Measurement Methods and Application Research of Triple Helix Model in Collaborative Innovation Management

Hai-Yun Xu, Zeng-Hui Yue, Shu Fang, Rong-Qiang Zeng, and Zheng-Biao Han

(Chengdu Library of the Chinese Academy of Sciences)

Paris, France
May. 26, 2015

Outline

- 1. Background
- 2. Methodology
- 3. Empirical Study
- 4. Discussion & Conclusion
- 5. Role of the TTO
- 6. Achievements and Improvement on the road ahead

1. Background

- **About Triple Helix innovation model**
  - Proposed by Etzkowitz and Leydesdorff in 1995 (Leydesdorff and Etzkowitz 1996), model to research institutions, industry and government in promoting innovation in the era of knowledge economy.
  - Both independent and interacting. (Fang 2004). High coordination degree can contribute to efficient innovation output, and facilitate the effective transfer and transformation of innovations to achieve a virtuous circle of innovation activities.

1. Background

- **Significance to carry out quantitative evaluation of collaborative innovation**
  - Maintain high innovation efficiency for countries and institutions.
  - Finding the shortages in the innovation chains of countries or agencies.
  - Further improving or amending management systems and policies.
  - Improving the low conversion rate of scientific research achievements.

1. Background

- **Theoretical research of triple helix collaborative innovation**
  - Etzkowitz emphasizes that the function change of university are essential to the forming of triple helix model .also stressed that an entrepreneurial university is the development motivation of triple helix. and university should take a proactive approach in the application of knowledge and increase investment in knowledge creation (Etzkowitz).
  - Mixed organizations are also known as interface organizations, which are within the overlapping regions of the triple helix's bilateral or trilateral areas. (Pan and Yin 2009).

1. Background

- **Theoretical research of triple helix collaborative innovation**
  - Liu describes the triple helix model as well as their role, arising problems and relationship of three elements, which is appropriate for China currently. (Liu 2011).
  - the TH model provides an ideal model for the cooperation among U-G–I. TH model has division and crossover, making up for the deficiency of simple binding in original GUI modes. (Shi 2010; Zi, etc. 2009) .

1. Background

- **Measurement methods and empirical research of triple helix collaborative innovation**
  - Using the U–I–G relations and the International Co-authorship Relations, Leydesdorff et al. studied the National and International Dimensions of the Triple Helix in Japan (Leydesdorff, etc. 2009).
  - Shin et al. analyzed the research productivity of Saudi academics using the TH model. (Shin, etc. 2012).

1. Background

- **Measurement methods and empirical research of triple helix collaborative innovation**
  - Traced the structural patterns of co-authorship between Korean researchers at three institutional types (U–I–G) and their international partners in terms of the mutual information generated in these relations (Kwon, etc. 2012).
  - The agricultural innovation systems of two Northeast Asian countries—Korea and China—were investigated and compared from the perspective of triple helix innovation (Kim, etc. 2012).

1. Background

- **Measurement methods and empirical research of triple helix collaborative innovation**
  - Mapped the emergence dynamics of the knowledge base of innovations of Research & Development by exploring the longitudinal trend of systemness within the U–I–G relations in Bangladesh on the TH model (Hossain, etc. 2012).
  - Investigated the outsourcing knowledge infrastructure from a network point of view by using triple helix indicators and social network analysis techniques (Swar, etc. 2013).

1. Background

- **Measurable indicators of the triple helix based on the mutual information**
  - Entropy is the occurrence probability of discrete random events. The bigger the uncertainty of events, the bigger the entropy value is. the more orderly the system, the lower the entropy value is(Shannon).
  - In the case of one variable, the entropy is calculated as follows:

$$T_{gia} = H_a + H_i + H_g - H_{ai} - H_{gi} - H_{ga} + H_{gia} \qquad \text{公式（5）}$$

1. Background

- **Measurable indicators of the triple helix based on the cooperation similarity**
  - Sun and Neiishi proposed that using ψ coefficient and partial correlation coefficients to measure status of the triple helix innovation system is easier to calculate and expand.
  - Ψ coefficient is used to analyze bilateral relations, and is calculated by Pearson product-moment correlation coefficient. The formula is as follows:

$$r=\frac{\sum_{i=1}^{n}(X_i-\bar{X})(Y_i-Y)}{\sqrt{\sum_{i=1}^{n}(X_i-\bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i-\bar{Y})^2}}$$ 公式（6）

1. Background (continued)

- **Limitations**
  - Single index can not avoid errors for neglecting other important factors.
  - There still lack comparing analysis about the various measurement indicators.
  - It is possible to obtain more comprehensive and accurate information(our work).

2. Methodology (continued)

- **Main steps**
  - (1) Calculate the collaborative innovation degree of the triple helix, and analyze their results respectively.
    - according to the measurable indicators of the triple helix based on the mutual information
    - and cooperation similarity
  - (2) In order to get a comprehensive assessment Conduct a comparing analysis, and compare the results of two measurement types.
    - similarity and difference, strong and weak correlation.

Measurement indicators

- **Main steps**
  - Research articles are retrieved from science and technology database.
    - Papers participated by government mean papers funded by government.
  - The critical step is the extraction of intermediate variables and conversion of measure variables.
    - Intermediate variables are those can be directly extracted from bibliographic data.
    - Measure variables are those can be directly used to calculate the degree of collaborative innovation.

Table1 Intermediate variables and extraction methods

Variables	Meaning	Extraction methods
A0	Number of papers published by academy	Author Affiliation includes UNIV*、COLL*、ACAD* or NIH*. Create a data subset: A0.
I0	Number of papers published by industry	Author Affiliation includes GMBH*、CORP*、LTD*、AG* or INC*. Create a data subset: I0.
G0	Number of papers funded by government	The dataset includes mark of Funding Organization. Create a data subset: G0.
AI0	Number of papers co-published by academy and industry	Author Affiliation includes both A0 and I0. Create a data subset: AI0.
G0A	Number of papers funded by government and published by academy	Extracts subset involved academy from G0. Create a data subset: G0A.
G0I	Number of papers funded by government and published by industry	Extracts subset involved industry from G0. Create a data subset: G0I.
G0IA	Number of papers funded by government and co-published by academy and industry	Extracts subset involved industry from AG0, or extracts subset involved academy from IG0. Create a data subset: G0IA.

Table2 calculation variables and extraction methods

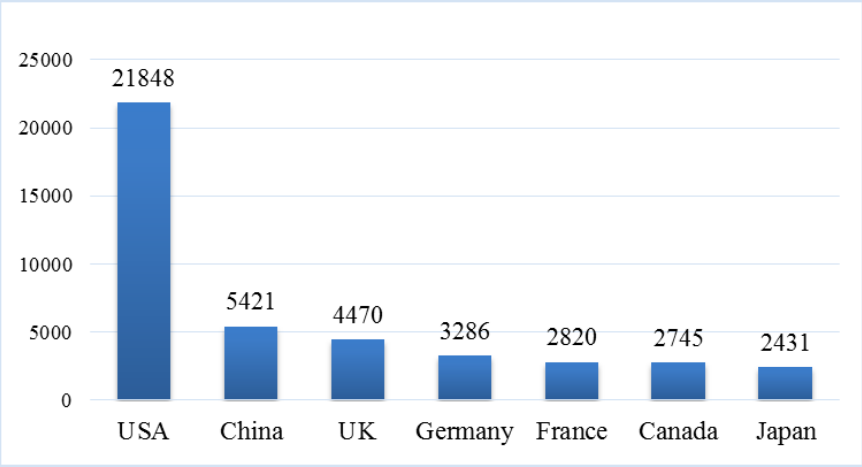
Variables	Meaning	Calculation formulas
A	Number of papers published only by academy	A=U0-UI0-UG0+UIG0
I	Number of papers published only by industry	I=I0-UI0-IG0+UIG0
G	Number of papers published only by government organization	G=G0-IG0-UG0+UIG0
AI	Number of papers co-published only by academy and industry	AI=Ul0-UIG0
GI	Number of papers funded by government and published only by industry	GI=IG0-UIG0
GA	Number of papers funded by government and published only by academy	GA=UG0-UIG0
GIA	Number of papers funded by government and co-published only by academy and industry	GIA=UIG0

3. Empirical Study (continued)

- **Data sources and analysis tools**
  - Select the core collection of Web of Science, index database includes: SCI-EXPANDED, SSCI, CPCI-S, CCR-EXPANDED and IC。
  - The type of document is article, and the time span is from 2000 to 2014. Retrieval strategy is: (TS = vaccin *).
  - 7 countries published over 5,000 papers: United States, Britain, China, Germany, France, Canada and Japan.

3. Empirical Study (continued)

- Statistical description



The United States' biomedical research output occupies the high ground in vaccine research field, and there is wide margin with the remaining six countries. The second is China, and then followed by the UK, Germany, France, Canada and Japan.

Fig.1 Thenumber of papers published by the top 7 countries（Recorded by web of science）

Seven major innovative countries all have a negative growth rate in 2012 , briefly into the doldrums. In 2013, apart from the United Kingdom and Canada still remaining negative growth, China has maintained a steady growth rate; the remaining four countries began to grow, especially France and Japan grow a lot.

Fig.2The annual growth rate of papers published by the top 7 countries

3. Empirical Study (continued)

The measurement of the triple helix collaborative innovation

- The measurement of the degree of collaboration based on mutual information.
- The measurement of the degree of collaboration based on cooperation similarity

3. Empirical Study (continued)

- Measurement of the triple helix collaborative innovation

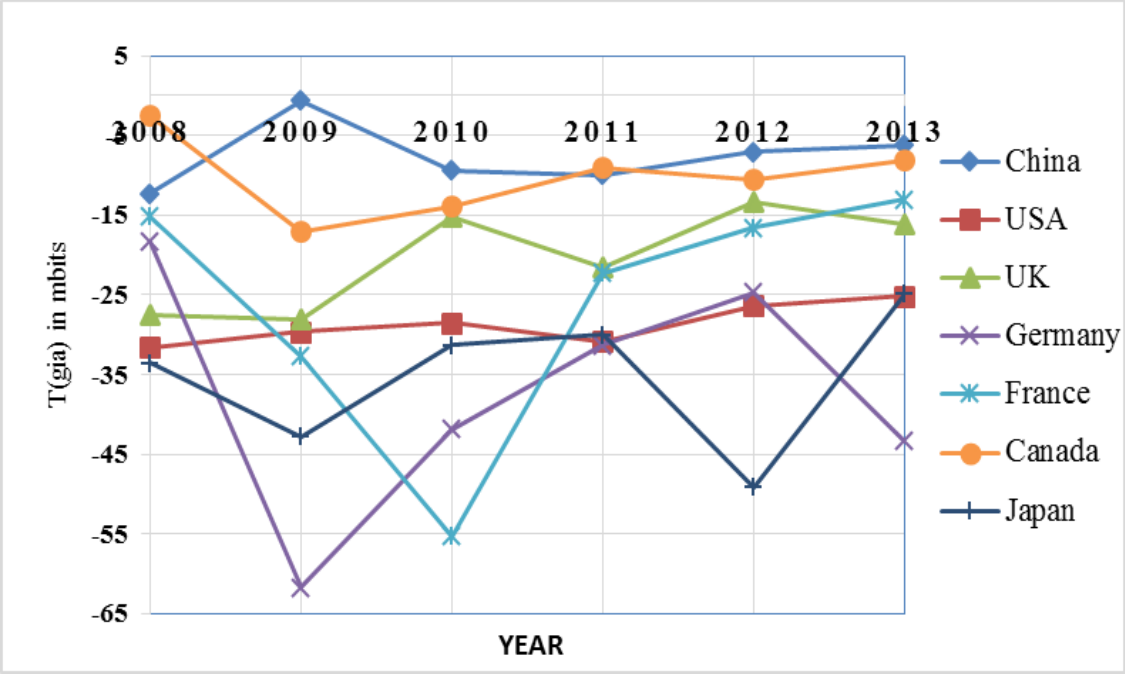


Fig.3 The T(gia） of the top 7 countries in the field of vaccine

Degree of collaborative innovation in Canada and the United Kingdom lie at a low level in seven countries, but remain stable. France's has greater volatility; it greatly improved from 2009 to 2010, but they began to fall after 2011.degree of collaborative innovation in China is the lowest and remains relatively stable, even occur positive value in 2009.

3. Empirical Study (continued)

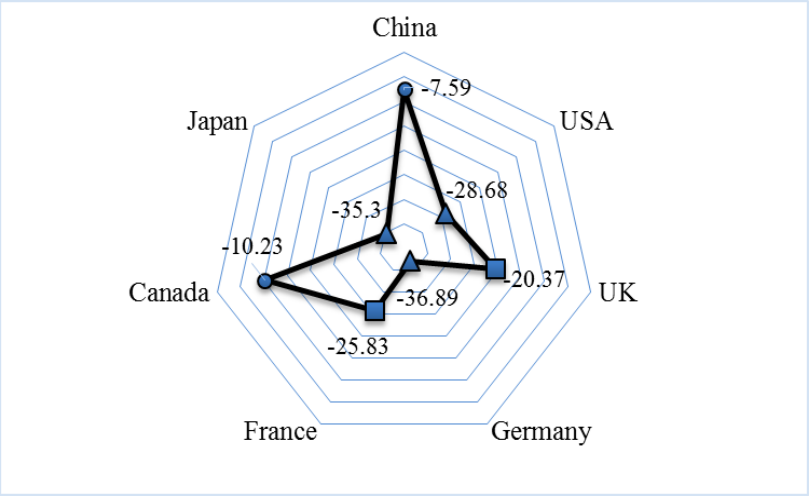


Fig.4The average ofT(gia） of the top 7 countries in the field of vaccine

Germany, Japan and the United States are among the top three, belong to the first gradient, and with the highest degree of collaborative innovation. France and Britain are in the second gradient, their collaborative innovation degree rank in the median. Canada and China are in the third gradient, belong to weaker countries.

Comparing Figure 4 and 5, the results have significant differences. This is because the calculation of collaborative similarity based on mutual information contains seven cooperation ratios, while R_{AIG} average is only the ratio of U-I- G cooperation. So R_{AIG} average can't accurately characterize the degree of collaborative innovation. We should integrate using seven kinds of ratios to measure the degree of collaborative innovation.

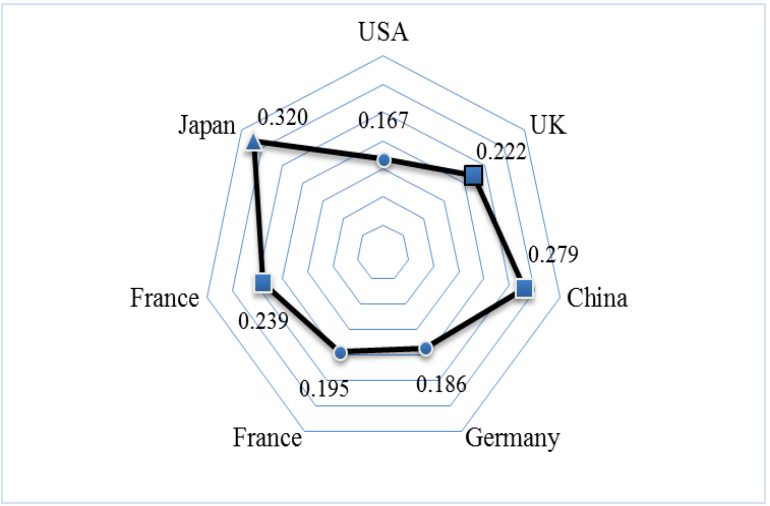


Fig. 5The average of R_{GIA} of the top 7 countries in the field of vaccine

3. Empirical Study (continued)

- (1) cooperation ratios of seven countries

● practice a survey of different cooperation ratios of seven countries, and make a comparative analysis.

●Research output rate of China's industry is significantly lower, and its funding rate by the government is also lower, while its cooperation with research institutions is not high.

●German companies not only have a high ratio of government funding, but also has a high proportion of independent research output..

Table 3 The cooperation ratio **of** top 7 countries in the field of vaccine

Ratio	United States	UK	China	Germany	France	Canada	Japan
R_A	0.2184	0.1793	0.1389	0.2503	0.2405	0.2049	0.1591
R_I	0.0204	0.0229	0.0030	0.0381	0.0202	0.0202	0.0458
R_G	0.0538	0.0424	0.0337	0.0373	0.0403	0.0131	0.0284
R_{AI}	0.0680	0.0876	0.0673	0.0962	0.1007	0.1019	0.1303
R_{GA}	0.4509	0.4126	0.4732	0.3701	0.3833	0.4088	0.2973
R_{GI}	0.0212	0.0330	0.0049	0.0217	0.0203	0.0123	0.0192
R_{GIA}	0.1672	0.2223	0.2790	0.1863	0.1948	0.2389	0.3198

3. Empirical Study (continued)

(2) Multidimensional scaling analysis

United States, France and Japan are similar in the status of Government, industry and Academy. Germany, Canada, UK and China have large differences with other countries, and thus they are on the edge of the image.

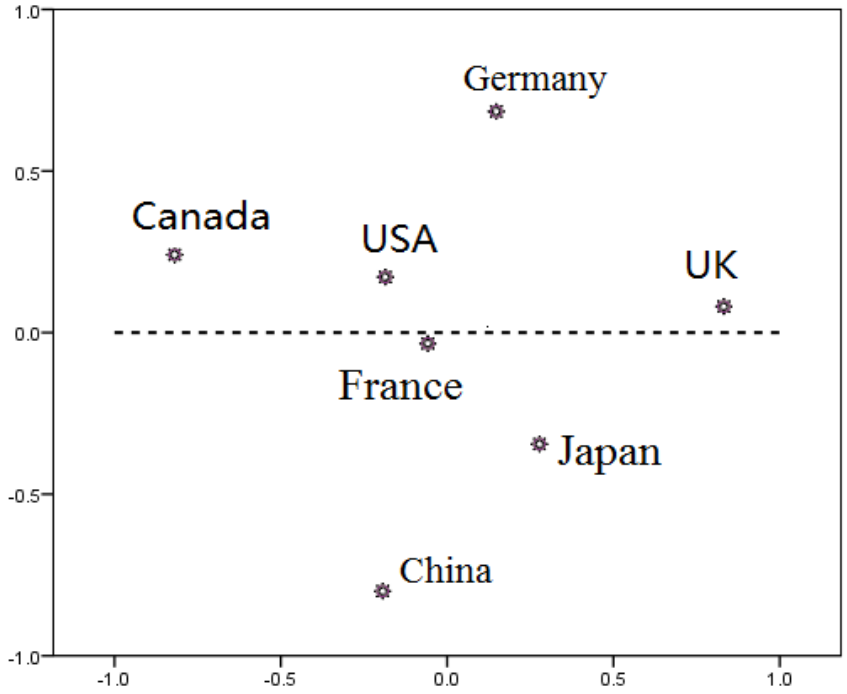


Fig. 6The multidimensional scaling cluster analysis of top 7 countries in the field of vaccine

4. Discussion & Conclusion

Pearson correlation

Find out that the relationship between the various collaborative evaluation indicators is complex. Indicators with high degree of correlation are less, so each index can be used as complementary measurement elements.

Table4 The correlation between cooperation ratio and collaborative degreeT (gia)

	R_A	R_I	R_G	R_{IA}	R_{GA}	R_{GI}	R_{GIA}	T(gia)
R_A	1.000	.256	.244	.040	-.121	.349	-.831	-.004
R_I	.256	1.000	-.092	.787	-.909	.465	.143	-.633
R_G	.244	-.092	1.000	-.524	.294	.487	-.575	.001
R_{IA}	.040	.787	-.524	1.000	-.955	.175	.473	-.554
R_{GA}	-.121	-.909	.294	-.955	1.000	-.309	-.370	.691
R_{GI}	.349	.465	.487	.175	-.309	1.000	-.402	-.353
R_{GIA}	-.831	.143	-.575	.473	-.370	-.402	1.000	-.288
T(gia)	-.004	-.633	.001	-.554	.691	-.353	-.288	1.000

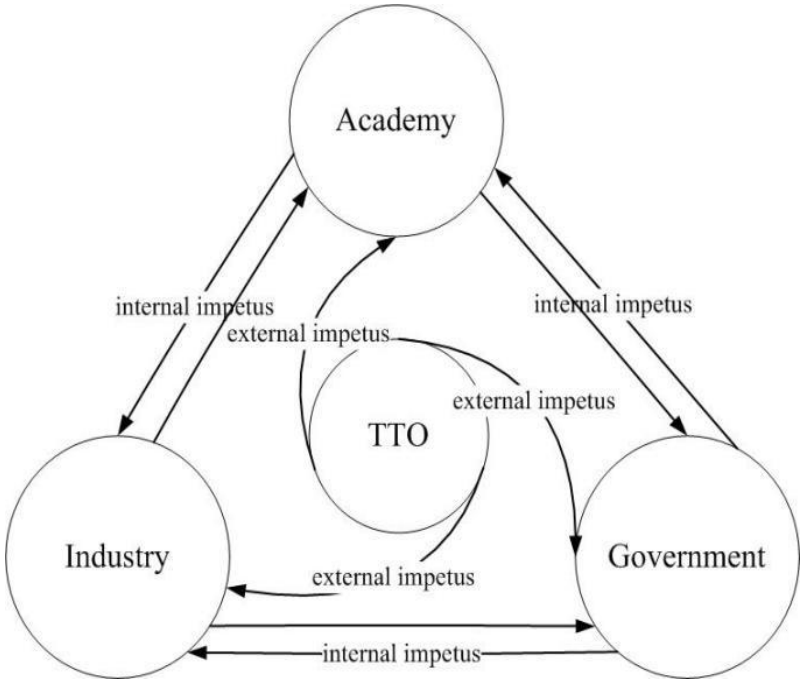


Fig. 7 The role of technology transfer intermediaries in collaborative innovation

Pay attention tothe role of technology transfer organizations(TTO) in collaborative innovation. Xiaoli Li (Li 2011) has analyzed the dynamic evolution of American university's patented technology transfer mechanisms in the triple helix model. Each participant forms interactive and reflexive close relationship, and promotes the further development of innovation activities.

The further development of relations between the triple helix is inseparable from the promoting of universities' TTOs.TTO can be used as effective external impetus supplement to the triple helix internal impetus. With the accelerated pace of development of science and technology, as well as refined specialization, external impetus perhaps become the main driving force to the collaborative innovation in GIA triple helix.

6 Achievements Improvement on the road ahead

- **Achievements**
  - The multi-index evaluation can find characteristics that cannot be found by single indicator. Thus, the indicators should be cross-referenced and integrated used.
  - Also can be applied by enterprise and other research institutes like universities.
  - Not only be valuable to scholars but also to policy makers and practitioners.
  - Enabling the industries and well-connected institutes to develop higher impact patent portfolios.

6 Improvement on the road ahead

- **Improvement on the road ahead**
  - Research on microscopic perspective is more important,
    - such as tracking collaborative features from the scientific output of research papers to application for patent protection, know the situation and influencing factors of collaborative innovation,
    - and then find the weak links to solve the crux and ills hindering innovation.
  - Increase monitoring to the collaborative innovation of the GIA in the process of patented technology transfer and transformation.
    - Form the collaborative innovation monitoring mechanism covering the entire innovation chain of technology incubation and industrialization from basic research to patent protection and technical implementation, so as to further support collaborative innovation decision, improve the technology implementation rate in China and promote the efficiency of technological innovation.

Part of References

- Leydesdorff, L.,Etzkowitz, H. Emergence of a Triple Helix of university-industry-government relations. Science and public policy, 1996,23(5): 279-286.
- Fang, Weihua. The Triple Helix model of innovation research: concepts, structure, and public policy implications . Dialectics of Nature, 2004,19(11): 69-72.
- Qi, Hongshan, & Wu, Si. The analysis of innovation strategy evolution and trend in China - Architecture based on the Triple Helix model . Liaoning Science and Technology Reference, 2007, (8): 9-12.
- Li, Xueqin, &Zhou, Huaiying, & Cai, Xiang. The construction of "entrepreneurial" university based on the "Triple Helix" theory . Technoeconomics & Management Research, 2010,(4): 46-49.
- Han, Gaojun. Entrepreneurial universities from the perspective of Triple Helix theory . Education Research Monthly, 2010,(6): 41-43.
- Pan, Donghua, & Yin, Dawei. The Triple Helix interface organization and innovation mechanism . Research Management, 2009,(1): 15-21.
- Liu, An. Study on the triple helix model of the transformation of scientific and technological achievements in China - take CAS as an example. Studies in Science of Science, 2011,29(8): 1129-1134.

Part of References (continued)

- Shi, Huaxue. The triple helix model: Ideal model of combination of university- industry- government . Chinese University Technology Transfer, 2010,(10):30-31.
- Zi, Wucheng, & Luo, Xinxing, & Lu, Xiaocheng. Study of university-industry-government innovation cluster model based on the Triple Helix theory . Science & Technology Progress and Policy, 2009,26(6): 6-7.
- Wang, Chengjun. Comparative study of the Triple Helix measurement at home and abroad . Research Management, 2007,27(6): 19-27.
- Park, H. W., Hong, H. D.,Leydesdorff, L. A comparison of the knowledge-based innovation systems in the economies of South Korea and the Netherlands using Triple Helix indicators. Scientometrics, 2005,65(1): 3-27.
- Leydesdorff, L.,Fritsch, M. Measuring the knowledge base of regional innovation systems in Germany in terms of a Triple Helix dynamics. Research Policy, 2006,35(10): 1538-1553.
- Leydesdorff, L.,Sun,Y. National and international dimensions of the Triple Helix in Japan: University–industry–government versus international coauthorship relations. Journal of the American Society for Information Science and Technology, 2009,60(4): 778-788.
- Shin, J., Lee, S.,Kim,Y. Knowledge-based innovation and collaboration: a triple-helix approach in Saudi Arabia. Scientometrics, 2012,90(1): 311-326.

Acknowledgement

This work in this paper was supported by National Social Science Fund of China (Grant No. 14CTQ033), supported by the Fundamental Research Funds for the Central Universities (Grant No. A0920502051408-25)， supported by the Scientific Research Foundation for the Returned Overseas Chinese Scholars (Grant No. 2015S03007) and supported by West Light Foundation of Chinese Academy of Science.

Thanks for your attention!

Haiyun Xu

(Chengdu Library of Chinese Academy of Sciences)

Add: P.O. Box 20, No. 16 South Sec. 2 Yihuan Rd., Chengdu 610041, P.R. China

Phone: +86-28-85228846

Fax: +86-28-85220439

Email: xuhy@clas.ac.cn