ISSN : 0974 - 7435 Volume 10 Issue 24

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(24), 2014 [15886-15893]

Performance measurement of university-industry knowledge innovation alliance based on decay model

Jianfeng Shi, Qingpu Zhang
School of management, Harbin Institute of Technology, Harbin, 150001, (CHINA)
Email: hitsjf@126.com, zzqp2000@126.com

ABSTRACT

According to the characteristics of university-industry knowledge innovation alliance, this paper analyzes the connotation of the alliance's performance evaluation, it takes the alliance cooperation as cicadas' change process, takes the relationship between each stage of the alliance cooperation as variable coefficient, calculates the decay model coefficient by using the BP neural network algorithm, gets the alliance's cooperation performance through the decay model, and takes this model to the empirical evaluation method for proving. The result shows that this kind of method based on the decay model not only measures the status of the alliance, but also evaluates each stage and the participants, the evaluation by objectives is beneficial to the cooperation of the alliance, and enhances the cooperation effectively.

INTRODUCTION

Currently, knowledge as the main competition has gradually become the trend of business competition, it has become a consensus that enterprises must enhance their competitiveness through knowledge innovation. Due to the limited resources and huge risks of a single enterprise investment in the process of knowledge and technology innovation, using others' resources to enhance their core competencies has become a very effective way to generate innovation[1,2,3]. With this adaptation, university-industry knowledge innovation alliance came into being. University-industry knowledge innovation alliance is a cooperative organization including multiple independent economic actors based on knowledge as a link, takes knowledge innovation as the target. The partners in the alliance share the resources, risks and gains in accordance with the prior agreement[4].

Uncertainty in university-industry knowledge innovation alliance is higher than in traditional joint research projects because they are characterized by more ambitious research targets. University-industry knowledge innovation alliance cooperation usually concerns R&D on the technological frontier, on new technological fields and aims at radical breakthrough innovation[5,6]. In addition, the alliance partner's differences, values and institutions of governance seriously affect the efficiency of cooperation[7,8]. In view of this, the cooperation is characterized by a generally high failure rate[9] and lower than expected performance[10,11]. Therefore, the study of knowledge innovation alliance cooperation performance will help promote the healthy development of cooperation.

With the deepening of university-industry knowledge innovation alliance, the discussion about the alliance performance is gradually increasing. Alliance performance measurement methods can be broadly grouped into five categories: measurement model based on motivation-expectancy Theory, model based on the balanced scorecard, based on input-output model, model based on resource dependence and transaction costs and model based on community ecology[12]. Comparative analysis of these measurement methods' advantages and disadvantages, we can find three common characteristics: First, measurement models are difficult to standardize influenced by cooperation body, industry, market environment and other internal and external factors, the research result is hard to promote; second, the measurement object is often the whole body of university-industry knowledge innovation alliance, performance measurement for individual participants is rarely considered, third, most of the research about performance measurement studies are static, On the one hand, static measurement models often can't change according to the market changes, on the other hand, they focused on the research results of the studies, failed to put the performance of university-industry knowledge process in the study, the measurement ignoring process usually brings immeasurable loss when the projects are millions even billions of dollars.

The accurate measurement of the alliance performance is not only able to determine the state of the alliance's cooperation, but also has a positive role in safeguarding the smooth functioning of the alliance, improving the performance of cooperation and reducing the cooperation risk in the same time.

Considering that university-industry knowledge innovation alliance is a consortium composed by three different stakeholders, on the basis of previous studies, this paper put forward the method of performance measurement of university-industry knowledge innovation alliance which combined process and result measurement.

DECAY MODEL

Decay model was proposed by Professor Wang etc.(2011). The model compared patent industrialization process to cicada's polymorphic transformation process, each transformation link shows new life qualities and forms, each patent industrialization process also shows the new forms and qualities of value in use. In contrast, the process of university-industry knowledge innovation alliance is

similar to decay process from alliance established to research, pre-production and MP stage, as shown in Figure 1.

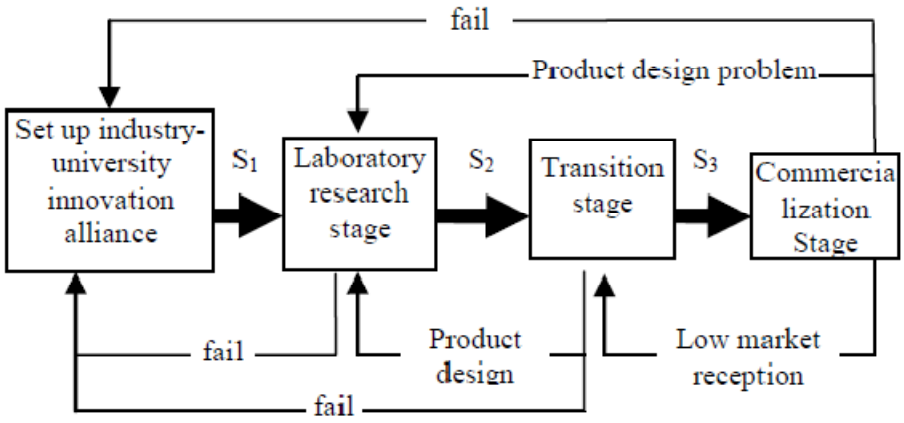

Figure 1: The decay process of university-industry knowledge innovation alliance

In Figure 1, S_i represents step i of university-industry decay process, is also called decay process node. In accordance with the characteristics of university-industry knowledge innovation alliance decay process, this paper introduced decay coefficients to performance measurement of the university-industry knowledge innovation alliance, the decay coefficients refer to the relationship between the current stage and the next stage during university-industry knowledge innovation alliance decay process. fi represents the coefficient when we get to stage i of the project, $f_i \in [0,10]$, the lowest score is 0, it means the process of alliance is very bad, we should stop the project, the current stage of alliance can't decay to the next stage; the highest score is 10, it means the process of alliance is smooth going. The alliance's overall performance (E) can be described as:

$$E = \sqrt[3]{\prod_{i=1}^{3} f_i}, E \in [0,10] \quad \textbf{(1)}$$

Mainly considering the geometric mean method has a more significant effect to represent each characteristic component disharmony, is more sensitive with uncoordinated scores[14], here we take the geometric mean of the alliance's phased performance as the alliance's overall performance, thus we can fully reflect the actual situation of the alliance performance, in terms of this project, the geometric mean has more versatility and accuracy than other average calculations. In the same way, we can evaluate the performance of the alliance participants separately, EP, EU and ER represent separately the performance of industry, university and institute, fP_i, fU_i and fR_i represent separately the scores of the evaluation team for the performance of industry, university and institute in stage i. Then:

Decay coefficient of stage i: $f_i = \sqrt[3]{fP_i \times fU_i \times fR_i}$ **(2)**

The performance of industry: $EP = \sqrt[3]{\prod_{i=1}^{3} fP_i}$ **(3)**

The performance of university: $EU = \sqrt[3]{\prod_{i=1}^{3} fU_i}$ **(4)**

The performance of institute: $ER = \sqrt[3]{\prod_{i=1}^{3} fR_i}$ **(5)**

The basic tasks are not the same at every stage of university-industry knowledge innovation alliance. Therefore, in the different stages, the contents of the evaluation of the alliance as well as the composition of the evaluating staff are to be differentiated, as shown in TABLE 1.

TABLE 1: The task and evaluation criteria of university-industry knowledge innovation alliance decay process

Stage	Module Goals	Evaluation Object	Evaluation Criterion	Expert Type Participating in the Performance Measurement and importance Sort
Laboratory Research Stage S_1	Function Design, Structural Framing	Industry University Institute	Product Demand, Capital Support Knowledge Supply, Staff Support Technology Research And Development, Staffing	Technology Development, Engineering Technology, Market Management
Transition Stage S_2	Samples Development, Functional Test	Industry University Institute	Functional Testing, Process Flow Structure Principle Product Function	Engineering Technology, Technology Development, Market Management
Commercialization Stage S_3	Industrialization	Industry	Gaining Profit, Knowledge, Technology Innovation	Market Management, Technology Development, Engineering Technology

THE EVALUATION INDEXES AND PROCESS

Determine the evaluation indexes

Performance measurement of university-industry knowledge innovation alliance is a complex system engineering, setting up university-industry knowledge innovation alliance performance measurement index system is the basis of specific performance measurement. On the basis of previous studies on performance measurement, according to the purpose of the evaluation, the evaluation principles and the theory of knowledge management, knowledge innovation, we construct the evaluation index system of performance measurement of university-industry knowledge innovation alliance using the Delphi method, the index system is divided into three stages by the process of operation of the project: laboratory-studies, productization, commercialization. According to the knowledge of supply and demand relationship, we divide partners into the industry, university and institute.

Evaluation process and method

Considering the focus involved at each stage of the cooperation process is different, so we set the chief expert M1, the important expert M2 and the participation expert M3 by the order for the performance measurement of experts (the sort situation of three types experts are shown in TABLE 1, "Expert Type Participating in the performance measurement and importance Sort"). The proportion of three types experts' score is 6:3:1 based on the Delphi method. In view of the subjective evaluation items, the number of each type of expert is preferably three or more, taking average score as every type expert's score. If average score of three types expert in item j of stage i for industry is P_{1ij}、P_{2ij}、$P_{3ij,}$ for university is U_{1ij}、U_{2ij}、U_{3ij}, for institute is R_{1ij}、R_{2ij}、R_{3ij}, then the score for industry of alliance in item j of stage i can be described as :

$$fP_{ij} = 0.6P_{1ij} + 0.3P_{2ij} + 0.1P_{3ij} \quad \textbf{(6)}$$

the score for university of alliance in item j of stage i can be described as :

$$fU_{ij} = 0.6U_{1ij} + 0.3U_{2ij} + 0.1U_{3ij} \quad \textbf{(7)}$$

the score for university of alliance in item j of stage i can be described as :

$$fR_{ij} = 0.6R_{1ij} + 0.3R_{2ij} + 0.1R_{3ij} \quad \textbf{(8)}$$

Considering the congruent relationship between fP_i, fU_i, fR_i and $fP_{ij}, fU_{ij}, fR_{ij}$, as long as we can use $fP_{ij}, fU_{ij}, fR_{ij}$ to evaluate fP_i, fU_i, fR_i accurately, then formula (3),(4) and (5) can be used to calculate the participation performance of industry, university and institute: EP, EU and ER. At the same time, we can get the alliance's decay coefficient f_i of stage i. Decay coefficient can evaluate the implementation of the project, so we can evaluate the operation of university-industry knowledge innovation alliance according to the score of the overall performance (E).

For the convenience of researchers to a better understanding of this calculation context, the logical relationship among the formulas is as follows:

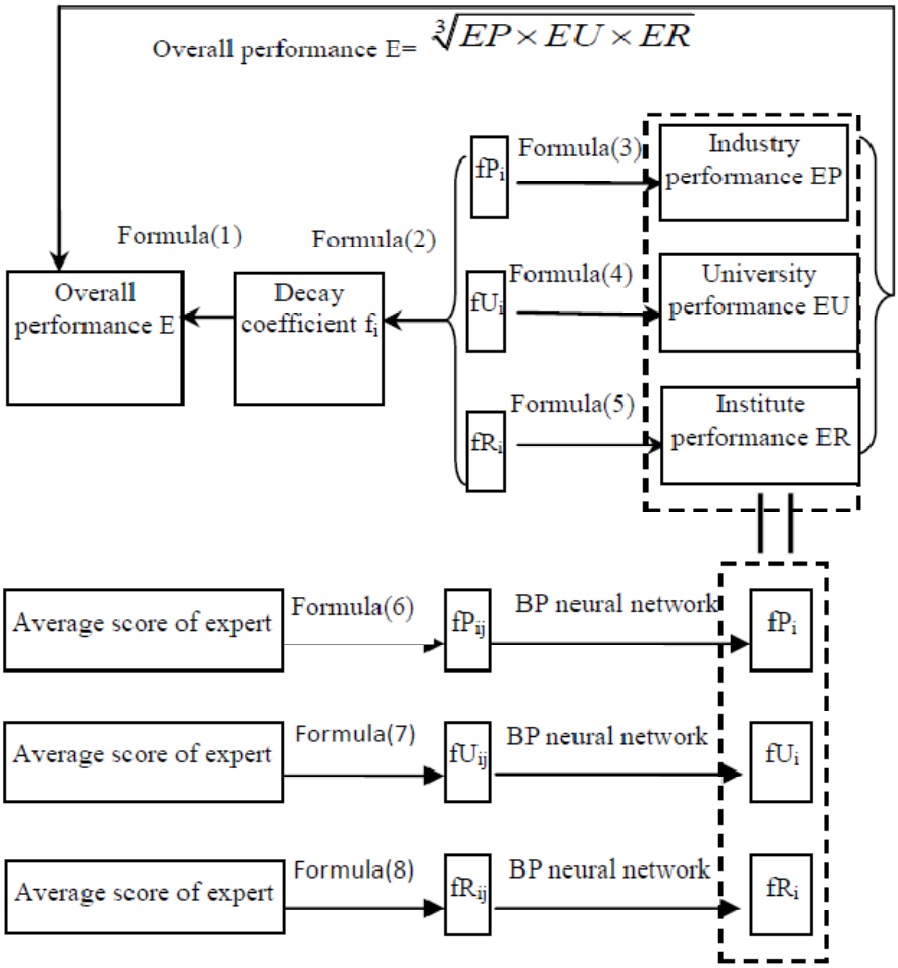

Figure 2: The logical relationship among the formulas in this paper

As can be seen from the above formulas, the evaluation on fP_i, fU_i, fR_i is an integrated problem, in which the correlation factors are uncertainty and strong variability. There isn't a certain functional relationship from feature set to state set, it is a complex nonlinear mapping process. Traditional performance measurement methods, such as analytic hierarchy process, fuzzy comprehensive method, require artificial weighting coefficients of the evaluation index, and the weights of the evaluation factors also need evaluation experts' considerations, these artificially determined weight of performance measurement of university-industry knowledge innovation alliance cause considerable arbitrariness and the effect of practical application is not obvious. For performance measurement of university-industry knowledge innovation alliance, a complex nonlinear problem which is unintuitive, uncertain and

incomplete between information input and output, BP neural network algorithm is undoubtedly the best solution.

BP (Back Propagation) network is proposed by a team of scientists led by Rumelhart and McCelland in 1986. BP network which is one of the most widely used neural network model, is a multi-layer feedforward network trained by error back propagation algorithm. BP network can learn and store a lot of input-output mapping relationship without prior revealing the mathematical equation that describe the mapping. The learning rule is to use the method of steepest descent, to constantly adjust the network weights and threshold values through backpropagation, minimizing the squared error of the network[15]. BP neural network has good self-learning ability, it can make a reasonable judgment and decision for complex issues according to the knowledge learned before and experience, and give a satisfactory answer. Performance measurement process first use BP neural network algorithm to train investigating sample data judged by experts in order to obtain the expert's experience judgment, then use the test sample data to enhance the learning ability of the network itself, making performance measurement process of university-industry knowledge innovation alliance more scientific, and to improve the quality of the performance measurement.

We issued and recovered 60 valid questionnaires totally from enterprise technology development, engineering technology, market operate personnel during the study process, the article only gives survey data of the laboratory research stage because of limited space, as shown in TABLE 2.

Normalize the data collected from the questionnaires, using 50 questionnaire survey data as the training set of neural network supplied by matlab toolbox. After 10000 times learning, if the convergence has been in the permitted extent, by the end of the training, we use the remaining 10 questionnaire survey data as a test sample to test BP neural network, and finally get performance measurement results. if the test result error is less than 5%, it indicates that the network has a certain reliability. Entering the test sample, the performance measurement can automatically give the score of the project fP_i, fU_i, fR_i.

TABLE 2: The questionnaire survey results of the laboratory research stage sample for institute

order	fR_1	fR_{11}	fR_{12}	fR_{13}	fR_{14}	fR_{15}	fR_{16}
1	8.8	7.5	9.2	7.9	8.1	8.2	9.7
2	8.6	8.4	7.3	9.3	9.6	9.2	9.7
3	8.4	9.3	6.4	8.8	8.6	9.8	9.8
4	7.9	6.6	9.5	8.4	6.3	8.7	6.3
5	8.2	8.9	7.2	7.2	8.0	9.8	8.6
…	…	…	…	…	…	…	…
56	1.5	2.8	2.1	0.3	0.5	2.0	1.3
57	2.3	0.7	1.3	3.9	1.3	1.2	3.4
58	2.2	1.5	1.9	3.6	3.5	0.1	1.2
59	1.1	0.6	0.1	0.9	4.6	1.2	0.3
60	1.5	2.5	1.8	2.3	1.6	1.0	0.8

Establish the mapping between the input and output indicators in accordance with the following formulas:

fR_1dnet=newff (fR_1p, fR_1t);(use newff to establish a BP neural network that can be trained for fR_1)

fR_1dnet.trainParam.epochs=10000;(Set the training times)

fR_1dnet.trainParam.goal=0.0001;(Set the training target)

fR_1dnet.trainParam.show=500;(the system will show the curve of training error per 500 times)

fR_1dnet=train (fR_1dnet, fR_1p, fR_1t);(Establish preliminarily performance measurement model of university-industry knowledge innovation alliance for institute in the laboratory research stage.)

THE EMPIRICAL RESEARCH

In this paper, we selected the project of blood analyzers in a medical equipment manufacturing enterprise during university-industry knowledge innovation alliance as the object of empirical study. The collected data are as follows:

TABLE 3: Empirical data in laboratory research stage

Participant	fR_{11}	fR_{12}	fR_{13}	fR_{14}	fR_{15}	fR_{16}
fR_1	6.8	8.5	8.2	7.7	7.5	9.0

Take the data above to formula fR_1sdz=sim (fR_1dnet, fR_1dbb)(fR_1dbb represents the experts' scoring results matrix for institute of the first phase of the current project), and get the score fR_1=8.0086, and also others:fP_1=8.9, fU_1=8.5, fR_2=8.2, fP_2=8.4, fU_2=8.3, fR_3=8.6, fP_3=8.6, fU_3=8.6, we can get the decay coefficient EP=8.63, EU=8.47, ER=8.27 by formula (2), and we can calculate the alliance's performance E=8.46 according to formula (1) High decay coefficient means the cooperation process went very smoothly, and the overall alliance's performance is also very high, which is consistent with the actual situation.

CONCLUSION

In this paper, we analyzed the overall performance and stage performance of university-industry knowledge innovation alliance using decay model and BP neural network algorithm, and the model was also applied to an empirical study. The study of alliance's performance has positive significance whether for the investors to choose invest objects or participants to carry out the benefits distribution, researchers can be able to further improve and adjust the evaluation indicators. With the deepening of international cooperation, the regulations, culture environment and other factors of different countries are also important factors to affect cross-border performance of the alliance, all these need to conduct in-depth research. In addition, in order to use the evaluation model more efficiently and conveniently, we can develop related evaluation software for generating real-time evaluation data. Another important function of establishing the evaluation system is to increase sample data, and improve the accuracy and timeliness of network training. Along with the computer technology fast-changing, the emergence of new math and simulation software makes the wide use of decay model and BP neural network algorithm possible, which also play a positive role in promoting the accurate evaluation of university-industry knowledge innovation alliance.

ACKNOWLEDGMENT

This work was supported by a grant from "Shandong province humanities and social science research project for institutions in 2014(No.J14WG70)".

REFERENCES

[1] J.E.Jankowski; Trends in academic research spending, alliances and commercialization, The Journal of Technology Transfer, **24(1)**, 55-68 **(1999)**.

[2] M.D.Santoro, S.C.Betts; Making industry–university partnerships work, Research Technology Management, 42-46 May–June **(2002)**.

[3] M.Perkmann, K.Walsch; Sourcing knowledge from universities: Opportunities and constraints for firms, In EURAM conference 2007 **(2007)**.

[4] Xiao Lingnuo, Shi Jianfeng, Sun Yuzhong; Performance measurement of university-industry knowledge innovation alliance based on BP neural network, China Soft Science, **12**, 177-178 **(2011)**.

[5] M.Nakamura, P.Mohnen, C.Hoareau; What type of enterprise forges close links with universities and government labs? Evidence from CIS 2, Managerial and Decision Economics, **24(2–3)**, 133-145 **(2003)**.

[6] E.M.Mora-Valentin, A.Montoro-Sanchez, L.A.Guerras-Martin; Determining factors in the success of R&D

cooperative agreements between firms and research organizations[J], Research Policy, **33(1)**, 17-40 **(2004)**.

[7] S.Woolgar, J.Vaux, P.Gomes, J.N.Ezingeard, R.Grieve; Knowledge and the speed of transfer and imitation of organizational capabilities: An empirical test, Organization Science, **6(1)**, 76-92 **(1998)**.

[8] D.Siegel, D.Waldman, A.Link; Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: An exploratory study, Research Policy, **32**, 27-48 **(2003)**.

[9] K.Brouthers, L.Brouthers, P.Harris; The five stages of the cooperative venture strategy process, Journal of General Management, **23(1)**, 39-52 **(1997)**.

[10] R.E.Spekman, T.M.Forbes, L.A.Isabella, T.C.MacAvoy; Alliance management: A view from the past and a look to the future, Journal of Management Studies, **35(6)**, 747-772 **(1998)**.

[11] A.Madhok, S.B.Tallman; Resources, transactions and rents: Managing value through interfirm collaborative relationships, Organization Science, **9(3)**, 326-339 **(1998)**.

[12] Wang Hao, Liang Yaoming; A review on the studies of university-industry collaboration performance evaluation[J], Science and Technology Management Research, **11**, 57 **(2011)**.

[13] Wang Yumin, Liu Haibo, Ma Weiye, Li Liming, Peng Maoxiang, Lei Xiaoyun; Decay model of verifying industrializable patent, China Soft Science, **7**,150-154 **(2011)**.

[14] Wang Chuan; The enterprise quality evaluation model ( ), Management World, **02**, 68 **(1985)**.

[15] Jiang Zongli; Introduction to artificial neural networks [M], The Education Press, 7-52 **(2001)**.