A Comparative Study of Measurement of Innovation Capability between China and the West

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Abstract: This paper introduces 13 measurement of innovation capability in China and in the West according to countries (regions) and field (industries), aiming to sort out their development history, evaluation index systems and the latest researching fruits and to present their subjects, characteristics and achievements briefly and objectively. A comparison has been made at last between the measurement of innovation capability between China and Western countries.

1. Introduction

The word "innovation" was first proposed by Joseph Alois Schumpeter, an Austrian political economist, in his book ***The theory of economic development (1911)***. In the book, when Schumpeter expounded the essence of economic development, the concept of "innovation" came out for the first time. The book regarded the innovation as a new production function, which aimed to introduce a new combination of factors of production and production conditions that has never been introduced into the production system before. Furthermore, the author further clarified the essence of economic development was the process that the whole society continuously introducing this "new combination" through enterprises. In addition, the book also described five forms of innovation: The introduction of a new good; The introduction of a new method of production; The opening of a new market; The conquest of a new source of supply of raw materials of half-manufactured goods; The carrying out of the new organization of any industry[1]. It can be seen that innovation at first was a concept belongs to economic category.

In 1985, Peter Ferdinand Drucker, a leader in the development of management education, introduced the concept "innovation" to management category in his book ***Innovation and Entrepreneurship***. He defined the innovation generated by entrepreneurs in management as "Innovation is the act that endows resources with a new capacity to create wealth[2]", bringing the concept "innovation" into the management realm.

British economist Chris Freeman first proposed the concept of National Innovation System (NIS) in 1987. Freeman analyzed the mechanism of technological innovation in Japan by studying the role of business organizations, production organizations, enterprises and governments. In 1987, he published the book ***Technology policy and economic performance: Lessons from Japan*** *to* stress the importance of government policies, enterprises and their R&D work, education and training, and industrial structure in the national innovation system. He construed the national innovation system as a network in both public and private scope, the main activities of which are to develop, introduce, transform and spread new technologies [3]. Freeman's national innovation system was essentially a national technology innovation system, in which the innovation was regarded as the power for technological progress.

In 1992, the OECD made its first concrete and widely accepted definition for"innovation" in its publication ***Oslo Manual, 1st Edition***, and in the third edition of ***Oslo Manual*** in 2005, the innovation was defined as "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations". Moreover, it also proposed that

"Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations." [4]

2. The measurement of innovation capability in China and in the West

The measurement of innovation capability is diverse and includes various classification methods. First, in terms of the quantity of evaluation target, it can be divided into Single-target measurement and Multi-targets measurement: single target measurement is to analyze and evaluate one target continuously; Multi-target measurement is a continuous analysis and evaluation on more than one target in various stages, either to make the prediction for the development and trend of a certain target in different stages, or to make a performance comparison among different targets in a same period. Second, the measurement of innovation capability can be classified as country (region)-level and field (industry)-level considering the nature of evaluation targets [5]. This paper is going to present 13 measurement of innovation capability in China and in the West depending on the second classification approaches.

2.1 The measurement of innovation capability in the West

2.1.1 Country(Region)-level

2.1.1.1. The Global Competitiveness Report(GCR)

The World Economic Forum (WEF) published the first annual report in 1979 and launched the Global Competitiveness Index (GCI) as the measurement of the competitiveness among countries in 2006, 40 annual GCR released so far.

The latest GCR was published on Oct.16, 2018, adopted GCI 4.0 to evaluate 140 economies worldwide. The GCI 4.0 score consists of four Sub-Index (not used in calculation)—Enabling Environment, Human Capital, Markets and Innovation Ecosystem,12 pillars and 98 indicators. All the indicators are assigned the same weight. The 2018 edition of the GCR shows that the United States, Singapore, and Germany take the top three, while China ranks the 28th, the same as the previous one [6].

2.1.1.2. World Competitiveness Yearbook (WCY)

The International Institute for Management Development (IMD) in Switzerland launched the first annual report in1989.

The World Competitiveness Ranking in 2018 is comprised of four Sub-Index—Economic Performance, Government Efficiency, Business Efficiency, Infrastructure, 20 pillars and 340 indicators (including 115 survey data). The Scientific Infrastructure and Technological Infrastructure under the Infrastructure has 19 and 25 indicators respectively, which is the main indicator applied to measure the technological competitiveness among countries.

The evaluation targets of the latest IMD WCY 2018, published on May.23, 2018, cover 63 countries and regions across the world, with the United States, Hong Kong (China), Singapore ranking at the top three and China the 13th [7].

2.1.1.3. European Innovation Scoreboard (EIS)

EIS (changed its name into Innovation Union Scoreboard (IUS) in 2011), is the influential measurement of innovation capability system in the world.

The European Commission, to meet the commitment of the European Union Lisbon Conference, launched the ***European Innovation Scoreboard 2001*** in Oct. 2001, containing four Sub-Index—Human Resources, Knowledge production, Knowledge spread and application, and Innovative finance, and 17 pillars, to evaluate the innovation performance of the fifteen EU countries at that time.

EIS, additionally, launched the Summary Innovation Index (SII) to reflect the overall technological innovation performance of EU so as to make a comparison between other countries and EU as a whole. As an indicator measuring innovation performance, SII is calculated as the arithmetic average between the indicator that exceeds 20% than the EU average and indicator that lowers 20% than the EU average [8]. Over years, adjustments have been made for the indicators and

the evaluation target has increased along with the growth of EU member states. Consequently, the EU can be treated as an innovation whole to compare with the global major economies in a system with fewer indicators.

In the year of 2018, IUS consists of 27 indicators in total: four main types of indicators—Framework conditions, Investments, Innovation activities, Impacts, ten dimensions (Human resources, Finance and support, Innovators, Employment impacts, etc.) and other indicators like New doctorate graduates, R&D expenditure in the public sector, SMEs with product or process innovations, Employment in knowledge-intensive activities. The evaluation targets include 28 EU member states and eight non-EU countries such as Israel, Turkey and Switzerland. EIS classified the EU member states into Innovation leader, Strong Innovator, Moderate Innovator and Modest Innovator according to their SII rank. Meanwhile, the EIS also compares EU with the "BRICS" countries, Australia, Canada, Japan, South Korea and the United States with fewer indicators which can be applied internationally [9].

In the ***2018 European Innovation Scoreboard***, which published on June 22,2018 in Brussel, demonstrates that the overall innovation performance of Sweden, Denmark and Finland ranks the top three in the EU member states, while Lithuania, Netherlands and Malta take the top three in the rate of innovation development. The comparison between EU and the other ten countries shows that the growth rate of innovation of EU has been improved continuously since 2010, and the development rate is higher than that of the United States, Japan, and Canada. China's innovation capability has developed rapidly, with an average growth rate three times than that of EU [9].

2.1.1.4. Global Innovation Index (GII)

GII was first launched by INSEAD in 2007.

The latest ***Global Innovation Index 2018,*** the 11th edition of GII, was co-released on July 10, 2018 by Cornell University, INSEAD, WIPO and its partner agencies.

GII contains two Sub-Index—Innovation Input、Innovation Output, 7 pillars，80 indicators(57 variables are hard data, 18 composite indicators, 5 survey questions). The latest report covers 126 economies with a global population of 90.8% and GDP of 96.3%, showing that the top three are Switzerland, Netherlands and Sweden. China ranks No.17 in this report, 5 places higher than that in the last report, ranking No.1 in the "upper-middle income" group [10].

2.1.2 Field (Industry)-level

The measurement of innovation capability for certain regions (industries) includes Silicon Valley Index and Global City Index.

2.1.2.1. Index of Silicon Valley

Index of Silicon Valley is an annual report that aims to assess the comprehensive development of Silicon Valley, which first released by Joint Venture Silicon Valley in 1995.

The latest report is the ***2019 Silicon Valley Index*** which released in Feb. 2019, applied with a three-tier indicator system. The first-tier indicators are People, Economy, Society, Place and Governance, including 17 pillars and 109 indicators. This indicator system enjoys greater flexibility in that except for the first-tier indicators is fixed, the second- and third-tier indicators sometimes will be adjusted subtly [11].

2.1.2.2. Global Cities

The ***2008 Global Cities Report*** was jointly announced for the first time by AT Kearney, Chicago Council on Global Affairs and Foreign Policy magazine on Nov.27, 2008. In 2015, another report called **Global Cities Outlook** was launched along with ***Global Cities Report***.

The ***2018 Global Cities Report*** is the latest that released in May 2018, containing the **Global Cities Index** and **Global City Outlook**. The **Global City Index** assesses the global influence of 135 cities in the world at present in five Dimensions—Business activity(30%), Human capital (30%), Information exchange (15%), Cultural experience (15%), Political engagement(10%) and another 27 indicators. The top three cities according to the Index is New York, London and Paris. Hong Kong (China) and Beijing ranked No.5 and No.9 respectively. The **Global Cities Outlook** measures the developmental potential of cities by referring to the changes of four Dimensions—Personal well-being, Economics, Innovation and Governance and another 13 indicators. In the latest

report, San Francisco, London and New York rank the top three, and Taipei (China) and Beijing rank 38th and 47th[12] respectively.

Other measurement of global cities include the Globalization and World Cities Study Group and Network (GaWC), World Cities Congress Istanbul, Carl Abbott List and the Ng & Hills etc.

2.2 The measurement of innovation capability in China

China started late in the measurement of innovation capability, resulting to less comprehensive measurement but more field (industry)-oriented measurement with relatively insignificant impact. This part will make a brief introduction to major measurement of innovation capability in China.

2.2.1 Country (Region)-level

2.2.1.1. National Innovation Index Report

Chinese Academy of Science and Technology for Development published the first ***National Innovation Index Report 2011*** In Feb. 2011, which employed the National Innovation Index (NII) to assess the innovation performance of 40 countries with proactive innovation activities in the world. The index system behind NII draw on the evaluation methodology of international authoritative organizations such as WEF and IMD, including five Sub-index—Innovation resources, Knowledge creation, Enterprise innovation, Innovation performance, Innovation environment and another 31 pillars as the indicators. The report selects 40 countries as targets and calculates NII score with the benchmarking method based on the statistical data from 2008 to 2010. As a result, the United States ranks No.1 with an index as 100 and China ranks 20th with 70.5 [13].

The latest ***National Innovation Index Report 2018***, released in Aug. 2018, has made a big change in its index system compared with the first report. The 30 pillars are comprised by 20 Quantitative indicators and 10 Qualitative indicators, all based on the survey data of 2016. According to the latest report, the top three countries are United States, Japan and Switzerland, while China remains No.17 as the last time [14].

2.2.1.2. China Innovation Index(CII)

CII was released by the China Innovation Index (CII) Research Group, Department of National Bureau of Statistics, utilizing four Sub-index to assess and study the innovation index of China: Innovation environment, Innovation input, Innovation output, and Innovation outcome. The assessment set the year of 2005 as Base Period and set the index value of the same year as the benchmark value to measure the growth rate of the current year. The Research Group uses the above index system and methods to measure the China Innovation Index in 2012, with a result that the China Innovation Index of 2012 is 148.2 comparing with 100 in 2005. So far, the author has not retrieved any new information of CII.

2.2.2 Field (Industry)-level

2.2.2.1. The Regional Evaluation Report of Scientific, Technology and Innovation Capabilities in China

The Regional Evaluation Report of Scientific, Technology and Innovation Capabilities in China was released by Chinese Academy of Science and Technology for Development. The index system is composed of five Sub-index—Innovation environment, Scientific and technological input, scientific and technological output, Industrialization of high-tech and Economic and social growth from technology, 12 pillars and 39 indicators. The assessment target is the innovation capability of science and technology in 31 provinces (municipalities and districts) across the country.

The latest one is ***Regional Evaluation Report of Scientific, Technology and Innovation Capabilities in China*** which published on Oct. 29, 2018, demonstrating the national innovation capability index as 69.63, up by 2.06 year-on-year. Meanwhile, Shanghai, Beijing and Tianjin are the top three cities in terms of overall innovation capability index. The three regions that enjoy the top annual growth rates are Anhui Province, Jilin Province and Zhejiang Province [15].

2.2.2.2. Cities Innovation Capability Index in China

The Cities Innovation Capability Index in China was first introduced in the ***China's Cities Report on Innovation (2008)*** which released by China Research Society of Urban Development in Nov.31, 2008.

China's Cities Report on Innovation (2015) is the latest report which utilizes three Sub-index—Innovation basic condition and supporting capability, Capability of industrialization, Brand innovation capability, and another 25 indicators to build the Cities Innovation Capability Index**.** The report collects processes and calculates the index data of 659 cities in the current period from 2014 to 2015 to make measurement from both comprehensive and single perspective according to various levels and groups[16]. In Dec. 2018, China Research Society of Urban Development and other units held the launching ceremony of the ***China's Cities Report on Innovation (2016-2019)***.

2.2.2.3. Zhong Guancun Index

The Zhong Guancun Index is the first index reflecting the development of high-tech zone in China, which published first by Beijing Municipal Bureau of Statistics in 2004 with referring to the data from the first six months of 2004 [17]. The index consists of five indicator groups and each of them contains several subordinated indicators. The five indicators are Economic growth, Economic efficiency, Technological innovation, Human capital and Enterprise development.

Zhong Guancun Index (2018) is the latest, jointly released by Zhong Guancun Institute of Innovation & Development and Beijing Fangdi Institute of Economic Development on Nov. 2, 2018. In the 2018 report, the Zhong Guancun Index consists of five Sub-index, 11 pillars, other indicators and monitoring indicators. Set the Base Period as the year of 2013 and set 100 as the benchmark value, we can get 200.9 for 2017.

2.2.2.4. Monitoring Report of Innovation Capability of Universities in China

So far, the Monitoring Report of Innovation Capability of Universities in China has only published ***Monitoring Report of Innovation Capability of Universities in China (2016)***, which was jointly released by the Ministry of Education of the PRC and the Ministry of Science and Technology of PRC on Oct. 9, 2017. The main data sources for the report stem from the scientific and technological statistics of universities in China from 2005 to 2014 and the study data of innovation of universities in 2015. The report aims to monitor the overall status and characteristics of innovation capabilities in Chinese universities through five Sub-index — Basic background information, Talent training, Research and development activities, Transformation of scientific and technological achievements, and Industry-university-research cooperation, and another 75 pillars [18].

2.2.2.5. Index Report of ST Innovation Capability of University in China

Only take the ***Index Report of ST Innovation Capability of University in China (2017)*** as an reference. The report uses Principal Component Analysis to measure the innovation capability of 64 universities that directly under the Ministry of Education of PRC based on a "4-12-35" measurement indicator system and the statistics from 2014 to 2016. The report presents that the top three are Tsinghua University, Peking University and Shanghai Jiao Tong University [19].

3. Comparison of the Measurement of Innovation Capability between China and the West

In respect of research history, the research and practice for the measurement of innovation capability started earlier in the West world (e.g. WEF released the first GCI as early as 1979 and has issued 40 issues so far), while the research in China has a late start and most influential measurement began after 2000.

In terms of types and quantities: China and Western countries barely have differentiations in the types of targets, with two sides including measurement in country-level, industry-level or region-level. The quantity of measurement in China is much less than the West.

The West boasts a better continuity in the measurement of innovation capability while many weaknesses still exist in the continuity of measurement in China, like the measurement report containing several years' measurement, incontinuous measurement and the measurement that only has one report so far.

As for indicators, Western countries pay more attention to the organic combination of Quantitative indicator, Qualitative indicator and Background data, while the measurement of innovation capability in China lay more stress on statistical data;

With the indicators, Western countries take more consideration of demonstrating the core of "innovation" through multi-dimensional indicators when designing the index system. For example, the Judicial independence and Workers' rights indicators in GCI, the Justice, Personal security and private property rights in WCI, and the Political stability & safety, Wikipedia edits/mn pop.15–69 in the GII. It is hardly to see the indicators above in the indicator system in China due the factors like data availability.

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