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A NON-PARAMETRIC SYSTEMATIC REVIEW OF THE LITERATURE AND FUTURE RECOMMENDATIONS ON THE EFFICIENCY OF THE NATIONAL INNOVATION SYSTEM

Uma Revisão sistemática não paramétrica da literatura e recomendações futuras sobre a eficiência do sistema nacional de inovação

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ABSTRACT

The national innovation system (NIS) is paramount in developing innovative strategies that can boost the competitive advantage of innovations while ensuring their long-term viability on a global scale. This study intended to underscore the scarcity of current research on the efficiency of the NIS operating Data Envelopment Analysis (DEA) through a thorough systematic literature review. The researcher categorised the literature accordingly and provided recommendations for future research. The conclusion substantiated that further research on NIS efficiency is required by paying more attention to the extended DEA model, especially bootstrapping, slack-based models, relational networks, dynamic networks, and super efficiency. Such an extended DEA model would provide a more reliable and scientifically proven efficiency values. Nonetheless, non-oriented approaches require more attention as they enable the researchers to deal with flexible measures in DEA. Since most innovation developments across countries are heterogeneous, using variable return to scale (VRS) is relevant in prospective analyses. The result confirmed a need to give more preference to institutional, infrastructural and market sophistication indicators as input variables, while creative output indicators as output variables in innovation efficiency measurement. These variables are critical in determining the value of innovation efficiency. The result also indicated that future studies focusing on the efficiency of low-middle and low-income countries are imperative. Hence, regardless of the income group of the NIS, a comparative cross-country analysis is needed that permits the NIS to compare themselves with high-calibre innovators and enhance their innovation performance. The comparative analysis would also provide policymakers with valuable data and a global sense of innovation.

Keywords: Data Envelopment Analysis, DEA; Efficiency, National Innovation System.

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UMA REVISÃO SISTEMÁTICA NÃO PARAMÉTRICA DA LITERATURA E RECOMENDAÇÕES FUTURAS SOBRE A EFICIÊNCIA DO SISTEMA NACIONAL DE INOVAÇÃO

A Non-parametric systematic review of the literature and future recommendations on the efficiency of the national innovation system

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RESUMO

O sistema nacional de inovação (SNI) é fundamental no desenvolvimento de estratégias inovadoras que possam aumentar a vantagem competitiva das inovações, garantindo sua viabilidade a longo prazo em escala global. Este estudo pretendeu ressaltar a escassez de pesquisas atuais sobre a eficiência da Análise Envoltória de Dados (DEA) operacional do SRI por meio de uma revisão sistemática completa da literatura. O pesquisador categorizou a literatura de acordo e forneceu recomendações para pesquisas futuras. A conclusão comprovou que mais pesquisas sobre a eficiência do NIS são necessárias prestando mais atenção ao modelo DEA estendido, especialmente bootstrapping, modelos baseados em slack, redes relacionais, redes dinâmicas e super eficiência. Esse modelo DEA estendido forneceria valores de eficiência mais confiáveis e cientificamente comprovados. No entanto, abordagens não orientadas requerem mais atenção, pois permitem que os pesquisadores lidem com medidas flexíveis em DEA. Como a maioria dos desenvolvimentos de inovação entre os países é heterogênea, o uso de retorno variável à escala (VRS) é relevante em análises prospectivas. O resultado confirmou a necessidade de dar mais preferência aos indicadores institucionais, de infraestrutura e de sofisticação de mercado como variáveis de entrada, enquanto os indicadores de produto criativo como variáveis de saída na medição da eficiência da inovação. Essas variáveis são fundamentais para determinar o valor da eficiência da inovação. O resultado também indicou que estudos futuros com foco na eficiência de países de baixa-média e baixa renda são imperativos. Assim, independentemente do grupo de renda dos NEI, é necessária uma análise comparativa entre países que permita aos NEI comparar-se com inovadores de alto calibre e melhorar seu desempenho em inovação. A análise comparativa também forneceria aos formuladores de políticas dados valiosos e um senso global de inovação.

Palavras-chave: Análise Envoltória de Dados, DEA; Eficiência, Sistema Nacional de Inovação.

INTRODUCTION

The notion of the National Innovation System or NIS has existed since the 1980s, but this approach has only recently obtained substantial research attention (Balzat & Hanusch, 2004; Fagerberg, 2003; Feinson, 2003; Groenewegen & Steen, 2006; Lorentzen, 2009; Lundvall, 2007; Teixeira, 2014; Watkins et al., 2015; Yoon & Hyun, 2009). Freeman developed the NIS approach (1987), Dosi et al. (1988) and Lundvall (1992), followed by Nelson (1993), Patel and Pavitt (1994), Metcalfe (1995) and Edquist (1997). It summarises the relationship or network between actors within the economy. The NIS is a conceptual framework for analysing innovation dynamics that concentrates on the interaction of multiple actors at the national level, including governments, businesses, universities/public research centres and funding agencies (Carlsson et al., 2002; Fagerberg et al., 2009; Fagerberg & Verspagen, 2009; Jia et al., 2020; Lu et al., 2022; Lundvall, 2007; Parkey, 2012; Wilson et al., 2020). The NIS is a framework for carrying out innovation activities throughout the economy.

The NIS has been used in policy studies since the late 1990s (Edler & Fagerberg, 2017; Groenewegen & Steen, 2006; Jia et al., 2020; OECD, 2002; Teixeira, 2014; Watkins et al., 2015). This approach provides an analytical framework (Edquist, 2011; Lundvall, 2007; Siedel et al., 2013; Yoon & Hyun, 2009) and conceptual tool (Yongabo & Goransson, 2020) that emphasises on the characteristics of innovation, rapid technological transformation and globalisation (Diez & Kiese, 2009; Sun & Liu, 2010; Watkins et al., 2015). The NSI approach can be advantageous as a generalised framework to explore the disparities between countries' efficiency (Alvarez & Marin, 2010; Bartels et al., 2012; Teixeira, 2014). Nevertheless, previous research has revealed shortcomings in the NIS approach (Neely & Hii, 1998). There have been many descriptions but little analysis (Lorentzen, 2009) and few policy recommendations for developing countries (Bartels et al., 2012; Casadella & Uzunidis, 2017; Choi & Zo, 2019; Intarakumnerd et al., 2002; Lundvall, 2007; Albuquerque, 2007; Lorentzen, 2009; Wilson et al., 2020), and a lack of formal studies, especially in less developed countries (Gu, 1999; Godin, 2009). Some theoretical studies on NSI have been published (Edquist, 2009; Carlsson, 2006; Lundvall, 2007; Godin, 2009; Fagerberg & Sapprasert, 2011), but bibliometric (Teixeira, 2014) and empirical (Roolaht, 2012) studies are still lacking. Furthermore, Grima et al. (2020), Patel & Pavitt (1994), and Yesilay and Halac (2020) noted that the comparative analysis of NIS is limited in explaining the efficiency of innovation (Narayanan et al., 2022). Additionally, Casanova et al. (2018) and Lundvall (2002) mentioned that less attention is paid to the emphasis on indicators that influences the efficiency of NIS. Nevertheless, there has been no systematic review of the more general empirical findings of the vast number of NIS studies published in the last five years.

1 CONCEPTUAL BACKGROUND FOR NIS USING DEA

As NIS plays a crucial role in shaping global economic development to devise and sustain competitiveness (Hu & Mathews, 2005), scholars have sparked interest in examining innovation from a global perspective. The NIS concepts have been employed as the primary analytical aim in research on innovation processes (Diez & Kiese, 2009; Lundvall, 2007) and have been widely adopted by scholars in efficiency studies (Guan & Chen, 2012; Kuhlmann & Ordonez-Matamoros, 2017; Meissner, 2015; Liu et al., 2015; Watkins et al., 2015). The significance of NIS is high nowadays, notably considering the increasing number of innovations put forward by distinct market players (Golichenko, 2016; Lundvall, 2016). Over time, recent deviations in the global economy has led to new perspectives on evaluating innovation efficiency value (Alnafrah, 2021). This development has led to a shift in measuring innovation performance from a single input dimension to multiple input dimensions (Hagedoorn & Cloodt, 2003; Pan et al., 2010). As innovation is a quite complex process (Clarke et al., 2018; Laperche et al., 2008), one should quantify its performance by evaluating the different dimensions instead of just being based on a single unit of input and output (Tidd & Bessant, 2020). Accordingly, the network application is made through Data Envelopment Analysis (DEA) when disseminating NIS among the relevant actors in an economy.

Futhermore, DEA is one such technology-carved product that is based on linear programming (Cooper et al., 2007; Hu et al., 2020; Nunamaker, 1985) and can transform the inputs and outputs used into a single measure of performance (Charnes et al., 1978; Kong et al., 2021; Xiong et al., 2020). The DEA method has been adopted extensively in various cross-border studies to reckon the efficiency of NIS (Kotsemir, 2013; Nasierowski &

Arcelus, 2003; Tarnawska & Mavroeidis, 2015). The technique that uses frontier transformation can measure the efficiency of different countries. These assessments assign a performance score between zero and one. Thus, represents the efficiency score achieved by the rated entity. In attaining these results, the DEA also specifies the sources and amounts of inefficiencies at each input and output for each Decision-Making Unit (Cooper et al., 2006). The use of DEA in NIS is the most typical subject in the literature to date. DEA's flexibility for nonparametric features indicates that DEA models have been used more often than parametric approaches in practice and theory (Kou et al., 2016). Although the concepts of NIS and DEA have recently been discovered to be very pertinent and practical, reviewed studies showed that authors pay little attention to the in-depth investigation of previous related deconstructions (Kotsemir, 2013; Yesilay & Halac, 2020). This systematic review intended to bridge the literature gap on the efficacy of NIS following the use of the DEA. The process identified the following research questions and attempted to generate noteworthy suggestions through systematic review validation. The research questions of the study are:

Which DEA model, DEA orientation, and scale assumptions is NIS efficiency research focused on?

What are the appropriate input and output variables for assessing the efficiency of the NIS?

What income groups do researchers pay attention to when measuring the efficiency of the NIS?

When measuring the efficiency of the NIS, which location of study and DEA model do researchers pay attention to?

Which combination of the DEA model and study location results in a high value of journal impact factors?

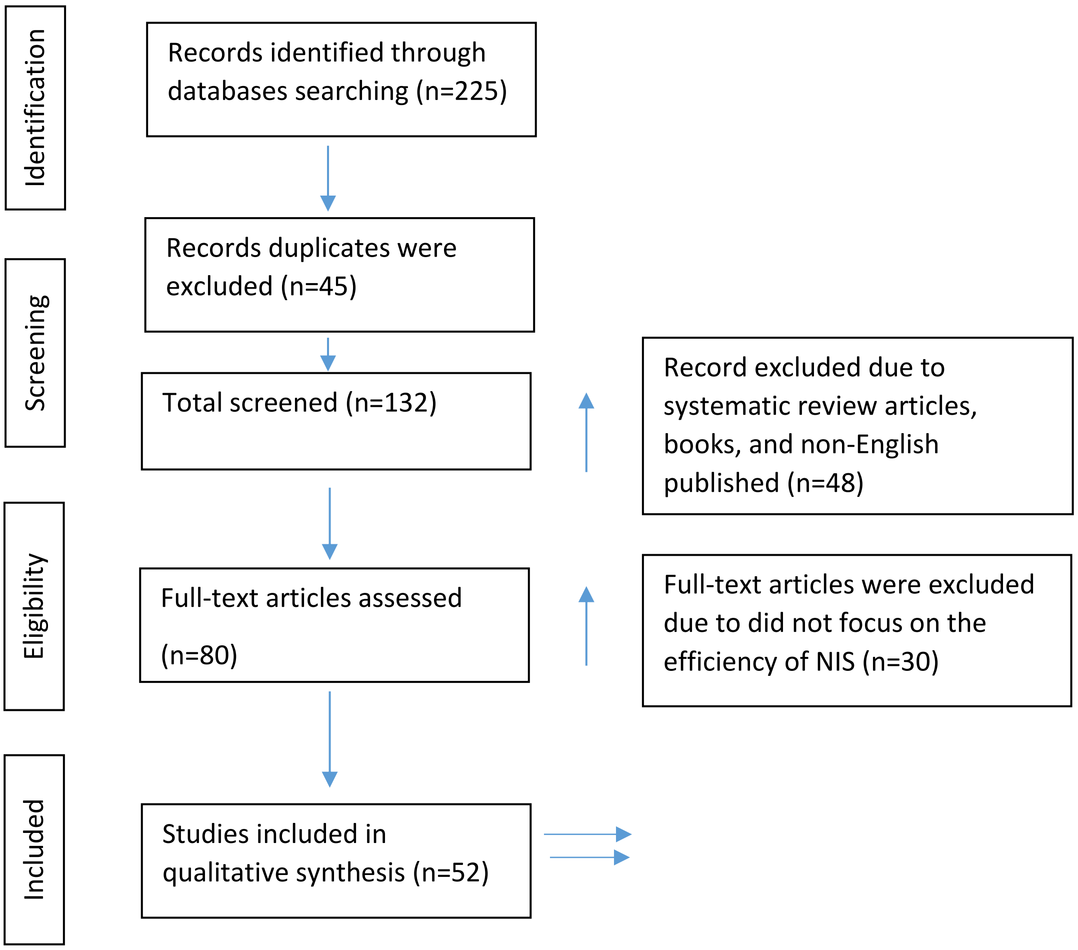
2 RESEARCH METHODOLOGY

The aim of the study is to demonstrate on the efficiency of the national innovation system with the use of data envelopment analysis. In general , researchers prefers systematic review in order to screen the overall documents thoroughly to ensure the reviewing process was conducted in an unbiased manner in comparison to the conventional literature reviews (Centobelli et al., 2017; Hallinger, 2013; Tranfield et al., 2003) (Gümüş et al., 2021).A systematic literature review has the advantage of allowing the researchers to publish the new knowledge that they have found in light of certain emerging situations while maintaining an informational flow. It will allow the researchers to learn more about the subject and develop their understanding of the research questions (Siddaway et al., 2019). As a result, this study tried to conduct a systematic literature review, which was proven to be an efficient way (Levy & Ellis, 2006; Mengist et al., 2020; Snyder, 2019; Xiao & Watson, 2017) to include the findings of vast volumes of previously collected data (Haddaway et al., 2015; Popay et al., 2006; Pullin et al., 2013). In the present study, classification procedure for previous literatures as described by Godinho and Veloso (2013) and the entire process scan was explained using the steps below.

- Step 1: Review the pertinent literature in light of the available information;
- Step 2: A structured code-based classification procedure;
- Step 3: Findings of the study are demonstrated;
- Step 4: A thorough analysis on the existing research gaps; and
- Step 5: Recommendations for future study.

Renowned databases such as Google Scholar, Web of Science, as well as Scopus are used by the researchers to obtain the articles for the literature review (Stahlschmidt & Stephen, 2022). The articles stored in the above-mentioned databases are of high quality (Dorsch et al., 2018; Pranckutė, 2021) and thus it is an authentic source for the present study. Selected keywords that includes National Innovation Systems, Data Envelopment Analysis, NIS, DEA, and Efficiency were used to conduct prior study search in the database. The prior study search was conducted for the duration of last 25 years which is from 1997 until 2021 and found around two hundred twenty-five items related to the study. Phased exclusion through applied criteria were used to select articles that only related to NIS and DEA approach (Liberati et al., 2009) while the journals that not related to the subject matter of the present study were excluded from the set of data. The remaining 52 journals after the phased exclusion were considered for literature review and data synthesis. The chosen methodology for meta-analysis of the present study is expected to aid the researchers to have better understanding as it will allow them to read the articles with customized codes. The **Figure1** shows the selection process of items for literature review.

Figure 1 - Records Selection Process



3 RESULTS

The details of the authors, publishing body of journals and the origin of author of the article were tabulated in Table 1.

Table 1 - List of selected articles

Code	Authors	Publication Journal	Author's Place of Origin
A-1	Alnafrah, 2021	Journal of Innovation and Entrepreneurship	Syria
A-2	Dobrzanski et al., 2021	Journal of Competitiveness	Poland, the US, the Czech Republic
A-3	Lacka & Brzezicki, 2021	European Research Studies Journal	Poland
A-4	Prokop et al., 2021	Technological Forecasting and Social Change	Czech Republic
A-5	Aparicio, et al., 2020	Computers & Industrial Engineering	Spain
A-6	Halaskova et al., 2020	Sustainability	Czech Republic, Slovakia

A-7	Klevenhusen et al., 2020	Journal of the Knowledge Economy	Brazil, Portugal
A-8	Yesilay & Halac, 2020	Contemporary Issues in Business Economics and Finance	Turkey
A-9	Zabala-Iturriagagoitia et al., 2020	Technovation	Spain
A-10	Anderson & Stejskal, 2019	Multidisciplinary Digital Publishing Institute (MDPI)	Czech Republic
A-11	Choi & Zo, 2019	Science and Public Policy	South Korea
A-12	Fotia & Teclean, 2019	EURINT	Romania
A-13	Afzal et al., 2019	Competitiveness Review: An International Business Journal	Bangladesh, Australia
A-14	Zhang & Wang, 2019	Behaviour & Information Technology	China
A-15	Dobrzanski, 2018	Zb. rad. Ekon. fak. Rij	Poland
A-16	Edquist et al., 2018	Research Evaluation	Sweden, Spain
A-17	Jurickova et al., 2017	New Trends and Issues Proceedings on Humanities and Social Sciences	Czech Republic
A-18	Bielicki & Lesniak, 2016	Proceedings of the 11th European Conference on Innovation and Entrepreneurship	Poland
A-19	Carayannis et al., 2016	Expert Systems with Applications	US
A-20	Chen & Hung, 2016	Technological Forecasting & Social Change	China
A-21	Edquist & Zabala-Iturriagagoitia 2016	21st International Conference on Science and Technology Indicators	Sweden, Spain
A-22	Gunay & Kazazoglu, 2016	Palgrave Macmillan	Turkey
A-23	Kou et al., 2016	Expert Systems with Applications	China
A-24	Lafuente et al., 2016	Journal of Technology Transfer	Hungary, Spain, UK
A-25	Ozkan & Kazazoglu 2016	Press Academia Procedia	Turkey
A-26	Carayannis et al., 2015	Operational Research	US
A-27	Liu et al., 2015	R&D Management	China
A-28	Tarnawska & Mavroeidis, 2015	Triple Helix	Greece
A-29	Afzal, 2014	International Review of Applied Economics	Bangladesh
A-30	Chang, 2014	Quality & Quantity	China
A-31	Guan & Zuo 2014	Scientometrics	China
A-32	Lu et al., 2014	Knowledge-Based Systems	China
A-33	Foddi & Usai, 2013	Search Working Paper	Italy
A-34	Hudec & Prochadzkova, 2013	Studies in Regional Science	Slovakia
A-35	Zhang, 2013	TECH MONITOR	China
A-36	Guan & Chen, 2012	Research policy	China
A-37	Matei & Aldea, 2012	Procedia-Social and Behavioral Sciences	Romania
A-38	Abbasi et al., 2011	International Journal of Technology Management & Sustainable Development	Iran
A-39	Cai, 2011	Economics Discussion Paper	China
A-40	Chen et al., 2011	Innovation Management, Policy & Practice	China
A-41	Cullmann et al., 2011	Oxford Economic Papers	Germany
A-42	Hsu, 2011	African Journal of Business Management	China
A-43	Pan et al., 2010	Asia-Pacific Journal of operational research	China
A-44	Cullmann et al. 2009	DIW Berlin	Germany
A-45	Hung et al. 2009	Scientometrics	China
A-46	Sharma & Thomas, 2008	Scientometrics	India
A-47	Hollanders & Esser, 2007	European Innovation Scoreboard	Netherlands
A-48	Wang & Huang, 2007	Policy Research	China & USA
A-49	Lee & Park, 2005	Asian Journal of Technology Innovation	South Korea
A-50	Nasierowski & Arcelus, 2003	Socio-Economic Planning Sciences	Canada
A-51	Rousseau & Rousseau, 1998	Scientometrics	Belgium

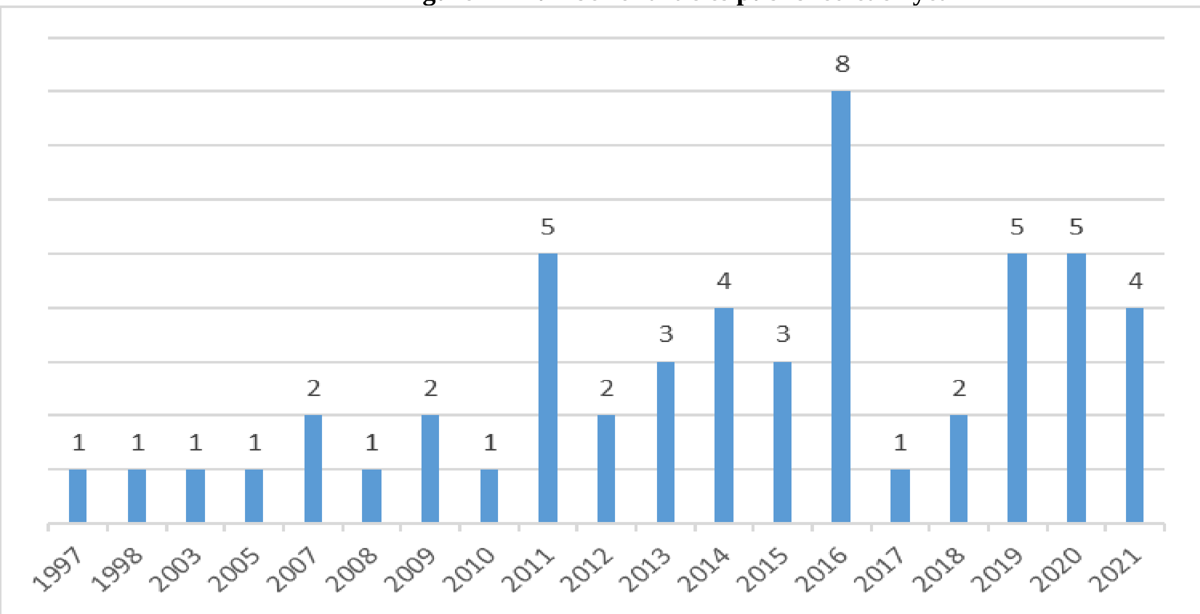
A-52	Rousseau & Rousseau, 1997	Scientometrics	Belgium

The review of the 52 articles was based on the eight parameters identified for review. Parameters were the DEA model, orientation, scale assumption, type of input and output variables, income group category, study location, and journal impact factors.

3.1 Descriptive analysis

Previously Belitz et al. (2011) reported that there are two approaches to NIS analysis, which are descriptive approach that depends on case studies (Nelson, 1993) and theoretical approach that depends on secondary analysis as well as quantitative indicators (Lundvall, 2010). However, the researchers used the quantitative approach in all 52 articles in this review. The number of articles published each year is shown in Fig. 2. It was noted that eight articles were published in 2016, while five articles were published in 2020, 2019 and 2011, respectively. The researchers found that fewer than four articles were published per year in other years and there were no publications in 2006, 2004, 2002, 2001, 2000, and 1999. Further research on NIS efficiency is critical to deliver appropriate information for countries currently lack in innovation in developing policies and strategies to enhance innovation sustainability.

Figure 2 - Number of articles published each year



3.2 DEA models, orientations, and return on the scale assumption

3.2.1 DEA models

It is undeniable that in recent years there has been a wide range of applications of DEA to assess the performance of various companies involved in activities at countries around the world and contexts (Cooper et al., 2006; Cooper et al., 2007). The primary pursuit of DEA is to assess the relative efficiency of a group of decision-making units (Andersen & Petersen, 1993; Aviles-Sacoto et al., 2020; Choi & Zo, 2019; Didenko et al., 2017; Firsova & Chernyshova, 2020; Jurickova et al., 2017; Kao & Liu, 2022; Niosi, 2018). DEA models are used extensively to measure the efficiency of NIS due to their adaptability and flexibility resulted from nonparametric features (Akay et al., 2012; Alnafrah, 2021; Aparicio et al., 2020; Choi & Zo, 2019; Kou et al., 2016; Murillo-Zamorano, 2004; Narayanan et al., 2022; Nasierowski & Arcelus, 2003; Zeng et al., 2021).

This nonparametric approach requires no assumption about the distribution (Choi & Zo, 2019; Jorda et al., 2012; Thanassoulis, 1993), uses multiple input and multiple output simultaneously (Aigner et al., 1977; Cruz-

Cazares et al., 2013; Dobrzanski, 2021; Halaskova et al., 2020; Kou et al., 2016; Lu et al., 2014; Murillo-Zamorano, 2004; Prokop et al., 2021; Thanassoulis, 1993; Zabala-Iturriagagoitia et al., 2020) and does not require the specification of desired functional form for the technology (Ajibefun, 2008). In addition, one can measure the inputs and outputs in different units (Cooper et al., 2006; Dobrzanski, 2021). Furthermore, DEA is very flexible (Andre, 2010; Cook et al., 2010; Tone & Tsutsui, 2010) and permits different economic assumptions regarding the returns on the scale (Samoilenko & Osei-Bryson, 2013; Seiford, & Zhu, 1999) and computational orientation (Cooper et al., 2006; Cooper et al., 2007; Choi & Zo, 2019). Contrary to Kotsemir (2013), most studies clearly explained the mathematical description of the DEA models used for the analysis.

The motivation to determine economic performance enabled the usage of NIS that uses nonparametric-based approach, DEA in particular among many other studies due to its efficiency (Kotsemir, 2013; Nasierowski & Arcelus, 2003). The DEA models used by the researchers to determine NIS efficiency and productivity values are shown in **Table 2**. Most studies continue to operate conventional DEA methods (T-DEA), besides network DEA (N-DEA) and Malmquist-based DEA (M-DEA). When measuring NIS efficiency, the use of bias-corrected DEA (B-DEA), slack-based model DEA (SBM-DEA), relational network DEA (RN-DEA), dynamic network DEA (DN-DEA) and Super Efficiency DEA (SE-DEA) is still relatively new. Consequently, an in-depth and additional study of DEA expansion is crucial since an accurate and reliable value of NIS efficiency will provide vital discernment into the sustainability of innovations.

Table 2 - DEA models

Model	Articles	Percentage (%)
T-DEA	***A-2, A-5, A-7, A-8, A-9, A-10, A-12, A-14, A-15, A-17, A-18, A-19, A-21, A-22, A-24, A-25, A-28, A-33, A-34, A-38, A-39, A-40, A-42, A-46, A-47, A-48, A-50, A-51, A-52***	***52.7%***
B-DEA	A-1, A-16, A-29, A-37, A-41, A-44	11.0%
SBM-DEA	A-3, A-6	3.6%
N-DEA	A-4, A-20, A-27, A-30, A-31, A-32, A-35, A-36	14.5%
RN-DEA	A-11, A-26	3.6%
DN-DEA	A-23	1.8%
SS-DEA	A-43	1.8%
M-DEA	A-2, A-5, A-9, A-13, A-45, A-49	11.0%

3.2.2 DEA orientation

The DEA model can be divided into three orientations, depending on whether the model used is input-oriented, output-oriented or non-oriented (Cooper et al., 2007; Murillo-Zamorano, 2004). Table 3 shows the DEA orientation used during the study period. Most studies have operated an output-oriented rather than an input-oriented and non-oriented approach. Maximising the output level for input levels determines the output-oriented method, while minimising the use of inputs to produce a given output level determines the input-oriented method (Gunay & Kazazoglu, 2016). About 14% of the studies have employed a non-oriented approach. It aims to find an increase in output and a decrease in input. Therefore, one should explore the non-oriented model more to overcome the problems of traditional DEA models that do not provide the closest possible targets (or peers) for inefficient entities (Silva et al., 2003). Thus, the non-oriented model can give flexible measures a unique status in the analysis, in contrast to earlier studies that require each variable to be specified as an input or output before measuring efficiency (Portela et al., 2013; Tohidi & Matroud, 2017). This model enables researchers to deal with flexible measures in DEA.

Table 3 - DEA orientation

Orientation	Articles	Percentage (%)
Input-oriented	A-1, A-2, A-5, A-9, A-15, A-18, A-21, A-26, A-34, A-42, A-43, A-46, A-48, A-50	29%
Output-oriented	A-3, A-4, A-14, A-17, A-24, A-28, A-29, A-33, A-36, A-37, A-38, A-39, A-40, A-41, A-44, A-45, A-47, A-49, A-51, A-52	42%
Input and output-oriented	A-7, A-8, A-10, A-12, A-16, A-19, A-22,	14.5%
Non-oriented	A-6, A-20, A-23, A-25, A-30, A-32, A-35	14.5%

3.2.3 Return on the scale assumption

Charnes, Rhodes, and Cooper created the first classic DEA model, also known as the CRS (Constant Return on Scale) DEA model, in 1978. In 1984, Banker, Charnes, and Cooper (BCC) invented the DEA model of variable returns to scale (VRS), which claims that it can increase, maintain, and decrease returns to scale at different points on the production frontier (Benicio & Soares de Mello, 2019). The principal difference between CRS DEA and VRS DEA is that in CRS DEA, an increase in input has no effect on average productivity, while in VRS DEA, the same increase in input has an impact on average productivity. Conversely, when returns to scale decrease, the same amount of input increases, leading to a decrease in average productivity (Gunay & Kazazoglu, 2016). The type of return-to-scale assumption used in the studies is presented in **Table 4**. In these studies, researchers utilised CRS and VRS equally, and some studies measuring NIS efficiency used both returns on the scale. Therefore, one should examine the CRS and VRS models under distinct conditions (Banker et al., 2011). CRS becomes appropriate if the sample countries are fairly homogeneous. On the other hand, if there are countries that are new to innovation and are still struggling to grow, VRS is more suitable.

Table 4 - Return on scale assumption

Return on scale	Articles	Percentage (%)
CRS	A-3, A-5, A-6, A-8, A-9, A-13, A-16, A-17, A-18, A-39, A-40, A-47, A-49, A-50, A-51, A-52	34%
VRS	A-1, A-4, A-14, A-19, A-20, A-24, A-26, A-27, A-28, A-30, A-37, A-43, A-44, A-45, A-48	32%
CRS and VRS	A-2, A-10, A-12, A-15, A-21, A-22, A-23, A-25, A-29, A-31, A-33, A-34, A-36, A-38, A-41, A-46	34%

3.3 Input and output variables

It is essential to analyse the variables, focusing on input and output indicators (Adam et al., 2006; Narayanan et al., 2022). **Table 5** shows the input and output variables representing the following determinant according to Cornell et al. (2018), Cornell et al. (2020), Tziogkidis et al. (2020) and WIPO (2021). In an attempt to achieve this, the associated input and output variables were retrieved (**refer to Table 6**), which included five input variables and two output variables. The innovation inputs included five pillars, which incorporated elements of the economy that enables innovation activities, while the innovation outputs provided information about the products that resulted from the innovation activities of the economies. The **Fig. 3** shows the number of articles for which the input and output indicators were used. Most studies used human capital and research indices (51 articles) and business sophistication indices (28 articles) as input variables. Conversely, indicators for institutions (3 articles), infrastructure (9 articles) and market sophistication (11 articles) as input variables received less attention from researchers. For output indicators, knowledge and technology indicators (52 articles) were the focus of research to measure the efficiency of NIS compared to creative indicators (14 articles). The results verified that an in-depth study of NIS efficiency requires institutional, infrastructural and market sophistication indicators rather than inputs and creative indicators for outputs.

Table 5 - Classification of input and output variables

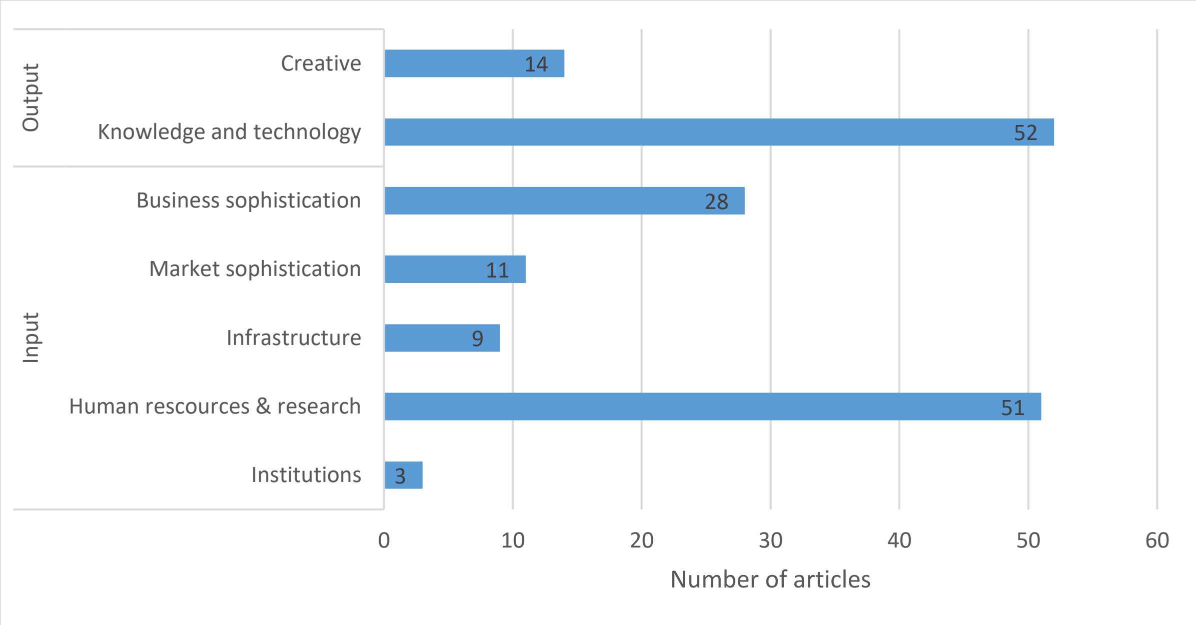
Variable	Indicator
Input	Institutions, Human Resources and Research, Infrastructure, Market Sophistication and Business Sophistication
Output	Knowledge and Technology output and Creative output

Table 6 - Mapping of input and output variables from the articles

Articles	Input variables					Output variables	
	Institutions	**Human resources and research**	**Infrastructure**	**Market sophistication**	**Business sophistication**	**Knowledge and technology**	**Creative**
A-1		●			●	●	●
A-2		●				●	
A-3		●	●		●	●	
A-4		●	●		●	●	
A-5		●		●	●	●	●
A-6		●			●	●	
A-7		●				●	
A-8					●	●	
A-9		●		●	●	●	●
A-10		●		●	●	●	●
A-11		●			●	●	
A-12		●				●	
A-13	●	●	●	●		●	
A-14		●				●	
A-15		●				●	●
A-16		●		●	●	●	●
A-17		●				●	
A-18		●				●	
A-19		●		●	●	●	●
A-20		●				●	
A-21		●				●	●
A-22		●	●		●	●	
A-23		●		●		●	
A-24		●				●	
A-25		●	●		●	●	
A-26		●		●	●	●	●
A-27		●			●	●	
A-28		●				●	
A-29	●	●	●	●		●	
A-30	●	●	●		●	●	
A-31		●			●	●	●
A-32		●			●	●	
A-33		●				●	
A-34		●			●	●	●
A-35		●			●	●	
A-36		●			●	●	●
A-37		●			●	●	
A-38		●				●	
A-39		●				●	
A-40		●				●	
A-41		●			●	●	
A-42		●	●		●	●	●
A-43		●		●	●	●	
A-44		●			●	●	
A-45		●				●	

A-46		●				●	
A-47		●	●	●	●	●	●
A-48		●				●	
A-49		●				●	
A-50		●			●	●	
A-51		●				●	
A-52		●				●	

Figure 3 - Number of articles for which the input and output indicators were used



3.4 Income group category

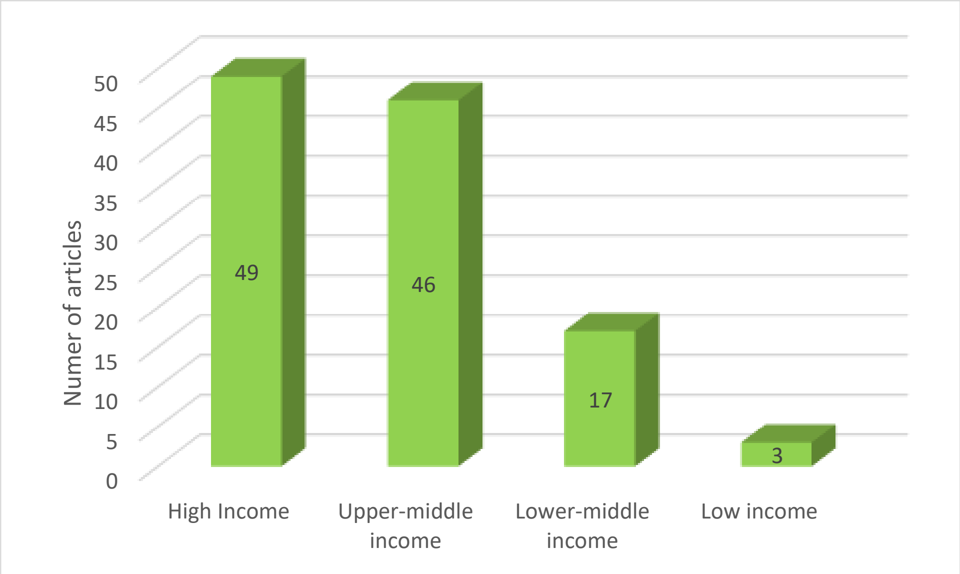
The present study also researched on the outcomes of classification of income group with particular focus on high, upper-middle, lower-middle as well as low-income based countries (Cornell et al., 2018; Cornell et al., 2020; World Bank, 2019; WIPO, 2021). The distribution study of countries' income status of the respondents is shown in Table 7 and the article numbers belongs to particular income group classification is shown in Fig. 4. In the present study, it was found that countries with higher-income and upper-middle income with citation of 49 articles and 46 articles respectively, had higher sampling rates in comparison to countries with lower-middle-income with citation of 17 articles. However, there were only three articles that reported on measurement of NIS efficiency in low-income countries as a sample. In contrast, one of the articles gathered data from all categories of income groups in the world and concluded that more attention needs to be given to lower-middle-income as well as low-income countries particularly focusing on the factors that limits their performance efficiency.

Hence, a comparative analysis, regardless of income group status, is beneficial from a global outlook, as these measures intend to bridge the literature gap in innovation efficiency between high, upper-middle, lower-middle and low-income countries.

Table 7 - Distribution of income group contexts

Articles	Income group category			
	High income	Upper-middle income	Lower-middle income	Low income
A-1	●	●	●	
A-2		●	●	●
A-3	●	●		
A-4	●	●		
A-5	●	●		
A-6	●	●		
A-7	●	●	●	
A-8	●	●		
A-9	●	●		
A-10	●	●		
A-11		●	●	●
A-12	●	●		
A-13	●	●	●	
A-14	●	●	●	
A-15	●	●		
A-16	●	●		
A-17	●			
A-18	●	●		
A-19	●	●		
A-20	●			
A-21	●	●		
A-22	●	●	●	
A-23	●	●		
A-24	●	●	●	●
A-25	●	●	●	
A-26	●	●		
A-27	●	●	●	
A-28	●	●		
A-29	●	●	●	
A-30	●	●	●	
A-31	●	●		
A-32	●	●		
A-33		●	●	
A-34	●			
A-35	●	●	●	
A-36	●	●		
A-37	●	●		
A-38	●	●	●	
A-39	●	●	●	
A-40	●	●		
A-41	●			
A-42	●	●		
A-43	●	●	●	
A-44	●	●		
A-45	●	●		
A-46	●	●		
A-47	●	●		
A-48	●	●		
A-49	●	●		
A-50	●	●		
A-51	●			
A-52	●			

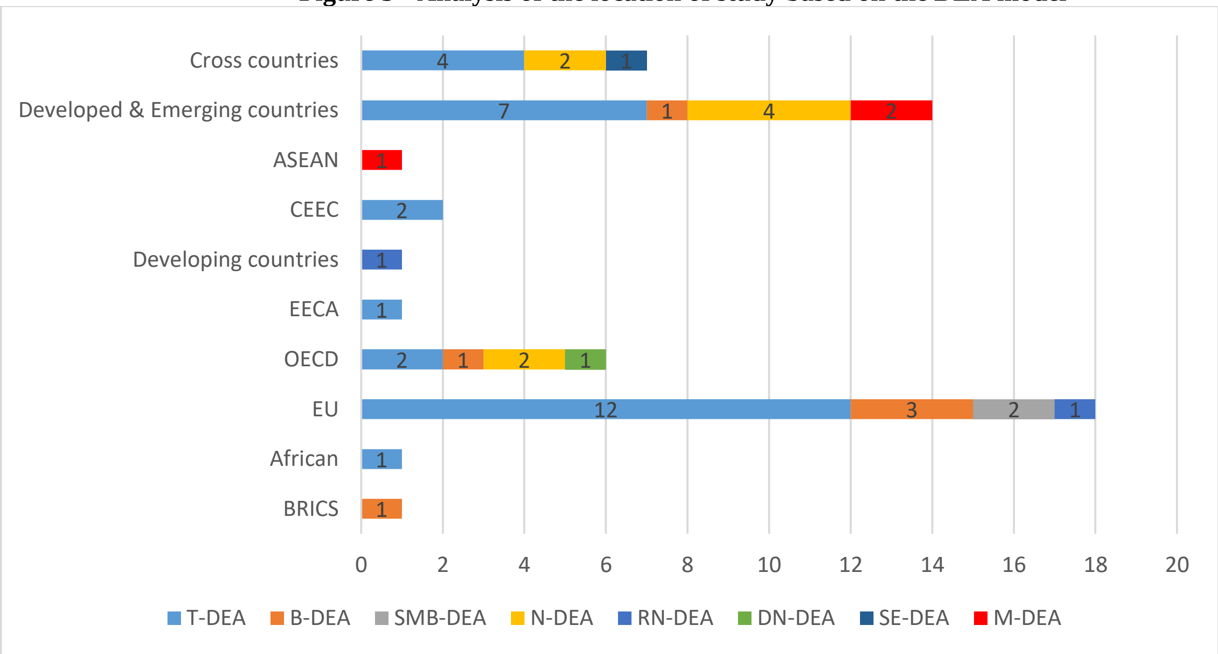
Figure 4 - Number of articles in sampled countries based on income group



3.5 Location of study based on the DEA model

In this study, the insights gained in the DEA model were also examined, focusing on the location of study. In an attempt to achieve this, the appropriate study combination was retrieved (**refer to Fig. 5**), which included eight DEA models and ten study sites. Following this analysis, the EU has received the most attention, followed by developed and emerging countries, cross-countries and the OECD. Meanwhile, BRICS, African countries, developing countries and ASEAN received the least research attention, suggesting that this study location needs more attention, especially in determining the factors hindering their innovation growth.

Figure 5 - Analysis of the location of study based on the DEA model



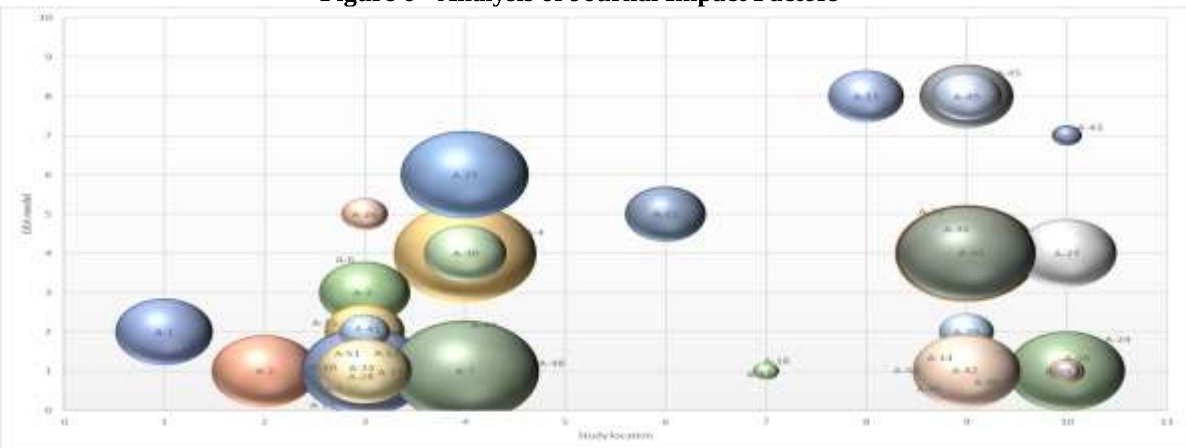
3.6 Publication of journal impact factors

Sharma et al. (2014) noted that the impact factor is typical for assessing a journal's relative importance within its area and calculating the frequency with which the "average article" in a journal has been referenced in a given period. Furthermore, Garfield (1996) stated that "impact simply reflects the journals' and editors' capability to attract the best paper available". **Table 8** describes the coding procedure used in this analysis. As illustrated in **Figure 6**, the researchers presented the results of a study that describes research centred on Journal Impact Factors (JIFs). According to the review, approximately 40% of JIF research articles are considered good because the value of JIF was three or higher. In the geographical location of JIF research, the OECD contributes significantly. EU-developed and emerging economies and cross-countries studies made noteworthy contributions to JIF. The initial publication selection for this study proved various types of DEA model studies on JIFs. Some models appear to contribute immensely more to JIF research than others. As confirmed by many previous studies, T-DEA and N-DEA contributed more than expected, given their overall scientific output.

Table 8 - The coding of DEA models and location of study

Coding	1	2	3	4	5	6	7	8	9	10
DEA model	T-DEA	B-DEA	SMB-DEA	N-DEA	RN-DEA	DN-DEA	SE-DEA	M-DEA		
Study Location	BRICS	African	EU	OECD	EECA	Developing countries	CEEC	ASEAN	Developed & Emerging countries	Cross countries

Figure 6 - Analysis of Journal Impact Factors

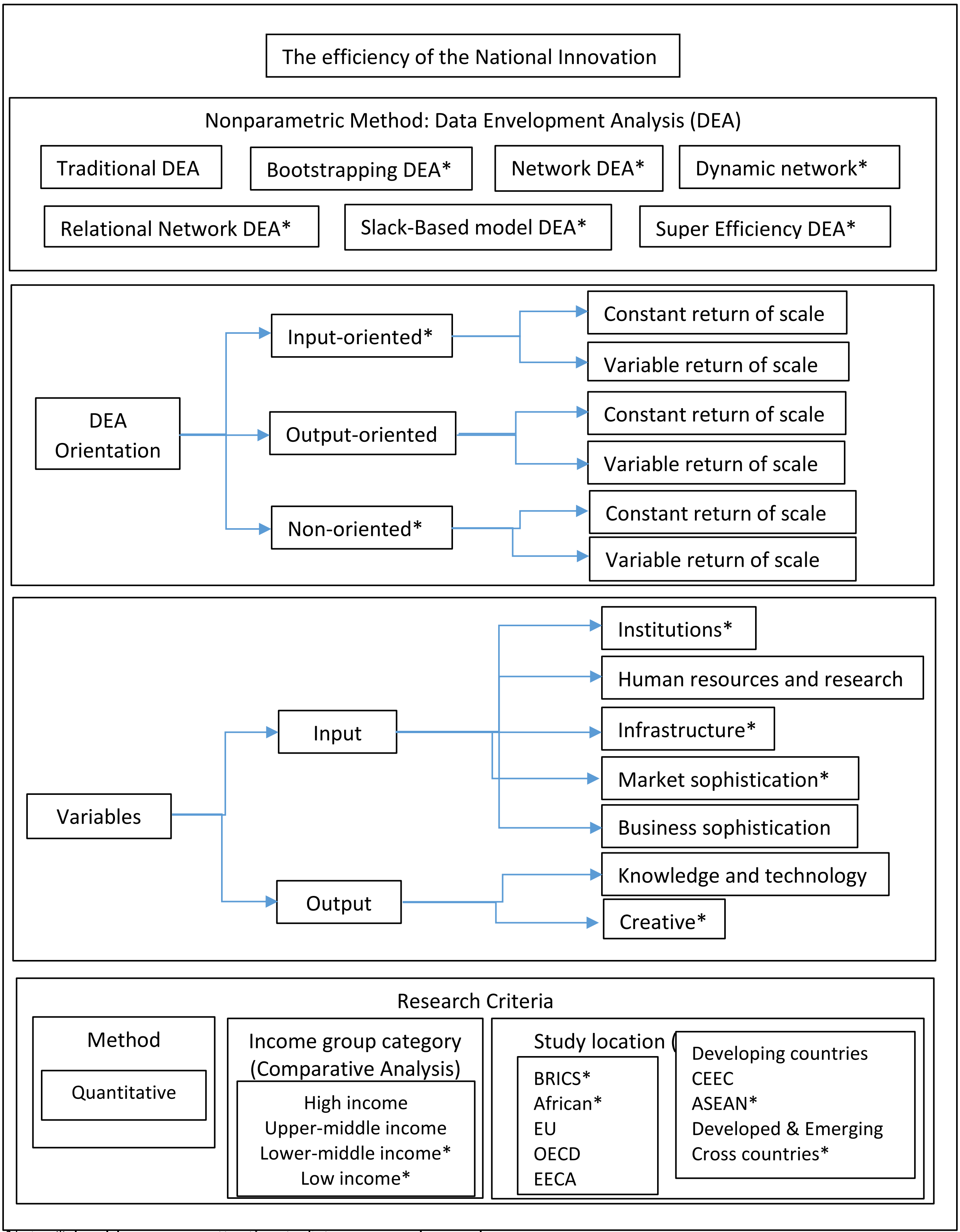


4 DISCUSSION

The researchers carefully examined the studies on the efficiency of NIS from a global perspective throughout the literature study. These findings agree with those of Cooper et al. (2006) and Cooper et al. (2007). They claimed that since 1978, when the DEA proven to be resistant to previous strategies, the intricate nature of the multiple-input and multiple-output relationship inherent in many of these activities had created opportunities for DEA exploitation.

The importance and attention on innovation are highlighted by the Global Innovation Index, the Bloomberg Index, and the European Innovation Scoreboard, which calls on all nations to foster and sustain innovation. Following this circumstance, numerous researches have been conducted to evaluate the efficiency of NIS in order to compare countries globally and improve the innovation policies and strategies. Based on all the findings from the literature, the final framework for subsequent research is shown in Fig. 7. To better comprehend global innovation sustainability, it is advised to conduct study on the DEA model's expansion, the types of input and output variable alternatives, and a comparative cross-country analysis.

Figure 7 - The framework for future research agenda



Note: *should pay more attention to future research agenda;
*need to pay more attention in future study

4.1 Expansion of the DEA model

Several studies, besides traditional DEA, focused on extended DEA approaches, such as B-DEA, SBM-DEA, RN-DEA, DN-DEA, and SE-DEA. B-DEA (Murillo-Zamorano, 2004) assists in the improvement of efficiency scores based on a multiple-sampling approach (Afzal, 2014; Halkos & Tzeremes, 2010; Simar & Wilson, 1998), and the efficiency scores provide a reasonable solution to the low discriminatory power of standard DEA techniques (Edquist et al., 2018). This estimation avoids bias (Afzal, 2014; Kneip et al., 2011; Simar & Wilson, 2007), reduces outliers (Afzal, 2014), and ensures that the sample distributions and standard deviations are close to the original data (Alnafrad, 2021).

Lacka and Brzazieki (2021) and Halaskova et al. (2020) have adopted a non-radial SBM-DEA. This model deals directly with input access and output scarcity and satisfies properties such as unit invariance and monotonicity regarding slacks. The measurement is determined solely by its reference set and is not influenced by statistics over the entire data set. It also has a well-defined dual programme that can be interpreted as virtual profit maximisation (Tone, 2001). Furthermore, by employing an SBM-DEA efficiency measure, one can obtain different frontiers and more relevant performance benchmarks for less efficient DMUs (Morita et al., 2005; Park et al., 2016; Tone et al., 2020; Zhu, 2014).

Choi and Zo (2019) and Carayannis et al. (2015) developed the RN-DEA, which is an extension of the N-DEA that considers the relationship of the processes to measure both system and process efficiencies (Kao, 2009). Unlike the analyses by Fare and Grosskopf (2000) and Fare et al. (2007), the process efficiencies in the N-DEA framework were calculated independently. Meanwhile, Bogetoft et al. (2009), Kao (2013), Tone and Tsutsui (2014), and Kou et al. (2016) used the DN-DEA approach in multi-division, multi-period efficiency measurements. Pan et al. (2010) and Chen and Guan (2012) adopted the SE-DEA technique, which was developed by Anderson and Peterson (1993), to generate a corrected ranking system.

The proliferation and diversity of DEA applications (Coelli, 1996; Cook & Seiford, 2009; Cooper et al., 2004) make DEA a powerful nonparametric tool for assessing the relative efficiency of NIS with multiple inputs and multiple outputs (Narayanan et al., 2022) into a single efficiency index. Based on the results, it is suggested that DEA models such as bootstrapping DEA, SBM-DEA, RN-DEA, DN-DEA, and SE-DEAbe extended to more efficiently and precisely determine the efficiency value in order to provide beneficial input and insights into NIS in the development of innovation-related policies.

4.2 The nature of the input and output variable options

The input and output variables are critical in determining NIS efficiency (Adam et al., 2006; Narayanan et al., 2022). The majority of the studies have used human resources and research (Lacka & Brzazieki, 2021; Nasierowski & Arcelus, 2003; Hollanders & Esser, 2007; Sharma & Thomas, 2008; Cullman et al., 2009; Abbasi et al., 2011; Guan &d Chen, 2012; Cai, 2011; Chen et al., 2011) and business sophistication indicators as inputs, while knowledge and technology indicators served as outputs. The result agree with Kotsemir's (2013) that different R&D indicators such as total R&D personnel, number of researchers, and R&D expenditure (Baesu et al., 2015; Doran et al., 2018; Faber & Hesen, 2004; Furman et al., 2002; Proksch et al., 2017) have been used in many peer-review papers as the primary input variable for human resources and research. Besides, the R&D expenditure in business (Doran et al., 2018; Faber & Hesen, 2004; Halkos & Skouloudis, 2018; Proksch et al., 2017; Rodríguez-Pose & Wilkie, 2019) and foreign direct investment (Filippetti et al., 2017; Halkos & Skouloudis, 2018; Malik, 2020; Wu et al., 2016) in the business indicator was used as the primary input variable for business sophistication. Various indicators of patent activity, publication in scientific and technical journals (Kotsemir, 2013; Rousseau & Rousseau, 1997; Nasierowski & Arcelus, 2003; Sharma & Thomas, 2008; Abbasi et al., 2011; Pan et al., 2010; Cai, 2011; Chen et al., 2011; Hsu, 2011; Guan & Chen, 2012) and high-tech exports (Furman et al., 2002; Guan & Chen, 2012; Hsu, 2011; Cai, 2011; Abbasi et al., 2011) as the primary knowledge and technology output have been used.

When performing the assessment, there is an opportunity to investigate the institution, infrastructure, and market sophistication indicators, as this input variable has an important impact on NIS performance (Bartels et al., 2012; WIPO, 2021). The institution variable captures an economy's institutional framework and includes political (Ege & Ege, 2019; Halkos & Skouloudis, 2018; Wu et al., 2016; Zang et al., 2019), regulatory (Meissner, 2019; Samara et al., 2012), and business environment indicators. Fostering an institutional framework (Afzal, 2014; Chang, 2014; Chobanyan & Leigh, 2006; Clarke et al., 2018; Cowen & Tabarrok, 2009; Cullmann et al., 2009; Hailin et al., 2012; Kneller & Manderson, 2012; Lundvall, 2009; Malik, 2020; Marion & Grazia, 2007; Meissner, 2015; Metcalfe & Ramlogan, 2008; Niosi, 1998; Pinto & Pereira, 2012; Samara et al., 2012; Schrempf et al., 2013; Siedel et al., 2013; Watkins et al., 2015) attracts business and encourages growth by providing good governance and the level of protection and incentives is integral to innovation.

Good and environmentally friendly communication, transportation, and energy infrastructures facilitate the production and exchange of ideas, services, as well as goods and feed into the innovation system through boosted productivity, efficiency, and sustainable growth (WIPO, 2021). Thus, indicators such as information and communication technologies (Ege & Ege, 2019; Filippetti et al., 2017; Lee et al., 2016; Menna et al., 2019; Yunis et al., 2018; Zhang & Wang, 2019), infrastructure (Lundvall, 2009; Niosi; 1998; Prokop et al., 2021), and environmental sustainability must be considered in future studies. This data is consistent with findings by Cai (2011), Dobrzaski and Boboswki (2020), Gunay and Kazazoglu (2016), and Prokop et al. (2021) that infrastructure variables are one of the most critical determinants of NIS efficiency (Kravencko, 2011; Zhang & Wang, 2019).

Furthermore, credit availability, an investment-friendly atmosphere, access to international markets, competition, and market size are vital to business success and innovation. As a result, market sophistication (WIPO, 2021) indicators based on market conditions and the overall level of transactions must be given the attention they deserve. These input variables indicate features of an economy's circumstances that promote innovation and are thus adequately supplied with crucial indicators that can be explored further. As noted by Bertoni and Tykvona (2015), Faber & Hesen (2004), Furman et al. (2002), Guan and Chen (2012), Kuhlmann & Ordonez-Matamoros (2017), Meissner (2015), Pan et al., (2010), Proksch et al., (2017), and Tylecote (1994), venture capital is one of the leading indicators below market sophistication to have a substantial impact on innovation, but still underdeveloped (Anderson & Stejskal, 2019).

In terms of output variables, there is an opportunity to dig deeper into the creative output indicator. Thus, creative output (Menna et al., 2019) variables are intangible assets, creative goods and services, and online creativity that results from innovative activities within an economy (WIPO, 2021). These indicators provided better wisdom of how an innovation-based economy develops innovation, production, and innovative products and services. In this context, trademark application indicators as creative output variables are the key critical capabilities that contribute to NIS efficiency (Andrijauskiene et al., 2021; Baesu et al., 2015; Edquist et al., 2018; Mendonca et al., 2004; Mendonca, 2014; Schmoch, 2003) and also produce quantitative insights into economic trends and brand dynamics (Schautschick & Greenhalgh, 2016). Design applications, as one of the creative output variables, are an essential indicator to be evaluated in determining innovation efficiency (Andrijauskiene et al., 2021; Baesu et al., 2015; Sunley et al., 2008). Therefore, it is paramount to develop additional studies related to it.

4.3 A comparative cross-country analysis

According to this review, most studies only focused on high-income countries (Wilson et al., 2020). The results are consistent with Kotsemirs' (2013) findings that most studies include high-income countries, particularly the European Union and the OECD (Godin, 2009; Gunay & Kazazoglu, 2016; Narayanan et al., 2022), while other income groups are relatively small. High-income countries in the European Union and the OECD have shown exceptional international innovation performance for several years (Leontitsis et al., 2018; WIPO, 2021). Nevertheless, as Mahroum and Al-Saleh (2013) mentioned, most countries underinvest in inputs that support innovation performance. Therefore, they do not demonstrate substantial innovation performance.

This analysis revealed that it limited the measurement of NIS efficiency to a few upper-middle and lower-middle-income countries. China, Russia, Turkey, Bulgaria, and Romania are upper-middle-income countries, while India is among the lower-middle-income countries examined previously. According to Lee et al. (2021), middle-income countries face slower growth and therefore fail to join the ranks of high-income countries. Nonetheless, according to WIPO (2021), countries such as Bulgaria, Malaysia, Vietnam and Ukraine show that middle-income countries can also do well in innovation. As a result, cross-country analysis is required to acquire more insights from a global perspective (Narayanan et al., 2022).

Figure 8: Shows the top 3 innovation economies by income group

High income	**Upper middle-come**	**Lower middle-income**	**Low income**
Switzerland Sweden The United States of America	China Bulgaria Malaysia	Vietnam India Ukraine	Rwanda Tajikistan Malawi

Source: The top three innovation economies by income group (WIPO, 2021)

Lafuente et al. (2016) and Klevenhusen et al. (2020) performed a comparative study regardless of income group classification. The results are consistent with Casadella and Tahi (2022), Choi and Zo (2019) and Gu (1999), who argued that middle- and low-income countries require more attention, particularly in determining the value of NIS efficiency, which hinders growth. Xu and Carlson (2005) proposed that only 12 per cent of the 750 innovation systems studied involve low- and middle-income countries. Future research should underline cross-country comparative and quantitative analyses (Patel & Pavitt, 1994), regardless of income group classification. As previously cited, the emphasis on a cross-country analysis of NIS performance is crucial in improving efficiency, as it delivers insights while maintaining a solid reputation for innovation worldwide. In order to promote long-term sustainable development, it would be preferable to assess innovation performance (Choi & Zo, 2019; Ozkan & Kazazoglu, 2016; Pan et al., 2010; Prokop et al., 2021; Sharma & Thomas, 2008; Wang & Huang, 2007; Yesilay & Halac, 2020) in future research. The comparative analysis furnishes policymakers with insights into developing and implementing the most effective strategies to foster innovation (Fotia & Teclean, 2019; Guan & Zuo, 2014; Narayanan et al., 2022; Seidel et al., 2013).

Regarding NIS efficiency, this review also describes very few studies concentrating on tie-up and regional countries like BRICS (Alnafrad, 2021; Cai, 2011), African countries (Dobrzanski, 2021), ASEAN countries (Afzal et al., 2019; Pan et al., 2010), VISEGRAD (Hudec & Prochadzkova, 2013) and G7 (Cai, 2011; Zhang, 2013). As a point, Klevenhusen et al. (2020) highlighted a need to examine the impact of membership in each free trade bloc on efficiency. Therefore, the future research agenda should underscore the comparative analysis of tie-up and regionally based countries. This analysis will demonstrate the ways membership in different coalitions can impact a country's ability to innovate. Thus, inefficient collisions can use efficient collisions as a benchmark to improve their innovation policies, strategies, and activities.

CONCLUSION

The primary aim of this study was to show the scarcity of current research on the efficiency of the NIS with the DEA. These results can guide scientists in the research system and support future research agendas. The prime approach in this study was a thorough literature review that was conducted in an unbiased manner. The framework then presented a prospective research agenda.

Gaps for future research

The findings showed that more investigation was required to determine the effectiveness of NIS, especially for DEA models, input and output variables, income categories, and study site. This study fills in the gaps left by earlier studies that failed to mention the evolution of DEA techniques through time in their reviews. In addition, the objectives and advantages of the advanced DEA approaches frequently found in earlier studies can be described. For more dependable and precise findings, it is essential to measure efficiency using the correct DEA model. It is advised to employ a non-oriented strategy that believes production units may manage and afterwards adjust input and output simultaneously because the typical DEA model does not offer the closest target (to peers) on efficient units.

Also, innovation development worldwide is heterogeneous. Hence, using VRS assumptions in measuring NIS efficiency is appropriate.

Accordingly, institution, infrastructure and market maturity were identified as critical input variables. The creative output has now been identified as a vital output variable. Everyone accepts that innovations need a reliable environment to thrive and spread. Innovation requires the development of an institutional environment that encourages growth and entrepreneurship by ensuring adequate levels of protection, incentives and good governance. Good and environmentally friendly communication, transport and energy infrastructures are also crucial for sustainable innovation growth. Market sophistication includes the availability of credit and an investment-friendly environment, access to the international market, competition and market size, all of which are vital for innovation to emerge. As for the output variable, the role of creative output for innovation is still primarily underestimated in measurement and policy debates.

Further, in the context of income taxonomies, there are chances for lower-middle and low-income groups to contribute their research to innovation policies and strategies, as this is a part of the Sustainable Development Goal to foster innovation. Therefore, a cross-country comparative study on innovation would also promote favourable influences and deserve attention.

Implications for theory and practice

In theory, the proposed framework corresponds to the enabling environment and outcomes of innovation activities as a critical factor for the success and growth of NIS. Efficient NIS enable them to use their input and output resources optimally. Faced with global challenges and developing new and emerging technologies, efforts to bridge existing gaps are imperative and necessary to help the NIS strengthen their respective innovation policies and strategies. Swift environmental shifts also challenge the optimal management of innovation resources. Therefore, one must regularly expand innovation sources. This study was based on a systematic literature review process. This conclusion is complemented by the diversity and extension of the DEA model, the nature of the input and output variable option, and a cross-country comparative study that can provide a comprehensive framework for future studies. Exhaustive research supports policymakers in planning and developing good innovation policies and in shaping and maintaining the sustainability of innovation at the international level. Subsequently, future research will help foster an innovative spirit as indicated in the Sustainable Development Goals.

Limitations

This research holds several limitations. For instance, the analysis did not consider regional and sectoral NIS efficiency. Therefore, it is better to study the comparison as the differences in innovation input and output variables exist for different NIS levels. Incorporating different levels of NIS into the future research agenda can encourage broader studies. The prospective study could also expand the range of input and output indicators and the number and category of countries identified in this study. Such an analysis can provide a clearer view of boosting NIS innovation at the global level. In addition, future studies could identify the environmental factors affecting the NIS efficiency value. Nevertheless, for some environmental factors, there is a close relationship between the input and output indicators of the NIS, and this situation demands a clear identification of the factors to achieve better results. In addition, the number of time lags for the aggregated data is also still up for debate. Publication numbers fluctuated around the time these papers were published, suggesting that future research is required to fully understand the impact of these papers on the scientific communities working on and operating JIFs.

REFERENCES

Abbasi, F., Hajihoseini, H., & Haukka, S. (2011). Use of virtual index for measuring the efficiency of innovation systems: A cross-country study. *International Journal of Technology Management & Sustainable Development*. 9(3), 195-212. http://doi.org/10.1386/ tmsd. 9.3. 195_1

Adams, R., Bessant, J. & Phelps. R. (2006). Innovation Management Measurement: A Review. *International Journal of Management Reviews*. 8(1), 21–48. https://doi.org/10.1111/j.1468-2370.2006.00119.x

Afzal, M. N. I. (2014). An empirical investigation of the National Innovation System (NIS) using Data Envelopment Analysis (DEA) and the TOBIT model. *International Review of Applied Economics*. 28(4), 507-523. https://doi.org/10.1080/02692171.2014.896880

Afzal, M. N. I., Lawrey, R., & Gope, J. (2019). Understanding national innovation system (NIS) using porter's diamond model (PDM) of competitiveness in ASEAN-05. *Competitiveness Review: An International Business Journal*. 29(4), 336-355. https://doi.org /10.1108/CR-12-2017-0088

Aigner, C.A., Knox, L., & Peter, S. (1977). Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics* 6(4): 21–37. https://doi.org/10.1016/ 0304-4076(77)90052-5

Ajibefun, I. A. (2008). An evaluation of parametric and nonparametric methods of technical efficiency measurement: Application to small scale food crop production in Nigeria. *Journal of Agriculture & Social Sciences*. 4(3): 95-100.

Akay, A. E., Ertek, G., Büyükozkan, G. (2012). Analysing the solutions of DEA through information visualisation and data mining techniques: SmartDEA framework. *Expert Syst. Appl*. 39(9), 7763–7775. https://doi.org/10.1016/j.eswa.2012.01.059

Albuquerque, E. M. (2007). Inadequacy of technology and innovation systems at the periphery. *Cambridge Journal of Economics*. Vol. 31, 669–90. https://doi-org.eres.qnl.qa/10.1093/cje /bel045

Alnafrah, I. (2021). Efficiency evaluation of BRICS's national innovation systems based on bias-corrected network data envelopment analysis. *Journal of Innovation and Entrepreneurship*. 10(1), 1-28. https://doi.org/10.1186/s13731-021-00159-3

Alvarez, I., & Marín, R. (2010). Entry modes and national systems of innovation. *Journal of International Management* 16(4), 340–353. https://doi.org/10.1016/j.intman.2010.09.005

Andersen, P., & Petersen, N. C. (1993). A Procedure for Ranking Efficient Units in Data Envelopment Analysis. *Management Science*. 39(10), 1261–1264. https://doi.org/10.1287/ mnsc.39.10.1261

Anderson, H. J., & Stejskal, J. (2019). Diffusion efficiency of innovation among EU member states: a data envelopment analysis. *Economies* 7:34. https://doi.org/10.3390/economies 7020034

Andre, F., Herrero, I., & Riesgo, L. (2010). A modified DEA model to estimate the importance of objectives with an application to agricultural economics. *Omega*. 38(5), 371–82. https:// doi.org/10.1016/j.omega.2009.10.002

Andrijauskiene, M., Dumciuviene, D., & Vasauskaite, J. (2021). Redeveloping the National Innovative Capacity Framework: European Union Perspective. *Economies*. 9(4), 201. https://doi.org/10.3390/economies9040201

Aparicio, J., Ortiz, L., Pastor, J. T., & Zabala-Iturriagagoitia, J. (2020). Introducing cross productivity: A new approach for ranking productive units over time in Data Envelopment Analysis. *Computers & Industrial Engineering.* 144. https://doi.org/10.1016/ j.cie.2020.106456

Aviles-Sacoto, S. V., Cook, W. D., Güemes-Castorena, D., & Zhu, J. (2020). Modelling Efficiency in Regional Innovation Systems: A Two-Stage Data Envelopment Analysis Problem with Shared Outputs within Groups of Decision-Making Units. *European Journal of Operational Research*. 287(2), 572-582. https://doi.org/10.1016/j.ejor.2020.04.052

Baesu, V., Albulescu, C. T., Farkas, Z-B., & Draghici, A. (2015). Determinants of the High-tech Sector Innovation Performance in the European Union: A Review. *Procedia Technology*. 19, 371–378. https://doi.org/10.1016/j.protcy.2015.02.053

Balzat, M., & Hanusch, H. (2004). Recent trends in the research on national innovation systems. *Journal of Evolutionary Economics,* 14(2), 197–210. https://doi.org/10.1007/ s00191-004-0187-y

Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis. *Management Science*. 30(9), 1078-1092. https://doi.org/10.1287/mnsc.30.9.1078
Banker, R. D. Cooper, W.W., Seiford, L. M., & Zhu, J. (2011). Returns to scale in DEA. *Handbook on Data Envelopment Analysis. Springer, Boston*, MA. https://doi.org/10.1007/ 978-1-4419-6151-8_2
Bartels, F. L., Voss, H., Lederer, S., & Bachtrog, C. (2012). Determinants of National Innovation Systems: Policy implications for developing countries. *Innovation: Organization & Management*. 14(1), 203-243. https://doi.org/10.5172/impp.2012.14.1.2
Belitz, H., Clemens, M., von Hirschhausen, C., SchmidtEhmcke, J., Werwatz, A., & Zloczysti, P. (2011). An Indicator for National Systems of Innovation – Methodology and Application to Industrialized Countries. *Discussion Paper*. https://doi.org/10. 2139/ssrn.1858751
Benicio, J., & Soares De Mello, J, C. (2019). Different Types of Return to Scale in DEA. *Pesquisa Operacional*. 39(2), 245-260. https://doi.org/10.1590/0101-7438.2019. 039.02. 0245
Bertoni, F., & Tykvova, T. 2015. Does governmental venture capital spur invention and innovation? Evidence from young European biotech companies. *Research Policy* 44: 925–35. https://doi.org/10.1016/j.respol.2015.02.002
Bielicki, M., & Lesniak, M. (2016). CEE cross-country comparison of national innovation systems efficiency: DEA approach. *Proceedings of The 11th European Conference on Innovation and Entrepreneurship*.
Bogetoft, P., Fare, R., Grosskopf, S., Hayes, K., Taylor, L., 2009. Dynamic network DEA: an illustration. *Journal of the Operations Research Society of Japan*. 52(2), 147–162. https://doi.org/10.15807/jorsj.52.147
Cai, Y. (2011). Factors Affecting the Efficiency of the BRICSs' National Innovation Systems: A Comparative Study Based on Dea and Panel Data Analysis. *Economics Discussion Papers, Kiel Institute for the World Economy (*IfW). https://doi.org/10.2139/ssrn.1974368
Carayannis, E. G., Goletsis, Y., & Grigoroudis, E. *(2015). Multi-level multi-stage efficiency measurement: the case of innovation systems. Operational* Research. 15(2), 253–274. https://doi.org/10.1007/s12351-015-0176-y
Carayannis, E. G., Grigoroudis, E., & Goletsis, Y. (2016). A multilevel and multistage efficiency evaluation of innovation systems: A multi objective DEA approach. *Expert Systems with Applications*, 62(C), 63-80. https://doi.org/10.1016/j.eswa.2016.06.017
Carlsson, B. (2006). Internationalisation of innovation systems: A survey of the literature. *Research Policy*, 35, 56–67. https://doi.org/10.1016/j.respol.2005.08.003
Carlsson, B., Jacobsson, S., Holmén, M., & Rickne, A. (2002). Innovation Systems: Analytical and Methodological Issues. *Research Policy, Innovation Systems* 31: 233–245. https://doi.org/10.1016/S0048-7333(01)00138-X
Casadella, V., & Uzunidis, D. (2017). National Innovation Systems of the South, Innovation and Economic Development Policies: A Multidimensional Approach. *Journal of Innovation Economics*. 23(2), 137-157. https://doi.org/10.3917/jie.pr1.0007
Casadella, V., & Tahi, S. (2022). National Innovation Systems in Low-Income and Middle-Income Countries: Re-evaluation of Indicators and Lessons for a Learning Economy in Senegal. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-022-00945-8
Casanova, L., Cornelius, P. K., & Dutta, S. (2018). Financing Entrepreneurship and Innovation in Emerging Markets. *Academic Press: Elsevier Inc*. url: https://doi.org/10.1016/C2015-0-01009-7
Centobelli, P., Cerchione, R., & Esposito, E. (2017). Environmental sustainability in the service industry of transportation and logistics service providers: Systematic literature review and research directions. *Transportation Research Part D: Transport and Environment*. 53, 454-470. https://doi.org/10.1016/j.trd.2017.04.032
Chang, C.-C. (2014). Influences of knowledge spill over and utilisation on the NIS performance: a multi-stage efficiency perspective. *Quality & Quantity*. 49(5), 1945–1967. https://doi.org/10.1007/s11135-014-0083-y
Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research*. 2(6), 429-444. https://doi.org/10.1016/0377-2217(78)90138-8

Chen, C. P., Hu, J. L., & Yang, C. H. (2011). An International Comparison of R&D Efficiency of Multiple Innovative Outputs: The Role of the National Innovation System. *Innovation: Management, Policy & Practice*. 13(3), 341–360. https://doi.org/10.5172/impp. 2011.13.3.341
Chen, K., & Guan, J. (2012). Measuring the Efficiency of China's Regional Innovation Systems: Application of Network Data Envelopment Analysis (DEA). *Regional Studies.* 46(3), 355-377. https://doi.org/10.1080/00343404.2010.497479
Chobanyan, A. & Leigh, L. (2006). The competitive advantages of nations: applying the 'diamond' model to Armenia. *International Journal of Emerging Markets.* 1(2), 147-164. https://doi.org/10.1108/17468800610658316
Choi, H., & Zo, H. (2019). Assessing the efficiency of national innovation systems in developing countries. *Science and Public Policy*. 46(4), 530-540. https://doi.org/10.1093 /scipol/scz005
Clarke, T., Chelliah, J., & Pattinson, E. (2018). National Innovation Systems in the Asia Pacific: A Comparative Analysis. *In Innovation in the Asia Pacific. Springer Singapore*. https://doi.org/10.1007/978-981-10-5895-0_6
Coelli, T.J. (1996). A Guide to DEAP Version 2.1: A Data Envelopment Analysis (Computer) Program. *CEPA Working Paper 96/08*, University of New England, Armidale.
Cook, W. D., & Seiford, L. M. (2009). Data Envelopment Analysis (DEA) — Thirty years on. *European Journal of Operational Research*. 192 (1), 1–17. https://doi.org/10.1016/j.ejor. 2008.01.032
Cook, W., Liang, L., & Zhu, J. (2010). Measuring performance of two-stage network structures by DEA: a review and future perspective. *Omega*. 38(6), 423–30.
Cooper, W. W., Seiford, L. M., & Zhu, J. (2004). *Data envelopment analysis:* History, models and interpretations. In W. Cooper, L. Seiford, & J. Zhu (Eds.), Handbook on data envelopment analysis. Boston, MA: Kluwer Academic Publishers.
Cooper, W. W., Seiford, L. M., & Tone, K. (2006). *Introduction to Data Envelopment Analysis and Its Uses with DEA-Solver and References;* Springer: New York, NY, USA. https://doi.org/10.1007/0-387-29122-9
Cooper, W. W., Seiford, L. M., & Tone, K. (2007). *Data envelopment analysis* (second edition). SpringerVerlag, US. https://doi.org/10.1007/978-0-387-45283-8
Cornell University, INSEAD & WIPO. (2018). *The Global Innovation Index 2018:* Energising The World with Innovation. Ithaca, Fontainebleau and Geneva.
Cornell University, INSEAD &. WIPO (2020). *The Global Innovation Index 2020:* Who Will Finance Innovation? Ithaca, Fontainebleau, and Geneva.
Cowen, T., & Tabarrok, A. (2009). Modern Principles of Economics. UK: Worth Publishers.
Cruz-Ca´zares, C., Bayona-Sa´ez, C., & Garcı´a-Marco, T. (2013). You Can't Manage Right What You Can't Measure Well: Technological Innovation Efficiency. *Research Policy.* 42(6–7), 1239–1250. https://doi.org/10.1016/j.respol.2013.03.012
Cullmann, A., Schmidt-Ehmcke, J., & ZloczystI, P. (2009). Innovation, R&D Efficiency and the Impact of the Regulatory Environment: A Two-stage Semi-parametric DEA Approach. *DIW Berlin Discussion Paper*, No: 883. https://doi.org/10.2139/ssrn.1460709
Cullmann, A., Schmidt-Ehmcke, J., & Zloczysti, P. (2011). R&D efficiency and barriers to entry: a two stage semi-parametric DEA approach. *Oxford Economic Papers.* 64, 176–196. https://doi.org/10.2307/ 41421491
Didenko, A., Loseva, O., & Abdikeev, N. (2017). Measuring Efficiency of Regional Innovation System with DEA and PCA. 2017 *IEEE 11th International Conference on Application of Information and Communication Technologies (AICT).* https://doi.org/10.1109/ICAICT. 2017.8687279
Diez, J. R., & Kiese, M. (2009). Regional Innovation Systems, in R., Kitchin and N., Thrift (ed.) International Encyclopedia of Human Geography. 246–251. Oxford: Elsevier.
Dobrzanski, P. (2018). Innovation expenditures efficiency in Central and Eastern European Countries. *Proceedings of Rijeka School of Economics*. 36(2), 827-859. https://doi.org/ 10.18045/zbefri.2018.2.827.
Dobrzanski, P., & Bobowski, S. (2020). The Efficiency of R&D Expenditures in ASEAN Countries. *Sustainability.* 12(7), 2686. https://doi.org/10.3390/su12072686

Dobrzanski, P., Bobowski, S., Chrysostome, E., Velinov, E., & Strouhal, J. (2021). Toward Innovation-Driven Competitiveness Across African Countries: An Analysis of Efficiency of R&D Expenditures. *Journal of Competitiveness.* 13(1), 5-22. https://doi.org/10.7441/ joc.2021.01.01
Doran, J., McCarthy, N., & O'Connor, M. (2018). Analysing national innovation capacity and its importance for competitiveness and growth. *International Journal of Competitiveness.* 1, 257–78.
Dorsch, I., Askeridis, J. M., & Stock, W. G. (2018) Truebounded, Overbounded, or Underbounded? Scientists' Personal Publication Lists versus Lists Generated through Bibliographic Information Services. Publications. 6(1), 7. https://doi.org/10.3390/ publications6010007
Dosi, G., Freeman, C., Nelson R., Silverberg G. & Soete, L. (Eds.) (1988). Technical change and economic theory, London, New York: Pinter.
Edler, J., & Fagerberg, J. (2017). Innovation policy: What, why, and how. *Oxford Review of Economic Policy.* 33(1), 2–23. https://doi.org/10.1093/oxrep/grx001
Edquist, C. (1997). Systems of Innovation. Technologies, Institutions and Organisations. Great Britain: Cassell imprint.
Edquist, C. (2009). *Systems of innovation—perspectives and challenges*, chapter 7 in Fagerberg, J., Mowery, D. C. and Nelson, R. (eds.). Oxford Handbook of Innovation, Oxford. https://doi.org/10.1093/oxfordhb/9780199286805.003.0007
Edquist, C. (2011). Design of innovation policy through diagnostic analysis: identification of systemic problems (or failures). Industrial and Corporate Change, 20(6), 1725-1753. https://doi.org/10.1093/icc/dtr060
Edquist, C., & Zabala-Iturriagagoitia, J. M. (2016). Assessing the performance of national innovation systems in Europe. *21st International Conference on Science and Technology Indicators.* Spain.
Edquist, C., Zabala-Iturriagagoitia, J. M., Barbero, J., & Zofío, J. L. (2018). *On the meaning of innovation performance*: Is the synthetic indicator of the Innovation Union Scoreboard flawed? Research Evaluation, 1-16. https://doi.org/10.1093/reseval/rvy011
Ege, A., & Ege, A., Y. (2019). How to Create a Friendly Environment for Innovation? A Case for Europe. *Social Indicators Research: An International and Interdisciplinary Journal for Quality-of-Life Measurement.* 144(1), 451–73. https://doi.org/10.1007/s11205-018-2039-4
Faber, J., & Hesen, A. B. (2004). Innovation capabilities of European nations: Cross-national analyses of patents and sales of product innovations. *Research Policy.* 33(2), 193–20. https://doi.org/10.1016/S0048-7333(03)00122-7
Fagerberg, J. (2003). Schumpeter and the revival of evolutionary economics: an appraisal of the literature. *Journal of Evolutionary Economics.* 13, 125-159. https://doi.org/10.1007/ s00191-003-0144-1
Fagerberg, J., & Verspagen, B. (2009). Innovation Studies – the emerging structure of a new scientific field. *Research Policy.* 38(2), 218-233. https://doi.org/10.1016/j.respol. 2008.12.006
Fagerberg, J., Mowery, D. C., & Verspagen, B. (2009). The evolution of Norway's national innovation system. Science and Public Policy. 36(6), 431–444. https://doi.org/10.3152/ 030234209X460944
Fagerberg, J., & Sapprasert, K. (2011). National innovation systems: The emergence of a new approach. Science and Public Policy. 38(9), 669–679. https://doi.org/10.3152/ 030234211X13070021633
Fare, R. & Grosskopf, S. (2000). Network DEA. Socio-Economic Planning Sciences. 34, 35-49. https://doi.org/10.1016/S0038-0121(99)00012-9
Fare, R., Grosskopf, S., & Whittaker, G., (2007). Network DEA. In: Zhu, J., Cook, W.D. (Eds.), Modeling Data Irregularities and Structural Complexities in DEA. Springer Verlag, New York.
Feinson, S. (2003). National Innovation Systems Overview and Country Cases. Knowledge Flows and Knowledge Collectives: Understanding the Role of Science and Technology Policies in Development. Center for Science, Policy and Outcomes, Columbia University.
Filippetti, A., Marion, F., & Grazia, I. G. (2017). The impact of internationalisation on innovation at countries' level: The role of absorptive capacity. *Cambridge Journal of Economics,* Oxford University Press. 41(2), 413–3. https://doi.org/10.1093/cje/bew032
Firsova, A., & Chernyshova, G. (2020). Efficiency Analysis of Regional Innovation Development Based on DEA Malmquist Index. *Information.* 11(6), 294. https://doi.org/ 10.3390/info11060294

Foddi, M., & Usai, S. (2013). Regional Knowledge Performance in Europe. *Growth and Change.* 44(2), 258–286. https://doi.org/:10.1111/grow.12007
Fotia, A., & Teclean, C. (2019). *The innovation efficiency in Central and Eastern Europe* - An input-output comparative analysis between Czech Republic, Hungary, Poland and Romania. Eurint, Centre for European Studies, Alexandru Ioan Cuza University. 6(1), 269-287.
Freeman, C. (1987). *Technology and economic performance:* Lessons from Japan. London, New York: Pinter Publishers.
Furman, J. L., Porter, M. E., & Stern, S. (2002). *The determinants of national innovative capacity.* Research Policy. 31(2002), 899–933. https://doi.org/10.1016/S0048-7333(01) 00152-4
Garfield, E. (1996). How can impact factors be improved? *British Medical Journal* (Clinical research ed.). 313(7054), 411–413. https://doi.org/10.1136/bmj.313.7054.411
Godin, B. (2009). National innovation system: The system approach in historical perspective. *Science, Technology and Human Values,* 34(4), 476–501. https://doi.org/10.1177/ 0162243908329187
Godinho, F, M., & Veloso S. E. (2013). From time-based competition (TBC) to quick response manufacturing (QRM): the evolution of research aimed at lead time reduction. *The International Journal of Advanced Manufacturing Technology,* 64, 5–8. https://doi.org/ 10.1007/s00170-012-4064-9
Golichenko, O. G. (2016). The National Innovation System Problems of Economic Transition. *Taylor & Francis Journals.* 58(5), 463-481. https://doi.org/10.1080/ 10611991. 2016. 1225452
Grima, S., Ozen, E., & Boz, H. (2020). Contemporary issues in business, economics and finance. Bingley, *UK: Emerald Publishing.* https://doi.org/10.1108/9781839096051
Groenewegen, J., & van der Steen, M. (2006). The Evolution of National Systems of Innovation. *Journal of Economic Issues.* 40(2), 277-285. https://doi.org/10.1080/00213624. 2006.11506905
Gu, S. (1999). Concepts and methods of NIS approach in the context of less developed economies. *DRUID Conference,* Aalborg school, Denmark.
Guan, J., & Chen, K. (2012). Modeling the relative efficiency of national innovation systems. *Research Policy.* 41(1), 102-115. https://doi.org/10.1016/j.respol.2011.07.001
Guan, J., & Zuo, K. (2014). A cross-country comparison of innovation efficiency. *Scientometrics*. 100(2), 541–575. https://doi.org/10.1007/s11192-014-1288-5
Gümüş, S., Arar, K., & Oplatka, I. (2021). Review of international research on school leadership for social justice, equity and diversity. *Journal of Educational Administration and History*. 53, 81–99. https://doi.org/10.1080/00220620.2020.1862767
Gunay, E. N., & Kazazoglu, G. R. (2016). *National Innovation Efficiency During the Global Crisis*. Palgrave Macmillan Books, Palgrave Macmillan. https://doi.org/10.1057/978-1-137-58255-3
Haddaway, N. R., Woodcock, P., Macura, B., & Collins, A. (2015). Making literature reviews more reliable through application of lessons from systematic reviews. *Conservation Biology.* 29(6), 1596–1605. https://doi.org/10.1111/cobi.12541
Hagedoorn, J., & Cloodt, M. (2003). Measuring innovative performance: is there an advantage in using multiple indicators? Research Policy. 32(8), 1365–1379. https://doi.org/10.1016/ s0048-7333(02)00137-3
Hailin, L., Xiaohui, L., & Chengang, W. (2012). Knowledge Spillovers, Absorptive Capacity and Total Factor Productivity in China’s Manufacturing Firms. *International Review of Applied Economics.* 26(4), 533–547. https://doi.org/10.1080/02692171.2011.619970
Halaskova, M., Gavurova, B., & Kocisova, K. (2020). Research and Development Efficiency in Public and Private Sectors: An Empirical Analysis of EU Countries by Using DEA Methodology. *Sustainability*. 12(17), 7050. https://doi.org/10.3390/su12177050
Halkos, G., & Tzeremes, N. (2010). Performance evaluation using bootstrapping DEA techniques: Evidence from industry ratio analysis. *Expert Systems with Applications*. 39(5), 5872-5880. https://doi.org/10.1016/j.eswa.2011.11.080
Halkos, G., & Skouloudis, A. (2018). Corporate social responsibility and innovative capacity: Intersection in a macro-level perspective. *Journal of Cleaner Production.* 182, 291–300. https://doi.org/10.1016/j.jclepro.2018.02.022

Hollanders, H., & Esser, C. (2007). Measuring innovation efficiency, European Commission. *European Innovation Scoreboard*.
Hallinger, P. (2013). A conceptual framework for systematic reviews of research in educational leadership and management. *Journal of Education Administration*. 51, 126–149. https://doi.org/10.1108/ 09578231311304670
Hsu Y. (2011). Cross National Comparison of Innovation Efficiency and Policy Application. *African Journal of Business Management*. 5(4), 1378–1387. https://doi.org/10.5897/ AJBM10.1255
Hu, X.Y., Li, J.S., Li, X.Y., & Cui, J.C. (2020). A revised inverse data envelopment analysis model based on radial models. *Mathematics*. 8(5), 803-817. https://doi.org/10.3390/ math8050803
Hu, M. C. & Mathews, J. A. (2005). *National innovative capacity in East Asia*. Research Policy. 34(9), 1322-1349. https://doi.org/10.1016/j.respol.2005.04.009
Hudec, O., & Prochadzkova, M. (2013). The relative efficiency of knowledge innovation processes in EU countries. *Studies in Regional Science*. 43(1), 145–162. https:// doi.org/10.2457/srs.43.145
Hung, W. C., Lee, L. C., & Tsai, M. H. (2009). An international comparison of relative contributions to academic productivity. *Scientometrics*. 81(3), 703–718. https://doi.org/ 10.1007/s11192-008-2210-9
Intarakumnerd, P., Chairatana, P.-A., & Tangchitpiboon, T. (2002). National innovation system in less successful developing countries: The case of Thailand. *Research Policy*. 31(8-9), 1445–1457. https://doi.org/10.1016/S0048-7333(02)00074-4
Jia, C., Tang, X., & Kan, Z. (2020). Does the Nation Innovation System in China Support the 719 Sustainability of Small and Medium Enterprises (SMEs) Innovation? *Sustainability*. 12(6), 2562. https://doi.org/10.3390/SU12062562
Jorda, P. Cascajo, R. & Monzon, A. (2012). Analysis of the Technical Efficiency of Urban Bus Services in Spain Based on SBM Models. *International Scholarly Research Notices*. https://doi.org/10.5402/2012/984758
Jurickova, E., Bobak, R., Pilik, M. & Hrusecka, D. (2017). Efficiency of innovation system in the Czech Republic: Comparison with other European countries. *New Trends and Issues Proceedings on Humanities and Social Sciences*. 4(10), 90–96. https://doi.org/10.18844/ prosoc.v4i10.3066
Kao, C. (2009). Efficiency decomposition in network data envelopment analysis: a relational model. *European Journal of Operational Research*. 192(3), 949–962. https://doi.org/ 10.1016/j.ejor.2007.10.008
Kao, C. (2013). Dynamic data envelopment analysis: A relational analysis. *European Journal of Operational Research.* 227(2), 325–330. https://doi.org/10.1016/j.ejor.2012.12.012
Kao, C., & Liu, S-T. (2022). Group decision making in data envelopment analysis: A robot selection application. *European Journal of Operational Research*. 297(2), 592-599. https://doi.org/10.1016/j.ejor.2021.05.013
Klevenhusen, A., Coelho, J., & Warszawski, L. (2020). Innovation Efficiency in OECD Countries: A Non-parametric Approach. *Journal of the Knowledge Economy*. 12(3), 1064-1078. https://doi.org/10.1007/s13132-020-00652-2
Kneip, A., Simar, L., & Wilson, P. W. (2011). A computationally efficient, consistent bootstrap for inference with nonparametric DEA estimators. *Computational Economics*. 38(4), 483–515. https://doi.org/10.1007/s10614-010-9217-z.
Kneller, R. & Manderson, E. (2012). Environmental regulations and innovation activity in UK manufacturing industries. *Resource and Energy Economics.* 34(2), 211–235. https://doi.org/ 10.1016/j.reseneeco.2011.12.001
Kong, M., Wang, X., & Wu, Q. (2021). The development efficiency of China's innovative industrial clusters-based on the DEA-Malmquist model. *Arabian Journal of Geosciences*. 14(7), 1-15. https://doi.org/10.1007/s12517-021-06927-5
Kotsemir, M. N. (2013). Measuring national innovation systems Efficiency: A review of DEA approach. Higher School of Economics research papers. *National Research University Higher School of Economics.* https://doi.org/10.2139/ssrn. 2304735
Kou, M., Chen, K., Wang, S., & Shao, Y. (2016). Measuring efficiencies of multi-period and multi-division systems associated with DEA: An application to OECD countries' national innovation systems. *Expert Systems with Applications*. 46(C), 494-510. https://doi.org/ 10.1016/j.eswa.2015.10.032
Kravchenko, N. A. (2011). The Problem of Measuring and Assessing National Innovation Systems. *Problems of Economic Transition.* 53(9), 61-73. https://doi.org/10.2753/ PET1061-1991530904

Kuhlmann, S. & G. Ordóñez-Matamoros, (2017). *Research Handbook on Innovation Governance for Emerging Economies*. Towards Better Models. Cheltenham, UK.: Edward Elgar Publishing. https://doi.org/10.4337/9781783471911
Lacka, I., & Brzezicki, L. (2021). The Efficiency and Productivity Evaluation of National Innovation Systems in Europe. *European Research Studies Journal.* XXIV(3), 471–496. https://doi.org/10.35808/ersj/2440
Lafuente, E., Szerb, L., & Zoltan J. (2016). Country level efficiency and national systems of entrepreneurship: a data envelopment analysis approach. *Journal of Technology Transfer*. 41(6), 1260-1283. https://doi.org/10.1007/s10961-015-9440-9
Laperche, B., Munier, F., & Hamdouch, A. (2008). The collective innovation process and the need for dynamic coordination: general presentation. *Journal of Innovation Economics.* 2(2), 3. https://doi.org/10.3917/jie.002.0003
Lee, H., & Park, Y. (2005) An International Comparison of R&D Efficiency: DEA Approach. *Asian Journal of Technology Innovation.* 13(2), 207-222. https://doi.org/10.1080/ 19761597.2005.9668614
Lee, S., Nam, Y., Lee, S., & Son, H. (2016). Determinants of ICT innovations: A cross-country empirical study. *Technological Forecasting and Social Change,* 110(C), 71-77. https:// doi.org/10.1016/j.techfore.2015.11.010
Lee, K., Lee, J. H., & Lee, J. Y. (2021). Alternative Pathways to Growth beyond the Middle-Income Stage and National Innovation Systems (NIS): Balanced, Imbalanced, Catching-up, and Trapped NIS. *World Development.* 144, 105472. https://doi.org/10.1016/j.worlddev. 2021.105472
Leontitsis, A., Philippas, D., Sickles, R., & Tziogkidis, P. (2018). *Evaluating countries' innovation potential: an international perspective.* Working Papers 18-011, Rice University, Department of Economics.
Levy, Y., & Ellis, T. J. (2006). A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research. *Informing Science Journal*. 9, 182–212. https://doi.org/10.28945/479
Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *PLOS MED*. 6(7), e1000100. https://doi.org/ 10.1371/journal.pmed.1000100
Liu, J. S., Lu, W.-M., & Ho, M. H.-C. (2015). National characteristics: Innovation systems from the process efficiency perspective. *R&D Management*, 45(4), 317-338. https://doi.org/ 10.1111/radm.12067
Lu, W. M., Kweh, Q. L., & Huang, C. L. (2014). Intellectual capital and national innovation systems performance. *Knowledge-Based Systems*. 71(1), 201–210. https://doi.org/10.1016/ j.knosys.2014.08.001
Lu, H., Du, D., & Qin, X. (2022). Assessing the Dual Innovation Capability of National Innovation System: Empirical Evidence from 65 Countries. *Systems,* 10(2), 23. https://doi.org/10.3390/systems10020023
Lundvall, B-Å. (ed.) (1992). National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter Publishers.
Lundvall, B.-Å. (2002). *Innovation, Growth and Social Cohesion:* The Danish Model. Cheltenham, Edward Elgar. https://doi.org/10.4337/9781781008348
Lundvall, B.-A. (2007). National Innovation Systems-Analytical Concept and Development Tool. *Industry & Innovation*. 14(1), 95–119. https://doi.org/10.1080/13662710601130863
Lundvall, B.-Å., Vang, J., Joseph, K. J., & Chaminade, C. (2009). *Innovation system research and developing countries. Handbook of Innovation Systems and Developing Countries:* Building Domestic Capabilities in a Global Setting. Edward Elgar Publishing.
Lundvall, B-A. (2010). *National Systems of Innovation:* Toward a Theory of Innovation and Interactive Learning, Volume 2 of Anthem Other Canon Economics Series. Anthem Press.
Lundvall, B.-A. (2016). *National Innovations Systems and Globalisation.* In The Learning Economy and the Economics of Hope. Chapter 13, 351-374. Anthem Press.
Mahroum, S., & Al-Saleh, Y. (2013). Towards a functional framework for measuring national innovation efficacy. *Technovation.* 33(10–11), 320-332. https://doi.org/10.1016/j. technovation.2013.03.013
Malik, S. (2020). Macroeconomic Determinants of Innovation: Evidence from Asian Countries. *Global Business Review*. 1, 1–15. https://doi.org/10.1177/0972150919885494

Marion, F., & Grazia, I. (2007). Does Multinationality Affect the Propensity to Innovate? An Analysis of the Third UK Community Innovation Survey. *International Review of Applied Economics.* 21(1), 99–117. https://doi.org/10.1080/02692170601035033

Matei, M. M., & Aldea, A. (2012). Ranking National Innovation Systems According to their technical efficiency. *Procedia - Social and Behavioral Sciences*, 62, 968-974. https:// doi.org/10.1016/j.sbspro.2012.09.165

Meissner, D. (2015). Measuring innovation: A discussion of innovation indicators at the national level. *Swiss Science and Innovation Council Secretariat Working Paper*, 3. http://doi.org/10.2139/ssrn.2649384

Meissner, D. (2019). Public-private partnership models for science, technology, and innovation cooperation. *Journal of the Knowledge Economy.* 10(4), 1341–1361. http://doi.org/10.1007 /s13132-015-0310-3

Mendonca, S., Pereira, T. S., & Godinho, M. M. (2004). *Trademarks as an indicator of innovation and industrial change*. Research Policy. 33(9), 1385–1404. https://doi.org/10.1016/j. respol.2004.09.005

Mendonca, S. (2014). *National adaptive advantages:* Soft innovation and marketing capabilities in periods of crisis and change. In A. Teixeira, E. Silva, & R. Mamede (Eds.), Structural change, competitiveness and industrial policy: Painful lessons from the European periphery. Routledge.

Mengist, W., Soromessa, T., Legese, G. (2020). Method for conducting systematic literature review and meta-analysis for environmental science research. *MethodsX* 7(2), 100777. https://doi.org/10.1016/j.mex.2019.100777.

Menna, A., R. Walsh, P., & Ekhtari, H. (2019). Identifying enablers of innovation in developed economies: A National Innovation Systems approach. *Journal of Innovation Management.* 7(1), 108-128. https://doi.org/10.24840/2183-0606_007.001_0007

Metcalfe, J. S. (1995). Technology systems and technology policy in an evolutionary framework. *Cambridge Journal of Economics.* 19(1), 25–46. https://doi.org/10.1093 /oxfordjournals.cje.a035307

Metcalfe, S., & Ramlogan, R. (2008). Innovation systems and the competitive process in developing economies. *The Quarterly Review of Economics and Finance.* 48(2), 433–446. http://doi.org/10.1016/j.qref.2006.12.021

Morita, H., Hirokawa, K., & Zhu, J. (2005). A slack-based measure of efficiency in context-dependent data envelopment analysis. Omega. 33(4), 357–362. https://doi.org/10.1016/ j.omega.2004.06.001

Murillo-Zamorano, L. R. (2004). Economic efficiency and frontier techniques. *Journal of Economic Surveys.* 18(1), 33–77. http://doi.org/10.1111/j.1467-6419.2004.00215.x

Narayanan, E., Ismail, W. R., & Mustafa, Z. (2022). *A data-envelopment analysis-based systematic review of the literature on innovation performance*. Heliyon. 8(12). https://doi.org/10.1016/j.heliyon.2022.e11925

Nasierowski, W., & Arcelus, F. J. (2003). On the Efficiency of National Innovation Systems. *Socio-Economic Planning Sciences*, 37(3), 215–34. https://doi.org/10.1016/S0038-0121(02)00046-0

Neely, A., & Hii, J. (1998). *Innovation and business performance*: A literature review. The Judge Institute of Management Studies, University of Cambridge.

Nelson, R. R. (ed.). (1993). *National Innovation Systems*. A Comparative Analysis, Oxford University Press, New York/Oxford.

Niosi, J. (2018). Gaps in the Relative Efficiency of National Innovation Systems and Growth Performance across OECD and BRICS Countries. *Innovation Systems, Policy and Management*. (8), 249–305. https://doi.org/10.1017/9781108529525.010

Nunamaker, T. R. (1985). *Using Data Envelopment Analysis to Measure the Efficiency of Non-Profit Organisations:* A Critical Evaluation. Managerial and Decision Economics. 6(1), 50-58. https://doi.org/10.1002/mde.4090060109

Ozkan, E. N. G., & Kazazoglu, G. N. (2016). *Performance of national innovation systems during the global crisis: A Cross-Country Analysis*. PressAcademia Procedia, 2(1), 37-48. https://doi.org/10.17261/Pressacademia.2016118626

Pan, T.-W., Hung, S.-W., & Lu, W.-M. (2010). DEA performance measurement of the National Innovation System in Asia and Europe. *Asia-Pacific Journal of Operational Research*. 27(03), 369-392. https://doi.org/10.1142/S0217595910002752

Park, Y.S., Lim, S. H., Egilmez, G. & Szmerekovsky, J. (2016). Environmental efficiency assessment of US transport sector: A slack-based data envelopment analysis approach. Transport Research. *D Transport and Environment*, 61, 152–164. https://doi.org/10.1016/ j.trd.2016.09.009

Parkey, M. (2012). *Assessing the national innovation system in a developing country context:* a framework and evidence from Thailand. Clemson University. TigerPrints.
Patel, P. & Pavitt, K. (1994). National Innovation Systems: Why They Are Important, and How They Might Be Measured and Compared. *Economics of Innovation and New Technology*. 3(1), 77-95. https://doi.org/10.1080/10438599400000004
Pinto, H., & Pereira, S. T. (2013). Efficiency of Innovation Systems in Europe: An Institutional Approach to the Diversity of National Profiles. *European Planning Studies.* 21(6), 755-779. https://doi.org/10.1080/09654313.2012.665033
Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., & Rodgers, M. (2006). Guidance on the conduct of narrative synthesis in systematic reviews. A product from the ESRC methods programme. Version 1. *ESRC.* https://doi.org/10.13140/2.1.1018.4643
Portela, C. A. S., Borges, P. D., & Thanassoulis, E. (2013). Finding closest targets in non-oriented DEA models: the case of convex and nonconvex technologies. *Journal of Productivity Analysis*. 19(2–3), 251–269. https://doi.org/10.1023/A:1022813702387
Pranckutė, R. (2021). *Web of Science (WoS) and Scopus*: The Titans of Bibliographic Information in Today's Academic World. Publications. 9(1), 12. https://doi.org/10.3390/publications9010012
Prokop, V., Hajek, P., & Stejskal, J. (2021). *Configuration Paths to Efficient National Innovation Ecosystems. Technological Forecasting and Social Change.* 168(C), 120787. https://doi.org/10.1016/j.techfore.2021.120787
Proksch, D. H., Max, M., & Andreas, P. (2017). Increasing the national innovative capacity: Identifying the pathways to success using a comparative method. *Technological Forecasting and Social Change.* 116(C), 256-270. https://doi.org/10.1016/j.techfore.2016.10.009
Pullin, A.S., Bangpan, M., Dalrymple, S., Dickson, K., Haddaway, N. R., Healey, J. R., Hauari, H., Hockley., N, Jones., J. P. G., Knight, Vigurs, C., & Oliver, S. (2013). Human well-being impacts of terrestrial protected areas. *Environmental Evidence*. 2(19). https://doi.org/ 10.1186/2047-2382-2-19
Rodríguez-Pose, A., & Wilkie, C. (2019). Innovating in less developed regions: What drives patenting in the lagging regions of Europe and North America. *Growth and Change*. 50, 4–37. https://doi.org/10.1111/grow.12280
Roolaht, T. (2012). *The Characteristics of Small Country National Innovation Systems, Innovation, Technology, and Knowledge Management*, in: Elias G. Carayannis & Urmas Varblane & Tõnu Roolaht (ed.), Innovation Systems in Small Catching-Up Economies. 21-37. https://doi.org/10.1007/978-1-4614-1548-0_2
Rousseau, S., & Rousseau, R. (1997). Data envelopment analysis as a tool for constructing scientometric indicators. *Scientometrics.* 40(1), 45–56. https://doi.org/10.1007/BF0245 9261
Rousseau, S., & Rousseau, R. (1998). The scientific wealth of European nations: Taking effectiveness into account. *Scientometrics,* 42(1), 75–87. https://doi.org/10.1007/bf0246 5013
Samara, E., Georgiadis, P., & Bakouros, I. (2012). The impact of innovation policies on the performance of national innovation systems: A system dynamics analysis. *Technovation.* 32(11), 624-638. https://doi.org/10.1016/j.technovation.2012.06.002
Samoilenko, S., & Osei-Bryson, K.-M. (2013). Using Data Envelopment Analysis (DEA) for Monitoring Efficiency-based Performance of Productivity-driven Organisations: Design and implementation of a decision support system. *Omega.* 41(1), 131-142. https://doi.org/ 10.1016/j.omega.2011.02.010
Schautschick, P. & Greenhalgh, C. (2016). Empirical studies of trade marks – the existing economic literature. *Economics of Innovation and New Technology*. 25(4), 358-390. https://doi.org/10.1080/10438599.2015.1064598
Schmoch, U. (2003). Service Marks as Novel Innovation Indicator. Research Evaluation. 12(2), 149–156. http://dx.doi.org/10.3152/147154403781776708
Schrempf, B., Kaplan, D., & Schroeder, D. (2013). *National, Regional, and Sectoral Systems of Innovation* – An overview, Report for FP7 Project "Progress". progressproject.eu.
Seidel, U., Muller, L., Köcker, G. M. zu A., & Filho, G. de A. (2013). A New Approach for Analysing National Innovation Systems in Emerging and Developing Countries. *Industry and Higher Education.* 27(4), 279-285. https://doi.org/10.5367/ihe.2013.0159

Seiford, L., & Zhu, J. (1999). An investigation of returns to scale in data envelopment analysis. *Omega.* 27(1), 1–11.
Sharma, S., & Thomas, V. J. (2008). Inter-country R&D efficiency analysis: An application of data envelopment analysis. *Scientometrics.* 76(3), 483–501. https://doi.org/10.1007/ s11192-007-1896-4.
Sharma, M., Sarin, A., Gupta, P., Sachdeva, S., & Desai, A. V. (2014). *Journal Impact Factor: Its Use,* Significance and Limitations. *World Journal of Nuclear Medicine.* 13(2), 146 https://doi.org/10.4103/1450-1147.139151
Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to do a systematic review: A best practice guide for conducting and reporting narrative reviews, meta-analyses, and meta-syntheses. *Annual Review of Psychology.* 70, 747–770. https://doi.org/10.1146/annurev-psych-010418-102803
Silva, M., Castro, P., & Thanassoulis, E. (2003). Finding closest targets in non-oriented DEA models: the case of convex and non-convex technologies. *Journal of Productivity Analysis.* 19(2), 251–269. https://doi.org/10.1023/A:1022813702387
Simar, L. & Wilson, P.W. (1998). Sensitivity analysis of efficiency scores: How to bootstrap in nonparametric frontier models. *Management Science*. 44, 49–61. https://doi.org/10.1287/ mnsc.44.1.49
Simar, L., & Wilson, P.W. (2007). Estimation and inference in two stage, semi-parametric models of productive efficiency. *Journal of Econometrics.* 136, 31–64. https://doi.org/ 10.1016/j.jeconom.2005.07.009
Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research.* 104(C), 333–339. https://doi.org/10.1016/j.jbusres.2019. 07.039
Stahlschmidt, S., & Stephen, D. (2022). From indexation policies through citation networks to normalised citation impacts: Web of Science, Scopus, and Dimensions as varying resonance chambers. *Scientometrics.* 127, 2413–2431. https://doi.org/10.1007/s11192-022-04309-6
Sun, Y. & Liu, F. (2010). A regional perspective on the structural transformation of China's national innovation system since 1999. *Technological Forecasting & Social Change.* 77(8), 1311–21. https://doi.org/10.1016/j.techfore.2010.04.012
Sunley, P., Pinch, S., Reimer, S., & Macmillen, J. (2008). Innovation in a creative production system: the case of design. *Journal of Economic Geography*. 8(5), 675–698, https://doi.org/ 10.1093/jeg/lbn028
Tarnawska, K., & Mavroeidis, V. (2015). Efficiency of the knowledge triangle policy in the EU member states: DEA approach. Triple Helix. 2(1), 1-22. https://doi.org/10.1186/ s40604-015-0028-z
Teixeira, A. (2014). Evolution, roots and influence of the literature on national systems of innovation: a bibliometric account. *Cambridge Journal of Economics.* 38(1), 181-214. https://doi.org/10.1093/cje/bet022
Thanassoulis, E. (1993). A Comparison of Regression Analysis and Data Envelopment Analysis as Alternative Methods for Performance Assessments, *The Journal of the Operational Research Society*. 44(11), 1129-1144. https://doi.org/10.1057/jors.1993.185
Tidd, J., & Bessant, J. (2020). *Managing innovation: Integrating technological, market, and organisational change.* Chichester, 7th Edition. John Wiley & Sons.
Todttling, F., & Trippl, M. (2005). *One Size Fits All?* Towards a Differentiated Regional Innovation Policy Approach. Research Policy. 34(8), 1203–1219. https://doi.org/10.1016/ j.respol.2005.01.018
Tohidi, G., & Matroud, F. (2017). A new non-oriented model for classifying flexible measures in DEA. *Journal of the Operational Research Society.* 68(9), 1019-1029. https://doi.org/ 10.1057/s41274-017-0207-6
Tone, K. (2001). A slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research.* 130(3), 498-509. https://doi.org/10.1016/S0377-2217(99) 00407-5
Tone, K., & Tsutsui, M. (2010). Dynamic DEA: a slacks-based measure approach. *Omega*. 38(3–4), 145–56.
Tone, K., & Tsutsui, M. (2014). Dynamic DEA with network structure: a slacks-based measure approach. *Omega*. 42(1), 124–131. https://doi.org/10.1016/j.omega.2013.04.002
Tone, K., Toloo, M., & Izadikhah, M. (2020). A modified slacks-based measure of efficiency in data envelopment analysis. *European Journal of Operational Research.* 287(2), 560-571. https://doi.org/10.1016/j.ejor.2020.04.019

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management.* 14(3), 207-222. https://doi.org/10.1111/1467-8551.00375
Tylecote, A., (1994). *Financial Systems and Innovation. I*n: Dodgson, Mark, Rothwell Roy (Eds.), The Handbook of Industrial Innovation. Edward Elgar, Cheltenham UK, Brookfield US.
Tziogkidis, P., Philippas, D., Leontitsis, A., & Sickles. R. C. (2020). A data envelopment analysis and local partial least squares approach for identifying the optimal innovation policy direction. *European Journal of Operational Research*. https://doi.org/10.1016/ j.ejor.2020. 02.023
Wang, E. C., & Huang, W. (2007). *Relative efficiency of R&D activities*: a cross-country study accounting for environmental factors in the DEA approach. Research Policy. 36(2), 260-273. https://doi.org/10.1016/j.respol.2006.11.004
Watkins, A., Papaioannou, T., Mugwagwa, J., & Kale, D. (2015). *National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries*: A critical review of the literature. Research Policy. 44(8), 1407-1418. https://doi.org/10.1016/j.respol.2015.05.004
Wilson, S., Maharaj, C. S., & Maharaj, R. (2020). Formalising the National Innovation System in a Developing Country. *The West Indian Journal of Engineering.* 42(2), 4-6.
WIPO. (2021). *Tracking Innovation through the COVID-19 Crisis.* Geneva: World Intellectual Property Organization. https://doi.org/10.34667/tind.44315
World Bank. (2019). *New World Bank country classifications by income level: 2021-2022.* https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2021-2022
Wu, J., Ma, Z., & Zhuo, S. (2016). Enhancing national innovative capacity: The impact of high-tech international trade and inward foreign direct investment. *International Business Review*. 26(3), 502-514. https://doi.org/10.1016/j.ibusrev.2016.11.001
Xiao, Y. & Watson, M. (2017). Guidance on Conducting a Systematic Literature Review. *Journal of Planning Education and Research.* 39(1). https://doi.org/10.1177/ 0739456X17723971
Xiong, X., Yang, G., & Guan, Z. (2020). A parallel DEA-based method for evaluating parallel independent subunits with heterogeneous outputs. *Journal of Informetrics.* 14(3). https://doi.org/10.1016/j.joi.2020.101049
Xu, Y. R., & Carlsson, B. (2005). *Analysing the dynamics and functionality of technological systems:* a manual. DRUID summer conference. Copenhagen.
Yesilay, R. B., & Halac, U. (2020). *An Assessment of Innovation Efficiency in EECA Countries Using the DEA Method. In Contemporary Studies in Economic and Financial Analysis.* Emerald: Bingley, UK. 203–215. https://doi.org/10.1108/S1569-375920200000104014
Yongabo, P., & Goransson, B. (2020). Constructing the national innovation system in Rwanda: efforts and challenges. *Innovation and Development*. https://doi.org/10.1080/2157930X. 2020. 1846886
Yoon, W., & Hyun, E. (2009). How relevant and useful is the concept of national systems of innovation? *Journal of Technology Management and Innovation*. 4(3). https://doi.org/ 10.4067/S0718-27242009000300001
Yunis, M., Tarhini, A., & Kassar, A. (2018). The role of ICT and innovation in enhancing organisational performance: The catalysing effect of corporate entrepreneurship. *Journal of Business Research.* 88, 344–356. https://doi.org/10.1016/j.jbusres.2017.12.030
Zabala-Iturriagagoitia, J. M., Aparicio, J., Ortiz, L., Carayannis, E. G., & Grigoroudis, E. (2020). The productivity of national innovation systems in Europe: Catching up or falling behind? *Technovation.* 102(C). https://doi.org/10.1016/j.technovation.2020.102215
Zang, L., Xiong, F., Lao, X., & Gao, Y. (2019). Does governance efficiency matter for national innovative capacity? One tale from different countries, *Technology Analysis & Strategic Management*. 31(2), 239-252. https://doi.org/10.1080/09537325.2018.1493450
Zeng, J., Ribeiro-Soriano, D., & Ren, J. (2021). Innovation efficiency: a bibliometric review and future research agenda. *Asia Pacific Business Review.* 27(2), 1-20. https://doi.org/ 10.1080/13602381.2021.1858591
Zhang, J. (2013). International comparison of national innovation system efficiency. *Tech Monitor*. 23–29. www.techmonitor.net/tm/images/d/da/13apr_jun_sf2.pdf.

Zhang, C., & Wang, X. (2019). The influence of ICT-driven innovation: a comparative study on national innovation efficiency between developed and emerging countries. *Behaviour & Information Technology*. https://doi.org/10.1080/0144929X.2019.1584645
Zhu, J. (2014). *Slack-Based DEA Models, International Series in Operations Research & Management Science,* in: Quantitative Models for Performance Evaluation and Benchmarking, Edition 3(5), 93-101. Springer. https://doi.org/10.1007/978-3-319-06647-9_5