

Exploring the SPM System Structure Model by Using Fuzzy DEMATEL for NPD

Yu-Yun Chang
Kainan University
Graduate Institute of Project
Management
Taoyuan, Taiwan
m09924002@ms.knu.edu.tw

Meng-Jong Kuan
Kainan University,
Graduate Institute of Project
Management
Taoyuan, Taiwan
mjkuang@mail.knu.edu.tw

Yen-Ching Chuang
Kainan University
Graduate Institute of Project
Management
Taoyuan, Taiwan
m09824001@ms.knu.edu.tw

Gwo-Hshiung Tzeng
Graduate Institute of Project
Management,
Kainan University, Taiwan
Institute of Management of
Technology, National Chiao
Tung University, Taiwan
ghtzeng@mail.knu.edu.tw;
ghtzeng@cc.nctu.edu.tw

Abstract—Standardized project management (SPM) is regarded as a well-structured system for improving the success of new product development projects. SPM can be defined as a standardized set of project management practices. It helps achieve the company's strategic goal through the effective use of project-driven approach. This paper used a Decision Making Trial and Evaluation Laboratory (DEMATEL) method to help companies to create a critical Standardized Project Management system and identify the influence of dimensions and criteria in the SPM system. First of all the dimensions and criteria of the SPM system are determined. DEMATEL approach is then applied to construct the SPM system structure model with Fuzzy number influence interrelationship among dimensions and associated criteria. An empirical case from industry is used to explore the effectiveness of the proposal approach.

Keywords—fuzzy number; DEMATEL; Standardized project management (SPM); FDEMATEL.

I. INTRODUCTION

According to multiple empirical studies, a company's effectiveness partly depends on the success of its projects. (Kerzner and Cooper, 2000). And some companies in high-velocity industries have recognized a standardized project management (SPM) as a strategy for managing development projects (Milosevic and Patanakul, 2005).

In constructing a SPM system, the interrelationship among the dimensions and criteria is very critical for an effective SPM system. For this reason, we have adopted an integrated decision framework based on Decision Making Trial and Evaluation Laboratory (DEMATEL) and the triangular fuzzy number for constructing the most appropriate SPM system structure model.

DEMATEL method is usually applied in gathering group knowledge for forming a system structural model, as well as visualizing the causal relationship of sub-systems through a causal diagram. Here, DEMATEL is used to detect complex relationships and build relation structure among criteria for constructing SPM system. Additionally, set priorities among

sub-system and criteria, and to determine the most appropriate SPM evaluation system structure.

We live in a global economy in which the turnaround of structural and technological change is rapid and sometimes unpredictable. Business processes are changing even as we speak, and traditional jobs and work settings are becoming virtual, e-driven, and mobile. This atmosphere of change creates the need to build the organization so that (1) people can create new products before they are anticipated by the customer, marketplace, or competition, and (2) the company can design, develop, and produce new products better, faster, and cheaper, and get them to market. Development life cycles have gone from years to months to days. (Barkley, 2008)

II. STANDARDIZED PROJECT MANAGEMENT SYSTEM

Some companies in high-velocity industries have recognized that a well-constructed standardized project management (SPM) is a critical success strategy for managing new product development projects. In their study, Milosevic and Patanakul (2005) have illustrated that SPM may increase new product development projects success which is approved. The Organizational Project Management Maturity Model (OPM3), a standard issued by Project Management Institute (PMI), also suggests SPM as a major strategy for projects success. These references suggest that SPM may have a significant place in many companies' approach to PM, especially to new product development (NPD) projects.

PMBOK has defined the PM life cycle which is divided into five phases: initial, planning, executing, control and closing. A company has to start to develop one NPD project in a fixed time before it has a full "strategy" to make sure achieve the goal. In the second phase, a cautious project management plan (PMP) is necessarily developed for PM. A good PMP is critical issue in the "process" planning which is required to show how to use the methodologies planning project and external environment interaction of PM. Those are the impact planning of the project processes. In the third phase, a project is executed by "people". People in the positive culture, to be independent finish missions and have a strong back-office team

of project in company, they are making decision correctly in a project. In the fourth phase, a project must have right tools to control processes, people and technology. Finally, the study is has constructed a standardized project management system for new product development. All of above through the expert questionnaires select the critical factors of SPM. Besides, according to the literature review the “resource” also is the main success factor of projects. The integration of project planning with resource planning ensures that the company does not take one more than it can handle, and can avoid the kind of resource constraints or bottlenecks characterized in the critical chain concept (Barkley, 2008). Because of a project is usually under limited in resource so that the SPM performance evaluation system is divided into five dimensions of seventeen criteria in this study, the result is shown in TABLE I.

TABLE I. FACTORS AFFECTING THE CONSTRUCTION OF SPM SYSTEM

Dimensions	Factors(Criteria)
A Strategy	a_1 , The project management strategy a_2 , Fit with long-term strategy a_3 , Fit with new strategic intent
B People	b_1 , Project organization b_2 , Project culture b_3 , Project leadership
C Tool	c_1 , PM tools / template c_2 , Technology dependency c_3 , Information management system c_4 , Project management measure index
D Process	d_1 , Project environment d_2 , Project management methodologies d_3 , Project management process d_4 , Project management metrics
E Resource	e_1 , Cost / expenses e_2 , Support of facility e_3 , Support of employees

III. DEVELOPING SPM EVALUATION MODEL

This study will through the expert questionnaires to select the critical success factors of SPM system. Then, DEMATEL is applied to confirm the influence on each factor and to explore the relevance of the SPM's multiple criteria. This section includes three parts: the first part is application the triangular fuzzy number; the second part is developing network relationship with the DEMATEL; the last part is according to empirical analysis result to construct the SPM system for the new product development.

A. FUZZY NUMBER

B. Buckley (1985) proposed geometric mean method to calculate the final fuzzy weights for each fuzzy matrix. Given an $m \times m$ positive reciprocal matrix $A = [a_{ij}]$ is derived by pairwise comparison from m participating evaluators, then $r_i = \left(\prod_{j=1}^m a_{ij} \right)^{1/m}$ represents the geometric mean of each raw.

According to Saaty's definition, $\lambda_{\max}$ be the largest eigen value of A and the weights, w_i as the components of the normalized eigenvector corresponding to $\lambda_{\max}$, where $w_i = r_i / (r_1 + \dots + r_m)$.

Buckley (1985) further considered a fuzzy positive reciprocal matrix $\tilde{A} = [\tilde{a}_{ij}]$, extending the geometric mean method to the fuzzy geometric mean method and exploited which to find the final fuzzy weights of each criterion as follows:

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \dots \otimes \tilde{a}_{im})^{1/m} \text{ and } \tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \tilde{r}_2 \oplus \dots \oplus \tilde{r}_m)^{-1}$$

where $\oplus$ and $\otimes$ called additive and multiplicative operators of two fuzzy number, respectively. These arithmetic operations will describe in next paragraph.

The evaluators choose a performance score for each participating company based on their subjective judgments. This way of estimating the achievement level of each criterion on each strategy can use the methods of fuzzy theory for treating the fuzzy environment. In evaluating process, after well define the criteria and their relationship, we have to determine the weights or measure of these criteria, and obtain then performance score of each alternative with respect to evaluated criteria. Furthermore, choose an suitable aggregating operator to derive the synthetic value of these alternatives respectively, the final step is to assign the preferred order for all alternatives based on their synthetic values.

In general case, we can employ triangular fuzzy number to express the aggregated fuzzy weights of j -th criterion as follows:

$$\tilde{w}_i = (l_i, m_i, u_i) \quad (1)$$

where $\tilde{w}_i$ is derived by Eq.(1)

It can be assumed that evaluation expert k has his fuzzy performance score of $\tilde{E}_{ij}^k$ for the criteria j under alternative i , and all the items to be evaluated is defined in feasible set S .

$$\tilde{E}_{ij}^k = (LE_{ij}^k, ME_{ij}^k, UE_{ij}^k), j \in S \quad (2)$$

Each expert may has his different academic and business careers, so as his objective understanding on the linguistic variables. This study utilizes the average number to integrate the fuzzy judgment values given by m experts. That is, $\tilde{E}_{ij}$ express the average fuzzy judgment given by the participated evaluators. Its triangular fuzzy number is shown below:

$$\tilde{E}_{ij} = (LE_{ij}, ME_{ij}, UE_{ij}), j \in S \quad (3)$$

where

$$\tilde{E}_{ij} = \left(\frac{1}{m} \right) \otimes (\tilde{E}_{ij}^1 \oplus \dots \oplus \tilde{E}_{ij}^m) \quad (4)$$

Specifically, $\tilde{E}_{ij}$ can be calculated by Buckley (1985a):

$$LE_{ij} = \left(\frac{1}{m} \right) \times \left(\sum_{k=1}^m LE_{ij}^k \right); ME_{ij} = \left(\frac{1}{m} \right) \times \left(\sum_{k=1}^m ME_{ij}^k \right); UE_{ij} = \left(\frac{1}{m} \right) \times \left(\sum_{k=1}^m UE_{ij}^k \right) \quad (5)$$

Moreover, the fuzzy synthetic matrix R can then be developed from both fuzzy weighting vector and fuzzy performance matrix as following:

$$\bar{R} = \bar{w} \Leftrightarrow \bar{E} \quad (6)$$

where

$$\tilde{w} = (\tilde{w}_1, \dots, \tilde{w}_j, \dots, \tilde{w}_n)^T; \tilde{E} = [\tilde{E}_{ij}] \quad (7)$$

“ $\Leftrightarrow$ ” in Eq.(6) indicates the aggregating operator of fuzzy weighting vector and fuzzy performance matrix.

How to assess the measure of evaluated criteria is the critical process. In traditional evaluation methods such as Analytic Hierarchy Process, ELECTRE, PROMETHEE, TOPSIS, VIKOR and Grey Relation Analysis, assume definitely mutually independent between each pair criteria, and the simple additive weighted (SAW) method is appropriately to aggregate the synthetic value from criteria weights with performance scores. However, in most of MCDM problems, dependence or feedback may exist in evaluating structure. This independent relationship can not satisfy the nature of real situations. We can not employ SAW to derive the synthetic values if the relationship among these criteria are not independent, then the other aggregating tools is more suitable. For instance, fuzzy integral will provide appropriate estimate of synthetic values while in dependent situation; Analytic Network Process (ANP) can be applied to estimate the synthetic values while in the situation of feedback exists in considered dimension with its lower level of hierarch system.

Finally, the final fuzzy synthetic judgment of individual alternative for j evaluated criteria can be illustrated as follows:

$$\tilde{R}_i = (LR_i, MR_i, UR_i) \quad \forall i \quad (8)$$

where

$$LR_i = \sum_{j=1}^n l_j \cdot LE_{ij}; \quad MR_i = \sum_{j=1}^n m_j \cdot ME_{ij}; \quad UR_i = \sum_{j=1}^n u_j \cdot UE_{ij} \quad (9)$$

According to Dubois and Prade (1978), a fuzzy number $\tilde{A}$ is a fuzzy subset of a real number, and its membership function is $\mu_{\tilde{A}}(x): R \rightarrow [0,1]$, where x represents the criteria, and is described by enshrined with the following characteristics:

- (1) $\mu_{\tilde{A}}(x)$ is a continuous mapping from R to the closed interval $[0,1]$
- (2) $\mu_{\tilde{A}}(x)$ is a convex fuzzy subset.
- (3) $\mu_{\tilde{A}}(x)$ is the normalization of a fuzzy subset, which means that there exists a number such that $\mu_{\tilde{A}}(x_0) = 1$.

It can be called fuzzy number if all the conditions above are satisfied. The triangular fuzzy number $\mu_{\tilde{A}}(x) = (L, M, U)$ can be defined as Eq.(10) and Figure 1 :

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-L)/(M-L) & L \leq x \leq M \\ (U-x)/(U-M) & M \leq x \leq U \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

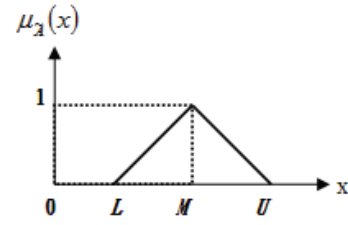


Figure 1. The triangular fuzzy number.

B. DEMATEL to develop network relationship

DEMATEL is an analytical method of structural model. It is mainly used to solve all kinds of complex problems to clarify the essential of the problem. Using matrix and related math theories to calculate the cause and effect on each element and the degree. This method widely used to solve various types of complex studies that can effectively understand the complex structure and provide viable options of problem solving (Tzeng, 2007).

DEMATEL divided into five steps. The first step is to confirm the system elements and develop the evaluating scale. To confirm the system has an elements and denoted by $E_1, E_2, \dots, E_n$. Then, using pair of dimensions to compare and using evaluating scale ranging from 0, 1, 2, 3, and 4 which in turn represents: no influence“0”, low influence“1”, medium influence“2”, high influence“3”, and extremely high influence“4” as measuring standard. The second step is to calculate the direct relation average matrix. Using pair of degree of interaction to obtain directly influence matrix $K = [k_{ij}]_{m \times m}$, k_{ij} represents the degree of effect on i factor effects j factor.

$$K = \begin{bmatrix} k_{11} & k_{12} & \cdots & k_{1m} \\ k_{21} & k_{22} & \cdots & k_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ k_{m1} & k_{m2} & \cdots & k_{mm} \end{bmatrix} \quad (11)$$

When the elements of i have a direct effect on the elements of j , then $k_{ij} \neq 0$, opposite $k_{ij} = 0$. The third step is to normalize the matrix. It can be obtained from formula (12) and (13). Its diagonal is 0, and maximum sum of row and column is 1.

$$X = \frac{K}{s} \quad (12)$$

$$s = \max \left(\max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}, \max_{1 \leq j \leq n} \sum_{i=1}^n a_{ij} \right) \quad (13)$$

The forth step is to obtain the total effect matrix T .

$$\text{When } \lim_{l \rightarrow \infty} X^l = [0]_{n \times n},$$

Its can be obtained by $T = X + X^1 + X^2 + X^3 + \cdots + X^m = X(I - X)^{-1}$.

Where I represents the unit matrix. The fifth step is to obtain prominence and relation. To sum of each row and column of the total effect matrix $T=[t_{ij}]$. Its will obtain the sum of all rows d and the sum of all columns r . If d_i represents the sum of all rows of the total effect matrix T , meaning directly or indirectly affects degree; r_j represents the sum of all columns of the total effect matrix T , meaning affected by other criteria. d_i represents the factor which will affect other factors, r_j represents the factor that is affected by other factors. According to the definition, d_i+r_j presents the degree of relationship between factors, meaning “prominence”; d_i-r_j presents the degree of effect and effected for the facto, meaning “relation” (Tamura et al., 2002; Tzeng et al., 2007).

IV. APPLICATION OF THE PROPOSED FRAMEWOR

The standardized project management system model aims to optimize the interface and standardization. It will survey research projects in the EU funded 6'h Framework Programmed (FP6) for standards related output, and serve as a platform to those projects seeking a cost-effective interface with standards bodies. In doing so, it will help projects upgrading their output and speed up market adoption of research results. Also, COPRAS will produce generic guidelines, supporting future research projects to build an interface to standardizations into their proposals, already at an early stage. In doing so, it will bring research and standardization closer together (Brusse & Wenning, 2005).

In this study will be exploring the quality assessment for SPM system within the case study of company X. We will consider standardized project management system model on purpose to constructing the mutual maneuverability and duplication in different projects.

A. DEMATEL to develop network relationship

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In this paper, we have confirmed FUZZY DEMATEL decision-making structure, and also analyzed five dimensions with seventeen criteria of the SPM system. According to the expert questionnaires, we obtain the total effect matrix T of SPM system's dimensions and criteria as shown in TABLE II. to TABLE III. We can find the cognition and opinion of experts in five dimensions and the relationship among the extents of the impact can be found which is compared to other dimensions as show in TABLE II. .

According to the prominence ($r + d$), the dimension B (people) is the highest impact of the strength of relation which means the most important influencing factors; in addition, the dimension E (resource) are all the factors that affect the least degree of other factors.

According to the relation ($r - d$), we also can find the dimensions A (strategy) and B (people) both are the highest

degree of impact relationship that affect other factors directly. They also have the interact characteristics. Otherwise, dimension C (tool) is the most vulnerable to impact that compare with other dimensions.

According to TABLE III. We can obtain all the criteria of the impact of relations with each factor. Furthermore, we also find in TABLE III. Which illustrates the criterion a_1 (project management strategy) is the highest degree of impact relationship in all the criteria. Otherwise, the criterion b_2 (project culture) is the most vulnerable to impact of criteria that compare with other criteria.

B. Identify the Headings

They show the relationship of each dimension and criterion. According to Fuzzy DEMATEL model that it indicates the dimension A (strategy) is the main influence of all dimensions. A project must give a clear definition of its goals in strategy. This step is constructing the SPM of the first importance. In the other hand, the tool in the SPM model is influenced by other dimensions. It is shows that through a complete strategy can use the right people in the right position. And then, the project usually constrained by lack of resource so a good strategy can allocate well of limed resource.

Consequently, the allocation not only influences the project process but also tool in a project. And then, people need training by company strategy to operation tools. To sum up, the company's strategy is the critical factor of constructing SPM system structure model. See following Figure 2, Tables II and III.

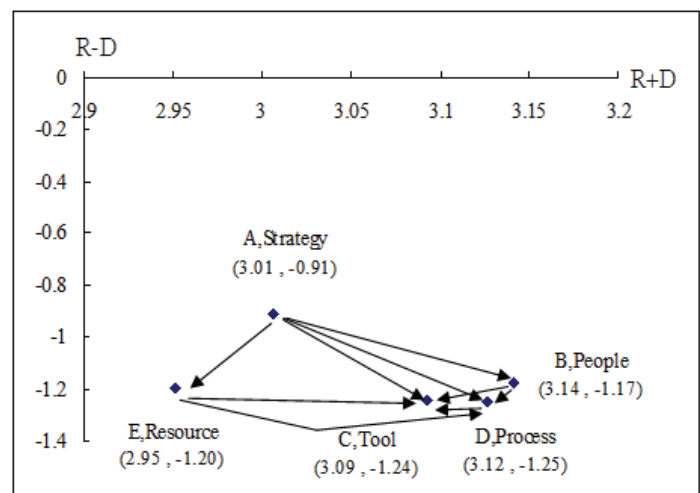


Figure 2. Influence map of total relationship of a standardized project management system model.

TABLE II. THE TOTAL EFFECT MATRIX OF T AND SUM OF EFFECTS ON DIMENSIONS

Dimensions	A	B	C	D	E	r	d	r+d	r-d
A	0.29	0.33	0.33	0.33	0.31	1.59	1.41	3.01	0.18
B	0.29	0.31	0.32	0.33	0.31	1.57	1.57	3.14	0.00
C	0.28	0.31	0.30	0.32	0.30	1.52	1.58	3.09	-0.06
D	0.29	0.32	0.32	0.31	0.30	1.53	1.59	3.13	-0.06
E	0.27	0.30	0.30	0.31	0.28	1.45	1.50	2.95	-0.05

TABLE III. THE FUZZY WITH DEMATEL MATRIX FOR CRITERIA

Criteria	a_1	a_2	a_3	b_1	b_2	b_3	c_1	c_2	c_3	c_4	d_1	d_2	d_3	d_4	e_1	e_2	e_3
a_1	0.28	0.32	0.31	0.33	0.37	0.33	0.35	0.33	0.36	0.36	0.35	0.35	0.36	0.36	0.32	0.30	0.35
a_2	0.30	0.25	0.29	0.31	0.34	0.31	0.32	0.30	0.32	0.33	0.32	0.32	0.33	0.34	0.30	0.29	0.33
a_3	0.30	0.29	0.24	0.31	0.34	0.31	0.33	0.30	0.32	0.33	0.33	0.32	0.32	0.33	0.29	0.30	0.33
b_1	0.32	0.31	0.28	0.28	0.36	0.32	0.33	0.32	0.35	0.35	0.35	0.33	0.35	0.34	0.31	0.30	0.35
b_2	0.29	0.29	0.28	0.31	0.29	0.31	0.32	0.29	0.33	0.32	0.33	0.32	0.33	0.33	0.29	0.29	0.33
b_3	0.30	0.30	0.28	0.32	0.34	0.27	0.32	0.30	0.33	0.33	0.32	0.32	0.32	0.33	0.30	0.29	0.34
c_1	0.29	0.28	0.26	0.30	0.32	0.29	0.27	0.28	0.32	0.31	0.30	0.29	0.31	0.31	0.28	0.27	0.31
c_2	0.27	0.27	0.26	0.29	0.31	0.30	0.31	0.25	0.31	0.30	0.30	0.30	0.31	0.30	0.28	0.28	0.31
c_3	0.30	0.30	0.29	0.32	0.35	0.32	0.33	0.32	0.29	0.33	0.33	0.32	0.34	0.33	0.31	0.30	0.34
c_4	0.30	0.29	0.28	0.32	0.34	0.31	0.33	0.30	0.32	0.29	0.33	0.32	0.33	0.34	0.30	0.29	0.34
d_1	0.29	0.28	0.27	0.31	0.33	0.31	0.31	0.29	0.32	0.32	0.27	0.31	0.32	0.33	0.27	0.29	0.33
d_2	0.31	0.30	0.28	0.33	0.35	0.32	0.33	0.32	0.34	0.33	0.32	0.28	0.34	0.34	0.30	0.29	0.34
d_3	0.30	0.29	0.28	0.30	0.34	0.31	0.32	0.30	0.33	0.32	0.32	0.31	0.28	0.31	0.29	0.29	0.32
d_4	0.29	0.28	0.26	0.30	0.33	0.30	0.32	0.30	0.32	0.31	0.31	0.30	0.31	0.27	0.28	0.28	0.32
e_1	0.27	0.26	0.25	0.28	0.30	0.29	0.30	0.27	0.32	0.30	0.31	0.29	0.29	0.30	0.24	0.27	0.31
e_2	0.26	0.25	0.25	0.28	0.29	0.26	0.28	0.27	0.30	0.29	0.30	0.28	0.28	0.29	0.27	0.23	0.30
e_3	0.30	0.29	0.29	0.32	0.34	0.31	0.32	0.31	0.33	0.33	0.33	0.33	0.34	0.34	0.30	0.28	0.29

C. Influence map of each dimension

In the strategy dimension, the criterion a_1 (project management strategy) is the most critical influence of the Figure 3.

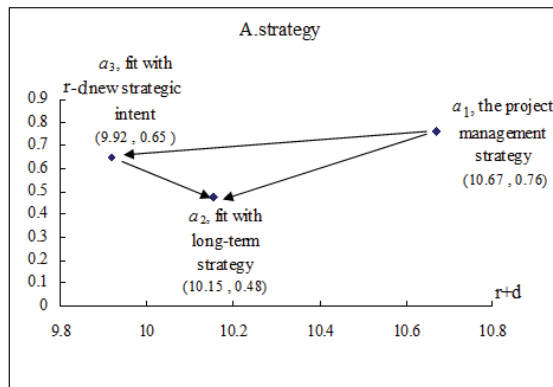


Figure 3. Influence map of strategy relationship.

In the people dimension, the criterion b_1 (project organization) is the most critical influencing factor. In a project which it has an excellent team-work to finishing the goal as soon as possible. Furthermore, the b_2 (project culture) and b_3

(project leadership) are influenced by the b_1 (project organization).

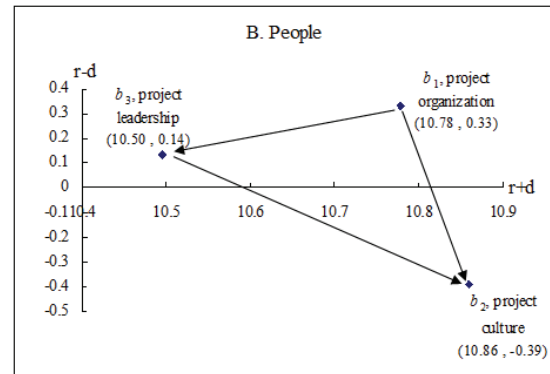


Figure 4. Influence map of people relationship.

The factor c_4 (information management system) is the influence of the tool dimension. In this study, we obtain that a project need a good communicate system with each team number to makesure their schedule every week.

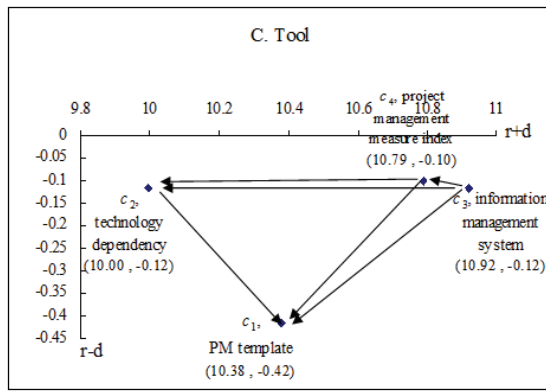


Figure 5. Influence map of tool relationship.

The factor d_2 (project methodologies) is the main influence in the dimension D “process”. In this study, we obtain that a methodology made a great impact on the project process.

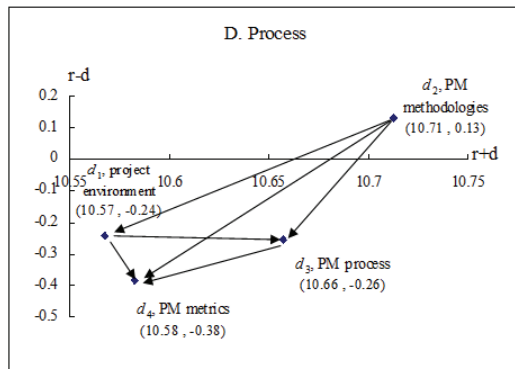


Figure 6. Influence map of process relationship.

Finally, a company always supplies a limited cost to development a project in practice. In the resource dimension, we also obtain the critical factor cost/expenses (e_1). Consequently, it is more or less of a company’s budget which impacts the project with support of facility (e_2) and support of employee (e_3).

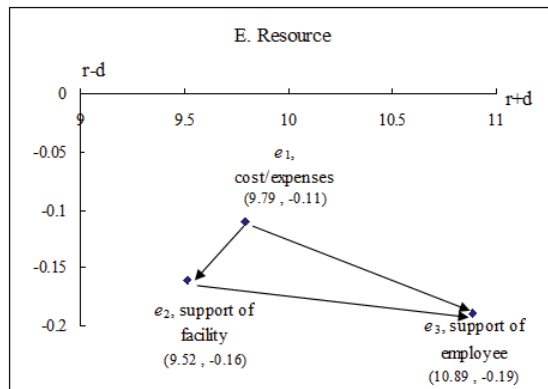


Figure 7. Influence map of resource relationship.

V. RESULTS AND DISCUSSIONS

In this paper, we use FUZZY DEMATEL to develop network relationship. According to the results of empirical analysis and the literature review to the past research, the study illustrates that shows dimension A (Strategy) is the critical and dimension C (Tool) is ultimate influenced dimension in the

standardized project management system, hence we can start improvement company total performance from company’s strategy. Because of that the “Process” and “Tools” will be promoted to high level. And then, the Tools not only easy to using by people but also the resource are allocated efficiently. In order to achieving company’s target it need change and improve all of dimensions from top to bottom.

In this paper, we find that dimensions of “Strategy”, “People” and “Resource” are the critical factors for total performance evaluate of constructing standardized project management system. According to the empirical analysis, we have used DEMATEL to construct the standardized project management model especially for new product development projects. We also obtains that the dimension A “Strategy” is the main index in constructing the SPM system. The results from this study provide a project management team a guidance to satisfy the company’s purpose and create the value of sustainable business.

The company must state that new product development and opportunity generation are the business. Not only remove barriers to the generation of new ideas and provide a system of information and feedback on current products and services but also create a positive, perhaps virtual place for new ideas to incubate. To generate a flexible process of filtering, evaluating and transitioning new ideas into a portfolio and new product development process and manage and control new product development and marketing. Then, real success stories are created to demonstrate that new ideas can produce products that grow the business.

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