Comparing between OECD Member Countries Based on S&T Innovation Capacity

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Abstract. As science & technology(S&T) has become a source of global competitiveness in knowledge-based economy, the level of S&T capacity determines a nation's competitive power. Countries therefore have been enhancing investment and political supports to strengthen S&T capacity. Most of all, accurate analysis and assessment of the level of nation's S&T ability of nations is needed to make effective policy measures. On the basis of the framework of the NIS(National Innovation System), this paper suggests indexes to cover the entire cycle of S&T innovation. And it creates models to measure S&T capacity comprehensively, and tries to appraise 30 OECD members. And to conclude, in COSTII Score of Individual Nations, the United States took the first place by scoring 18.873 (out of 31) and was followed by Switzerland, Japan, and Iceland. Meanwhile, Korea ranked 10th with 11.019 points

Keywords: S&T, OECD, Capacity, Innovation

1. Introduction

Today S&T is a main source of national competitive power, specially in knowledge based economy. The necessity for an accurate diagnosis and evaluation of science and technology innovation capacity has previously been emphasized. So, for the improvement of a national S&T capability, need to evaluate a present level of S&T accurately.

S&T indicators are quantitative knowledge about the parameters of scientific, technological and innovation activity, at institutional, disciplinary, sectoral, regional, national or pluri-national levels (Barré, R. 1997). They can be used in variety of ways from decision making to research and analysis. Governments track their S&T resources and activities, assess how far these activities are meeting their goals, and predict future trends and needs for finance and human resource development. If indicators are derived on a systematic basis and according to accepted definitions, S&T indicators can be used to compare investments and performance between countries.

As we know, there are some surveys for inspect a national competitiveness, such as IMD, WEF and OECD STI. But they have a limitation of these evaluation methods. In IMD report, S&T is regarded as infrastructure of internal enterprise's competitiveness. And it has No based model, No composite index. In case of OECD STI, it has difficulty in overall comparison of innovation capabilities levels among nations and R&D input & outcome is too centered on the private sector

So, we have tried to develop the COSTII(Composite Science and Technology Innovation Index) to overcome those limitations and to evaluate a nation's capability of S&T Innovation compositely by the medium of rational model, Based on National Innovation System model. COSTII is an indicator developed by Korea to look into the innovation capacity of 30 OECD members. It is created in order to obtain S&T information far beyond merely statistical numbers. Unlike simple statistical data that outlay all related S&T information, COSTII gathers innovation-related S&T statistics and reinterpret them in order to compare with those from other countries. There are five dimensions for COSTII - resources, activities, network, environment, and performance - which are further categorized into human resources, organization, R&D investment, international cooperation, etc. 31 individual indicators comprise these dimensions, and the mean data for each dimension are rescaled to produce comparable international rankings.

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2. Method

In, National Innovative Capacity is defined as the ability of a country to produce and commercialize a flow of innovative technology over the long term (Porter & Scott Stern, 1999)

Science and technology capacity is defined for the purpose of this exercise as the ability of a country to absorb and retain specialized knowledge and to exploit it to conduct research, meet needs and develop efficient products and processes (Wagner, Caroline S., et al.). The ability to use specialized knowledge emerges from interactions of institutions and people, responds to public missions, and relies upon infrastructure. These bases can be represented by indicators, and it is possible to measure S&T capacity from a broad perspective of overlapping indicators representing direct and indirect measures. While it is possible to list countries merely by the percentage of investment in research and development (GERD), or by scientific papers or patents, which are direct measures of the outcomes of S&T, many countries would not be represented in such a list. These direct measures would provide little insight into the potential development of one country if it conducts various S&T activities, collaborates with other nations, or even uses existing resources to build additional capacity.

In this paper we defines Science and Technology Innovation Capability as a nation's capability to produce outcomes that are of economic and social value at the final stage through innovation and improvement in the field of S&T, just like OECD definition. And our goal is to evaluate science and technology innovation capacity by developing a model and indicators that can give comprehensive diagnosis and later, identifies strengths and weaknesses to propose policy to improve science and technology innovation capacity.

Evaluated Nations featured 30 member countries of the OECD(Organization for Economic Cooperation and Development). Although OECD now has 34 member countries, new members were excluded in COSTII due to low data availability. Information of additional members is expected to be reflected when relevant data can be collected.

Evaluation Model based on the framework of the National Innovation System (NIS), the innovative process consists of five dimensions of innovation: resources, activities, network, environment, and performance. Innovation Resource, Innovation Activities, Innovation Network, Innovation Environment are in Input field, Innovation Performance is in Output. An arrow means that those 5 areas exchange an influence each other systematically

The Concept of NIS is the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge ... And are either located within or rooted inside the borders of a nation State…(Lundvall, 1992)

On the basis of the framework of National Innovation System (NIS), the evaluation of science & technology innovation capacity consists of comprehensive review of the overall process of innovation, from input and activities to performance. The process assumes a systematic approach that regards the active interaction between the different elements as being a decisive factor of national science and technology innovation capacity.

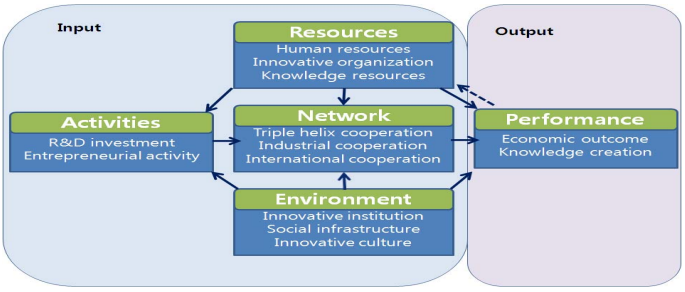

Fig.1. Evaluation Model

Then establish a weighting among 13 items, through expert surveys which based on fuzzy set theory. And Convert a ratio of weighting into integer numbers to allocate the number of indicators to each items. After Select 31 indicators out of the first selected 79 indicators pool, allocate the number of indicators by

according to the importance of each items. And Select the indicators of each items, with a conditions as follows.

area	items	weights	# of indicators
Innovation resources(7)	Human resources	0.79	3
	Innovation organization	0.53	2
	Knowledge resources	0.59	2
Innovation activities(7)	R&D investment	0.99	5
	Start-up activities	0.60	2
Innovation Networks(5)	Triple-helix cooperation	0.60	2
	Industrial cooperation	0.40	1
	International cooperation	0.50	2
Innovation environment(6)	Innovation support system	0.55	2
	Physical infrastructure	0.55	2
	Innovation culture	0.55	2
Innovation outcomes(6)	Knowledge creation	0.80	3
	Economic outcomes	0.80	3

Fig. 2. Structure of Evaluation Indicators

For the selection of proper indicators, the possibility of acquiring statistical data is critical to compare OECD member country. Rationale for model and upper-level, like 5 areas and 13 items and distinction from other indicators is important, too. If the indicators that possess high statistical relevance, the indicator expert committee selects most plausible and representative one. Then we draw 5 elements, 13 items, 31 indicators. It has 26 quantitative, 5 qualitative indicators

Innovation Resource Indicator *shows how much basic resources innovation entities can utilize for science and technology innovation. And it consists of human resources, innovation organization, and knowledge resources, such as researchers, top 100 universities and paper and patent stock.*

Innovation Activities Indicator *identifies innovation entities' activities of creating and utilizing new knowledge, and volition for innovation activities. It measures each entity's innovation activities according to the scale and distribution of material resources, such as R&D investment, the level of R&D activities, and start-up activities*

Innovation Network Indicator *shows the network among innovation entities and cooperation through the network, such as flow of knowledge and technology diffusion, within the innovation system. So it identifies the status of cooperation among industry·academia·research institutes, major players of domestic research and development, and international cooperation*

Innovation Environment Indicator *shows whether infrastructure is duly established for efficient innovation activities. Innovation environment is composed of various systems that support or facilitate innovation activities, innovation culture, and physical infrastructure, such as Tax advantage, protection of intellectual property right, broadband subscriber.*

Innovation Outcome Indicator *measures concrete outcomes of innovation activities. innovation performance can divided into knowledge creation and economic outcome. Knowledge creation is composed of indicators related with papers and patents. And economic outcome comprised of creation of added value, and improvement of trade balance.*

In steps of collecting the data, most data are from international statistical indicators, for comparability with other countries. For the quantitative indicators, datas get from OECD MSTI, OECD scoreboard, USPTO, Thomson ISI, Global Entrepreneurship Monitor, and World bank. And for qualitative data, use IMD competitiveness yearbook and WEF global competitiveness report

The collected data are then "re-scaled" for standardization. The methodology is, for each country's indicator, the maximum data is designated "1", while the minimum data is "0".

Re-scaled standard value is,

$$Standardized\ Value = \frac{Value_{(object)} - Value_{(lowest)}}{Value_{(highest)} - Value_{(lowest)}}$$

** To revise the missing value, if any, replaced it by the mean value of all indicators within the same dimension.*

In order to produce COSTII value, it is needed to calculate the standard value of 5 items. Items' value is draw through combining a standard value of indicators which are belonging to each items

In this formula, weight of each indicators is equal

$$CI = \sum_{1}^{n} w_i X_i \qquad CI = \text{items index } X_i \text{ : standard value of indicators}$$
$$\mathrm{w_i} = 1$$

Finally, COSTII is calculated by combining five items values from each dimension

$$COSTII = \sum_{1}^{5} CI_i \quad CI = \text{items index}$$

This methodology is applied to 30 OECD members, with values lying between 0 and 31.

3. Result and Conclusion

In COSTII Score of Individual Nations, the United States took the first place by scoring 18.873 (out of 31) and was followed by Switzerland (14.146), Japan (14.133), and Iceland (13.093). Meanwhile, Korea ranked 10th with 11.019 points.

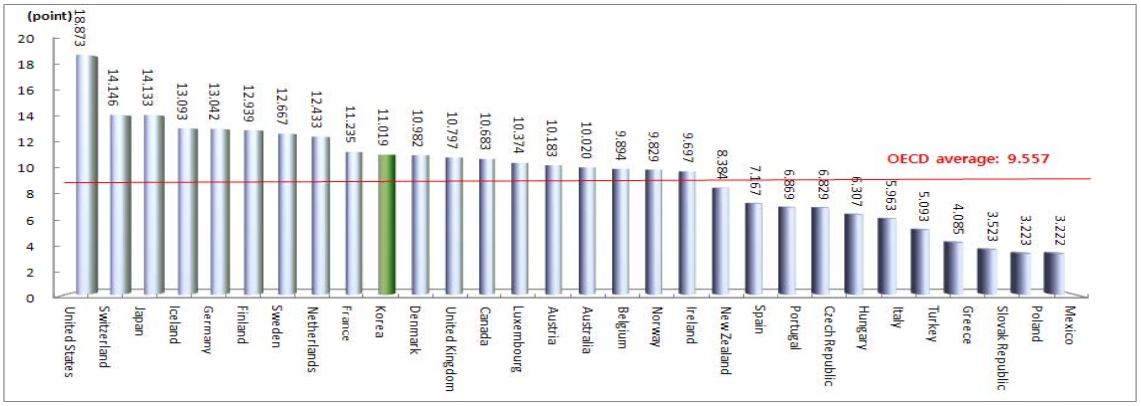

Fig. 3. COSTII Score of 30 OECD Member Nations

Putting United States, the best performer, at 100.0%, the relative level of Switzerland, the runner-up, is around 75.0% while South Korea stands at around 58.4%.

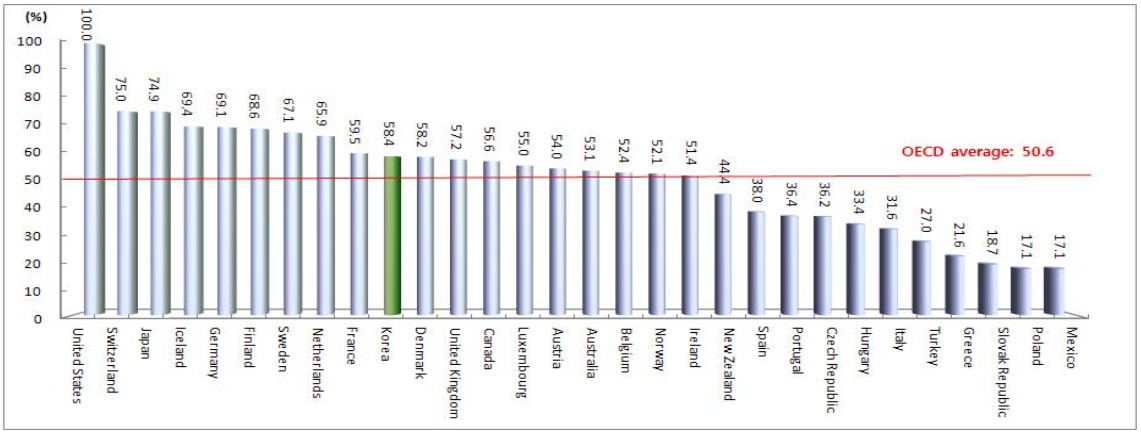

Fig. 4. Relative Level of 30 OECD Nations (United States = 100)

In case of analysis by dimension, In resources, the United States ranked first, which was more than twice of the OECD average score. The US was followed by Japan, Germany, and United Kingdom. As for activities, the leading group consists of the United States, Finland, Iceland, and Sweden. In network, Luxembourg scored the highest and the leading group includes Switzerland, Japan, and Iceland. In environment, Canada ranked first, followed by the Netherlands, Finland, and Denmark. In case of performance, the leading group includes the United States, Switzerland, Japan, and the Netherlands.

There are some challenges to improve COSTII. First, to internationalize, it need to promote the international recognition. Seek ways to utilize not only Korean experts but also NESTI expert within OECD. And Develop an own survey indicators to overcome the limitation of quantitative indicators. And to Enhance an application, revise a present S&T policy and establish a new one which is reflected the result of COSTII Raising a rationality of methodology. To raise a rationality of this methodology, it need to compare the outcomes by using such methods as AHP, Factor Analysis and fuzzy set theory

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