCTURAL SELF-INTERACTION MATRIX (SSIM)

To begin, a group of experts was assembled. During this step, group members were consulted to understand the direction of contextual relationship among knowledge management criteria. In order to begin calculation, we needed to identify what criteria are the most favored to measure KM success.

Hence, the mean scores of both Important and Effectiveness were computed for each criterion. The results identify the favored dimension to each criterion. The favored scores of criteria were shown in Table I. The criterion in which the mean is more than or equals to 3.85 can be shortlisted as the most favored criterion. According to the results of Table I, the most favored criteria consisted of Enhanced collaboration (M=4.12, SD=1.02), Improved communication (M=4.07, SD=1.01), Improved learning/adaptation capability (M=3.94, SD=0.98), Sharing best practices (M=3.89, SD=0.95), Better decision making (M=3.89, SD=1.06), Enhanced product or service quality (M=3.89, SD=0.48), Enhanced intellectual capital (M=3.86, SD=1.01), and Increased empowerment of employees (M=3.85, SD=0.39).

These results provide input to structural self-interaction matrix (SSIM). This matrix provides an initial notion of whether and how the KM criteria are related. According to [13], the structural self-interaction matrix represents these directional relationships among variables using following four symbols:

- V: Criterion i will assist to reach Criterion j;
- A: Criterion j will assist to reach Criterion i;
- X: Criterion i and j will assist to reach each other; and
- O: Criterion j and i are unrelated.

In this study, the Structural self-interaction matrix (SSIM) for KM Criteria was shown in Table II.

VI. DETERMINE THE REACHABILITY MATRIX (RM)

A converted symbolic SSIM matrix into binary matrix (elements are 0 or 1) provides the reachability matrix [8]. Reference [8] suggested the conversion rules as below:

In SSIM, if the relation C_i to $C_j = V$ then element $C_{ij}=1$ and $C_{ji}=0$ in RM

In SSIM, if the relation C_i to $C_j = A$ then element $C_{ij}=0$ and $C_{ji}=1$ in RM

In SSIM, if the relation C_i to $C_j = X$ then element $C_{ij}=1$ and $C_{ji}=1$ in RM

In SSIM, if the relation C_i to $C_j = O$ then element $C_{ij}=0$ and $C_{ji}=0$ in RM

After exploiting initially reachability matrix, driving power and dependence power were calculated for each criterion. According to [13], the driving power for each criterion is the total number of criteria involves itself that it may assist reach and the dependence power for each criterion is the total number of criteria involves itself that may assist reach it.

TABLE I
THE LIST OF CRITERIA BASED ON THEIR FAVORED RATE

KM Criteria	N	Mean	Std. Dev
Enhanced collaboration	79	4.12	1.02
Improved communication	79	4.07	1.01
Improved learning/adaptation capability	79	3.94	0.98
Sharing best practices	79	3.89	0.95
Better decision making	79	3.89	1.06
Enhanced product or service quality	79	3.89	0.48
Enhanced intellectual capital	79	3.86	1.01
Increased empowerment of employees	79	3.85	0.39
Improved productivity	79	3.8	1.03
Improved business processes	79	3.78	1.09
Improved employee skills	79	3.72	0.92
New or better ways of working	79	3.71	0.86
Return on investment of KM efforts	79	3.65	0.97
Increased profits	79	3.61	0.91
Better staff attraction/retention	79	3.51	0.93
Better customer handling	79	3.45	0.92
Improved new product development	79	3.43	1.05
Creation of more value to customers	79	3.23	0.70
Faster response to key business issues	79	3.19	1.13
Increased innovation	79	3.19	1.09
Creation of new business opportunities	79	3.13	0.67
Entry to different market type	79	3.06	0.63
Increased market share	79	3.03	0.81
Increased market size	79	2.93	0.95
Reduced costs	79	2.86	1.10
Increased share price	79	2.65	0.58

TABLE II
STRUCTURAL SELF-INTERACTION MATRIX (SSIM) FOR KM CRITERIA

CN	Criterion Description	CN ^a						
		8	7	6	5	4	3	2
1	Enhanced collaboration	V	V	V	V	X	X	A
2	Improved communication	V	V	V	V	V	V	
3	Improved learning/adaptation capability	V	X	V	X	X		
4	Sharing best practices	V	X	V	V			
5	Better decision making	A	A	V				
6	Enhanced product or service quality	O	A					
7	Enhanced intellectual capital	X						
8	Increased empowerment of employees	X						

^a CN=Criterion Number

VII. IDENTIFY THE LEVEL PARTITIONS

According to [13], the Reachability set and Antecedent set for each criterion were derived from initial reachability matrix. The reachability set consists of KM criterion itself and other KM criteria that it may help reach whereas antecedent set consists of KM criterion itself and other KM criteria that may help in reaching it [13]. Afterward, the intersections of these sets were exploited for all KM criteria. If elements of which reachability and intersection sets are similar then those are level I elements [8]. Once the level I is determined, it is removed and then next same process is reiterated to discover next level elements [13].

VIII. CLASSIFICATION OF KM CRITERIA

Reference [13] proposed a classification of elements based on their driving and dependence power. Hence, all KM criteria were classified based on their driving and dependence power. Using this classification, provided four categories included autonomous criteria, dependent criteria, linkage criteria, and independent criteria. The cluster of KM criteria was depicted in Fig. 1. It can be clearly seen that KM Criterion 6 has a dependence power of 7 and driving power of 1. It is therefore

TABLE III
INITIAL REACHABILITY MATRIX TO KM CRITERIA

Criterion Number	Criterion Description	Criterion Number								Driving Power
		1	2	3	4	5	6	7	8	
1	Enhanced collaboration	1	0	1	1	1	1	1	1	7
2	Improved communication	1	1	1	1	1	1	1	1	8
3	Improved learning/adaptation capability	1	0	1	1	1	1	1	1	7
4	Sharing best practices	1	0	1	1	1	1	1	1	7
5	Better decision making	0	0	1	0	1	1	0	0	3
6	Enhanced product or service quality	0	0	0	0	0	1	0	0	1
7	Enhanced intellectual capital	0	0	1	1	1	1	1	1	6
8	Increased empowerment of employees	0	0	0	0	1	0	1	1	3
	Dependence power	4	1	6	5	7	7	6	6	

placed at a point, which related to a dependence power of 7 and a driving power of 1. Using this method allows us to arrange all KM Criteria into four distinctive clusters. As Fig. 1 shown, there were no autonomous criteria. It indicates that there were no disconnected criteria from the system. The second cluster included driver criteria that had strong driving power and weak dependence power.

TABLE IV
LEVEL PARTITIONS TO KM CRITERIA

Criterion Number	Reachability Set	Antecedent Set	Intersection	Level
1	1,3,4,5,6,7,8	1,2,3,4	1,3,4	IV
2	1,2,3,4,5,6,7,8	2	2	VII
3	1,3,4,5,6,7,8	1,2,3,4,5,7	1,3,4,5,7	VI
4	1,3,4,5,6,7,8	1,2,3,4,7	1,3,4,7	V
5	3,5,6	1,2,3,4,5,7,8	3,5	II
6	6	1,2,3,4,5,6,7	6	I
7	3,4,5,6,7,8	1,2,3,4,7,8	3,4,7,8	III
8	5,7,8	1,2,3,4,7,8	7,8	II

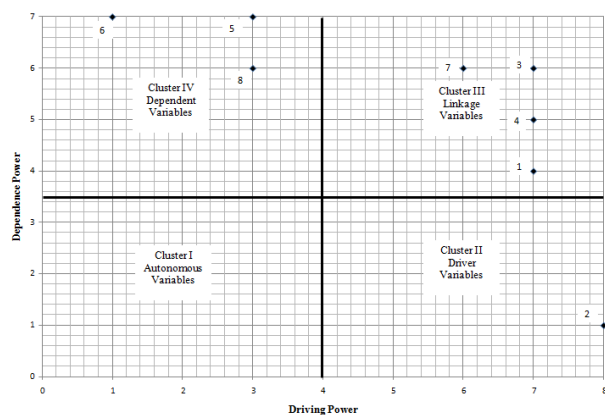


Fig. 1 The Cluster of KM Criteria

In the current study, only KM Criterion 2 was in the cluster of driving variables. According to Fig. 1, the criteria 1, 3, 4, and 7 were positioned in the group of linkage criteria. Any stimulate to these criteria may have an influence on the other criteria and therefore get a new feedback from the system. The criteria 5, 6, and 8 were positioned in the category of dependent criteria.

IX. ISM DIGRAPH TO KM CRITERIA

Reference [13] stated that ISM directed graph (digraph) is created from initial reachability matrix. According to [13], if there is a relationship between criteria i and j , then the relationship is shown with an arrow that points from i to j . Following digraph was generated to portray the relationship among KM criteria for measuring knowledge management outcomes.

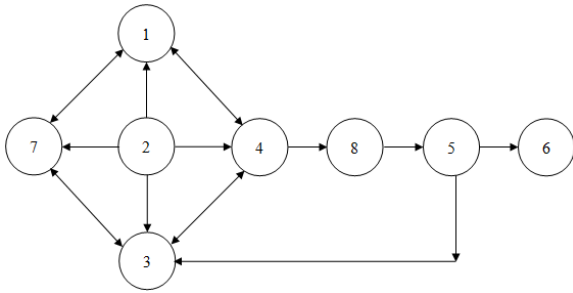


Fig. 2 The Directed Graph (Digraph) Among KM Criteria

X. DISCUSSION

The Fig. 2 portrayed visually both the direct and the indirect relationships between KM criteria inside Malaysian organizations. The current research determined that improved communication is one of the top most efficient criterion in order of its low dependence power and high driving power among all most favored knowledge management criteria. This result is also confirmed by earlier study results of [8]. By contrast, enhance product or service quality with highest dependence power and lowest driving power is positioned in the category of dependent criteria. This criterion is the result of conceptual model. Beside, both criteria 5 and 8 are also classified in the category of dependent criteria. As shown in Fig. 2, criterion 5 is affected by criterion 8 as well as all linkage variables directly. This criterion plays an important role in achieving system's result, which is to enhance quality. It is also identified that the criterion 5 has significant influence in supporting linkage criteria. The linkage variables include enhanced collaboration, improved learning/ adaption capability, sharing best practices, and enhanced intellectual capital. These criteria have no direct relationship with end result of the system. In the current study, findings revealed that the linkage variables co-influence each other. Any stimulate to these criteria may have an influence on the other criteria and therefore get a new feedback from the system. Therefore, these criteria need more consideration from top management due to their much impact on the KM system. In this research, we had no autonomous criteria. Hence, it is proposed that all favored criteria require more serious managerial attention.

The intangible aspect of above-mentioned criteria; make it complex to develop measurements for these criteria. Therefore, developing the measurements for these criteria needs critical thinking. A number of solutions were suggested by [1] due to develop measurements to the above-preferred criteria. These suggestions elaborated as bellow:

- To establish advanced communication channels based on the cloud computing, wiki platform, and social network. Through these communication channels, a continuous flow of employees' knowledge to organizational knowledge and vice versa can be facilitated.
- Strategies to establish quantitative methods can be used to verify and measure communication aspect.
- To promote publicity in meetings and organizational communities. This is not only facilitate to measure outputs of the teams but also promote organization's sense of purpose and community awareness.
- To embed performance monitor tools into network infrastructure in order to track employees' role in sharing best practices, participating in webinars, and contributing in team working activities.
- To measure empowerment of employees through feedback systems, suggestion box, and organizational surveys.
- To implement Total Quality Management (TQM) used to measure the enhancing of product or service quality.

XI. LIMITATIONS

Budget constraints, time restriction, and transportation problem forced researcher to select a medium sample size. As the population framework was limited to virtual communities and email lists, the findings cannot be generalized across all Malaysian organizations. This is also invigorated by the limited amount of data.

XII. FUTURE RECOMMENDATIONS

This survey specifically addressed the criteria for measuring KM outcomes inside Malaysian organizations. There are a number of future recommendations that would be valuable for researchers. Researchers can conduct a same survey with a larger sample size in order to increase precision in estimates of various aspects of the population. A criteria breakdown structure is needed to facilitate measuring these criteria. Furthermore, focus serious attention on various industries and geographical regions can provide better picture of KM criteria.

XIII. CONCLUSION

This paper attempted to establish the relationships among the criteria for measuring knowledge management results using Interpretive Structural Modeling. Leveraging knowledge assets toward business performance and organization's missions was the main contribution of the current survey. Hence, top management commitment in defining well-organized mission, goals, and objectives is very imperative. This will lead organization to meet its expected results of KM initiatives. Analyzing the inter-relationship between KM Criteria helped us to determine that by setting up well-defined criteria and being aware of the importance of each criterion in measuring KM success, managers can adjust their programs on where they should spend their efforts and which area requires more concentration in order to get high achievement.

Therefore, these criteria need more consideration from top management due to their much impact on the KM system. In this research, we had no autonomous criteria. Hence, it is proposed that all favored criteria required more serious attention of top management. All in all, increasing the effectiveness of KM implementation and enhancing the quality of KM efforts to translate intellectual assets toward business performance and organization's goals would be the

main implication of the study. This leads a company to address the organization's future success factors.

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