Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 13 (8): 1392-1396, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.1392.1396

Dynamic Comprehensive Evaluation of Knowledge Innovation Capability of Enterprises

[1]Weiwei Liu and [1,2]Kexin Bi
[1]School of Economics and Management, Harbin Engineering University, Harbin, China
[2]School of Management, Harbin University of Science and Technology, Harbin, China

Abstract: Knowledge Innovation Capability (KIC) is very crucial for enterprises. Therefore, evaluation method of KIC is a hot topic in recent years. Although dynamic comprehensive evaluation of KIC is urgently needed to develop, researches have rarely taken it into consideration. In order to grasp the whole situation of KIC in consecutive multi-periods, this study proposes a new research on dynamic comprehensive evaluation model of enterprises' KIC. First, based on the niche theory, KIC of enterprises consists of the niche-occupying capability, the niche-adapting capability and the niche-evolving capability. Each capability is further divided into more detailed elements and also an evaluation index system of KIC is proposed. Also, the proposed state evaluation model is used to describe KIC development state in a view of integration, while the trend evaluation model can represent KIC development trend by considering the change speed of KIC. Based on the above, a dynamic comprehensive evaluation model is constructed by syncretising KIC development state and trend. Moreover, a computing example is pulled into to illustrate the feasibility and availability of dynamic comprehensive evaluation model from the empirical perspective. This study is expected to be helpful for enterprises to evaluate their knowledge innovation capabilities from a dynamic perspective.

Key words: Dynamic comprehensive evaluation, knowledge innovation capability, the niche theory, the state, the trend

INTRODUCTION

As the core capability of enterprises, the level of Knowledge Innovation Capability (KIC) has become an important indicator to measure an enterprise's comprehensive strength.

At present, there are intensive studies on capability evaluation, but the concentration is more on static evaluation (Sun, 2010; Fan *et al*., 2009; Grafton *et al*., 2010) and fewer on dynamic evaluation. KIC development of enterprises is a continuous process with dynamic development and incessant improvement. The gaps of knowledge innovation capabilities gradually form, develop and expand over time, while some laps narrow and even disappear over time among different enterprises. Therefore, it is necessary to make a dynamic comprehensive evaluation for KIC of enterprises. As the niche theory is a great research achievement of ecological development, this study proposes a dynamic comprehensive evaluation model that integrates the state and the trend of KIC based on the niche ecostate-ecorole theory. Through dynamic comprehensive evaluation, overall development situation of KIC in different periods can be analyzed, which provides strategic choices for enterprises to recognize their development status, advantages and disadvantages, then to conduct characteristics construction and to cultivate and enhance their knowledge innovation niche. The method used in this study offers a valuable reference for enterprises to identify and evaluate the overall development trend of KIC and enhance it accordingly.

NICHE THEORY AND KIC EVALUATION OF ENTERPRISES

Principle of the niche theory: The niche ecostate-ecorole theory is one of the ecological theories which not only widely used in natural ecosystems, but also has an important implication for the social and economic ecosystem. The niche ecostate-ecorole theory describes that any biological unit has two properties-"ecostate" and "ecorole". The "ecostate" of the biological unit represents the accumulation consequences of growth, development, learning, socio-economical development and the interacting with surrounding environment in the past. The "ecorole" shows the present effects on the environments, such as the exchange rates of energy and substance, productivity, the rates of growth, economic development and expanding into new space etc (Chunquan, 1997; May, 1974). The niche is a description of the relative position and role which is formed by the interaction process between the organism units and the environment in a particular ecosystem and also a synthesis of the "ecostate" and "ecorole".

Corresponding Author: Weiwei Liu, School of Economics and Management, Harbin Engineering University, Harbin, China

A new interpretation of KIC based on niche theory: As a social and ecological system, the enterprise is an organic system composed of human beings with a certain ecological track that shows biological properties similar to natural species following the niche theory. Due to the strong abilities of thinking and choice selecting, the enterprise has the property combining the "ecostate" and the "ecorole".

From the above, according to the simulation based on the niche theory, KIC of enterprises is composed of the niche-occupying capability, the niche-adapting capability and the niche-evolving capability. As shown in Fig. 1, the niche-occupying capability is represented by C_O (the aspect of the "ecostate", NOC); the niche-adapting capability is represented by C_A (the aspect that combines the "ecostate" and the "ecorole", NAC); the niche-evolving capability is represented by C_E (the aspect of the "ecorole", NEC) and KIC-synthetical effects of C_O, C_A and C_E is represented by C. The intersection angle between C and CO is represented by α, the intersection angle between C and CA is represented by β, the intersection angle between C and CE is represented by γ.

Knowledge acquisition should be seen as a spiral of epistemological and ontological content that grows upward by transforming tacit knowledge into explicit knowledge, which in turn becomes the basis for a new spiral of knowledge generation (Cairo and Guardati, 2012). Organizational learning is regarded as the process of knowledge diffusion occurring in the internal organization and projection is regarded as the process of knowledge diffusion interacting with the external environment (Tsai, 2008). Knowledge integration is a fundamental process by which firms gain the benefits of knowledge and create competitive advantage (Yang, 2005). Knowledge sharing has implication for innovation capability and innovation performance of the firms (Yesil *et al*., 2013). Knowledge creation is the major resource of organizational innovation and it, therefore, plays a more crucial role in developing a sustained competitive advantage for organizations, especially in a dynamic environment (Huang, 2009; Esterhuizen *et al*., 2012).

On account of the previous KIC evaluation index system and analysis of the three capabilities above, the evaluation index system of KIC of enterprises is constructed based on the niche theory, which is shown in Fig. 2.

DYNAMIC COMPREHENSIVE EVALUATION MODEL OF KIC OF ENTERPRISES

Some achievements are made on dynamic evaluation (Guo, 2002; Fan and Wang, 2000; Xu and Da, 2003;

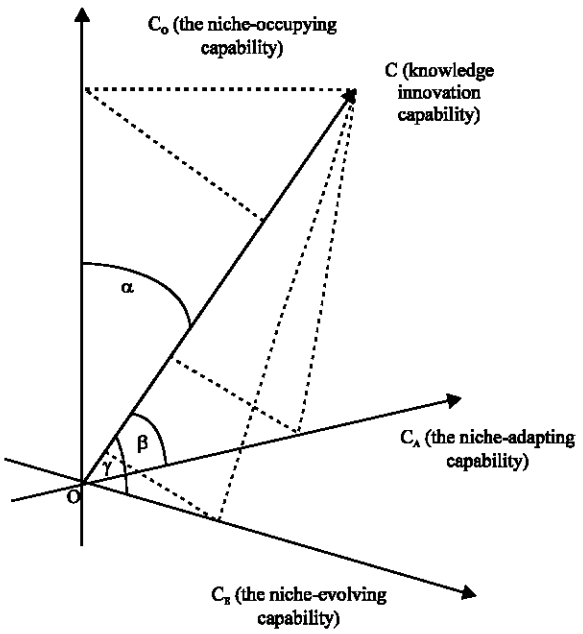

Fig. 1: A new interpretation of KIC: The composite force of NAC, NIC and NOC

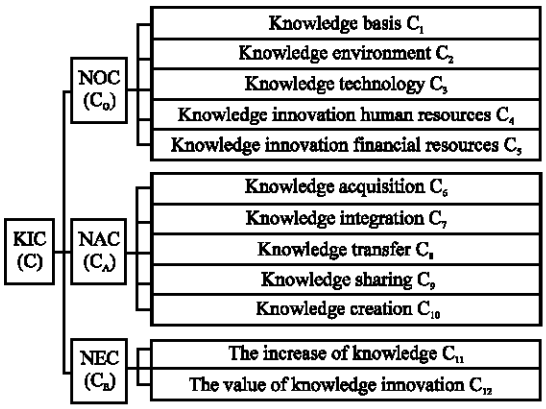

Fig. 2: Evaluation index system of KIC

Jin *et al*., 2004; Guo *et al*., 2007) which concentrate upon multi-period information integration. As KIC is changing and developing with time, dynamic comprehensive evaluation of KIC can be reflected synthetically by both considering the development state and trend of KIC. A dynamic comprehensive evaluation model which integrates the state and the trend of KIC is proposed.

KIC state evaluation model: In a certain interval, it is supposed that the KIC of enterprise i (S_i, i = 1, 2, …, m) changes equably. Figure 3 shows the information aggregation situation of KIC state in multi periods.

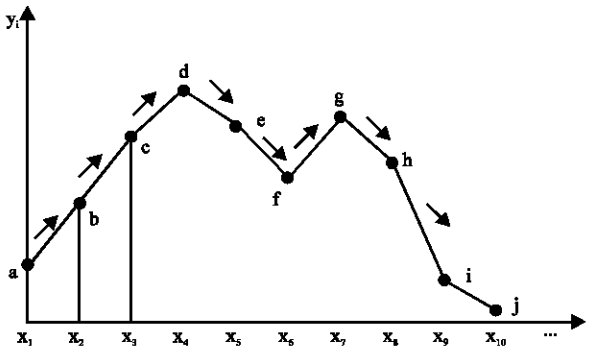

Fig. 3: Multi-periods information aggregation model of KIC state

By connecting KIC state values y_{ij} with $y_{i, j+1}$ which locate in two adjacent time intervals ($[T_j, T_{j+1}]$, j = 1,2,…, n-1) on X axis, the motion trail of KIC state is denoted by the connecting lines between y_{ij} and $y_{i, j+1}$ (Yi *et al*., 2007, 2010). The area which is surrounded by x_j y_{ij} $y_{i, j+1}$ x_{j+1} and X axis reflects overall situation of KIC state in $[T_j, T_{j+1}]$. Therefore, KIC state can be denoted as a form of integral of $s_i (x_j, x_{j+1})$:

$$s_i(x_j,x_{j+1}) = \int_{x_j}^{x_{j+1}} [y_{ij} + (x - x_j) \bullet (y_{i,j+1} - y_{ij})/(x_{j+1} - x_j)]dx \quad (1)$$

The integral area of KIC state of S_i equals to trapezoid area, namely:

$$s_i(x_j,x_{j+1}) = (y_{i,j+1} + y_{ij})(x_{j+1} - x_j)/2 \quad (2)$$

KIC trend evaluation model: Suppose that v_{ij} denotes the rate of KIC change of S_i in $[T_j, T_{j+1}]$, $v_{ij} = (y_{i,j+1}-y_{ij})/(x_{j+1}-x_j)$, β is the function about v_{ij}, according to the need of KIC development trend, the function of β is constructed as follows:

$$\beta(v_{ij}) = \frac{\phi}{1 + e^{v_{ij}}} \quad (3)$$

Set when $v_{ij} = 0$, $\beta(v_{ij}) = 1$, which denotes that there is no trend stimulation for the phase without KIC change, so we can obtain $\lambda = 2$.

When $v_{ij} = 0$:

$$\beta(v_{ij}) = \frac{2}{1 + e^{v_{ij}}} = 1$$

nothing will be done to KIC with a even trend when KIC state is multiplied by the coefficient 1.

When $v_{ij}>0$:

$$\beta(v_{ij}) = \frac{2}{1 + e^{v_{ij}}} > 1$$

reward will be given to KIC with a ascending trend when KIC state is multiplied by the coefficient more than 1.

When $v_{ij}<0$:

$$\beta(v_{ij}) = \frac{2}{1 + e^{v_{ij}}} < 1$$

punishment will be given to KIC with a descending trend when KIC state is multiplied by the coefficient less than 1.

Dynamic comprehensive evaluation model: According to Newton's second law of classical mechanics:

$$\Sigma F = kma \quad (4)$$

Force is denoted by F, quality is denoted by m, coefficient is denoted by k and acceleration is denoted by a.

The values of dynamic comprehensive evaluation of KIC can be expressed as follows:

$$Y_j = k_j \bullet s_i (x_j, x_{j+1}) \bullet \beta(v_{ij}) \ (j = 1, 2,..., n-1) \quad (5)$$

The "quality" of KIC is represented by $s_i (x_j, x_{j+1})$, namely the state of KIC; the "speed" of KIC is represented by $\beta(v_{ij})$, namely the trend of KIC; coefficient is denoted by k_j, it is set that $k_j = 1$. Then, the dynamic comprehensive evaluation value of S_i in $[T_j, T_{j+1}]$ can be described as follows:

$$Y_j = s_i^{\circ}(x_j,x_{j+1}) = \beta(v_{ij}) \bullet \int_{x_j}^{x_{j+1}} [y_{ij} + (x - x_j) \bullet (y_{i,j+1} - y_{ij})/(x_{j+1} - x_j)]dx \quad (6)$$

And the total dynamic comprehensive evaluation value of KIC of S_i in $[T_1, T_n]$:

$$s_i^{\pm\circ} = \sum_{j=1}^{n-1} s_i^{\pm *}(x_j,x_{j+1}) \quad (7)$$

CALCULATION EXAMPLE STUDY

This study takes 7 enterprises (Enterprise A, B, C, D, E, F, G) as a calculation example to make a dynamic

Table 1: Evaluation values of KIC of enterprise A, B, C, D, E, F, G from 2006 to 2011

Time enterprise	T_1(2006)	T_2(2007)	T_3(2008)	T_4(2009)	T_5(2010)	T_6(2011)
A	0.3368	0.3283	0.3168	0.4102	0.4098	0.4235
B	0.2707	0.2290	0.3211	0.2518	0.2967	0.2923
C	0.1598	0.2206	0.1996	0.1823	0.2133	0.2214
D	0.2233	0.2807	0.2486	0.2720	0.2865	0.2877
E	0.5960	0.5006	0.5298	0.5049	0.5112	0.5224
F	0.1344	0.1433	0.1391	0.1610	0.1887	0.1996
G	0.3489	0.3848	0.3208	0.2885	0.3124	0.3321

2001, 2002, 2003, 2004, 2005 and 2006 are represented by T_1, T_2, T_3, T_4, T_5 and T_6, respectively, Enterprise A, B, C, D, E, F, G are represented by A, B, C, D, E, F, G, respectively

Table 2: KIC state values of enterprise A, B, C, D, E, F, G in multi-periods

Time enterprise	$[T_1, T_2]$	$[T_2, T_3]$	$[T_3, T_4]$	$[T_4, T_5]$	$[T_5, T_6]$
A	0.33255	0.32255	0.36350	0.41000	0.41665
B	0.24985	0.27505	0.28645	0.27425	0.29450
C	0.19020	0.21010	0.19095	0.19780	0.21735
D	0.25200	0.26465	0.26030	0.27925	0.28710
E	0.54830	0.51520	0.51735	0.50805	0.51680
F	0.13885	0.14120	0.15005	0.17485	0.19415
G	0.36685	0.35280	0.30465	0.30045	0.32225

2001, 2002, 2003, 2004, 2005 and 2006 are represented by T_1, T_2, T_3, T_4, T_5 and T_6, respectively, Enterprise A, B, C, D, E, F, G are represented by A, B, C, D, E, F, G, respectively

Table 3: KIC trend values of enterprise A, B, C, D, E, F, G in multi-periods

Time enterprise	$[T_1, T_2]$	$[T_2, T_3]$	$[T_3, T_4]$	$[T_4, T_5]$	$[T_5, T_6]$
A	0.9958	0.9943	1.0467	0.9998	1.0068
B	0.9792	1.0460	0.9654	1.0224	0.9978
C	1.0304	0.9895	0.9914	1.0155	1.0040
D	1.0287	0.9840	1.0117	1.0072	1.0006
E	0.9523	1.0146	0.9876	1.0031	1.0056
F	1.0044	0.9979	1.0109	1.0138	1.0054
G	1.0179	0.9680	0.9839	1.0119	1.0098

2001, 2002, 2003, 2004, 2005 and 2006 are represented by T_1, T_2, T_3, T_4, T_5 and T_6, respectively, Enterprise A, B, C, D, E, F, G are represented by A, B, C, D, E, F, G, respectively

comprehensive evaluation of KIC from 2006 to 2011. Raw data is standardized by improved normalization method and weight is determined by the subjective and objective weight method combined AHP with entropy method. The evaluation values of KIC of 7 enterprises from 2006 to 2011 are shown in Table 1.

KIC state evaluation of 7 enterprises: According to the Eq. 2, KIC state values $s_i(x_j, x_{j+1})$ in $[T_j, T_{j+1}]$ (j = 1, 2,...5) of 7 enterprises are shown in Table 2.

KIC trend evaluation of 7 enterprises: According to the Eq. 3, KIC trend values $\beta(v_{ij})$ in $[T_j, T_{j+1}]$ (j = 1, 2,...5) of 7 enterprises are shown in Table 3.

Dynamic comprehensive evaluation of KIC of 7 enterprises: According to the Eq. 6 and 7, dynamic comprehensive evaluation values of KIC of 7 enterprises are shown in Table 4.

Table 4: Dynamic comprehensive evaluation values of KIC of enterprise A, B, C, D, E, F, G in multi-periods

Time enterprise	$[T_1, T_2]$	$[T_2, T_3]$	$[T_3, T_4]$	$[T_4, T_5]$	$[T_5, T_6]$	$[T_1, T_6]$
A	0.3311	0.3207	0.3805	0.4099	0.4195	1.8617
B	0.2446	0.2877	0.2765	0.2804	0.2939	1.3831
C	0.1960	0.2079	0.1893	0.2009	0.2182	1.0123
D	0.2592	0.2604	0.2633	0.2813	0.2873	1.3515
E	0.5222	0.5227	0.5109	0.5097	0.5197	2.5851
F	0.1395	0.1409	0.1517	0.1773	0.1952	0.8045
G	0.3734	0.3415	0.2997	0.3040	0.3254	1.6441

2001, 2002, 2003, 2004, 2005 and 2006 are represented by T_1, T_2, T_3, T_4, T_5 and T_6, respectively, Enterprise A, B, C, D, E, F, G are represented by A, B, C, D, E, F, G, respectively

RESULTS ANALYSIS AND DISCUSSION

In 2006-2011, the descending order of dynamic comprehensive evaluation of 7 enterprises is: E>A>G>B> D>C>F. Both KIC state and KIC trend are considered in the result of each period.

In 2006, the descending order of KIC of 7 enterprises is: E>G>A>B>D>C>F; in 2011, the order is: E>A>G> B>D> C>F. The descending order of Enterprise A and Enterprise G has changed, KIC value of Enterprise A increased from 0.3168 to 0.4102 in $[T_3, T_4]$ (2008-2009) with the function value of KIC trend 1.0467, while the KIC value of Enterprise G decreased from 0.3208 to 0.2885 with the function value of KIC trend 0.9839.

From dynamic comprehensive evaluation results of 7 enterprises, it shows that the state and the trend of KIC are equally important for an enterprise.

The whole development situation of KIC of 7 enterprises can be obtained by using the dynamic comprehensive evaluation model, in which the state and trend of evaluated objects are merged together. Guo (2002) proposed a dynamic evaluation method which can determine the weights for evaluation indexes at different time, without considering to synthesize the state and trend of evaluated objects. Fan and Wang (2000) proposed a new analytical method, in which the rankings of alternatives reflects not only the level but also the increase rate of attributes, while the method cannot obtain comprehensive evaluation results considering the state and trend of evaluated objects. Yi *et al.* (2007) proposed a multi-periods information aggregation model which can obtain evaluation results in multi-periods; however, this method ignored the development trend of evaluated objects. Yi *et al.* (2010) proposed another multi-periods information aggregation model which can make a dynamic comprehensive evaluation considering the state and trend of evaluated objects, while this method was not used for the evaluation of KIC of enterprises.

CONCLUSION

This study sets up a KIC evaluation index system on the perspective of the niche ecostate-ecorole theory, which introduces both KIC state evaluation model and KIC trend evaluation model respectively. On this basis, it proposes a dynamic comprehensive evaluation model synthesized KIC state and KIC trends. The method used in this study reveals comprehensive development situation of KIC of the evaluated enterprises, which contributes to analyzing and mastering the dynamic development trend of evaluated enterprises. Finally, this study takes 7 enterprises as a calculation example to illustrate the feasibility and availability of dynamic comprehensive evaluation model empirically. In further dynamic comprehensive evaluation studies, the state and the trend of KIC change speed can be integrated to make a comprehensive evaluation of KIC change speed of enterprises as well as further analyze how fast the KIC of enterprises change. In addition, the index system needs to be studied in depth in future research.

ACKNOWLEDGMENTS

This study is supported by Natural Science Foundation of China (71302028), Fundamental Scientific Research Funds for the Central Universities (HEUCF110914) and Heilongjiang postdoctoral funding (3236310094).

REFERENCES

Cairo, O. and S. Guardati, 2012. The KAMET II methodology: Knowledge acquisition, knowledge modeling and knowledge generation. Expert Syst. Appl., 39: 8108-8114.

Chunquan, Z., 1997. The niche ecostate-ecorole theory and expansion hypothesis. Acta Ecol. Sin., 17: 324-332.

Esterhuizen, D., C.S.L. Schutte and A.S.A. du Toit, 2012. Knowledge creation processes as critical enablers for innovation. Int. J. Inform. Manage., 32: 354-364.

Fan, Z.P. and X.R. Wang, 2000. A new method for multiple attribute decision of making problem with time series. Forecasting, 4: 49-50.

Fan, Z.P., B. Feng, Y.H. Sun and W. Ou, 2009. Evaluating knowledge management capability of organizations: A fuzzy linguistic method. Expert Syst. Appl., 36: 3346-3354.

Grafton, J., A.M. Lillis and S.K. Widener, 2010. The role of performance measurement and evaluation in building organizational capabilities and performance. Account. Organiz. Soc., 35: 689-706.

Guo, Y.J., 2002. New theory and method of dynamic comprehensive evaluation. J. Manage. Sci. China, 4: 49-54.

Guo, Y.J., Y. Yao and P.T. Yi, 2007. Method and application of dynamic comprehensive evaluation. Syst. Eng. Theory Pract., 10: 154-158.

Huang, J.J., 2009. The evolutionary perspective of knowledge creation-A mathematical representation. Knowledge-Based Syst., 22: 430-438.

Jin, J.L., S.J. Wang and Y.M. Wei, 2004. Projection pursuit model for dynamic multiple attribute decision problems. Chin. J. Manage. Sci., 12: 64-67.

May, R.M., 1974. On the theory of niche overlap. Theor. Popul. Biol., 5: 297-332.

Sun, C.C., 2010. A performance evaluation model by integrating fuzzy AHP and fuzzy TOPSIS methods. Expert Syst. Appl., 37: 7745-7754.

Tsai, C.M., 2008. Integrating intra-firm and inter-firm knowledge diffusion into the knowledge diffusion model. Expert Syst. Appl., 34: 1423-1433.

Xu, Z.S. and Q.L. Da, 2003. An overview of operators for aggregating information. Int. J. Intell. Syst., 18: 953-969.

Yang, J., 2005. Knowledge integration and innovation: Securing new product advantage in high technology industry. J. High Technol. Manage. Res., 16: 121-135.

Yesil, S., A. Koska and T. Buyukbese, 2013. Knowledge sharing process, innovation capability and innovation performance: An empirical study. Procedia-Social Behav. Sci., 75: 217-225.

Yi, P.T., Y.J. Guo and D.N. Zhang, 2007. A multi-phase information aggregation method based on double inspiriting control lines. Forecasting, 26: 39-43.

Yi, P.T., D.N. Zhang and Y.J. Guo, 2010. A multi-phase information aggregation method based on extensive inspiriting control lines. Oper. Res. Manage. Sci., 19: 49-55.