Standing Points of Innovation Capacity

Sofia Mouhallab and Wei Jianguo

***Abstract*—Until the twenty one century, innovation and ideas have been a valuable asset to accelerate the process of technological catch-up, sustain productivity growth and competitiveness. To determine where innovation is standing up, countries and organizations need to adapt innovation capacity to overcome their economies' defeats for the purpose of boosting the growth and economic performance of the economy. Therefore the aim of our research is to define the innovation capacity first, and then define an approach to assess it base on the countries characteristics. Further, this study highlights the most important indexes to estimate innovation capacity, and uses Porter's model to facilitate the estimation of the innovation capacity and rank the countries depending on their category.**

***Index Terms*—Innovation capacity, innovation capacity index (ICI), Porter's model, research and development (R&D).**

I. Introduction

Through the economic history, the measure of *innovation capacity* was originally introduced as "*the level of invention and the potential for innovation in any nation, geographical area or economic activity*" [1]. Since 1986, the assessment of the capacity to innovate becomes an important asset to provide information about the dynamics of invention in the economic activity. Hence, many indexes were defined by economists to measure innovation capacity and provide pathways to accelerate the economy process for nations. As result, charting the innovation capacity index can provide overall innovation performance of the nation as well as organizations.

The remaining article is organized as follows: Section II provides a brief review of the building of the innovation capacity within the economy. The presentation of some indexes used to assess it is reviewed in Section III. A study case is discussed in the Section IV, and finally the Section V is a closing part of the article.

II. Building of the Innovation Capacity

In a world of increasing competition, countries are competing to enhance their capacity to innovate for the purpose of growth and economic performance. Indeed, nations and organizations invest all their sources to have the ability to create and manage things differently better, quicker and more cost efficiently. Besides that, they generally innovate depending on impositions and laws of the government and effective management of human resource and learning development. The relative importance of various drivers of economic growth and prosperity has evolved over time and for a growing number of countries, innovation capacity and its dimensions are emerging now as leading factor.

In the late 1980s, C. Freeman has introduced National innovation capacity (NIC) as a "*grown subsystem of the national economy in which various organizations and institutions interact and influence each other in the carrying out of innovation activity*". The build-up of the national innovation capacity – as the innovation in the whole country- has played a central role in the growth of the successful developing countries. Those nations have recognized that innovation is not a matter of high technology, or skillful scientists, but it needs to be launched at the beginning of any development process to promote economic and social development by innovating more with a great benefice [2].

In addition to this, the complementary policies are critical for generating the desired benefits, specifically for more inclusive development processes. In addition to that, we should not forget that specialization patterns induced exclusively by market forces might accelerate the build-up process of innovation capabilities, and consequently, industrial policies that seek to target specific sectors would enhance the development of domestic innovation.

Within organizations and companies the innovation capacity is considered as a mechanism by which the company produces new products and service processes, and adapts a new concept to catch-up or to be a leader in the market. Since 1989, a lot of economists highlight the need to integrate the human factors into technology management in order to deliver effective innovation performance and it's the best way to build the *innovation capacity*. Furthermore, most of the companies are concerned about the role played by the innovation capacity. Recently, the purpose of this innovation is to create new things with the least cost possible and the most benefit to the organization rather than bringing the new.

III. Indexes to Assess Innovation Capacity

Since it increases the economy growth, national competitiveness and productivity, innovation is not only crucial for companies but it also has a great influence on the economy as a whole. Modern economies are based on knowledge and innovation which became the key factors of development rather than capital and labor.

At the first, the world was interested by knowledge for the purpose of view to develop the economic situation and create the wealth of nations. After many steps of development, economists recognized that knowledge and innovation are intertwined. In the 1980s, the human capital

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concept began to appear and it is considered to be important input to innovation.

In the economics of innovation, many economists concluded that the quality of human capital, the creation of new ideas and knowledge are the drivers of progress. The latter creates disparities in the productivity and growth of different countries.

In the present section, we briefly reviewed the different ways and indexes to measure the innovation capacity in the economy.

A. Patent Data or International Patenting

Patent is the most reliable statistics used to analyze the innovation capacity. Moreover, the historical of the patent data are available for most developed nations, as an example, in the United States, the patent data are available since 1790 and it is an annually variable. It serve as an important indicator or index to evaluate and analyze the innovation capacity for each organization in the country [3]. These data are based on the investment of the company in the research and development, the recruitment of the maximum of scientists and researchers and the ownership of the intellectual property protection, it will be very simple to determinate the patenting rate of this firm and then we can know if it's an innovative organization or not.

B. Social Educational Data

The governance, education and social inclusion have been a particularly important driven in the development of the capacity for technological innovation. Japan, Finland, Sweden, Korea, and Taiwan, considered being good example for those data. Indeed, the countries which have invested heavily in creating a well-developed infrastructure for tertiary education have gained enormous benefits in terms of growth. This driven was one of the most used driven to assess capacity to innovate in several countries. Moreover, the adoption of a new technology depends on the "*absorptive capacity*" of the population of the nation and it is determinate by the level of education [4]. Actually, an educated workforce means a greater productivity in business.

The two first approaches (Patent data and social educational data) are the proxy methods to measuring innovation capacity, where rather than measuring innovation capacity directly. Those methods are tracked as a proxy for the level or rate of change of innovation; they can be useful tools for understanding the capacity to innovate in an organization – for the first method - and in a country – for the second method.

C. Economic Data

Many countries discourage the development of entrepreneurship and hence the capacity for innovation of their own sectors. Indeed, government economic policies that reduce inflation and encourage macroeconomic stability have played a critical role in fostering economic growth and more generally in creating an environment that will foster innovation. The latter depends on the investments of capital, time, effort and human resources to ensure sustainable economic growth, future prosperity or create jobs and industries of the future. This approach relies on economic view, where economic growth is explained by factors that are measurable, such as the macroeconomics aggregate; Investment, labor force and its quality... In general, we refer to economic growth in this approach as the "*multifactor* productivity" or the "*total factor productivity*" in the economic jargon.

D. Human Capital Index (HCI)

Many ways to assess the capacity to innovation were enumerated by the economists and the difference between comes from which are composed and the methodology of how are calculated. However, human capital enters to some extent to all of them due to the tight connection between innovation and human capital, the latter has a big influence on competitiveness of the countries. In general, most of the Innovation Capacity indexes are defined as the function (1):

$$F = f(HC, ED, Pro\&Em, EWb). \quad (1)$$

HC: Human Capital
ED: Economic Dynamics
Pro&Em: Productivity and Employment
EWb: Economic well-being

In the present paper, we considered the Human Capital Index (HCI) an index that simplifies the cross-country study of the capacity of innovation, and we define it as:

$$HCI = g(Educ, HEm, PopG, OM) \quad (2)$$

- *The education (Educ)*: the measure of the growth rate of persons aged between 25 and 64;

$$Educ = \frac{A}{B} \quad (3)$$

A: Number of population with tertiary education completed
B: Population in given territorial unit aged 25 to 64

- *The population growth (PopG)*: the measure of skills and knowledge as necessary input to *population's* capacity to innovate

$$\text{Pop}_{grow} = \frac{\ln(Pop_i) - \ln(\text{Pop}_{2003})}{i - 2003} \quad (4)$$

i: represent the present year, when we want to assess the capacity to innovate

- *The occupational mix (OM):* the measure of the number of employees aged between 25 and 64 and work in "creative occupations [5]" such as socioeconomic classification, physicists, chemists, engineers, doctors…

$$\text{Occup mix} = \frac{nbofcreativeoccupationfori}{totalemploymentfori} \quad (5)$$

C: Number of creative occupation for *i*
D: Total employment for *i*

- *The high-tech employment share (HEm):* the measure of the number of the workforce in the high tech industry, the latter is an important source for contribution to innovation

$$\text{HTES}_i = \frac{\sum_t high\ tech\ employment\ int}{\sum_t total\ employment\ int} \quad (6)$$

In the end, we defined the human capital index as:

$$\text{HCI} = 100 \sum_{i=1}^{n} \alpha_1 \left(x_{ij}/x_{im}\right) \ldots \alpha_n \left(x_{nj}/x_{jm}\right) \quad (7)$$

n: the number of the variables defining the function (2).

m: refers to the other country, which we compare with

α: % the weight of the ration

x_{ij}: i^{th} Measure region j relative to the concerned country average for x_{im}.

E. Innovation Capacity Index (ICI)

The Innovation Capacity Index (ICI) is a global standard tool used across the world by governments, in all countries, to assess the ability to create an environment, to support and encourage innovation in the economy, and to reflect the extent to which nations have succeeded in developing a climate that will nourish the potential for innovation. This Index is proposed as a policy tool in order to promote dialogue between countries regarding policies and institution that's foster an environment for enabling innovation. The ICI allows and helps the policymakers and the entrepreneurs around the world to create a quantified framework for formulating and implementing better policies for the creation of an environment supportive of innovation.

To construct this index, we would like to answer the following questions:

- Which variables can we use to assess the innovation capacity?
- Is there some specific factors and policies which improve this capacity to innovate?
- How are they dependent on a country's given stage of development and political system?

Using those questions and others, Lopez Claros and Mata (2002) have developed a good methodological tool that would allow the countries and organizations to track their progress in the capacity of innovation. In their work, the ICI is built upon five pillars [6]: Institutional environment (15 variables); human capital, training, and social inclusion (8 variables); regulatory and legal framework (9 variables); research and development (10 variables); adoption and use of information and communication technologies (19 variables). Those pillars content 61(in the 2009 edition[1] of the innovation capacity index ICI) variables[2]. Note that this index ranks countries according to their overall performance.

The construction of this index includes some notions. In fact, there are a lot of factors which will have an attitude on countries' capacity to innovate; the relative importance of these will vary depending on their stage of development. However, the relative importance of those factors varies, depending on the country development level, political regime, and the policies implemented in the nation.

ICI is not the first attempt at the complex task of measuring innovation. There are several example of innovation analysis, consisting of "score boards" of non-aggregated indicators, variables and/or bench marks which track the performance of a particular region, nation or groups of nation.

- Other example of indexes

Summary innovation index–European innovation capacity-,

Innovation index –US innovation capacity-[3],

National innovation capacity index –derived from the US innovation index-,

Global innovation index[4]

Creative class or knowledge economy index.

F. Porter's Model

A very interesting model was developed by Porter [7] in order to analyze and understand why certain industries are more successful than others in specific countries. However, he made a repartition of the countries and their industries into three categories to facilitate the estimation of the innovation capacity index, and to classify the countries depending on their stage. Those categories are: Factor driven, investment driven, innovation driven and wealth driven.

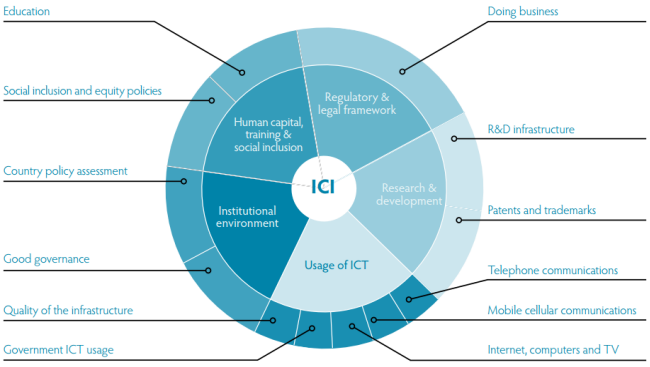

Fig. 1. The components of the innovation capacity index [6].

In this paper we will focus only on the three first stages, because in the last stage, normally the country stops to innovate. We need to mention that the three categories are correlated with the rising economic prosperity.

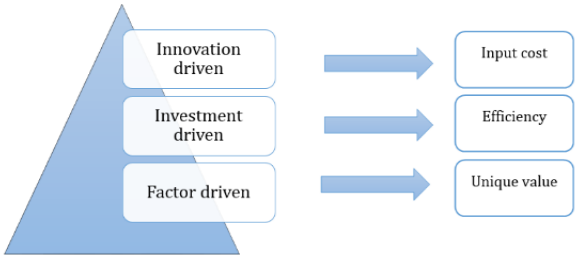

Fig. 2. The three stages model of Porter.

1) Factor driven

In the factor driven stage, Porter describes it as the stage where nations and industries base their competitive advantage in factor conditions. Actually, the countries derive their advantages from five basic factors of production: human resources, physical resources, knowledge resources, capital resources and infrastructure. Those factors include also the natural resources, inexpensive labor and climate. In this stage, the basic requirements are:

[1] In this edition the index covers 131 countries and identifies over 60 factors that are seen to have a bearing on a country's ability to create an environment that will encourage innovation.

[2] example of the variables: the human capital endowment, the budget deficit, the expenditure in education, the infrastructure for research and development, the research and development intensity, the adoption and the use of information and communication technologies, the regulatory and legal framework, etc.

[3] Assess innovation capacity and it has been monitored for 25 years, it's used for cross country comparison

[4] http://www.wipo.int/wipo_magazine/en/2012/04/article_0009.html

- Well-functioning public and private institutions; the government regulation and transparency in policy making.
- Well-developed infrastructure; transport, including roads and railroads, ports and airports, electricity.
- A stable macroeconomic environment.
- A healthy workforce with a basic education.

In the Porter's Model, we can identify that almost all the developing nations are in this stage. Furthermore, Porter recognized that just a few nations are able to move from the factor driven stage to the investment driven stage.

To move from this stage to the investment driven stage, the nations have to focus on the requirements listed in the next point and improve each of them.

2) Investment driven

In the investment driven stage, or efficiency driven stage [8], the countries and their firms are able to invest in an aggressive way. In this stage, the basic requirements are;

- Higher education and training inside businesses.
- Have good market efficiency and a healthy competition.
- Well-functioning labor markets, which ensure the labor forces, are distributed in the most efficient use to the economy.
- A developed financial markets, the availability of capital for investment, the transparency and trustworthy of financial market and the appropriate regulation to protect all the actors in the economy.
- The ability to harness the benefit of existing technologies; information and communication technologies.
- Market size comparing to the foreign markets.

3) Innovation driven

In this stage, the nations do not only appropriate and improve technology but they create it.

IV. Innovation Capacity in China

Recently, high-technologies and innovated products and services competition were played between United States, Japan, and Western Europe countries, but this situation is rapidly changing. There has been a remarkable growth in innovative capabilities in a number of countries that 30 years ago were classified as developing economies. Taiwan and South Korea, followed by China and India, are the leading examples of this phenomenon.

As everybody knows, the main macroeconomic indicators of China are: A high growth rate; a low inflation; a high savings rate; a moderate public debt. But the country still has many economic problems to solve, such as; a poor secondary/ tertiary education system, corruption and a state controlled banking sector… If the country works on those problems and its R&D department, it can be the global leader of innovation during the next 30 years. Otherwise, there are some chances that Japan or United States be the leader of innovation in the next decades.

Nowadays, China has become a major exporter of manufactured goods, beside that the country becomes a destination of first or second choice for foreign investment. The Chinese population has seen a steady increase in average income, and there has been a sharp drop in poverty rates.

Recording to those indicators and using the Porter's Model represented above, China is still in the investment driven stage.

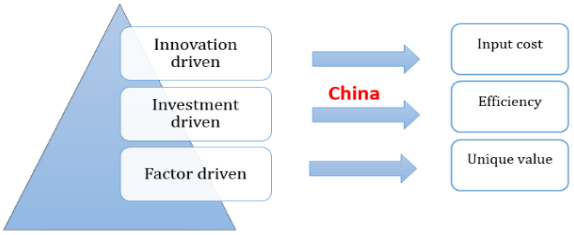

Fig. 3. China and the Porter's model.

Country	ICI rank	ICI score
Sweden	1	80.3
Switzerland	2	78.1
Singapore	3	76.7
Finland	4	76.1
United States	5	74.8
Denmark	6	74.3
Canada	7	73.6
Netherlands	8	72.8
Taiwan	9	72.5
Luxembourg	10	72.2
Korea, Republic of	11	72.1
Norway	12	72.0
Hong Kong SAR	13	71.4
New Zealand	14	71.3
United Kingdom	14	71.3
Japan	16	70.2
Mauritius	46	54.7
Malta	47	54.6
Tunisia	48	54.1
Saudi Arabia	48	54.1
Azerbaijan, Republic of	50	53.8
Jordan	51	53.7
South Africa	52	53.2
Croatia, Republic of	52	53.2
Kazakhstan, Republic of	54	53.1
Romania	55	53.0
Uruguay	56	52.8
Russian Federation	56	52.8
Oman	58	51.8
Kuwait	59	51.3
Costa Rica	59	51.3
Ukraine	61	50.4
Turkey	62	50.2
Mexico	62	50.2
China, People's Republic of	64	49.9

Highest – 80.3
China (64) 49.9
Lowest – 27.4

Fig. 4. Innovation capacity index "China's rank".

To improve in this domain, the country should focus on higher education and training, market efficiency and technological readiness, without omitting the public institution reform.

In "*the innovation for development report 2010-2011: innovation as a driver of productivity and economic growth*" [6], Augusto Lopez-Claros assessed the capacity for innovation using the ICI for 131 country and made a raking table to classify them [9]. China was in the 64 rank, Even if the country has a good and competitive product market and the workforce is playing the leading role in setting of prices and the behavior of agents in the broader economy. China has a number of other indicators used in the measure of innovation and which the nations don't score very well (spending less than 2% of GDP in education). Besides that, the country still has the problem of the aging of the population after the law of one child. Some observers said that the country is surging in its efforts to spur innovation but it still has a long way to go before achieving innovation driven growth. Some sectors other than education, where China can make particular contributions to global science and technology include biology and Chinese medicine, nanotechnology, space science and technology, and energy, including cleaner technologies.

V. Conclusion

Building innovation capacity is crucial survival in the global market and it also played a central role in the growth dynamics of successful developing countries. Different

ways were listed in this paper to assess this variable and classified it depending in the different levels; the most important one are the international patenting and Innovation capacity index.

As we mentioned, several economies –such as china – have become significant actors in the global innovation system and overpass the Factor driven stage. Actually, the economy of China has grown rapidly over the past couple of decades, and it is widely accepted that this emerging giant will transform the global economy in numerous ways over the coming decades.

Despite the importance of this country, its strengths and weaknesses, the sources of its growth, and the missing ingredients to sustain high growth rates are not widely known. In fact, China's economic growth has been caused more by the low cost of labor and high investment than by innovation. China has insufficient investment in innovation, an unbalanced allocation of innovation resources, and too little R&D.

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