Technological Forecasting & Social Change xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

A measure of technological capabilities for developing countries ☆

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ARTICLE INFO

Article history:
Received 7 December 2013
Received in revised form 6 August 2014
Accepted 10 September 2014
Available online xxxx

JEL classification:
C19
C49
I32
J24
O30
O32

Keywords:
Innovation index
Technological capabilities
Innovation diffusion
Human skills
Socio-economic indicators

ABSTRACT

The study was conducted to develop an index as a new measurement tool analyzing the innovativeness of developing countries. The role of science and technology in enhancing the rate of innovation is also investigated. The index is estimated for 61 countries observed during 2003–2008. The countries are classified into three groups based on their innovation level. The highest rate of innovation was noticed in China, followed by Estonia and Malaysia. The lowest innovation rate was reported in Iran, Bangladesh, Tadzhikistan, and Cambodia. It is recommended that governments (1) to allocate significant share of their budgets to the factors that enhance technological capability such as the science education, gross education enrollment rate and internet connectivity, (2) to promote policies of national awards for scientists and researchers who make sound breakthroughs in science and technology, (3) to develop international relations in the social, economic, cultural, and scientific spheres, (4) to modify school curriculum and syllabus, so that higher emphasis is given to the creativity and spontaneity of the children, (5) to relax portion of corporate taxes for developing an innovative way of product and production processes, which are environmentally friendly and economically viable. Finally, (6) the special focus must be given to the encouragement of local organizations to conduct the specialized training programs to promote innovation activities.

1. Introduction

The definition of innovation has evolved over time. In Drucker (1985) innovation is defined as the specific tool of entrepreneurs and the means for exploiting the change as an opportunity for a different business or services. Damanpour (1991) defines innovation as any practice that is new to organizations, including equipment, products, services, processes, policies, and projects. More recently, Afuah (2003) proposed that innovation is the use of new technical and administrative knowledge to offer a new product or service to customers. It is a process of coming up with new ideas leading to higher convenience for human existence. In other words, innovation is a gradual process of converting the opportunity into new ideas which will be further employed for development of new practices leading to technological advancement (Tidd, 2001).

The inter-relationship between science and technology and innovation is significant. They both positively influence each other. The existing literature suggested that the rate of innovation and contribution from science and technology has not been satisfactory in several developing countries in Asia, Middle East, South America, and Africa (Almeida and Fernandes, 2008; Archibugi and Coco, 2004; Fagerberg and Verspagen, 2007). Though some types of methodologies were used for measuring the extent of innovation in few studies, they lack the clarity in identifying the extent of innovation in

☆ The authors are grateful to anonymous referees and the Editor of the journal for very useful comments and suggestions on an earlier version of the manuscript.

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http://dx.doi.org/10.1016/j.techfore.2014.09.003
0040-1625/

developing countries and their relative status with that of developed countries. Moreover, the role of developing science and technology in enhancing the rate of innovation were not focused specifically in those studies. For example, the Technology Index developed by the World Economic Forum (WEF, 2011), and the Technology Achievement Index (TAI) developed by UN Development Program (UNDP, 2001) concentrate much on the extent of advancement in technology, rather than creativity and innovation. Similarly, the UN industrial development scorecard developed by UNIDO (2002) emphasizes more on the rate of industrial growth which is not fully linked with the rate of innovation.

All these methods did not take science and technology development as a major component of measuring the technology indices. Few studies were concentrated on measuring science and technology development and growth rate such as Science and Technology Capacity Index by Rand Corporation (Wagner et al., 2001). However, its interrelation with the rate of innovation is yet lacking. Though some efforts were made by researchers to find better measurement tools relative to that of the above said methods, they too could not integrate the various factors affecting science and technology and innovation in an integrated manner. Hence, there is a necessity for identification and standardization of new means of estimating the extent of contribution made by science and technology for the innovation in developing countries, and accordingly the policy initiatives can be taken.

As well described by Archibugi et al. (2009), there are mainly three benefits to make technological capabilities' based index measure: First, theoretical analysis which enables the researchers to test different innovation theories and their relation as a drive engine to the economic growth, second, technological capabilities' based index as a source of information will enable policy makers to place their countries in a position where strength and weaknesses can be identified, and accordingly appropriate innovation policies may be formulated and finally, such indices may act as inputs for firms' and industries' strategies to enable managers to understand the extent of the technological advance to better develop their innovation activities.

There is a need for increasing the extent of innovation through better focus on science and technology and research to promote and strengthen development in developing countries. Developing countries should try to match their rate of development with that of the newly developed countries such as South Korea. For achieving the same development, there is a need for identifying the present rates of innovation and extent of contribution made by the science and technology towards the process of innovation. As mentioned earlier, the existing measurement tools lack some key factors of science and technology, such as average number of citations per science and education article, and local availability of specialized training and resources affecting innovation rate. Hence the formulation of future strategies for enhancing the innovation rate becomes a major challenge.

Keeping these points in view, the present study has been conducted to answer questions such as "what is the most efficient way of measuring innovation rate and technological capabilities in developing countries?" and "whether there is a scope for further development of an integrated innovation index that measures the rate of innovation more accurately than the existing methods". The present study develops a new measurement tool of innovation called a technological capability index (TC-index) which is multidimensional and more effectively accounts for the factors underlying innovation and technological capability of developing countries, than the existing methods. Based on the identified factors affecting innovation rate derived from TC-index, future management strategies have been suggested for the achieving a higher growth rate of science and technology and innovation in developing countries. The TC-index through its better coverage of underlying development is superior to the existing indices, and as such it makes a contribution to the literature.

The rest of this study is organized as follows. Section 2 is a review of the literature on factors affecting the rate of innovation and existing measurement methods. The theoretical framework and methodology in the design of the proposed TC-index is outlined in Section 3. Empirical results and its discussion accounting for country group heterogeneity found in Section 4. Section 5 concludes and provides policy recommendations.

2. The review of literature

2.1. Factors affecting the rate of innovation

The existing literature on technology and innovation indices used in assessing development is relatively new and developing but yet with major limitations. A number of factors are identified to affect the rate of innovation at both micro- and macro-levels. These include firms' innovation ability and capacity, industry level collective capability and networks, innovation friendly environment, global economic system and trade related intellectual property rights protection, state support in interacting learning and technological capability, multinational corporation role in organizational and geographical mobility of innovation, indigenization of learning capability, global and regional innovation networks and systems, and coordination between public and private agencies.

The ability to innovate is generally accepted as a critical success factor to growth and future performance of firms. Carayannis and Provance (2008) investigated how firms can influence their innovation capacity. The author proposed a '3P' construct of innovation measurement at the micro-level, Posture, Propensity and Performance related to a firm's innovation capabilities. Schmitz and Strambach (2009) revealed that there exists a fundamental change in the process of innovation in developed countries. They found that the origin of innovation has been changed from centralized system to decentralized mode. It was also found that the '*organizational decomposition of the innovation process*' changes the global distribution of innovation of activities, which may also influence innovation in the developing world. Iizuka (2009) by correlating the knowledge creation and innovation, suggested that '*today*' global environment requires different types of knowledge and

Please cite this article as: Khayyat, N.T., Lee, J.-D., A measure of technological capabilities for developing countries, Technol. Forecast. Soc. Change (2014), http://dx.doi.org/10.1016/j.techfore.2014.09.003