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Global innovation index: Moving beyond the absolute value of ranking with a fuzzy-set analysis☆

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ABSTRACT

This study applies a fuzzy-set qualitative comparative analysis to data from the Global Innovation Index (GII). Building on the National Innovation System's approach, this study posits that a country can achieve high innovation performance via several combinations of causal conditions. These conditions are the five input enablers of GII: institutions, human capital and research, infrastructure, market sophistication, and business sophistication. By defining two subsamples of countries (high-income and low-income), this study finds that several causal combinations of conditions lead to high innovation performance in both groups. In order to obtain better innovation performance, the low-income countries show more multifaceted solutions. These results indicate that none of the conditions is necessary for predicting high innovation performance in both samples. Additionally, in the low-income group, none of the conditions, individually, is sufficient to predict higher innovation performance, while in the high-income group the infrastructure and human capital and research conditions, on their own, are sufficient to obtain better innovation performance. These results indicate that the political decision-making processes required for improving the level of innovation need to be different for each group of countries.

1. Introduction

The *Oslo Manual* (OECD/Eurostat, 2005) states that 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." This definition also includes the generation of new ideas as well as the recombination of existing ideas.

However, innovation does not occur in a vacuum. Institutional structures, support activities, and infrastructures, also called the National Innovation System (NIS), play a key role in promoting innovation activities and as a result economic growth (Lundvall, 2007). As Metcalfe and Ramlogan (2008, p. 436) state "successful economic development is intimately linked to a country's capacity to acquire, absorb, disseminate, and apply modern technologies, a capacity embodied in its NIS." According to the NIS concept, innovation includes not only the work of firms individually but also as a system of interaction, that combines the efforts of these firms with the actions of other actors such as universities and government agencies (Metcalfe & Ramlogan, 2008; Watkins, Papaioannou, Mugwagwa, & Kale, 2015).

In order to evaluate the effectiveness of government intervention and to compare the position of countries regarding innovation policies and performance, the research has developed several innovation indices over the years (Mahroum & Al-Saleh, 2013). Using data from one of those indices – the Global Innovation Index (GII) – this study examines the relation between countries' innovation enablers and innovation performance by comparing developed (or high-income) countries to developing (or low-income) countries. The sample in the study comprises 141 countries: 86 classified as high-income countries and 55 as low-income countries. Several arguments support the selection of the GII: large number of countries, the inclusion of input and output measures, and the nexus of GII measures with some of the NIS' key elements.

This study has two main objectives: to identify the specific country's innovation enablers, or combinations of innovation enablers, that lead to high innovation performance, and to assess how countries with different levels of income differ in terms of combinations of innovation enablers that lead to high innovation performance. The set of innovation enablers represents the different facets of the NIS: institutions, human capital and research, infrastructure, market sophistication, and business sophistication (Cornell, INSEAD,, & WIPO, 2015).

To test the causal relations between innovation enablers and innovation performance, this study uses a fuzzy-set qualitative comparative analysis (fsQCA) approach. Qualitative comparative analysis (QCA) is

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increasingly popular in management research, particularly in innovation research (Seny Kan, Adegbite, El Omari, & Abdellatif, 2015), because this approach offers important advantages in relation to regression-based approaches (Woodside, 2013). The use of the fsQCA is suitable for this research because this approach allows for the exploration of complex causal relations. This approach can identify how innovation enablers (causal conditions) combine to achieve a high level of innovation performance (outcome) and if multiple combinations of causal conditions lead to the same outcome (Fiss, 2007; Ragin, 2000). This study sheds a new light on the GII data because the GII research primarily focuses on the rankings alone (using the global or partial indexes or enablers), the innovation efficiency ratio (that compares the innovation output and innovation input subindices), or regression-based techniques. By using the fsQCA, the current study complements the knowledge about the NIS, and particularly GII research, by overcoming the limitations of using average and net effects analyses.

After this introductory section, the study proceeds as follows. Section 2 focuses on the literature review and propositions. Section 3 describes the method and calibration procedures necessary for the fsQCA, and Section 4 presents the results. Section 5 presents a discussion on the results, the conclusions, and the limitations and future research opportunities.

2. Literature review

2.1. National innovation systems

As a reaction to the neoclassical approaches of growth, Freeman (1987) and other authors (e.g. Dosi, Freeman, Nelson, Silverberg, & Soete, 1988; Edquist, 1997; Lundvall, 1992) propose the NIS approach. Falling back on the work of Nelson and Winter (1982) and their Schumpeterian-based theory of economic growth through evolutionary technological change, Freeman (1987) argues that neoclassical growth models overlook the role that technological change and innovation play in order to achieve economic growth. Therefore, those models are inadequate.

The approach by Freeman not only considers innovation as the individual work of firms but also as the collective effort where governments and institutions play a key role orchestrating both the generation and diffusion of innovation in a national economy (Watkins et al., 2015). The approach also views innovative activity in a broader sense. Although the definition of NIS has evolved over the years, one of the most cited (Metcalfe, 1995, p. 463) presents NIS as a "set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provide the framework within which governments form and implement policies to influence the innovation process. As such, it is a system of interconnected institutions to create, store, and transfer the knowledge, skills, and artifacts which define new technologies."

Although the NIS approach is not a theory (Alcorta & Peres, 1998), the research considers NIS a conceptual framework "intended to capture the processes of innovation, their determinants and some of their consequences […] in a useful way." (Edquist, 1997, p. 29). Key elements in the NIS literature are the following: First, the NIS framework involves organizations (formalized structures or actors that operate in the NIS) and institutions (laws, rules, common habits and established practices and routines that manage organizations' and individuals' behavior regarding innovation processes) (Alcorta & Peres, 1998). Second, organizations link and interact in different ways and intensities to benefit from one another's knowledge and competencies (Alcorta & Peres, 1998). Third, the level and efficiency of intangible investments are one of the most important elements of NIS (OECD, 1992). Being the main source of knowledge accumulation and growth in NIS, this type of investment includes investments in technology, training and education, management techniques and support systems, and investments in creating commercial and technological links with other organizations. Fourth, public policy implements the direction and coordination of NIS (Freeman & Soete, 1997). Governments orchestrate the relations between the different organizations as well as support certain research the market considers too risky. That research creates some incentives and programs to define priorities for the NIS. Fifth, the NIS offers a cumulative outcome (Lundvall, 1992). This outcome is slow and combines the impacts of organizations, institutions, their links and interactions, intangible investments, and public policy together. Therefore, the measure of innovative performance should include both quantitative indicators and the analysis of the technological activities across sectors. Hence, to achieve higher innovation performance, economies should have good indicators in the different areas that represent the integrated NIS (Balzat & Hanusch, 2004; Metcalfe & Ramlogan, 2008). Even so, innovation systems are complex: countries can achieve similar innovation performances by relying on different factors (Mahroum & Al-Saleh, 2013). These arguments suggest:

Proposition 1. None of the innovation enablers individually is a necessary condition to predict high innovation performance.

Proposition 2. Different combinations of innovation enablers are sufficient to predict high innovation performance.

Several international organizations such as OECD, the European Union, UNCTAD, the World Bank, or the International Monetary Fund have adopted the NIS concept as part of their analytical approach (Sharif, 2006). As such, innovation has become a strategic endeavor for several countries in which policies stimulate the creation and exploitation of new knowledge and innovation (Mahroum & Al-Saleh, 2013).

2.2. Development of indices to measure national innovation

Performance evaluation is intrinsic to the development of the NIS. In order to assess countries' positions and to evaluate the effectiveness of governments' interventions regarding the innovation policies, policymakers need to have some measures of the different countries' innovation level and performance, particularly in relative terms. The preliminary work in this field focuses mainly on the description and analysis of different countries' innovation systems and on their comparative results (e.g. Nelson, 1993). However, since the late 1990s, the most common way to compare the performances of different innovation systems is the use of indices and rankings because of their popular appeal and political and operational importance for decision making (Sonrexa & Moodie, 2013).

Thus, several international institutions developed a range of innovation indices. Some examples are the European Innovation Scoreboard, the National Innovative Capacity Index from the World Economic Forum, the UNCTAD's indices, the Innovation Index of the World Bank, the Nordic Innovation Monitor, the OECD Science, Technology and Industry scoreboard, the Bloomberg Innovation Index, and the GII (Mahroum & Al-Saleh, 2013). Several aspects differentiate these indices: structure, formulation, number of countries in the analysis, and the type of data in their construction. For instance, the National Innovative Capacity Index uses a large amount of data from the World Economic Forum's 2001 Executive Opinion Survey, while the GII uses mainly hard data.

An analysis of the rankings of these indices helps policymakers and governments throughout the world, particularly in industrialized countries, to identify paths for future development and design innovation policies. These indices help countries learn from their own experience and that of other countries in terms of defining NIS as a major input to innovation policy design (Balzat & Hanusch, 2004; Mahroum & Al-Saleh, 2013). Therefore, all of the studies that go beyond the comparison of rankings can help countries to develop policies and adopt measures to promote innovation.

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