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Construction and Research of Evaluation Indicator System for Technological Innovation Performance

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Abstract In view of sci-tech innovation and innovation-driving requirements of Chinese President Xi Jinping, it is necessary to establish a complete evaluation indicator system for technological innovation performance in Guizhou Province, to accurately evaluate development situation of technological innovation in Guizhou Province, promote close connection of science and technology with economy, and boost rapid development of national economy. In Guizhou Province, there is still no complete evaluation indicator system for technological innovation performance, so it is impossible to comprehensively reflect its technological innovation situation. On the basis of analyzing regional technological innovation and development of Guizhou Province, this paper presents evaluation principles, analysis framework and evaluation methods and gives counter-measures and recommendations for evaluation indicator system for technological innovation performance in Guizhou Province.

Key words Evaluation of regional technological innovation performance, Indicator, Evaluation research

1 Introduction

In new stage, a fundamental requirement of sci-tech reform and development is to provide system and mechanism guarantee for China entering innovative countries in 2020 and becoming a powerful sci-tech country before 2050. Since the Twelfth Five-Year Plan period, Chinese President Xi Jinping asked to put more effort in autonomous innovation on the basis of industrial development demands of Guizhou Province, build sci-tech innovation system, enhance the capacity of sci-tech introduction, digestion, absorption and re-innovation, promote conversion of sci-tech innovation achievements to actual productivity, so as to bring economic development to the sci-tech innovation and innovation-driven road. Building innovative country has direct relation with building a well-off society in an all-round way, and it also directly concerns performance of speeding up economic development and promoting scientific development, as well as competitive power and status of China in the world. At present, Guizhou Province is also improving autonomous innovation capability. It takes autonomous innovation capability as the core of its development strategy and key point for improving its competitive power. Following the principle of "speeding up development and transformation and promoting leapfrog development" and work requirement of "increasing ratio, getting into advanced position, and making breakthrough", Guizhou Province focuses on implementing strategy of synchronous industrialization, urbanization and agricultural modernization and establishing evaluation indicator system for technological innovation performance, to reflect development level and progress of

close connection of local science and technology with economy. At macroscopic level, the performance indicator should reflect close connection with scientific and technological progress and innovation, and transformation of economic development mode, to realize scientific development and bring into play supporting and leading function of science and technology to leapfrog socio-economic development. At microscopic level, the performance indicator should have description, analysis and evaluation functions, and closely connect the coordination degree of relevant economy, society and environment, as well as objectives and requirements to be realized.

2 Documentary overview

Performance has multiple meanings. From the perspective of evolution analysis, performance is a progressive evolution process from one-dimensional, two-dimensional, to multi-dimensional^[1]. Campbell, McCloy, Oppler and Sager believe that the performance is a multi-dimensional concept, there is no single performance variable, and they consider performance as process rather than result. Michael Porter put forward the innovation driven, and directly takes per capita GDP as a mark to distinguish development stage of a country. Huang Lucheng introduces the concept of regional technological innovation ecosystem, and states that in certain spatial range, technological innovation composite organizations interact and inter-depend with technological innovation environment through innovating upon materials and energy and information flow, and then forming the regional technological innovation ecosystem^[2]. Luo Yafei defines the evaluation indicator system of regional technological innovation ecosystem performance as logically reasonable and clearly hierarchical integration of indicators directly or indirectly reflecting performance of regional technological innovation ecosystem^[3]. Liu Xieli thinks that 13 provinces (autonomous regions and municipalities directly under the Central Government), typical examples as Chongqing and Guizhou, are basi-

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cally investment-driven regions^[4]. Development stage of different regions is varied. Some regions will become innovative regions firstly, and some regions will become innovation regions later. In sum, the framework of evaluation indicator system for technological innovation performance in Guizhou Province is based on input and output. The evaluation indicator system for technological innovation performance in Guizhou Province is a typical evaluation indicator system. In the process of primary selection, we mainly referred to *Annual Report of Regional Innovation Capability of China* (2011), *Autonomous Innovation Enterprise Evaluation Indicator System of State Statistics Bureau, the Second R&D Resource Survey Data Compilation of Guizhou Province* (2011), regional evaluation indicator system for technological innovation performance, evaluation indicator system for sustainable development, and practice of Xiamen, Shenzhen and Jinan in sci-tech innovation. The evaluation indicator system should comprehensively reflect implementation of technological innovation performance in Guizhou Province. Through efforts of Guizhou Province in the Eleventh Five – Year Plan period, tasks of medium and long-term sci-tech planning outline have been accomplished. In the mean time, we should also note that as one of less developed western regions, Guizhou Province has arduous task. It is urgent to pool strength in overcoming all difficulties, to ensure smooth realization of the objective of building an innovative country. Therefore, it is required to set up a set of evaluation indicator system for Guizhou Province technological innovation performance suitable for economic development level. Local government should provide new idea for promoting local economy, give prominence to status of innovation in regional development, and bring into play active function of local government in industrial upgrade and transformation of economic development mode.

3 Evaluation principle and analysis framework

To evaluation innovation capability of a region, it needs a set of indicators. Selection of indicators, quality of indicators, selection of weight, proportion of subjective and objective will influence final performance of innovation capability and development trend. Firstly, regional technological innovation is an integral part of national innovation system, is important support of regional socio-economic development, and plays an essential role in industrial upgrade, structural adjustment, and realizing sustainable development of economy, society and environment. Secondly, from perspective of the statistics, a single indicator only reflects a point of the study problem, so it is not ideal to use a single indicator of few indicators to reflect performance of regional technological innovation. Thirdly, the establishment of evaluation indicator system for technological innovation performance in Guizhou Province should base on national and provincial conditions, comply with technological innovation development policies of Guizhou Province, follow principles of unity, hierarchy, conciseness and dynamic and static evaluation.

3.1 Evaluation principles In accordance with design princi-

ples of the above stated regional evaluation indicator system for technological innovation performance, and on the basis of related domestic and foreign experience in building regional evaluation indicator system for technological innovation performance, Guizhou Province should stick to following principles:

(1) The framework must take connection with industrial adjustment into consideration. Knowledge intensive industry takes up larger and larger proportion in industrial structure, which transforms the dependence of development of traditional industry on material resources. Regional technological innovation performance evaluation provides powerful sci-tech support for fast and sound development of economy, and transforms original economic development mode fundamentally. For example, new high technology plays a leading role in upgrade of traditional industries.

(2) The framework must stress importance of construction of innovative environment. The design system should be able to reflect local innovation system and policy timely, have powerful sci-tech strength, share certain quantity of public service platforms, possess a lot of influential innovative enterprises, including private enterprises and sci-tech enterprises, form excellent industrial agglomeration, effectively allocate various innovation indicators and resources, advocate civilized innovation culture, and promote external cooperation. Enterprises are subjects of innovation, rather than scientific research institutes, colleges and universities. Besides, major contents for judging performance of local government are not traditional plan or intervention, but how to create environment favorable for enterprises innovation. For example, construction of technological innovation platform, cultivation of innovative enterprises, and cultivation of private sci-tech enterprises.

(3) The framework must take the relationship between environment carrying capacity and economic benefits into consideration. Technological innovation can raise resource utilization rate and lower energy consumption per unit of output value. To solve the conflict of resource and environment in a region, it should not sacrifice environment for the sake of rapid economic development. Instead, it should consider functions and influences of technological innovation activities and environment carrying capacity on economy, society and resources. For example, total energy consumption per 10^4 yuan GDP and per capita GDP (USD).

3.2 Indicator system The evaluation indicator system for technological innovation performance in Guizhou Province consists of 3 levels and 27 indicators. The indicators are based on 7 indicator groups, as listed in Table 1. Since such design can properly reflect the relationship between government, enterprises and people's material life, reflect social and economic factors, and reflect the technological innovation effect of input and output supported by innovative environment in the new stage, it can reflect realities of technological innovation performance in Guizhou Province in a better way. In particular, the evaluation indicator system incorporates transformation of economic growth mode, environmental quality and social progress, to reflect influence of technological innovation on society, economy and natural environment. The de-

tailed indicator system is shown in Table 1.

Table 1 Evaluation indicator system for technological innovation performance in Guizhou Province

	Indicators	Weight//%
I. Transformation of growth mode Y_1	1. Percentage of R&D personnel in employees of industrial enterprises above the designated scale//%	X_1
	2. Average amount input into technological transformation in industrial enterprises above the designated scale// 10^4 yuan	X_2
	3. Percentage of large and medium industrial enterprises with income from main operation of scientific research institutes equal to or above 5 million yuan// %	X_3
	4. Percentage of internal gross sci-tech fund expenditure into total sales income of industrial enterprises above the designated scale//%	X_4
	5. Sales income of new products of industrial enterprises above the designated scale// 10^8 yuan	X_5
	6. Percentage of sales income of new products into total sales income in industrial enterprises above the designated scale//%	X_6
	7. Percentage of output value of new high technological industries into total industrial output value//%	X_7
	8. Percentage of added value of the tertiary industry into GDP//%	X_8
II. Input into technological innovation Y_2	9. R&D/GDP//%	X_9
	10. GDP per capita//USD	X_{10}
	11. Sci-tech expenditure into financial expenditure// 10^8 yuan	X_{11}
	12. Percentage of local finance sci-tech allocation into local financial expenditure//%	X_{12}
	13. Full-time equivalent personnel (FTE) per 10000 population//person / years	X_{13}
	14. Percentage of people with education above college level in people older than 6//%	X_{14}
	15. Per capita amount of domestic investment in fixed assets//1000 yuan/person	X_{15}
III. Conditions of technological innovation Y_3	16. Sci-tech input of government// 10^8 yuan	X_{16}
	17. GDP// 10^8 yuan	X_{17}
	18. Financial expenditure of government// 10^8 yuan	X_{18}
	19. R&D fund expenditure// 10^8 yuan	X_{19}
IV. Output of technological innovation Y_4	20. Transaction amount of technological market (as per flow direction)// 10^4 yuan	X_{20}
	21. Domestic papers//Pcs	X_{21}
V. Awareness of technological innovation Y_5	22. International papers published every 105 people//Pcs	X_{22}
	23. Average number of acceptance of patent application every 105 people//Pcs	X_{23}
VI. Improvement of environmental quality Y_6	24. GDP(10^8 yuan) /total energy consumption per 10^4 yuan GDP (10^4 ton standard coal/ 10^4 yuan)	X_{24}
VII. Promoting social progress Y_7	25. Average telephone users every 100 people//households/100 people	X_{25}
	26. Average Internet users every 100 people//poople/100 people	X_{26}
	27. Consumption level of residents//yuan	X_{27}

4 Evaluation method

(1) Setting of indicator weight: through consulting related experts, referring to domestic research achievements and Soft System Methodology introduced by Professor Checkland in 1981, in combination with actual situations and characteristics of technological innovation in western less developed regions, According to intrinsic characteristics of regional technological innovation, we assign respective weight to 7 types of indicators. Firstly, in the new period, transformation of economic growth mode takes up the largest part in scientific and technological support. Secondly, the support of science and technology for socio-economic development is mainly reflected from improvement in new high technology and environmental quality. Thirdly, the World Economic Forum takes the development stage with per capita GDP less than 2 000 USD as indicator driven development stage. Compared with developed prov-

inces and regions, Guizhou Province realized 2 495 USD per capita, which is worth considering.

(2) Standardized processing of data: the evaluation indicator system for technological innovation performance of Guizhou Province includes 27 indicators. 26 indicators are positive indicators and 1 indicator is negative indicator. The higher realization value of positive indicators, the higher degree of regional technological innovation performance; on the contrary, the lower realization value of negative indicators, the higher degree of regional technological innovation performance. Considering consistency of comprehensive indicators, environmental quality improvement is conversed into positive indicator from "GDP (10^8 yuan) total energy consumption per 10^4 yuan GDP (10^4 ton standard coal/ 10^4 yuan)".

(3) Calculation of comprehensive indicator index: the evaluation indicator system for technological innovation performance of

Guizhou Province includes three levels: comprehensive evaluation index, secondary indicator and tertiary indicator. The formula for calculating evaluation system index of technological innovation performance of Guizhou Province: Step 1: according to original data, to eliminate influence of high absolute value gap due to difference of dimensions on analysis results, and reduce analysis error as far as possible, take natural log of original data of each indicator, calculate performance of each basic level indicator X_{ij} ($j=1, 2, 3, \dots, m$), and then calculate $\sum_{j=1}^m x_{ij}$. Step 2: according to secondary indicator, i. e. the secondary indicator performance degree Y_i ($i=1, 2, 3, 4, 5, 6, 7$), calculate $Y_i \sum_{i=1}^7 \sum_{j=1}^m x_{ij}$. Step 3: use the formula of Rural Comprehensive Well-off Index RCWI $= Y_i \sum_{i=1}^7 \sum_{j=1}^m x_{ij}$ to calculate evaluation index for technological innovation performance of Guizhou Province.

5 Countermeasures and recommendations for evaluation indicator system for technological innovation performance in Guizhou Province

5.1 Enhancing supervision and evaluation Specifically, it is recommended to incorporate transformation of growth mode, conditions of technological innovation, output of technological innovation, improvement of environmental quality, and promoting social progress into annual statistical content. In addition, it should include input of provincial, city (prefecture and district), county (city, district and special district), industrial park, colleges and universities, scientific research institutes and enterprises in technological innovation and improvement of environmental quality into major content of annual evaluation of Provincial Party Committee and Provincial Government on cities (prefectures and districts), departments directly under the control of Provincial Government, and related enterprise and institutions.

(From page 7)

career resources, working together to enhance the professional competence of the new generation migrant workers is an important task. It is recommended that various departments should take advantage of these educational resources with clear aim and evaluate the training effect, or conduct short-term or long-term follow-up survey on the training effect of migrant workers, to effectively enhance the employability of migrant workers.

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5.2 Establishing and perfecting statistical work system At first, it should set up coordination mechanism for statistical statement department. Data of varied statistical statement should be strictly reviewed as per disciplines. Secondly, it should set up statistical indicator evaluation system. The setting of statistical indicators should proceed from the reality. Sci-tech indicators reflecting legal person entities should make clear concept and scope. Indicators of statistical object should be clear, to make indicators of regional technological innovation really provide services for close connection of science and technology with economy, as well as demands. Thirdly, acquisition of statistical data should adopt scientific statistical method.

5.3 Strengthening research and exploration on analysis methods After establishment of the evaluation indicator system for technological innovation performance of Guizhou Province, the key work should be application, conversion of achievements, and analysis of statistical data with the aid of evaluation indicator system. For current situations and development of technological innovation activities, it should carry out scientific research and analysis, and provide valuable evaluation analysis report. In actual analysis, it should apply scientific and reasonable analysis method, to raise working efficiency and improve quality of analysis report.

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