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Intellectual capital and national innovation systems performance

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ABSTRACT

Innovation is a key resource for the well-being of national economies and international competitive advantages. First, this study develops a network data envelopment analysis (DEA) production process to evaluate the R&D efficiency and economic efficiency of the national innovation system (NIS) in 30 countries. Our findings show that the R&D efficiencies of the NIS are better than the economic efficiencies. Second, this study examines the effect of intellectual capital (IC) on the NIS performance through truncated regression. Our findings indicate that IC does play an important role in affecting the NIS performance. Finally, this study presents a managerial decision-making matrix and makes suggestions through a performance improvement strategy map to help government and managers improve the NIS performance.

1. Introduction

In the survey of 2007 global industrial technology innovation policy development, the Science, Technology and Industry Scoreboard of Organization for Economic Co-operation and Development (OECD) finds that a large majority of OECD countries emphasize technological system and innovation because these two factors affect not only domestic and international competition, but also economic growth [61]. A technological system is the system that affects specific technology or industry. According to Carlsson and Stankiewicz [13], technological system is a dynamic network among economic entities in a specific technological area that aim to create, transmit, and apply technology. In contrast, a national innovation system (NIS) affects the overall development of innovation. That is, a NIS is the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies [28]. Technological system differs significantly from NIS on the following three perspectives. First, technological system emphasizes creations of new technology, while NIS focuses on the transmission and application of technology. Second, the strength of technological system in each technological area differs significantly within a country. Third, the classification of technological system is based on technology rather than national boundaries.

Since the seminal work of Freeman and Christopher [29], which studies Japanese technological development, NIS research has evolved into an important research agenda. NIS is formed by the interaction among innovation creation, transmission, and application of various institutions. In other words, NIS is an important contributor for economic growth when the interactions among various institutions are well organized. NIS not only offers recommendations on innovation planning and competitiveness enhancement on technological front to policy makers, but also attracts the attention of researchers in the field of economic and innovation. The establishment of NIS thus becomes more important because the interaction among government, research institution, academia, and industry could result in commercialization of technological research outputs, which in turn would increase national competitiveness.

The innovation of a country or an industry does not originate from a single economic entity; rather, it is a combination of a composite and systematic mechanism. According to OECD [60], the development of technology and innovation is the outcome of the interaction among corporations, academia, and government research institution. The knowledge and technology possessed by the personnel and institutions are the key factors in the innovation process. The development of NIS is to improve the network relationship among the system members, which leads to enhancement in the overall national innovative capability [59]. As noted earlier, the NIS performance is the primary determinant of national competitiveness. A holistic assessment that considers overall industrial effects would enable a greater understanding on the impact of NIS on national competitiveness. Besides, this can be guidance for technological policies and research resource allocation in a country.

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To determine its own global positioning, a country can obtain the recent NIS performance of other countries from the historical data of NIS development. However, it remains a challenge to evaluate NIS, which is characterized by multiple dimensions, especially in a cross-country setting. To dates, there is no consensus about the NIS measurement. The common problems include the lack of consensus in the measurement model, ambiguous measurement indicators, and the lack of an effective holistic measurement model. These situations suggest that there is a critical need for a more objective and reliable measurement to express the relative efficiency of cross-countries NIS.

To ensure proper decision making, the performance of an institution needs to be measured using multiple indicators [16]. Most studies have recommended the use of multi-factor performance measure model to measure organizational operating performance [2,4,6]. Data envelopment analysis (DEA) is an approach that simultaneously evaluates multiple inputs and multiple outputs via linear programming technique to determine the production frontier as a basis of efficiency measure [3,33]. Traditional DEA models, however, ignore intermediate measures or interconnecting activities in a production process. Therefore, this study does not apply the traditional DEA that ignores the connectivity of internal economic activities. Set in a slightly different research setting, this study employs a network DEA model that is able to explore the 'black-box' process of NIS in estimating the performance of NIS, the R&D and economic efficiencies.

The comprehensiveness of NIS cannot be assessed merely through the performance. Other measurement methods should be employed to provide an overall assessment on NIS. In this globalized knowledge-based economy, knowledge, an important factor of production, has gradually replaced machinery, equipment, capital, raw materials, and labors. The concept of intellectual capital (IC) dates back to the work of Galbraith [31], where IC is interpreted as the difference between market value and book value. Stewart [72] suggests that IC can be deemed as a major source of enhancing or creating competitive advantage for an institution and it is also the most important resource of overall value creation.

Many scholars employ Tobit regression to examine the impact of a variety of external environmental factors on organizational operating efficiency [8,18,64,65,74,78]. Simar and Wilson [71], however, utilize truncated regression with bootstrapping approach and find that truncated regression provides greater validity than Tobit regression. Consistently, this study employs Simar and Wilson [71] truncated regression to investigate the impact of IC on the NIS performance of 30 countries.

The purposes of this study are threefold. First, we develop a network DEA model that comprises R&D efficiency and economic efficiency to measure the NIS performance. Second, we examine the relationship between IC and NIS performance using truncated regression with the aim to provide recommendations for improving NIS performance. Third, we construct a decision-making matrix and a performance improvement strategy map to assist countries to enhance their competitiveness through the integration of the network efficiency and IC dimensions.

The remaining sections of this study are organized as follows. Section 2 provides literature review. Section 3 describes data collection and research methodology. Section 4 presents the findings. Section 5 provides conclusions.

2. Literature review

2.1. National innovation system

The high-tech industry plays a vital role in a country's global competitiveness. Numerous studies have examined determinants of industrial economy and global competitiveness (for example, [7,27,34,51,63,80]. Although there is no single accepted definition of NIS, the importance of NIS has been emphasized in various research such as business and industry [5,11,15,38,43,79], science [40], and policy-making institutions [1,19,22,42,46,58].

The institutional interactions related to innovation and the underlying production systems are the basic characteristics of NIS. The basic meaning of NIS is the national innovation effort invested by each division, which is transformed into economic development and productivity growth that ultimately gear toward national competitiveness. In summary, the definition of NIS in this study encompasses the developmental concept of industry, government, and academia to investigate the network operating relationship among business, academia, and research systems. From the innovation and knowledge creation perspective, NIS creates technological innovation, stimulates the development of the national economy [26,28,35,44,57], and ultimately the national competitiveness of a country [76].

OECD [60] analyzes the efficiency and interaction of various innovation elements with knowledge creation, proliferation, and application through a series of indicators. McKelvey [53] suggests that the adoption of NIS in new technology is dissimilar. While Freeman [28] emphasizes improvement on social and policy-related issues, Lundvall et al. [49] focuses on the interactive learning between the manufacturer and the customer. Nelson [57] emphasizes the company capacity and the creation of innovative routine. Freeman [28] points out that the interaction and mutual feedback among NIS members including enterprise, academia, and research institutions are critical to NIS performance. Specifically, R&D policy is an important factor that affects national productivity. However, changes in national productivity cannot fully explain differences in R&D policy, which is still likely to distort market forces. Nasierowski and Arcelus [56] are the first scholars to apply non-parametric DEA to unlock the relationship between countries' commitments and both technological efficiency and productivity, in order to measure the input and output conversion process of NIS. The findings show that the interaction variable affects the overall efficiency.

2.2. Intellectual capital

The term "IC" was first proposed by the economist Galbraith [31]. He states that IC refers to the behavior of using brain instead of just using knowledge and mere intelligence. In order to create valuable IC, an organization should establish valuable organizational network to link the interdepartmental working team, and also to link the external parties like customers and suppliers to accelerate the company's value creation. Skandia led the way in 1994 by developing and issuing the first IC report in addition to traditional financial report in order to convey supplementary information on its effort in measuring knowledge assets. Based on Skandia work, Edvinsson and Malone [24] categorize IC into human capital and structural capital. The structural capital is further subdivided into customer capital and organizational capital. They also provide market structure and guidelines of IC. However, there is no clear and consistent definition of IC. In summary, IC can be defined as intangible assets, or the value whereby market value exceeds book value, which in turn will enhance organizational value and nurture firms' competitive advantage [25].

McElroy [52] proposes another theory, which highlights that extant IC measurement neglects social capital. According to the social capital theory, the mutual trust, mutual benefit, common values, networks, and social norms that exist in an organization itself and other organizations can increase the organizational values and inter-organizational values, which can speed up the transfer of information and the development of new knowledge.