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

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Configurational conditions of national innovation capability: A fuzzy set analysis approach

Anis Khedhaouria[a,*], Roy Thurik[b,c]

[a] Montpellier Business School and Montpellier Research in Management, 2300 avenue des Moulins, 34185 Montpellier Cedex 4, France
[b] Erasmus University of Rotterdam, The Netherlands and Montpellier Business School, France
[c] P.O. Box 1738, 3000 DR Rotterdam, The Netherlands

ARTICLE INFO

Keywords:
Innovation capability
Configurations of conditions
National innovation system
Fuzzy set
Qualitative comparative analysis

ABSTRACT

Building upon the national innovation system perspective and using a fuzzy set qualitative comparative analysis approach (fsQCA), we propose an integrating framework to determine the conditions that lead to high levels of national innovation capability outcomes. We discriminate between five conditions, *viz.*, building national institutions, developing human capital and research systems, improving infrastructures, and facilitating business and market conditions. We do so by analyzing data collected from the Global Innovation Index database containing 74 indicators and 133 countries between 2012 and 2015. The results show no singular path leading to high levels of innovation capability but there are three configurations of conditions. Two configurations highlight that the combination of three distinct conditions is *sufficient* for a country to reach a *high* innovation capability (one in which market conditions 'are not necessary' and one in which institutions 'are not necessary' conditions). The third configuration highlights that the combination of all five conditions is *necessary* for a country to reach a *very high* innovation capability. Some crucial implications of these findings for theory and practice are discussed.

1. Introduction

The importance of national innovation capability for economic development has been widely addressed in the literature (Archibugi et al., 2009; Filippetti and Archibugi, 2011; Freeman, 1995; Khayyat and Lee, 2015). Understanding how countries can enhance their innovation capabilities may help them to catch up with the highest performing countries (Abramovitz, 1986; Archibugi et al., 2009).

National innovation capability refers to the ability of a country to manage resources and skills to transform existing knowledge into new knowledge, technology, and creative outputs for the benefit of firms, industries, and the entire economy (Fagerberg and Srholec, 2008; Furman et al., 2002; Lopez-Carlos and Mata, 2009). National innovation capability is an evolutionary learning process that occurs within institutional structures (Nelson, 1988; Nelson and Winter, 1982; Freeman, 1987). Indeed, effective learning requires institutional structures with appropriate legal institutions that develop human capital through appropriate education and research systems, build common infrastructures to enable knowledge sourcing and transfer, and facilitate business and market conditions to absorb, adopt and implement advanced technologies (Nelson and Winter, 1982; Reddy, 1997). The so-called national innovation system perspective addresses the importance of all these five conditions (Freeman, 1995; Lundvall, 1992; Lundvall et al., 2002).

Despite substantial research on national innovation capability using the national innovation system perspective, little is known about which specific configurations of conditions lead to higher levels of national innovation capability (Fagerberg and Srholec, 2008; Pustovrh and Jaklič, 2014). The *first* reason is that the literature on national innovation capability is fragmented—various theoretical studies have been developed—and an integrating framework is lacking (Fagerberg and Srholec, 2008; Lundvall et al., 2002). For instance, reviews of studies on national innovation capability show that individual studies only cover a fraction of the innovation conditions that are considered to be important in other studies (Fagerberg and Srholec, 2008; Filippetti and Archibugi, 2011; Khayyat and Lee, 2015). This is striking because the national innovation system perspective stresses the systemic nature of national innovation capability and the fact that it is an evolutionary learning process leading to coherent outcomes (Nelson, 1988; Freeman, 1995; Lundvall et al., 2002).

The *second* reason for the lack of knowledge about configurations of conditions is that research on national innovation capability suffers

* Corresponding author.
E-mail addresses: a.khedhaouria@montpellier-bs.com (A. Khedhaouria), thurik@ese.eur.nl (R. Thurik).

http://dx.doi.org/10.1016/j.techfore.2017.04.005
Received 18 October 2016; Received in revised form 24 February 2017; Accepted 5 April 2017

from a mismatch between theory and methods (Fagerberg and Srholec, 2008). This is because theory suggests that the explanation of national innovation capability is best understood in terms of combinations of conditions, also known as configurational conditions, whereas methods primarily use individual and 'independent' conditions (Pustovrh and Jaklič, 2014). Proponents of the configurational approach take a systemic view (Fiss, 2007, 2011). By reducing national innovation capability to a small number of individual conditions, a large number of studies do not grasp the complex interaction effects between various conditions that influence innovation capability (Pustovrh and Jaklič, 2014).

To address this gap in the literature, we propose a framework based on the national innovation system perspective (Lundvall, 1992; Lundvall et al., 2002) and a configurational approach based on fuzzy set Qualitative Comparative Analysis (fsQCA: Ragin, 2008) to determine configurational conditions leading to high levels of national innovation capability. The fsQCA approach offers a pragmatic way to organize multiple interdependent relationships among conditions into a coherent framework explaining the outcomes (Ragin, 2000). In the present research, fsQCA is applied to a sample of 133 countries and 74 indicators are retrieved from the database of the Global Innovation Index 2012–2015.

Our results demonstrate that no single path leads to high levels of national innovation capability. Instead, they show the existence of three distinct configurations of conditions. The *first* configuration of conditions shows that building national institutions, developing human capital and research systems, improving infrastructures, and facilitating business are sufficient conditions for a high level of innovation capability. The *second* configuration of conditions shows that developing human capital and research systems, improving infrastructures, and facilitating business and market conditions are also sufficient to reach a high level of innovation capability. The two configurations point to a situation of "*equifinality*", where the combination of three distinct conditions is *sufficient* for a country to reach a *high* innovation capability. The *third* configuration shows that the combination of all five conditions is *necessary* for a country to reach a *very high* innovation capability. All of these configurations consist of twenty high-income countries that are obviously not entirely the same across the three configurations.

Our study is novel in that it proposes a comprehensive framework based on the national innovation system perspective and a holistic approach based on fsQCA to determine the configurations of conditions that lead a country to reach high levels of innovation capability. From a theoretical perspective, our study holds considerable promise for closing the abovementioned gap between theory and methods and enables a detailed analysis of the sufficient and necessary conditions for reaching high and very high innovation capability. From a practical perspective, our research provides useful insights for understanding how countries can improve their innovation capabilities in order to catch up with performing economies.

In the next section, we present our framework from the national innovation system perspective and we put forward the fuzzy set approach as theoretical background of the empirical analysis. Section 3 presents the data source and the methodology. Section 4 presents the results of a fuzzy set approach. Section 5 contains the discussion and the conclusion.

2. National innovation capability from the national innovation system perspective

2.1. Innovation capability conditions

The national innovation system perspective considers innovation capability as an evolutionary learning process (Nelson, 1988; Nelson and Winter, 1982) that occurs within institutional structures "in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" (Freeman, 1987: 1). Institutional structures encompass not only prevailing institutions with legal rules but also organizations and their activities, practices and policies (Edquist and Johnson, 1997). For countries aiming to enhance their innovation capabilities, the basic challenge is to develop institutional structures with strong absorptive capacity in order to assimilate existing knowledge and generate new knowledge, technology, and creative outputs (Nelson, 2008). In this perspective, the key driving force of innovation capability "is assimilation, learning to do effectively what countries at the frontier have been doing, often for some time" (Nelson, 2008: 16). Indeed, effective learning requires institutional structures with appropriate legal institutions that develop human capital through appropriate education and research systems, build common infrastructures to enable knowledge sourcing and transfer, and facilitate business and market conditions to absorb, adopt and implement foreign advanced technologies (Nelson and Winter, 1982; Reddy, 1997).

Our framework builds on this perspective and considers innovation capability as the result of the interplay between five institutional conditions, *viz.*, institutions, human capital and research, infrastructure, market and business conditions (Fig. 1). Originally, the framework was developed by the global innovation index (GII, 2015) as a key tool to measure innovation capability under the assumption that if a country aims to achieve high levels of innovation capability, it should improve all of its individual conditions. In our research, we assume that innovation capability is an evolutionary learning process that emerges from the mutual interactions and complementarities between several and not necessarily all institutional conditions (Nelson and Winter, 1982; Nelson, 2008). The entire evolutionary learning process leads to outcomes which are relatively stable and coherent per country, but not necessarily similar across countries.

At the core of the definition of the national innovation system perspective resides the neo-Schumpeterian theory of innovation that stresses the role of *institutions* in fostering innovation activities (Nelson and Winter, 1982). Institutions capture policy, legal and institutional framework of a country related to its political, regulatory, and business environments (Edquist and Johnson, 1997). Indeed, institutions are considered as the rules of the game that regulate political, economic and social interactions within a national system (Edquist and Johnson, 1997; Nelson and Winter, 1982). According to Edquist and Johnson (1997: 51), institutions, by their nature, regulate the relations between economic actors at different levels within a national innovation system. For instance, at the firm level, institutions influence innovation by affecting the relations between R & D, production, and marketing. At the market level, institutions influence innovation processes through the feedback mechanisms for consumer reactions on new products. Relations between government agencies and private firms and technology policies are examples at a third level in which institutions influence innovation. The set of communications and interactions in relation to innovation activities are thus shaped by the institutional framework of the economy. Indeed, institutions are needed to cope with the high levels of uncertainty that characterize innovation activities (Nelson, 2008). A political environment that favors political stability and government effectiveness reduces uncertainty about doing business and encourages innovation activities (Feng, 1997). A business environment that helps new entrants to easily start a business, resolve insolvency, and pay taxes reduces uncertainty about doing business and encourages competitiveness necessary for innovation (Djankov et al., 2002; Lopez-Carlos and Mata, 2009). It is also common to say that institutions control and regulate conflicts and cooperation between economic actors (Edquist and Johnson, 1997). Conflict has argued to be a very serious problem in relation with innovation activities (Nelson, 2008). A regulatory environment that shapes the government's ability to promote private-sector development and to evaluate the extent to which rule of law prevails reduces conflicts and increases cooperation necessary for innovation processes (Furman et al., 2002). Another