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A Study on Competence Sets Expansion Facing on Engineering Management Decision

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Abstract
Engineering management decision making is a complicated system problem whose traits are multiple persons and multiple objective. There are much uncertain influence factors during its decision making process which requires decision-makers and participants expanding their competence set. Competence set expansion refers to decision-makers and participants to make decision of expanding from the obtained competence set to the required one of resolving problem on a particular issue in a limited time. This paper establishes the multiple persons and multiple objective competences set expansion model combining with the traits of engineering management decision making, it can lay a necessary theoretical foundation of research on engineering management decision making and analysis problem.

Key words: Decision model; Multi-person and multi-objective; Competence set expansion

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INTRODUCTION

Any country, in the process of developing the national economy and carrying on the modernization, all must construct certain important engineering projects, then can constitute the independence, the integrity national economic system. Like US "Star War" plan, England and France "Cross-harbor Tunnel" project, Japan "Human New Domain" plan and so on. China is not exceptional, Daqing petrifies, the Baoshan Steel Corporation constructs, and Three Gorges Project and so on, all of them has pivotal function to national economy development.

Any engineering, speaking of its construction engineering consequence, either has the positive impetus function to rapid development of the national economy, or causes the national economy development to have "the baggage", that make the engineering management decision-making question be very important (WU, 2003). Many engineers, because of co tempting the preliminary decision-making activity, have created serious bad consequence (CAO & XIN, 2012). The key question cannot belong to the work quality of the implement link during the engineering construction time, what is more important, many engineering management decision-making lack the systematic characteristic, essentially, lack the scientific decision-making to take the safeguard, all those make these engineering have the flaw which is congenitally deficient when setting up the item (YANG & MA, 2011).

In engineering management decision-making process, engineering's scale is big, so that the decision-making is extremely complex; the engineering influence factor is multitudinous, so the decision-making have to depend upon the multi-disciplinary theory to carry on the analysis; the engineering management involves multitudinous department, so the decision-making have to depend upon the community competence to carry on (YU & CHEN, 2010). These multitudinous influent factors request that decision-makers and participants expand their competence set during engineering management decision-making (LIN, 2006). But the research on engineering management decision-making question not only is the method research but also needs to set up the scientific idea, under this

instruction; we should establish the reasonable competence set expansion decision-making mechanism (FENG & YU, 1998; FENG, 1999; Shee, 2006).

From the decision-making unit angle, the engineering management decision-making must have the various experts of the industry development environment, technique, market, finance, the ecological environment and the talented person competence cultivation and so on to participate in the decision-making, sometimes also needs to establish a total decision-making brain trust, all these obviously have the multi-people decision-making and community decision-making's characteristic. Speaking of the general conventional management, it can take the long-term economic efficiency as the pursuing basic goal and realizes other benefits as the definition condition or the attached goal. The engineering management can not be sole goal decision-making. The decision-making total goal is the system overall optimal. The overall goal is composed of the society, the economy, politics, the technology, the ecology, the talented person competence and so on many other big goals, and each big goal is composed of many small goals, each small goal is divided into many sub-targets until using some kind of criterion to weigh. The total goal – big goal – small goal – sub-target – criterion level form the multi-target system which is the handed over step structure. The engineering management decision-making question has the very strong fuzziness and uncertainty, and is a kind of extremely complex non-structure decision-making question. How to grasp in these complex changeable influence factors which influence the engineering management decision-making and then providing the basis for the correct science management decision-making is the urgent need of the engineering management domain in the theory and the practice development.

1. COMPETENCE SET AND ITS EXPANSION

The earliest thought and the work of studying the decision-making question based on competence set analysis (Competence Set Analysis, i.e. CSA) or studying competence set analysis question facing on the decision-making question stems from that management science outstanding Professor Po-Lung YU (doctor) working in Business school, US University of Kansas researched on the habitual domain 1980s (YU & CHEN, 2010a, 2010b). The habitual domain main idea is that each person cerebrum codes, storage knowledge, experience, thought, method, skill as well as each kind of information and so on, after passing through the suitable time, if they do not have big event's stimulation, do not have complete information entry, will be at the relative stabilization condition (YU & CHEN, 2010b, 2010c). As soon as the thought or the idea (cerebrum code, storage and so on) is stably, the response to the human, to the matter, to the question and to the information, including the cognition, the understanding, the judgment, the procedure and so on, has one kind of habitual, i.e. has the quite fixed method and the convention either or called the pattern or the scheme. These habitual view, procedure and behavior, are the habitual domain's concrete manifestations.

After the habitual domain theory proposed, it has caused various countries management educational world, the behavior educational world and the enterprise organization's enormous interest, and rapidly has launched the related question research around the world; competence set analysis research is the most active content. Now, competence set analysis has already developed into an independent research area, competence set analysis application scope is very broad, including enterprise, engineering management, interpersonal relationship and daily life.

1.1 Competence Set's Boundary

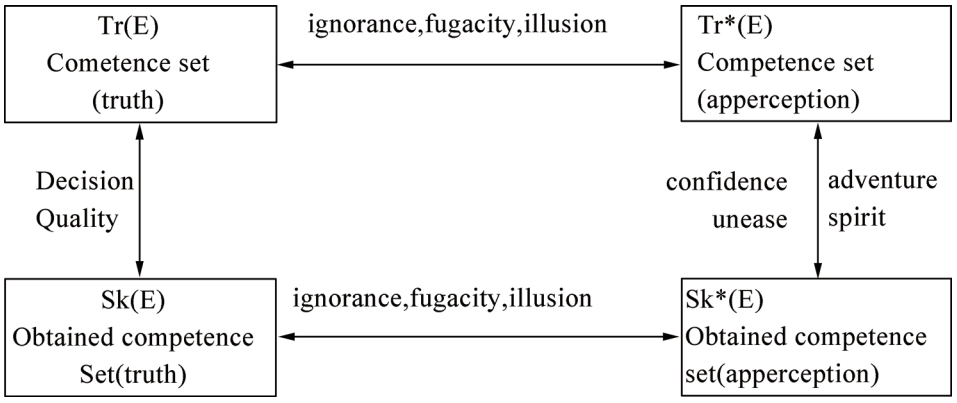

Figure 1
Competence Set and the Constitution Diagram

Regarding competence set, YU (1991) and FENG (2001) believed that is the knowledge, the information, the skill in order to obtain one key or key set of one or a set of question. Competence set contains four basic concepts (Figure 1).

Among them, E expresses some decision-making question, Tr (E) indicates the actual requisite competence set of resolving the question (the actual requisite thought, skill and so on for resolving question E), Tr* (E) expresses the competence set that should be possessed if decision-maker wants to successfully resolve problem, Sk (E) expresses obtained the competence set that decision-maker have had in fact, Sk* (E) expresses the competence set which decision-maker have recognized and obtained.

1.2 Boundary of Competence Set Expansion

The competence set analysis goal lies in defining the actual requisite competence set, and the competence set is actually possessed by decision-maker, that helps the decision-maker effectively to expand own competence set to favor the decision-making. Here, expansion of competence set refers to decision-makers making decisions of expanding from the obtained competence set to the required one of resolving problem on a particular issue in a limited time.

The research on competence set is an extremely active domain in personal habitual domain (PHD), its research has provided mathematics method for the PHD quantitative investigation. Like early YU and ZHANG got the competence set's minimum cost expansion process by the Next-best method; LI and YU resolved it using the deduction graph by 0-1 Integer Programming, and discovered the optimal competence set expansion process; FENG's table method and so on, these researches mainly concentrated the competence set expansion aspect, and made qualitative analysis to personal, single objective decision of competence.

YU and ZHANG introduced the conception of competence set expansion based on the minimum cost. If the needed is only the cost, we can develop the algorithm using Next-best to find the minimum cost expansion process. But, besides the cost, the income still must be taken into the consideration, so the net income can decide the true optimal expansion process. YU and ZHANG compared the cost with the income of competence set expansion process, and then decided whether to be worth expanding.

If Tr (E) and Sk (E) are regarded as fuzzy set, the subordinate function can express the relations. Because of uncertainty of actual decision-making question, competence set can be divided into several stochastic sets to discuss. YU and ZHANG discovered the optimal expansion process using expansion process expectation reward and the union expansion cost way. SHI and YU promoted YU and ZHANG the early Next-best method the situation in which the asymmetrical cost expanded, and proposed the minimal tree expansion process which still used the Integer Programming method, but greatly enhanced the expansion method serviceability.

2. MULTI-PEOPLE AND MULTI-GOALS DECISION-MAKING MODEL

E is the engineering management decision-making question equipped with the multi-people's competence set and many actual requisite competence sets, HD is the habitual domain of the skill, the knowledge and the experience related with the decision-making question E. After the project is chosen and the scale is determined, the manager provides m actual requisite competence sets to compose the engineering management actual requisite set $Tr(E) = \{Tr_1(E), Tr_2(E),\cdots, Tr_m(E)\}$, $Tr_i(E) = \{Tr_{i1}(E), Tr_{i2}(E)\cdots, Tr_{ij}(E),\cdots\}$, $Tr_i(E) \in HD$, $i = 1, 2,\cdots, m$.

Because the engineering management receives the influence of the stochastic uncertain element, there objectively are the many kinds of conditions, and different actual requisite competence set facing the future condition will possibly be different, so the decision-maker will rest on own obtained competence set to expand to the engineering management actual requisite set $Tr(E)$; $Tr_1(E) \cup Tr_2(E) \cup \cdots \cup Tr_m(E) = \{a_1, a_2,\cdots, a_j,\cdots\}$, $Sk_1(E) \cup Sk_2(E) \cup \cdots \cup Sk_n(E) = \{x_1, x_2,\cdots, x_i,\cdots\}$.

$m(a,b)$ is the needed expense of expansion between various competence in actual requisite set $Tr(E)$, m is the expense function. Getting the competence training and expansion expense through market investigation, also determining the needed expense of expansion between various competences by arriving the consultant firm to carry on consults, A expresses the obtained expense matrix $\{a_{ij}\}$ between various competences.

$$A = \begin{array}{c} \\ a_1 \\ a_2 \\ \vdots \\ a_i \\ \vdots \end{array} \begin{array}{c} \begin{array}{ccccc} a_1 & a_2 & \cdots & a_j & \cdots \end{array} \\ \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} & \cdots \\ a_{21} & a_{22} & \cdots & a_{2j} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix} \end{array} \tag{1}$$

From obtained competence set $Sk_i(E)$ to actual requisite competence set $Tr_j(E)$, the least expense expansion process has recorded as Ψ, $C_{ij}(\Psi)$ is the least expense, $C = \{C_{ij}(\Psi)\}$ expresses all least expenses set of expanding from obtained competence set $Sk_i(E)$ to actual requisite competence set $Tr_j(E)$:

$$C = \{C_{ij}(\Psi)\} \begin{array}{c} \\ Sk_1 \\ Sk_2 \\ \vdots \\ Sk_n \end{array} \begin{array}{c} \begin{array}{ccccc} Tr_1 & Tr_2 & Tr_3 & \cdots & Tr_m \end{array} \\ \begin{bmatrix} C_{11} & C_{12} & C_{13} & \cdots & C_{1m} \\ C_{21} & C_{22} & C_{23} & \cdots & C_{2m} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ C_{n1} & C_{n2} & C_{n3} & \cdots & C_{nm} \end{bmatrix} \end{array} \tag{2}$$

Computation step:

Step 1 Using expansion method, getting the least expense expansion process and the least expansion expense $C_{1j}(\Psi)$, j = 1, 2,⋯, m of expanding from $Sk_1(E)$ to various set of $Tr_j(E)$

The optimal expansion process $\Psi_{1j}=\{y_{k_1}, y_{k_2},\cdots, y_{k_n}\}$ is got as following method,

$y_{k_i}\in Tr_j(E)\setminus[Sk_1(E)\bigcup\{(y_{k_1}, y_{k_2},\cdots, y_{k_n})\}]$, we also make the ith step expansion be least:

$$M(Sk_1(E)\bigcup\{y_{k_1}, y_{k_2},\cdots, y_{k_{i-1}}\}, y_{k_i})=$$
$$\min\{M(Sk_1(E)\bigcup\{y_{k_1}, y_{k_2},\cdots, y_{k_{i-1}}\}, y)$$
$$\left|y\in Tr_j(E)\setminus((Sk_1(E)\bigcup\{y_{k_1}, y_{k_2},\cdots, y_{k_{i-1}}\})\right\}, \ i=1,2,\cdots,n \quad (3)$$

$$M(A,x)=\min\{m(s,x)\,|\,s\in A\}, \text{ for arbitrary } A\subseteq HD. \quad (4)$$

$M(A,x)$ is the expense of expanding from the obtained competence set A to competence x, m is the expense function between the element.

Step 2 using the same method, getting the least expense expansion process and the least expansion expense $C_{ij}(\Psi)$, j =1, 2,…, m of expanding from $Sk_i(E)$ to various set of $Tr_j(E)$

Step 3 getting the decision-making plan using 0-1 integer programming

Let z_{ij} is 1, when ith obtained competence set is chosen to expand to jth actual requisite competence set, or 0, when ith obtained competence set is not chosen to expand to jth actual requisite competence set.

Then the least expense question, selecting m from n obtained competence set $Sk_i(E)$ to expand to actual requisite competence set $Tr_j(E)$, becomes the following 0-1 integer programming question.

$$\min C=\sum_{i=1}^{n}\sum_{j=1}^{m}C_{ij}(\Psi)z_{ij}$$
$$\text{s.t.}\quad \sum_{i=1}^{n}z_{ij}=1 \quad (5)$$

z_{ij}=1, when ith obtained competence set is chosen to expand to jth actual requisite competence set;

z_{ij}=0, when ith obtained competence set is not chosen to expand to jth actual requisite competence set.

3. THE APPLICATION OF MODEL

Some an important engineering needs cultivate four high-grade managers to act as α, β, γ, δ four departments' officers, α is the engineering investigation and development department, β is the engineering quality examine department, γ is the administration department, δ is the engineering superintendence department. Now, we have known that the habitual domain of being competent for these four department managers {*a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, *L*, *m*, *n*, *r*}.

Table 1
The Requisite Cost Between Competence (Table Is Symmetrical)

	a	b	c	d	e	f	g	h	i	k	L	m	n	r
a	0	9	6	4	3	5	2	7	12	8	7	18	13	20
b		0	2	3	4	8	1	9	10	11	13	15	12	14
c			0	10	8	7	4	13	9	6	5	17	15	10
d				0	2	5	7	9	6	10	8	20	5	17
e					0	4	5	6	8	12	9	20	7	15
f						0	3	4	6	13	10	25	9	13
g							0	6	7	9	11	23	10	18
h								0	5	8	9	19	6	12
i									0	4	3	12	8	13
k										0	2	15	9	20
L											0	16	10	16
m												0	14	9
n													0	25
r														0

Note: unit is ten thousand yuan

a is target direction competence, *b* is decision competence, *c* is creativity, *d* is authorization competence, *e* is organization competence, *f* is harmony competence, *g* is the competence of meeting an emergency, *h* is negotiation competence, *i* is sociality competence, *k* is investigation and development competence, *L* is market information, *m* is work competence, *n* is language, *r* is technology experience. The actual requisite competence sets of these four department managers separately are Tr_α = {*a*, *b*, *c*, *d*, *e*, *f*, *L*, *m*}, Tr_β = {*a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *k*, *L*, *r*}, Tr_γ = {*a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*, *n*, *r*}, Tr_δ = {*b*, *d*, *e*, *f*, *h*, *L*, *m*, *r*, *i*}, and the expansion cost between competences as follows table. Now, there are 甲、乙、丙、丁、戊

five manager candidates, four of them will be chosen as department managers of these four departments, who are? Which department can make the cultivate cost minimum?

We have known that the obtained competence set of them separately are $Sk_{甲} = \{a, b, c, e, f, m, n\}$, $Sk_{乙} = \{a, b, c, d, i, k, m\}$, $Sk_{丙} = \{a, b, d, g, i, r\}$, $Sk_{丁} = \{a, b, d, L, m, r\}$, $Sk_{戊} = \{b, c, e, g, h, k\}$. Obviously, we can know that their obtained competence sets do not include the actual requisite competence sets of these four department managers, so, as soon as they are chosen and department is appointed, they must take in training to expand their competence sets to respective department's actual requisite competence set, so that can be competent for manager.

Answer:

(1) We can get the expansion process and minimum expansion cost of expanding from $Sk_{甲}$ to each actual requisite competence set in Tr by using expansion method.

① Expansion cost function $M(Sk, x)$ of expanding from $Sk_{甲}$ to Tr_{α}, as follows

x	d	L	
M(Sk, x)	2	5	$x_1 = d, C_1(Y) = 2$

x		L	
M(Sk $\cup${d}, x)		5	$x_2 = L, C_2(Y) = 5$

So, the minimum cost expansion process Ψ of expanding from $Sk_{甲}$ to Tr_{α} is (d, L), the minimum expansion cost TC is $2 + 5 = 7$.

② The method of expanding from $Sk_{甲}$ to Tr_{β} likes above

the minimum cost expansion process Ψ is (g, d, h, i, L, k),

the minimum expansion cost TC is $1 + 2 + 4 + 5 + 3 + 2 + 9 = 26$.

③ The method of expanding from $Sk_{甲}$ to Tr_{γ} likes above

the minimum cost expansion process Ψ is (g, d, h, i, n, r),

the minimum expansion cost TC is $1 + 2 + 4 + 5 + 5 + 7 = 24$.

④ The method of expanding from $Sk_{甲}$ to Tr_{δ} likes above

the minimum cost expansion process Ψ is (g, d, L, i, r),

the minimum expansion cost TC is $1 + 2 + 5 + 3 + 8 = 20$.

(2) Using the same expansion method, we can get the minimum cost expansion process and the minimum expansion cost of expanding from $Sk_{乙}$、$Sk_{丙}$、$Sk_{丁}$、$Sk_{戊}$ to each actual requisite competence set in Tr:

① expanding from $Sk_{乙}$ to each actual requisite competence set

Tr_{α}: the minimum cost expansion process Ψ is (e, L, f),

the minimum expansion cost TC is $2 + 2 + 4 = 8$;

Tr_{β}: the minimum cost expansion process Ψ is (g, e, L, f, h),

the minimum expansion cost TC is $1 + 2 + 2 + 3 + 4 = 12$;

Tr_{γ}: the minimum cost expansion process Ψ is (g, e, f, h, n, r),

the minimum expansion cost TC is $1 + 2 + 3 + 4 + 5 + 9 = 24$;

Tr_{δ}: the minimum cost expansion process Ψ is (g, e, L, f, r),

the minimum expansion cost TC is $1 + 2 + 2 + 3 + 9 = 17$.

② expanding from $Sk_{丙}$ to each actual requisite competence set

Tr_{α}: the minimum cost expansion process Ψ is (c, e, f, L, m),

the minimum expansion cost TC is $2 + 2 + 3 + 3 + 9 = 19$;

Tr_{β}: the minimum cost expansion process Ψ is (e, f, L, k, h),

the minimum expansion cost TC is $2 + 3 + 4 + 5 = 14$;

Tr_{γ}: the minimum cost expansion process Ψ is (e, f, h, n),

the minimum expansion cost TC is $2 + 3 + 4 + 5 = 14$;

Tr_{δ}: the minimum cost expansion process Ψ is (e, f, L, m),

the minimum expansion cost TC is $1 + 2 + 2 + 3 + 9 = 17$.

③ expanding from $Sk_{丁}$ to each actual requisite competence set

Tr_{α}: the minimum cost expansion process Ψ is (c, e, f),

the minimum expansion cost TC is $2 + 2 + 4 = 8$;

Tr_{β}: the minimum cost expansion process Ψ is (g, e, k, i, f, h),

the minimum expansion cost TC is $1 + 2 + 2 + 3 + 3 + 4 = 15$;

Tr_{γ}: the minimum cost expansion process Ψ is (g, e, i, f, h, n),

the minimum expansion cost TC is $1 + 2 + 3 + 3 + 4 + 5 = 18$;

Tr_{δ}: the minimum cost expansion process Ψ is (g, e, i, f),

the minimum expansion cost TC is $1 + 2 + 3 + 3 = 9$.

④ expanding from $Sk_{戊}$ to each actual requisite competence set

Tr_{α}: the minimum cost expansion process Ψ is (d, L, a, m),

the minimum expansion cost TC is $2 + 2 + 3 + 15 = 22$;

Tr_{β}: the minimum cost expansion process Ψ is (g, d, L, a, i, r),

the minimum expansion cost TC is $1 + 2 + 2 + 2 + 3 + 10 = 20$;

Tr_{γ}: the minimum cost expansion process Ψ is (g, d, a, i, n, r),

the minimum expansion cost TC is $1 + 2 + 2 + 4 + 5 + 10 = 24$;

Tr_{δ}: the minimum cost expansion process Ψ is (g, d, L, i, r, m),

the minimum expansion cost TC is $1 + 2 + 2 + 3 + 10 + 12 = 30$.

So, according to above, the minimum expansion cost matrix is

$$\begin{array}{c} \\ 甲 \\ 乙 \\ 丙 \\ 丁 \\ 戊 \end{array}\begin{array}{c} \begin{array}{cccc} Tr_\alpha & Tr_\beta & Tr_\gamma & Tr_\delta \end{array} \\ \begin{bmatrix} 7 & 26 & 24 & 20 \\ 8 & 12 & 24 & 17 \\ 19 & 14 & 14 & 17 \\ 8 & 15 & 18 & 9 \\ 22 & 20 & 24 & 30 \end{bmatrix} \end{array}$$

(3) Seeking decision answer by 0-1 Integer Programming

Let y_{ij} is 1, when the ith candidate is chosen as manager of the jth department, or 0, when the ith candidate is not chosen as manager of the jth department. So,

$$\begin{aligned} MinC &= 7y_{11} + 26y_{12} + 24y_{13} + 20y_{14} + 8y_{21} \\ &+ 12y_{22} + 24y_{23} + 17y_{24} + 19y_{31} + 14y_{32} + 14y_{33} \\ &+ 17y_{34} + 8y_{41} + 15y_{42} + 18y_{43} + 9y_{44} + 22y_{51} \\ &+ 20y_{52} + 24y_{53} + 30y_{54} \end{aligned}$$

$$\text{S.t.} \quad \begin{aligned} y_{11} + y_{21} + y_{31} + y_{41} + y_{51} &= 1 \\ y_{12} + y_{22} + y_{32} + y_{42} + y_{52} &= 1 \\ y_{13} + y_{23} + y_{33} + y_{43} + y_{53} &= 1 \\ y_{14} + y_{24} + y_{34} + y_{44} + y_{54} &= 1 \\ y_{ij} &= 0 \text{ or } 1 \end{aligned}$$

Answer: $y_{11} = y_{22} = y_{33} = y_{44} = 1$

So, 甲 is chosen as manager of engineering investigation and development department, the cost is 7, the process is (*d*, *L*); 乙 is chosen as manager of engineering quality examine department, the cost is 12, the process is (*g*, *e*, *L*, *f*, *h*); 丙 is chosen as manager of administration department, the cost is 14, the process is (*e*, *f*, *h*, *n*); 丁 is chosen as manager of engineering superintendence department, the cost is 9, the process is (*g*, *e*, *i*, *f*).

4. CONCLUDING REMARK

In view of the engineering management decision system multi-people and multi-goal's characteristics, based on the competence set idea, utilizing programming thought, which make decision-makers effectively resolve many decision-making main bodies or departments' benefit conflict in the engineering management decision-making process, through unceasingly expanding their obtained competence set to the actual requisite competence set of engineering management and unceasingly improving engineering management decision-making goal as well as the restraint condition scope. We have established the multi-people and multi-goal's competence set expansion decision-making model in view of the engineering management decision-making, which provides the effective decision-making support for the engineering management decision-making.

REFERENCES

[1] CAO, S. Q., & XIN, X. F. (2012). Analysis on Teaching in Course of Architecture Structure of Engineering Management Major. *Engineering Education and Management*, *11*(1), 171-174.

[2] FENG, J. W., & YU, P. L. (1998). Minimum Spanning Table and Optimal Expansion of Competence Sets. *Journal of Optimization Theory and Applications*, *99*(3), 310-325.

[3] FENG, J. W. (1999). Competence Set Analysis. *Journal of Management Sciences in China*, *2*(2), 77-83.

[4] FENG, J. W. (2001). Organization Habitual Domains Theory. *Systems Engineering and Electronics*, *23*(6), 40-43.

[5] LIN, C. M. (2006). Multiobjective Fuzzy Competence Set Expansion Problem by Multistate Decision-Based Hybrid Genetic Algorithms. *Applied Mathematics and Computation*, *181*(10), 1402-1516.

[6] Shee, Daniel Y. (2006). An Analytic Framework for Competence Set Expansion: Lessons Learned from an SME. *Total Quality Management & Business Excellence*, *17*(8), 981-997.

[7] WU, J. W. (2003). Engineering Construction Project Investment Management and Decision-Making Analysis. *Construction and Design for Project*, *23*(4), 29-31.

[8] YANG, Y. H., & MA, Y. (2011). Study on Project Contract Management Practice in Manufacturing Engineering. *Advanced Material Research*, *3*(23), 239-241.

[9] YU, P. L. (1991). Habitual Domains. *Operations Research*, *10*(6), 869-876.

[10] YU, P. L., & CHEN, Y. C. (2010a). Dynamic Multiple Criteria Decision Making in Changeable Spaces: From Habitual Domains to Innovation Dynamics. *Annals of Operations Research*, *10*(5), 1-20.

[11] YU, P. L., & CHEN, Y. C. (2010b). Blinds, Fuzziness and Habitual Domain Tools in Decision Making with Changeable Spaces. *Human Systems Management*, *29*(4), 231-242.

[12] YU, P. L., & CHEN, Y. C. (2010c). Dynamic MCDM, Habitual Domain and Competence Set Analysis for Effective Decision Making in Changeable Space. *International Series in Operations Research & Management Science*, *14*(2), 1-35.