

## Evaluation of Critical Factors of Knowledge Management in Project-Based Businesses Using Interpretive Structural Modeling

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**Abstract:** In today's business environment, knowledge is a key factor well-known for its impact on the competition of organizations. Agencies have recognized that intellectual capitals play an important role in keeping the organizations competitive. Thus, a large number of companies investing on knowledge management (KM) are considerably growing. Project-based organizations are also facing the same challenges. The temporary nature of projects, short-term orientations, non-routine and complex activities in organizations have shaped different characteristics for this type of organizations. It is also notable that project team members will leave the team after the end of project. For this reason, project-based businesses face particular barriers in implementing KM practices. Project-based organizations have difficulties incorporating time orientations and knowledge processes into their existing activities. In this paper, with a careful review of existing literature, the critical factors for implementing KM in project-based businesses have been discussed. Then by using Interpretive Structural Modeling (ISM), the impact of these factors on each other and also on project as a whole are specified.

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**Keywords:** Knowledge Management (KM), Critical Factors, Project-Based Businesses, Interpretive Structural Modeling (ISM)

### Introduction

In general, achieving an economic development in business environment requires particular attention to capital management, technology management and etc. However, due to the globalization of business markets, international competition and rapid technological changes, the knowledge is known as a critical asset for organizations. Thus, the real assets of organizations are their human resources and expertise (Karina et al., 2003). In organizations which are project-based, Knowledge Management (KM) plays an important role. Furthermore, applying KM in project-based businesses is a powerful tool for creating sustainable competitive advantage. In fact, organizations compete with each other based on their knowledge (Ajmal et al., 2010).

KM is a comprehensive and systematic approach for identifying, managing and sharing individual's knowledge including documents, policies, procedures, and experience as well as their proficiency (Akhavan et al., 2006). Knowledge and its accurate management have identified as a strategic source for the success of project and create a sustainable competitive advantage (Astrid et al., 2006).

It is undeniable fact that temporary and project-oriented works in organizations are dramatically growing in number and purpose. Although knowledge content of jobs is increasing, the nature of projects cannot support knowledge transferring from a

particular project to another one (Linder et al., 2010). Fundamentally, project-oriented organizations are facing special problems in implementing KM since they are basically temporary and short-term (Demarset et al., 1997). Moreover, after finishing the projects there would not be cooperation and communication between employees regarding the work. Hence, knowledge would be branched and fragmented. Despite permanent organizations where different divisions act as a source of knowledge, temporary organizations procedures as well as their organizational memory are different. In these organizations there is a shortage of mechanisms to receive and store organizational development and training (Disterer et al., 2000).

The barriers and problems in implementing KM within project-based organizations have also been specified. Most of the previous researches are considered KM within several project-based organizations through case studies and qualitative research. Consequently, many critical factors have been identified (Akhavan et al., 2006).

In order to perform a proper evaluation of critical factors for KM success, the first step is to accurately identify the possible difficulties. Eventually, difficulties can be firmly eliminated by the help of appropriate decisions. With regard to the determination, effectiveness and impacts of barriers and to prioritize them, different methods can be used.

Therefore, this paper will illustrate a method using Interpretive Structural Modeling (in this paper is referred as ISM) due to its simplicity to achieve a better result.

The remaining of this paper is organized as follows: The first section presents literature review and critical factors for implementing KM within projects. Sections 2 and 3 argue definitions and preliminaries about ISM and also the research method. The paper concludes in sections 4 and 5. It also suggests a number of further research directions related to the topic.

### **Project-Based Businesses (Project-Based Organizations)**

Project management is defined as the discipline of some factors such as preparation, organizing, securing, and managing organizations' resources in order to achieve particular goals. A project is a temporary effort with an obvious starting and ending points which occurs to meet particular goals and objectives. It's usually time-constrained, while it's mostly constrained by funding or deliverables. It's normally occurred to add value or to cause a valuable change. The temporary nature of projects often stands in contrast with business or operations; those which are repetitive, permanent, or semi-permanent functional activities in order to produce products or services. In practice, management of these two systems is quite different, and requires the development of distinct technical skills and management strategies (Halavi et al., 2006).

Project-based businesses or project-based organizations refer to a wide range of organizations that create a temporary system. Throughout organizations project activities are implemented (Boh, 2007). Project-based organizations achieve their business goals through projects (Boh, 2007). In the other word, project-based organizations are seeking to achieve their goals during projects. Most of the project-based companies are simultaneously engaged in several different projects. Such projects are typically large, expensive, exclusive, high risk, and are at an acceptable performance level. They are also performed within definite time and cost (Akhavan et al, 2010; Kerzner, 1998).

### **Project Knowledge Management (PKM)**

According to Oxford Dictionary, knowledge is a familiarity with someone or something, which can include information, facts, descriptions or skills acquired through experience or education. It can refer to the theoretical or practical understanding of a subject. There are different types of knowledge, implicit which is defined as a practical skill or expertise. While explicit one is the theoretical understanding of a subject and it's more or less known as formal or systematic. KM comprises a range of

strategies and practices used in an organization to identify, create, represent, distribute, and adoption of insights and experiences. Such insights and experiences including knowledge either embodied or embedded in individuals and organizations as processes or practices respectively. Project Knowledge Management (PKM) is illustrated as KM in a project environment. In fact, PKM makes a link between the principles of KM and project management (Bastian et al., 2009).

The level of complexity and collaboration required in project-based activities is noticeably more than routine and everyday works. Therefore, these works heavily depend on team members' expertise and experiences. Also, they require a wide range of collaborative innovation and initiative. As a result, knowledge is an essential resource in project-based businesses. If knowledge effectively managed, it will lead to reduced implementation time, saved money, improved quality as well as customer and stakeholder satisfactions.

In project environment, typically explicit knowledge has a high priority, to the extent most of the "Guide to Project Management Body of Knowledge (PMBOK)" focuses on a comprehensive solution to increase this type of knowledge. For instance, most of the processes and mechanisms defined according to this standard including project charter, project statement, work breakdown structure, and project scope management are attempting to increase explicit knowledge. Essentially, PMBOK in its essence is not defined any process for acquisition implicit knowledge (Reich et al., 2004).

Zack, 1999 explains two categories of project knowledge as follows:

a. Knowledge of Project Management: according to PMBOK 2008, Knowledge of project management including knowledge needed to begin, plan, implement, control, and terminate a project. For example, the knowledge of work structure and how it is created.

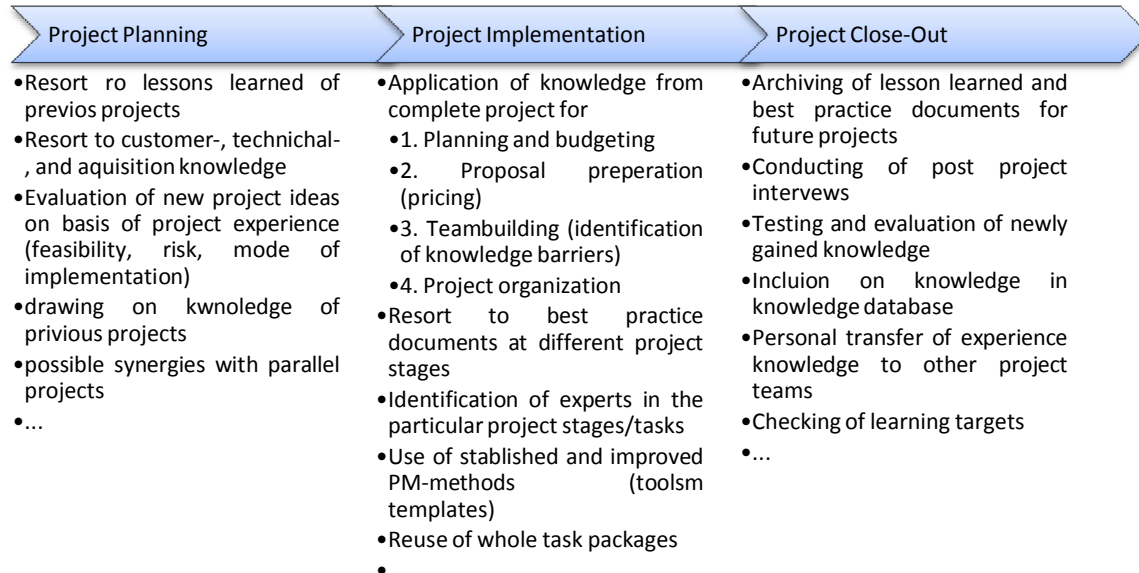
b. Knowledge of Project Environment: knowledge about business, industry, environmental organizations, technology as well as technical knowledge. Technical knowledge is required to complete the project. For example, how the work breakdown structure in a construction project should be applied. This type of knowledge in PMBOK 2008 is referred as "knowledge of specific functional area". Moreover, knowledge of business processes is included in this category.

Types of knowledge, during the diverse stages of a project life cycle is different and changing (Barzinpour et al., 2003). Experiences of previous projects, information on team formation, the technology and market knowledge are some examples

for different types of knowledge. These examples are emphasized to demonstrate the significance of early project stages. Furthermore, Knowledge about all available technical solutions, scheduling experiences, utilizing project management’s tools and processes

can be used in implementation stage (Bastian et al, 2009).

**Figure 1 shows the** Types of knowledge and project life cycle.



**Figure 1.** Types of knowledge and project life cycle

**Challenges of KM in Project Environment**

KM including implicit and explicit knowledge is an essential factor for success in today's dynamic and changing business environment. The intellectual capital management including physical, financial, human management is newly known as a challenging phenomenon for project-based businesses (Fong, 2005). Many project-based organizations are not well papered to leverage their knowledge assets duo to the lack of necessary skills. As a result, most of KM initiatives in project-oriented companies may be unsuccessful due to the technological, cultural, knowledge content and managerial errors (Ajmal et al., 2010).

The inherent characteristics of projects is caused to produce challenges which some of them are as follows: First, identify the critical knowledge and ability to exploit it is one of the main project’s challenges (Akhavan et al., 2009).. Due to the nature of projects, the knowledge gained during the project will disperse easily after finishing the project when project team members are leaving the team. Furthermore, because of uniqueness and short-term orientations, temporary companies in implementing of KM have encountered certain challenges or obstacles (Fong, 2005). The following cases are considered in this regard:

1. Exclusivity and temporary nature of projects prevent the development of organizational memory as well as organizational learning (Bresnen et al., 2003).

2. “Non-continuous works and non-continuous teams, leading to the rupture of individual and organizational knowledge” (Principe et al., 2003).

3. Compared with permanent organizations, the project lacks the intrinsic mechanisms of learning. Thus, transferring knowledge from one project to another one or to a permanent part of an organization is difficult (Boh, 2007).

4. Projects and other forms of temporary organizations, comparatively have short-term orientation. They are focusing on immediate delivery of deliverables, while KM requires a long-term vision. This conflict in objectives may lead to insufficient transfer of knowledge between the projects (DeFillippi, 1998)

**Critical Factors for Implementing KM within Project-Based Businesses**

Many scholars have argued about identifying critical factors to practice a successful KM in different organizations. Hence, the first step in implementing a KM system is recognizing the critical factors. In relation to design and performance of PKM in organizations, it appears that some factors may play a more important role than others do. It seems that

critical success factors can help organizations to focus on main areas, in order to facilitate and accelerate the process of implementing KM system. It can also help putting a stop to wasting resources (Akhavan et al., 2009).

As the implementation of KM in the project-based organization is a great challenge, in these types of organizations, many key elements should be considered during the implementation of KM process. Therefore, according to existing literature in the area of project KM, critical factors for implementing KM

are outlined in following table. Among these factors, organizational project management is only applied in project-based organizations while the other factors generally can be used for all organizations.

Table 1 displays the main critical factors with highest frequency in the related studies. The table also presents similar and related factors to implementing KM in project-based businesses.

**Table 1 shows the** Critical factors for implementing KM in project-based businesses.

**Table 1.** Critical factors for implementing KM in project-based businesses

Main Factor	Critical	Similar Or Related Factors	Related Researches
Culture		Employee Participation, Cooperation And Teamwork, Trust, Communication, Flexibility, Acceptance Of False	Chua and Lam (2005), Davenport et al. (1998), Ryan and Prybutok (2001), Moffett et al. (2003), Yeh et al. (2006), Ajmal et al (2010), Lindner, Wald (2010), Ajmal, Keka`le (2009)
Management		Leadership, Support, Commitment And Support Of Senior Management, Strategy	Davenport et al. (1998), Ryan and Prybutok (2001), Moffett et al. (2003), Yeh et al. (2006), Ajmal et al (2010)
Organizational Structure		Organizational Readiness, Integration, Process And Organization	Ajmal et al, Lindner, Wald (2010)
Information System Infrastructure		Technology, Information Systems, Knowledge Base, KM Systems, ICT Systems	Chua and Lam (2005), Davenport et al. (1998), Ryan and Prybutok (2001), Moffett et al. (2003), Yeh et al. (2006), Ajmal et al(2010), Lindner, Wald (2010), Vital A and Shivraj k (2008)
KM Methodologies		Performance Measurement, Training, Modeling, Pilot, Authority	Ajmal et al(2010), Leseure Michel j., brookes Naomi (2004)
Reward And Recognition		Incentives Financial And Non-Financial Packages	Ajmal et al (2010)
Staff		Understanding And Learning, Motivation, Job Security, Employee Involvement	Davenport et al. (1998), Ryan and Prybutok (2001), Yeh et al. (2006)
Knowledge Content		Knowledge Structure	Chua and Lam (2005), Moffett et al. (2003)
Organizational Project Management		Project Management, Project Management Maturity	Lindner, Wald (2010)

**Interpretive Structural Modeling (ISM)**

Interpretive Structural Modeling (ISM) is an effective methodology to identify relationship among specific items, which define a problem or issue. It is firstly proposed by J. Warfield in 1973. ISM generally has following steps according to Luthra and colleagues:

- Step 1. Variables affecting the system are listed.
- Step 2. Using the identified variables in step 1, contextual relationship among them are examined with respect to each pairs of variables.

- Step 3. A SSIM is developed for variables, which indicates pair wise relationship among variables of the system under consideration.

- Step 4. A reachability matrix is developed from the SSIM and the matrix is checked for transitivity. The transitivity of the contextual relationships is defined as a basic assumption made in ISM. It states that if variable A is related to variable B and variable B is related to variable C, then variable A is necessarily related to variable C.

- Step 5. The reachability matrix obtained in Step 4 is partitioned into different levels.

- Step 6. Based on the contextual relationships in the reachability matrix, a directed graph is drawn and the transitive links are removed.

- Step 7. The resultant diagram is converted into an ISM by replacing variable nodes with statements. (Luthra et al., 2011)

### Research Methodology

This study is a descriptive-survey research in terms of method. A qualitative approach was employed to identify factors facilitate and inhibit KM success in project-based businesses. This study is based on 98 expert interviews with expertise relevant to the automobile industry such as Pars Khodro Company, Iran Khodro Company, and Saipa Industrial Group which are from the largest automobile companies in Iran and Middle East. The data collected during 2011 in face-to-face interviews with responsible managers for KM and/or project management. Also some interviews have been conducted electronically. Delphi technique was utilized during two months, to obtain the views of participants. Then, ISM matrix was completed according to the gathered data.

In order to use ISM in this study, the following steps are taken into account:

#### 1. Structural Self-Interaction Matrix (SSIM)

It refers to establish a contextual relationship between critical factors when a pairs of them is considered. The obtained SSIM indicates pair-wise relationship between the critical factors. For analyzing the critical factors in developing SSIM, the following four symbols are used to represent between-factors relationships (i and j):

- V - Factor i affects on factor j;
- A - Factor j affects on factor i;
- X - Factors i and j will affect on each other; and
- O - Factors i and j are unrelated.

The following table displays SSIM for the factors.

**Table 2,** Structural self-interaction matrix

#### 2. Reachability matrix

In continue, the SSIM is converted into a binary matrix, namely initial reachability matrix by substituting V, A, X and O by 1 and 0. The substitution of 1s and 0s are based on the following rules:

- If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0;
- If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1;

- If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1; and

- If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Through the initial reachability matrix and considering transitivity in factors, the final reachability matrix is acquired. The transitivity of the contextual relationships made in ISM is a basic assumption. It states that if variable A is related to variable B and variable B is related to variable C, then variable A is necessarily related to variable C.

The driving power for each factor is the total number of factors (including itself), which are in each row. Dependence is the total number of factors (including itself), which are in each column.

**Table 3,** Reachability matrix

#### 3. Level partitions

From the final reachability matrix, the reachability and antecedent sets for factors are obtained. The reachability set contains the element itself and the other elements which it may help achieve, whereas the antecedent set consists of the element itself and the other elements which may help in achieving it. Afterward, the intersection of these sets is derived for all the factors. The factors that show the same place of reachability and intersection sets are located at the top level of the ISM hierarchy. The top-level elements in the hierarchy are not affected by other elements. Repeat the same practice to find the elements in the next level. This process continues until the level of each factor is clearly found. These levels finally build diagram and model consequently.

**Table 4,** Initial leveling

As shown in the above table, critical factors in PKM have divided into six categories. In this table, Management is in the lowest level and this shows management has an importance role in implementing PKM.

**Table 5,** Final leveling

Culture, organizational structure and KM methodology, and informational infrastructure are in the next levels. This shows the influence of these factors in the above factors and as a result, its importance in successful implementation of project KM can be concluded.

**Table 2.** Structural self-interaction matrix

No.	Factor Description	9	8	7	6	5	4	3	2
1	Culture	X	X	V	V	X	V	X	X
2	Management	X	X	V	V	V	V	V	
3	Organizational Structure	X	X	V	V	X	V		
4	Information System Infrastructure	X	V	V	V	A			
5	KM Methodologies	X	X	V	V				
6	Reward And Recognition	A	A	V					
7	Staff	A	X						
8	Knowledge Content	O							
9	Organizational Project Management								

**Table 3.** Reachability matrix

No.	Critical Factor	1	2	3	4	5	6	7	8	9	Driving Power
1	Culture	1	1	1	1	1	1	1	0	1	8
2	Management	1	1	1	1	1	1	1	1	1	9
3	Organizational Structure	1	0	1	1	1	1	1	0	1	7
4	Information System Infrastructure	1	0	0	1	0	1	1	1	1	6
5	KM Methodologies	1	0	1	1	1	1	1	1	1	8
6	Reward And Recognition	0	0	0	0	0	1	1	0	0	2
7	Staff	0	0	0	0	0	0	1	1	0	2
8	Knowledge Content	0	0	0	0	1	1	1	1	0	4
9	Organizational Project Management	1	1	1	1	1	1	1	0	1	8
	Dependence Power	6	3	5	6	6	8	9	5	6	

**Table 4.** Initial leveling

Critical Factor	Reachability Set	Antecedent Set	Intersection	Level
Culture	1,2,3,4,5,6,7,9	1,2,3,5,9	1,2,3,5,9	
Management	1,2,3,4,5,6,7,8,9	1,2,9	1,2,9	
Organizational Structure	1,3,4,5,6,7,9	1,2,3,5,9	1,3,5,9	
Information System Infrastructure	1,4,6,7,8,9	1,2,3,4,5,9	1,4,9	
KM Methodologies	1,3,4,5,6,7,8,9	1,2,3,5,8,9	1,3,5,8,9	
Reward And Recognition	6,7	1,2,3,4,5,6,8,9	6	
Staff	7,8	1,2,3,4,5,6,7,8,9	7,8	1
Knowledge Content	5,6,7,8	2,3,5,7,8	5,7,8	
Organizational Project Management	1,2,3,4,5,6,7,9	1,2,3,4,5,9	1,2,3,4,5,9	

**Table 5.** Final leveling

Critical Factor	Reachability Set	Antecedent Set	Intersection	Level
Culture	1,2,3,4,5,6,9	1,2,3,5,9	1,2,3,5,9	5
Management	1,2,3,4,5,6,8,9	1,2,9	1,2,9	6
Organizational Structure	1,3,4,5,6,9	1,2,3,5,9	1,3,5,9	5
Information System Infrastructure	1,4,6,8,9	1,2,3,4,5,9	1,4,9	4
KM Methodologies	1,3,4,5,6,8,9	1,2,3,5,8,9	1,3,5,8,9	5
Reward And Recognition	6	1,2,3,4,5,6,8,9	6	2
Staff	5,6,8	2,3,5,8	5,8	3
Knowledge Content	1,2,3,4,5,6,9	1,2,3,4,5,9	1,2,3,4,5,9	3
Organizational Project Management	1,2,3,4,5,6,9	1,2,3,5,9	1,2,3,5,9	5

**4. Formation of ISM digraph and model**

The structural model is generated from initial reachability matrix. If there is a relationship between the factors i and j, this is presented by an arrow which points from i to j. This graph is called as an initial

directed graph, or initial digraph. After removing the transitivities, the final digraph is formed which is shown in the following figure. This final digraph is converted into the ISM-based model.

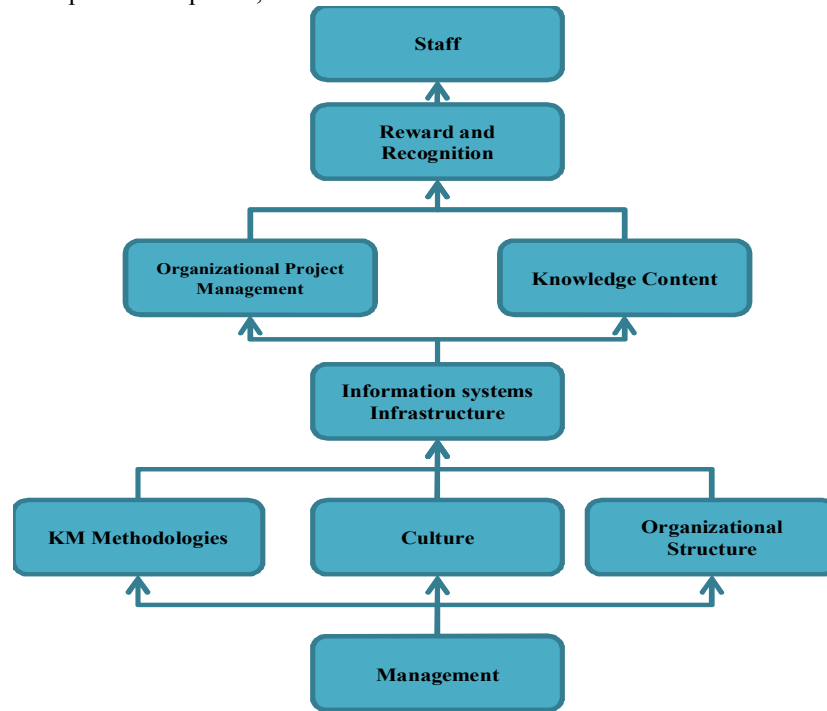
As is shown in the above graph, management in hierarchy is in the highest level and this shows the importance of this factor in project KM. All of above mentioned factors are from most important critical factors of KM, but the factors which are in the top of model accept the influence from other factors.

**Discussion**

All factors have been classified, based on their driving power and dependence power, into four

categories. These categories are autonomous factors, dependent factors, linkage factors, and independent factors. Driving power and dependence power diagrams are shown in figure xx. As it is seen the driving power of factor 2 equals 9 and its dependence power is 3. Therefore, it is positioned at a place that corresponds to a driving power of 9 and a dependence power of 3 as shown in the following figure.

**Table 6 shows the** Dependency Power- Driving Power matrix.



**Figure 2.** ISM model

**Table 6.** Dependency Power- Driving Power matrix

<b>Driving Power</b>	9			2					
	8					1,5			
	7		Cluster IV			3	9	Cluster III	
	6						4		
	5								
	4					8			
	3		Cluster I						Cluster II
	2								
	1								
		1	2	3	4	5	6	7	8
	<b>Dependency Power</b>								

The aim of factor classification is to analyze the driving power and dependence power of the factors. According to this classification, first cluster comes from autonomous category that has a weak driving power and weak dependence power. The autonomous factors are relatively disconnected from the system. In present study, there is no autonomous factor. The

second cluster includes dependent factors with weak driving power and strong dependence power. In the present case, factors 4, 7, and 9 are in the category of dependent factors. The third cluster consists of linkage factors that have strong driving and dependence power. Any action on these factors will have an effect on the other factors and also a feedback effect on

themselves. In this case, factors, 1, 3, 4, 5, and 9 are in the category of linkage factors. While the fourth cluster including independent factors displays strong driving power and weak dependence power. In this case, factor 2 is in the category of independent factors.

### Conclusion and further Research

This paper focused on the importance of KM in project-based organizations. It is emphasized that the effective management as a vital source of knowledge in project-based business leads to reduced time, improved quality as well as customer and stakeholder satisfactions. With a careful review on literature, the following factors are illustrated as critical factors for implementing KM in project-based businesses: culture, management, organizational structure, information infrastructure, KM methodology, motivation and reward, staff, knowledge content, and PKM. ISM technique used to analyze these factors. As a result, senior management is regarded as an important factor. Senior managers need paying most attention to culture, organizational structure and KM methodologies as the next step. It is concluded that all of 9 factors even with different degrees are important for implementing KM in project-based businesses. The factors were only classified in order to determine the most critical factors.

In this research, the relationship model among the identified PKM factors was not statistically validated. Structural Equation Modeling (SEM) referred to linear structural relationship approach. It has the capability of testing the validity of such hypothetical models. Thus, this approach can be applied in the future research to test the validity of this model. ISM is a tool which can be helpful to develop an initial model whereas SEM has the capability of statistically testing an already developed theoretical mode. Hence, it suggests that future research may be targeted to develop the initial model through ISM and then testing it by using SEM. Additionally, using linguistic terms and fuzzy variables to overcome the difficulties of vague and uncertain environment is recommended.

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