http://ansinet.com/itj

ITJ

ISSN 1812-5638

INFORMATION TECHNOLOGY JOURNAL

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Information Technology Journal 12 (4): 817-822, 2013
ISSN 1812-5638 / DOI: 10.3923/itj.2013.817.822

Study on the Performance Evaluation of Scientific Innovation Team in Universities Based on Gray Fuzzy Theory

Sha Fu, Hangjun Zhou, Dan Song and Yezhi Xiao
Department of Information Management, Hunan University of Finance and Economics, 410205, China

Abstract: According to the incomplete and fuzziness performance evaluation information, the performance evaluation of scientific innovation team in universities was studied based on the gray fuzzy theory, a more comprehensive set of indicator system was built to conduct a comprehensive evaluation. Based on gray system theory and fuzzy set theory, the membership and the gray-scale was introduced into the evaluating process, a gray fuzzy comprehensive evaluation model of scientific innovation team in universities was built, the feasibility and effectiveness of the model was proved through application.

Key words: Gray system theory, fuzzy set theory, scientific innovation team, performance evaluation, indicator system

INTRODUCTION

The building of scientific innovation team was a major initiative to promote talent organizational model innovation, an important measure to implement the strategy of rejuvenating the country through science, education and talents and also had an important role to enhance the innovation capability and competitiveness of high schools. Continuous scientific innovation ability is the key to build world-class universities and long-term competitiveness. The strengthening of the continuous innovation of the innovation team, has already become one of the most important work of the universities and other technology management departments (Maolin and Zefang, 2011). Xiaohong and Baosheng (2011) constructed the index system for the evaluation of network capacity and knowledge flow ability of the two coupled degrees, Proposed measure both the associate degree and the degree of coupling model using the basic idea of gray relational analysis and have empirical research on technological innovation team of Harbin Institute of Technology. Wang (2011) against the composition modes and features of science and technology innovation team, proposed the excellent leaders, reasonable composition, teamwork, scientific and efficient operation of mechanism is the core elements to create a team of science and technology innovation and described it combined with the radar Technology Institute of Beijing Institute of Technology. Qiu (2012) proposed local University of Science and Technology Innovation team is an important force for local university to enhance their own scientific and technological innovation capability, the service area's economic construction, cultivation of innovative talents for the country and building an innovative country and researched the local University of Science and Technology Innovation Team Incentive Model, built and analysis technological innovation team incentive model. Guo and Zhiping (2012) proposed the members of the scientific and technological innovation team chose to determine the composition of the team and its scientific and technological innovation and design the technology innovation team members selected index system based on a collaborative network information theory.

With the strengthening of intellectual pluralism, marginalization and the shorten of update cycles, "alone", personal research gradually give way to "coordinated operations", "win-win cooperation" team study, the benefits of team running mode generated widespread attention of the people. The Ministry of Education launched the personnel project of “Changjiang Scholars and innovative research team development plan”; The State Council issued the <<Some supporting policies to the implementation of <National mediuni and long-term science and technology development plan> (2006-2020)>> to plan this. The plan emphasized to "cultivate a batch of innovation ability of high level academic leaders and build an excellent innovation talent and innovation team group With Chinese characteristics". These initiatives showed the high attention of the relevant competent department (Xiaozhuo and Junmin, 2008). General Secretary Hu Jintao raised the strategic

Corresponding Author: Sha Fu, Department of Information Management, Hunan University of Finance and Economics, 410205, China Tel: 13875982792

goal of building an innovative country and the specific tasks of building a world-class research team, research institutes and universities, " at the Fourth Conference on Science and Technology (Bu and Cai, 2008). At present, the research on China's scientific innovation team performance evaluation is still immature. It has certain theoretical innovation and practical significance to explore the problem of performance evaluation indicator system and establish a more comprehensive set of gray fuzzy comprehensive evaluation model using the gray fuzzy theory.

MEANING OF UNIVERSITY SCIENTIFIC INNOVATION TEAM

Chris Harris think the work of innovation team is non-continuity and meet the super-normal demand for unconventional work efficiency and benefits. An innovative team has the characteristic of collaboration, unity, integrity, competence, complementary, self-confidence, teamwork. Professor think the work of scientific innovation team works is science and technology research and development, it is composed by a few of researchers who willing to bear the responsibility for the same research objective (Bu and Cai, 2008). Scientific innovation team is not an administrative organization, but rather a new "strategic integration" organization, its organizational mechanisms is for the major opportunities and tasks, integrating superior forces, are flexible and effective forms of organization of university research in academic management (Weiming and Xiaoxia, 2009). Scientific innovation team is the college's research team which has a high level of innovation capability, it is the benchmark of scientific innovation ability, it plays an increasingly important role in scientific innovation, guidance and development.

OVERVIEW OF THE GRAY FUZZY THEORY

Gray system theory: Gray system theory was first proposed in 1982 by the Chinese scholar, Professor (Ju-Long, 2005). Gray system is the system which has white parameters (known parameters) and black parameters (unknown parameters), its study includes the quantitative, modeling, forecasting, decision-making and control of objective things. Its study point to the small sample which information is not already fully known and the uncertainty system has poor information. It gets the correct description and effective monitoring of the system's running behavior and evolution rule mainly though the generation, development and extracting valuable information.

Gray system theory has the advantage of theoretical analysis on small sample system which information is inaccurate and not fully known, it deal effectively with the uncertainty of things, multi-variable input, discrete data and data incompleteness problem, it can also predict based on the existing sequence. It study and process the complex systems start from the completeness, not start form within special law, but through the mathematical treatment of a certain level observations to reach a higher level understanding of mechanisms such as the system's internal trend and interrelation (Zheng-Jun *et al*., 2007).

Fuzzy set theory: The fuzzy set theory is simply known as fuzzy sets. In 1965, American scholars LA Zadeh founded mathematical way to describe the blurring -- fuzzy set theory, pioneered the theory of fuzzy system and fuzzy control. This method treat the object to be investigated and the fuzzy concept it reflected its as fuzzy sets, analysis the fuzzy object though the building of suitable membership function accompanied by relevant operation and transformation. Fuzzy set theory based on fuzzy math and study the inaccurate phenomenon.

CONSTRUCTION OF THE EVALUATION INDICATOR SYSTEM

According to the characteristics of scientific innovation team, combined with its constituent elements and the domestic and international innovative ability evaluation index design plan, established the university scientific innovation team performance evaluation indicator system, as shown in Fig. 1.

Dimension index of the research team's performance: Scientific innovation team should be an efficient research groups which continued to produce new results, specially the major scientific achievements (Kang *et al*., 2005). The team is an important form to promote the college's high level scientific research and shoulders the historical mission to enhance the level of university research, resulting in high level scientific researches. Therefore, research performance evaluation in the development process has gradually become the core content of scientific innovation team performance evaluation.

Evaluation indicators include: (1) academic papers, including domestic CSCD included papers as well as the Three major international search papers, evaluate from both quantity and quality; (2) research projects, including vertical and horizontal research projects, evaluate from the level of the project, the number of funding and the actual benefits and expected value; (3) awards from scientific research achievements, including various types of

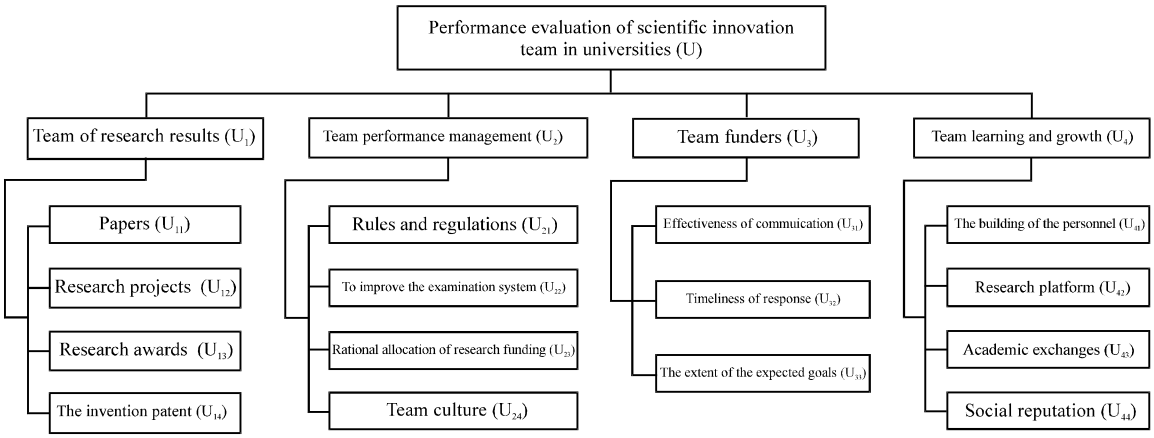

Fig. 1: The evaluation indicator system of performance evaluation

research awards from the papers, writings and research report and (4) invention patents, including the number of the authorized, granted patents and the actual benefits and the expected value.

Dimension indicators of team performance management: The effective operation of the team management is an important guarantee for the development of scientific innovation team success. Any organization, if there is no system of organization, its members will have no cohesion and combat effectiveness, will just be in the state of disunity, if there is no systemic scientific system, its members work to come out of nowhere, the tasks can not be completed as planned (Guan and Hu, 2004). Scientific innovation team should first develop practical rules and regulations according to their own situation, at the same time it should strictly strength the team culture and create a good cultural environment. The evaluation indicators include: (1) establish and improve rules and regulations, including the degree of perfection of the system, the effectiveness and implementation; (2) improve the examination system, the evaluation system of scientific innovation team has a very strong role in guiding and promoting to the innovative activity, it's an important measures to continuously improve the level of scientific research; (3) reasonable allocation of research funding, to strengthen the team research funding reasonable management and distribution will helpful to stimulate the enthusiasm and creativity of the team members in order to ensure that research projects successfully completed and high-quality outcomes; (4) team culture, it is a comprehensive strength to promote the cooperation and development of the team, it can be measured from the academic exchanges between the team members and collaborate circumstances (Chuandong, 2008).

Dimension indicators of team funders: Education, technology and other relevant government departments and universities invest human, material and financial resources in order to support and promote the team's development of scientific innovation, some enterprises cooperate with the scientific innovation team take the form of a project commissioned and give the funds support, these funding body in some sense is the scientific innovation team's "customer". Thus, the performance evaluation should also take the interests of the customer's demands into account, evaluate from the customer's satisfaction. The validity of the evaluation indicators include: (1) communication with the customers; (2) the timeliness of the response on the customer and (3) the degree of realization of targets, as a sustainable developing innovation team, it should have a clear team goals as well as a common vision through the integration process.

Dimension indicators of team learning and growth: Scientific innovation team can only maintain the vitality though sustained, effective learning and continue to promote their own growth. Thus, the team leader should actively strengthen the construction of team personnel and research platform, encourage and support academic exchange activities, constantly gain new knowledge to enhance the team's ability of getting new knowledge. Its evaluation indicators include: (1) the construction of personnel, including talent import, training situation, the leadership of the team leader, the cohesion of the team members, collaboration, etc.; (2) research platform construction, including the construction of the research base and discipline which the development of scientific innovation team relying on; (3) academic exchanges, including the academic discussion between the team

members, symposium sponsored by the team (or participate in) situation and (4) the social reputation of the team, which is major indicators the evaluate the situation of the team's learning and growth (Zhu *et al*., 2009).

GRAY FUZZY COMPREHENSIVE EVALUATION MODEL OF PERFORMANCE EVALUATION

Similar to the fuzzy comprehensive evaluation, gray fuzzy comprehensive evaluation's mathematical model can be divided into one-level model and multi-level. Let the evaluation object factors set be $U = \{u_1, u_2, ..., u_n\}$, have n related factors; reviews of various factors set $V = \{v_1, v_2, ..., v_m\}$, have m reviews.

Determination of the weight set: Weight set is used to describe the gray fuzzy relationship between the evaluation objects and factors set. As shown in Fig. 1, the hierarchical relationship between the influencing factors gives weight and corresponding Grayscale between each factor on the same level of to upper discipline, which is where the weight set come from. We get the weighting indicators by invite a number of experts to do a dispersed assess at all level factors and the experts give weight assignment corresponding gray value according to their degree of familiarity with the index factors. Based on the full extent of the information, it is divided into five levels, the Grayscale values are {0~0.2,0.2~0.4,0.4~0.6, 0.6~0.8,0.8~1.0} (Wen and Qiang, 2007), as shown in Table 1.

Averaging the weight assignment and normalize it, then averaging the Grayscale assignment corresponding to weight values, we get gray fuzzy set corresponding to all levels factor's indicators weight:

$$\tilde{A}_{\otimes} = \left(\tilde{A}, A_{\otimes}\right) = \left[(a_1, v_1), (a_2, v_2), \cdots, (a_m, v_m)\right]$$

$\left(\tilde{A}, A_{\otimes}\right)$ is the segment of gray fuzzy set $\tilde{A}_{\otimes}$, where $\tilde{A}$ is the fuzzy part of $\tilde{A}_{\otimes}$, $A_{\otimes}$ is the gray part of $\tilde{A}_{\otimes}$, the gray fuzzy set can be seen as the comprehension and promotion of the fuzzy set and Gray set. The weight values meet the requirements of normalization, i.e:

$$\sum_{i=1}^{m} a_i = 1^{\circ}$$

Table 1: Grayscale corresponding to information

No.	Amount of information	Gray value
1	More fully	0~0.2
2	Full	0.2~0.4
3	General	0.4~0.6
4	Poor	0.6~0.8
5	More poor	0.8~1.0

The establishment of the evaluation matrix: The evaluation matrix reflected the gray fuzzy relationship between the evaluation factors set and the reviews set, based on expert evaluation method get the membership degree $\mu_{ij}(i = 1,2,\ldots,m; j = 1,2,\ldots,n)$ and in accordance with the full extent of the information get the corresponding gradation v_{ij} (I = 1,2, ..., m; j = 1,2, ..., n), we can establish the evaluation matrix:

$$\tilde{R}_{\otimes} = \begin{bmatrix} (\mu_{11}, v_{11}) & (\mu_{12}, v_{12}) & \cdots & (\mu_{1n}, v_{1n}) \\ (\mu_{21}, v_{21}) & (\mu_{22}, v_{22}) & \cdots & (\mu_{2n}, v_{2n}) \\ \vdots & \vdots & \ddots & \vdots \\ (\mu_{m1}, v_{m1}) & (\mu_{m2}, v_{m2}) & \cdots & (\mu_{mn}, v_{mn}) \end{bmatrix}$$

In the matrix, the fuzzy part is composed of fuzzy membership degree given by experts , the gray part is composed of average Grayscale given by experts related to the corresponding membership degree.

Layer gray fuzzy comprehensive evaluation: Once we get gray fuzzy evaluation matrix $\tilde{R}_{\otimes}$ to a certain level indicators and the gray fuzzy sets $\tilde{A}_{\otimes}$ corresponding to its index weight, we can obtain the gray fuzzy comprehensive evaluation results $\tilde{B}_{\otimes}$ by the synthesis computation. The evaluation results set $(\tilde{B}_1, \tilde{B}_2, ..., \tilde{B}_j)$ is the upper layer indicator factor's gray fuzzy evaluation matrix $\tilde{R}_{\otimes} = (\tilde{B}_1, \tilde{B}_2, ..., \tilde{B}_j)^T$. Repeat the synthetic computing layer by layer, we get the top-level factors gray fuzzy comprehensive evaluation results. In order to maintain the evaluation results as more as much, so that the evaluation results can be closest to reality, we should use M (•, +) operator in the mold part computation and M (□ +) operator in the gray part operations (Shao and Hu, 2008). As a result, the gray fuzzy comprehensive evaluation results:

$$\tilde{B}_{\otimes} = \tilde{A}_{\otimes} \circ \tilde{R}_{\otimes} = \left[\left(b_j, v_j\right)\right]_n = \left[\left(\sum_{k=1}^{m}\left(a_k \bullet \mu_{kj}\right), \prod_{k=1}^{m}\left(1 \wedge \left(v_k + v_{kj}\right)\right)\right)\right]_n \quad (1)$$

Processing of the evaluation results: For gray fuzzy comprehensive evaluation results $\tilde{B}_{\otimes} = \left[\left(b_j, v_j\right)\right]_n$. Considering the fuzzy and gray, according to the principle of maximum membership degree and minimum Grayscale, Transformed $\tilde{B}_{\otimes}$ into the result set (Zhang and Feng, 2012):

$$\tilde{B} = \left[\frac{b_j \times \left(1 - v_j\right)}{\sum_{j=1}^{n} b_j \times \left(1 - v_j\right)}\right] = \left(B_1, B_2, \cdots, B_n\right) \quad (2)$$

APPLICATION EXAMPLES

Take a scientific innovation team in Central Region as an example, invited 10 experts for a decision-making panel,

based on the expertise and experience of the experts, determine the weights of the indicators of the scientific innovation team performance evaluation factors, average the scores of the information indicator to get its Grayscale at all levels, we get the weight set.

Determine index weights of all levels: Indicators weight set of the target layer U:

$$\tilde{A}_{\otimes} = \left[(0.28,0.3),(0.25,0.3),(0.25,0.25),(0.22,0.25)\right]$$

Indicators weight set of indicator layer $U_i(i = 1,2,3,4)$:

$$\tilde{A}_{1\otimes} = \left[(0.26,0.2),(0.28,0.2),(0.25,0.25),(0.21,0.3)\right]$$

$$\tilde{A}_{2\otimes} = \left[(0.5,0.3),(0.5,0.3)\right]$$

$$\tilde{A}_{3\otimes} = \left[(0.31,0.25),(0.37,0.25),(0.32,0.2)\right]$$

$$\tilde{A}_{4\otimes} = \left[(0.2,0.15),(0.3,0.15),(0.25,0.2),(0.25,0.2)\right]$$

The establishment of the evaluation matrix: Invite a number of experts access the performance evaluation factors U, get the indicator of the evaluation index layer $U_i(i = 1,2,3,4)$, establish the gray fuzzy evaluation matrix according to the opinions of experts. Grade the performance of scientific team to 4 rank, establish a remark set V = { excellent, good, medium, poor }. As an example, to make a fuzzy evaluation of scholar paper U_{11} in scientific research performance U_1, if 50% members are excellent, 20% members are medium and 10% members are poor, the membership of U_{11} is (0.5,0.2,0.2,0.1); Similarly, we can get the rest membership in U_1 and other indicators memberships of the layer, the Grayscale can be gain though averaging the experts judging scores:

$$\tilde{R}_{1\otimes} = \begin{bmatrix} (0.5,0.3) & (0.2,0.6) & (0.2,0.5) & (0.1,1) \\ (0.3,0.3) & (0.5,0.3) & (0.2,0.3) & (0,0.3) \\ (0.7,0.4) & (0.1,0.2) & (0.1,0.2) & (0.1,0.4) \\ (0.1,0.3) & (0.6,0.4) & (0.2,0.5) & (0.1,0.5) \end{bmatrix}$$

$$\tilde{R}_{2\otimes} = \begin{bmatrix} (0.4,0.5) & (0.4,0.4) & (0.2,0.6) & (0,0.5) \\ (0.3,0.2) & (0.3,0.3) & (0.3,0.3) & (0.1,0.25) \end{bmatrix}$$

$$\tilde{R}_{3\otimes} = \begin{bmatrix} (0.7,0.4) & (0.2,0.35) & (0.1,0.4) & (0,1) \\ (0.6,0.5) & (0.2,0.55) & (0.1,0.5) & (0.1,0.6) \\ (0.2,0.35) & (0.7,0.5) & (0.1,0.3) & (0,0.5) \end{bmatrix}$$

$$\tilde{R}_{4\otimes} = \begin{bmatrix} (0.6,0.3) & (0.2,0.4) & (0.1,0.5) & (0.1,0.5) \\ (0.3,0.25) & (0.5,0.3) & (0.2,0.3) & (0,0.25) \\ (0.1,0.4) & (0.7,0.35) & (0.2,0.35) & (0,0.4) \\ (0.2,0.3) & (0.4,0.4) & (0.3,0.5) & (0.1,1) \end{bmatrix}$$

Layer gray fuzzy comprehensive evaluation: The gray fuzzy comprehensive evaluation of U_i can be obtained from the formula (1):

$$\tilde{B}_{1\otimes} = \tilde{A}_{1\otimes} \circ \tilde{R}_{1\otimes} = \left[(0.41,0.098)\ \ (0.343,0.126)\ \ (0.175,0.126)\ \ (0.072,0.26)\right]$$

$$\tilde{B}_{2\otimes} = \tilde{A}_{2\otimes} \circ \tilde{R}_{2\otimes} = \left[(0.35,0.4)\ \ (0.35,0.42)\ \ (0.25,0.54)\ \ (0.05,0.44)\right]$$

$$\tilde{B}_{3\otimes} = \tilde{A}_{3\otimes} \circ \tilde{R}_{3\otimes} = \left[(0.503,0.268)\ \ (0.36,0.336)\ \ (0.1,0.244)\ \ (0.037,0.595)\right]$$

$$\tilde{B}_{4\otimes} = \tilde{A}_{4\otimes} \circ \tilde{R}_{4\otimes} = \left[(0.285,0.054)\ \ (0.465,0.082)\ \ (0.205,0.113)\ \ (0.045,0.156)\right]$$

Combine the Gray fuzzy evaluation matrix:

$$\tilde{R}_{\otimes} = \left[\tilde{B}_{1\otimes}\ \ \tilde{B}_{2\otimes}\ \ \tilde{B}_{3\otimes}\ \ \tilde{B}_{4\otimes}\right]^{T}$$

The gray fuzzy comprehensive evaluation of the scientific team is:

$$\tilde{B}_{\otimes} = \tilde{A}_{\otimes} \circ \tilde{R}_{\otimes} = \left[(0.391,0.044)\ \ (0.376,0.06)\ \ (0.182,0.064)\ \ (0.052,0.142)\right]$$

Processing of the evaluation results: Transform gray fuzzy comprehensive evaluation $\tilde{B}_{\otimes}$ to results set $\tilde{B}$, based on formula (2):

$$\tilde{B} = (0.397\ \ 0.375\ \ 0.181\ \ 0.047)$$

The maximum is 0.397, the evaluation rank is good.

CONCLUSIONS

This study uses a gray fuzzy theory to establish a scientific innovation team performance evaluation indicator system, further enriched and developed the theory, it has some reference significance and value to the construction and management of scientific innovation team. The practice should be based on the characteristics of the different types of scientific innovation team and build niche targeting evaluation indicator system to enhance the scientific and operability of the evaluation indicators.

REFERENCES

Bu, L.H. and D.Z. Cai, 2008. Research on influence factors of innovation capability of university science and technology innovation team. J. Harbin Institute Technol., 10: 113-118.

Chuandong, Z., 2008. Approach to harmonious culture construction in sci-tech innovation team. J. Wuhan Univ. Sci. Technol., 10: 87-91.

Guan, J. and C.Y. Hu, 2004. Construction and management of sci-tech research teams in colleges and universities. J. Wuhan Univ. Sci. Technol., 1: 22-24.

Guo, X. and W. Zhiping, 2012. A study on the index system for selecting the members of the scientific and technological innovation team base on collaborative information. Sci. Manage. Res., 30: 63-65.

Ju-Long, D., 2005. Bilingual Gray Basic Methods. 2nd Edn., Huazhong University of Science and Technology Press, Wuhan.

Kang, X.D., Q. Wang and D.M. Guo, 2005. Some theoretical problems on the construction of research team. Studies Sci. Sci., 2: 232-236.

Maolin, Z. and D. Zefang, 2011. Empirical study of relationship between quantity of innovation team and ability of Sci-tech innovation in college. Sci. Technol. Prog. Policy, 28: 151-155.

Qiu, K., 2012. Research of incentive model for local university science and technology innovation team based on cooperation. Sci. Manage. Res., 30: 59-62.

Shao, R.J. and B. Hu, 2008. Study on the evaluation of enterprise innovation vitality based on gray fuzzy theory. Sci. Technol. Manag. Res., 4: 131-133,136.

Wang, W., 2011. Component model and core elements of university science and technology innovation team. Heilongjiang Res. Higher Educ., 4: 83-85.

Weiming, Z. and Z. Xiaoxia, 2009. Evaluation on innovation capability of the science and technology innovation team in universities and colleges based on AHP. Sci. Technol. Prog. Policy, 26: 187-190.

Wen, C. and Z. Qiang, 2007. Grey fuzzy comprehensive evaluation on TPL' performance of customer service. Fuzzy Syst. Math., 21: 148-154.

Xiaohong, W. and Z. Baosheng, 2011. Based on gray relational analysis of network capacity and knowledge flow capacity coupled-technology innovation team of HIT. Sci. Technol. Prog. Policy, 28: 126-131.

Xiaozhuo, W. and W. Junmin, 2008. Bottleneck restraints in construction of scientific and technological innovation team of universities and countermeasures. J. Jiangsu Univ. Sci. and Technol. (Social Sci. Edn.), 8: 102-108.

Zhang, Z. and Z.X. Feng, 2012. The evaluation of technology roadmap effect based on gray fuzzy theory. Stat. Decision, 6: 182-185.

Zheng-Jun, H., L. Gang-Fu and Z. Da-Shui, 2007. Application study of grey theory in intrusion detection technology. Comput. Eng. Design, 28: 5610-5612.

Zhu, Y.Y., Z.Q. Ma and Y.Q. Chen, 2009. Performance evaluation of science and technology innovation team based on BSC and gray fuzzy theory. Sci. Technol. Manage. Res., 12: 431-433.