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Ana Maria Ortega Alvarez, Ricardo Pino Jordan

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Innovation systems performance drivers and outputs: a systematic literature review and directions for future research

Ana Maria Ortega Alvarez*

Department of Marketing,
Universidad EAFIT,
Carrera 49, Número 7 Sur 50, Cra. 49,
Medellín, Antioquia, Colombia
Email: aortega1@eafit.edu.co
*Corresponding author

Ricardo Pino Jordan

Graduate School,
Universidad Peruana de Ciencias Aplicadas
Prolongación Primavera 2390, Lima 15023, Peru
Email: ricardo.pino@upc.pe

Abstract: Innovation is a requirement to tackle social, economic and environmental challenges. Understanding how to measure innovation is important for policymakers, business and social leaders, as it allows the design of better strategies related to the development and evaluation of innovation systems (ISs). The purpose of this systematic literature review (SLR) is to identify and explain the key innovation system performance (ISP) drivers and outputs through descriptive and content analyses. A total of 139 articles between 1998 and 2021 were included in the SLR, and the analyses were performed using software for qualitative research data analysis. The main conclusions are that while research about ISP is increasing, there is little consensus on how to measure innovation drivers and outputs. Future research should address composite and standardised indicators to measure ISP, allowing a better understanding of performance and comparisons among different ISs.

Keywords: innovation systems; business innovation; literature review; metrics; performance drivers and outputs; indicators.

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Biographical notes: Ana Maria Ortega Alvarez works as a Professor and researcher at the Department of Marketing at Universidad EAFIT, in Medellin, Colombia, since 2012. She graduated from the Universidad Catolica de Peru (PUCP) in 2019 and received his Doctoral degree in Strategic Business Management. Her main areas of research are related to innovation, innovation systems, consumer behaviour and technological change.

Ricardo Pino Jordan is a Professor and researcher since 2005. He has worked as a Consultant in quality management systems and continuous improvement since 2000. He is the Academic Director of the Graduate School at Universidad Peruana de Ciencias Aplicadas, in Lima, Peru. His main research interests lie in the fields of organisational studies, quality management systems and innovation.

1 Introduction

Innovation is at the core of organisational continuance; therefore, knowing the innovation drivers should be equally important for researchers and professionals (Hogan and Coote, 2014). Iosif and Tăchiciu (2016) listed some basic functions of the innovation systems (ISs):

a creating knowledge

b competence building and consulting

c creating organisations

d finance for innovation

e networking.

The Oslo Manual (OECD/Eurostat, 2018) pointed out the importance of conducting research using innovation data, to understand innovation performance (IP) and the factors affecting it, to provide an informed basis for public policy decisions. It was found that, between 1992 and 2020, more than 1,000 academic articles related to IS were published in the Web of Science (WoS) and numbers are rising fast, as there is a growing interest in the matter, especially for innovation policymakers. Being as important as it is to drive economic and social progress around the world, the key innovation system performance (ISP) drivers and outputs need to be identified. Additionally, no study has analysed the drivers and metrics proposed in the literature. This systematic literature review (SLR) contributes to the consolidation of solid conceptual bases for the measurement of the ISP, in theoretical and practical terms.

This article is organised as follows: first, the processes of documentation and of the SLR are described; second, a descriptive analysis of academic content available about ISs is presented; third, the key notions to understand ISP under different academic perspectives are developed; followed by the discussion and recommendations for future research.

2 Methodology

A SLR is an effective method to evaluate the available scientific information in an academic field and to identify the knowledge gaps in an organised and structured manner (Mulrow, 1994). This SLR was conducted following the steps described by Tranfield et al. (2003):

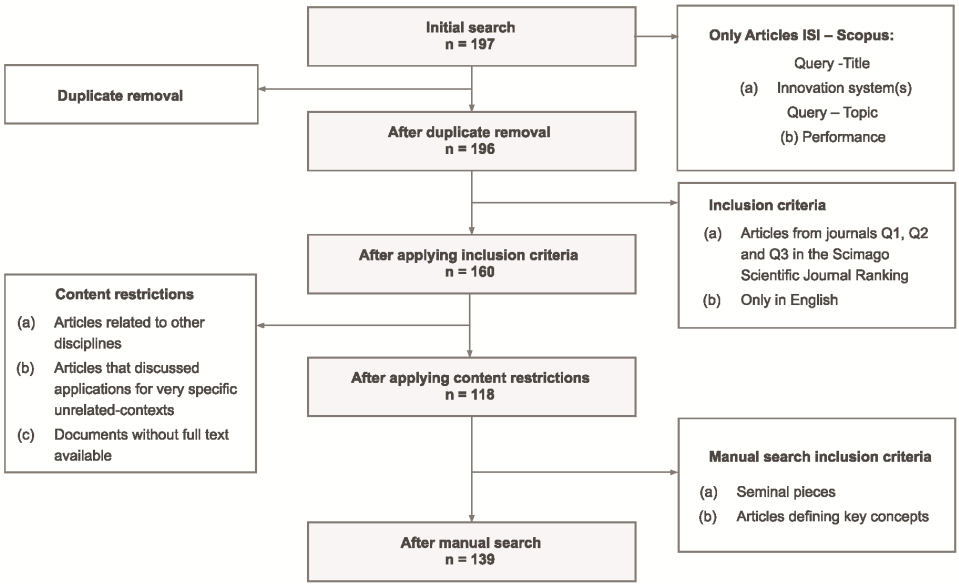
a planning the literature review

b conducting the literature review

c reporting the relevant findings using descriptive and content analyses.

A search was conducted using the WoS and Scopus databases, identifying articles from January 1998 to May 2021 that included the words 'IS' in the title and 'performance' in the title, abstract or keywords. Only articles published on Q1, Q2, or Q3 journals were selected, obtaining 160 articles from 80 journals. Then, articles related to other disciplines, articles that discussed applications for unrelated contexts, and articles without full text available were discharged (see Figure 1).

Figure 1 SLR process



The phases of the data analysis process, suggested by Clarke et al. (2015), were followed:

a familiarisation with the data

b coding of the most important aspects in the data

c search for themes that group codes

d themes definition and naming

e presentation of the results obtained.

A thematic analysis allows to identify, organise, analyse in detail, and provide patterns or themes from a careful reading of the information collected, and thus infer results that promote an adequate understanding of the topic (Clarke et al., 2015). In addition, the thematic analysis offers an exhaustive process to identify cross-references between the topics, allowing to link various concepts and compares them to find an answer to the research question (Alhojailan, 2012).

3 Results

3.1 Results of the thematic analysis

The articles' analysis was performed using Voyant Tools and Atlas.ti 8, generating a document with 29,032 words and 3,450 single-word forms, with a vocabulary density of 0.138, and an average of 26.2 words per sentence. Text from the articles' abstracts and keywords was reviewed. The main concepts in order of frequency of appearance were innovation (786), systems (291), performance (206), regional (172), knowledge (159), policy(ies) (151), development (121), analysis (118), efficiency (113), national (101), technological (88) and technology (83). Other important concepts found in the articles, in order of frequency of appearance were regions, countries, firms, data, level, model, economic, industry, process, growth, public, dynamics, indicators, capacity, networks, government, institutions, patents and production (Figure 2).

Figure 2 Word cloud resulting from 'abstract' and 'keywords' processing (see online version for colours)

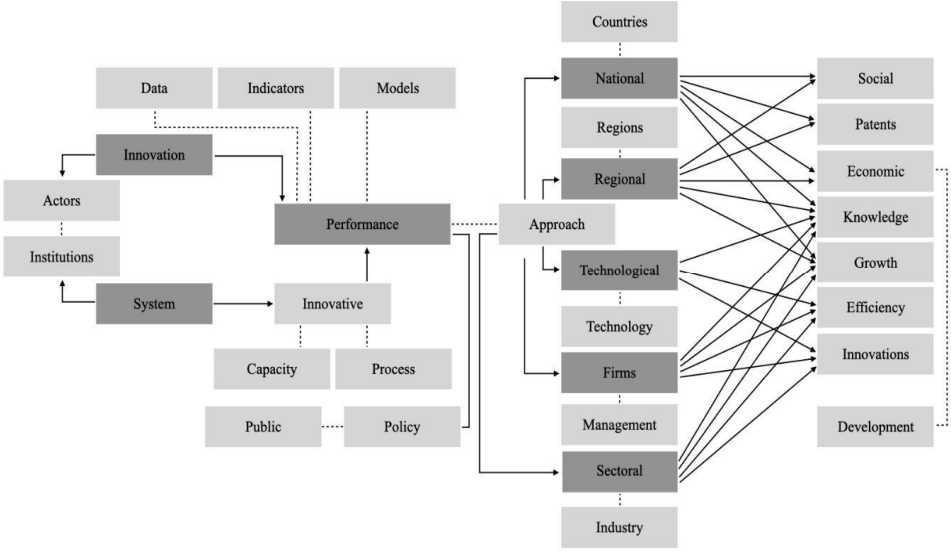
The architecture of a semantic network was built from the main codes, according to their frequency of appearance and relations (Figure 3). As Friese (2019) noted, by coding data and finding conceptual connections in the qualitative analysis, it is possible to know if in a specific dataset the concepts are functioning as the theory predicts.

3.2 Results of the content analysis

Content analysis revealed that there is no consensus in the literature regarding ISP metrics. Literature review showed that several authors recognised the need to measure performance, but they also acknowledge that there is not yet a developed standard to measure it and that there is need for more research to be done to define and test valid

indicators for a RIS performance (Cirillo et al., 2019; Pino and Ortega, 2018; Toivonen et al., 2021). Rudskaya and Rodionov (2018) stated that there are available methods to measure IP in a RIS but there is a lack of a common understanding of those methods.

Figure 3 Architecture of the semantic network



Chu et al. (2014) recognised that the national innovation system performance (NISP) measure has not been addressed yet in a systematic way in the literature, while Afshari-Mofrad et al. (2020) remarked on the importance of measuring the efficiency, effectiveness, and changeability of institutions as they directly affect the IP of the NIS. For a start, the operationalisation of the NIS concept is not an easy task because of the rich institutional details involved in any NIS. The problem is that the soft part of a NIS: institutions, processes, coordination, policies, and others are difficult to measure, at least in an objective way (Breschi and Malerba, 1997). Guan and Chen (2012) recognised the need to build a new measurement framework to find the best innovation regions or countries, and according to Jenson et al. (2016a) an objective measure of performance can only occur when all conditions in the qualitative comparative analysis have been met. Loikkanen et al. (2009) recognised that performance comparison is important because countries' ISs compete against each other. Carlsson et al. (2002) mentioned that the literature was short in explaining what constituted input and output of an IS, as well as the consideration of the level of analysis applied: firm, industry or region.

Carlsson et al. (2002) stated that technological systems cannot be measured directly, but through several indicators, and concluded that to measure the ISP it is necessary to evaluate how each individual company performs, although Oberg (2019) noted that measuring performance of the different actors could lead to agency problems, as the ultimate goal is the performance of the whole system and not of any of its actors. Finally, Edquist et al. (2018) focused on the importance of measuring IP, using the productivity lens, which means a ratio between the inputs (drivers) and the outputs. Performance drivers are key factors to develop an IS and achieve ISP, while the outputs are the desired

or expected results of the IS. Next, we discuss each of the most cited drivers and outputs in the analysed articles.

4 ISP drivers

4.1 Interaction

Bartels et al. (2012) recognised that innovation can only lead to economic performance when there are close relationships between actors. Brown (2016) and Castaneda et al. (2016) found that network actors can nurture competitive advantage but only when complemented with a firm's absorptive capacity.

Chang and Shih (2004) and Van Lancker et al. (2016) stated that NISP depends on interactions between all actors and the interconnectedness of its different system levels. Cirillo et al. (2019) concluded that IS linkages are difficult to measure as they are part of the soft part of a NIS and that single indicators of IP cannot capture the dimensions of innovative activities. Jenson et al. (2016a), Jespersen (2018) and Zhao et al. (2018) mentioned that an IP depends on the effectiveness and intensity of the actors' interaction to generate and diffuse knowledge.

Lundvall (2007) and Samara et al. (2012) stated that it is key to understand the linkages among the actors to improve the NISP, as the innovation process is the result of the relationships among actors. The same result was also obtained by Howells et al. (2012), Scheel (2002), Solleiro and Castanon (2005) and Trigkas et al. (2012), who indicated the importance of alliances to promote organisational linkages to generate innovation.

Networks are to produce information exchange (Alkemade et al., 2007) and the propensity to cooperation is a key aspect for the RISP (Ponsiglione et al., 2018). Belussi et al. (2010) found that research collaboration contributes to innovative output, even at the degree of compensating low levels of internal investment. Calvo-Gallardo et al. (2021) and Guan and Chen (2012) indicated that technological cooperation between enterprises is part of the environmental factors to innovation in TISs. Bartels et al. (2012) and Lau and Lo (2015) concluded that to improve IP, firms must learn and improve and that is enhanced by proximity, networking and research collaboration (Belussi et al., 2010).

4.2 Knowledge generation and diffusion

Cirillo et al. (2019) and Liu (2019) stated that the performance of a NIS depends on knowledge generation, development and diffusion. Alkemade et al. (2007), Khanin et al. (2019), Kilkis (2016) and Spencer (2003) stated that knowledge development is the main part of innovation processes, while Chu et al. (2014) found that the accumulated knowledge is as important as new knowledge. Besides, Chu et al. (2014) found that sharing tacit knowledge increases the internalisation of innovation knowledge while Chu et al. (2014) found that explicit knowledge increases innovation knowledge in the IS. Lee et al. (2016) concluded that in a NIS firms need to complement local knowledge with knowledge available in other countries.

Van Lancker et al. (2016) included the knowledge skills of employees as a key factor of a NIS success. Alkemade et al. (2007) noticed the use of diffusion of new

technological knowledge as an ISP indicator, as diffusion is not common in emerging economies. Knowledge transfer offices can play an important role in an RIS for knowledge generation and diffusion (Pinto and Fernández-Esquinas, 2018).

4.3 R&D expenses

Alkemade et al. (2007), Khanin et al. (2019) and Wang et al. (2016) identified R&D expenses as one driver of IS performance. Chen et al. (2011) concluded that the more the investment of R&D expenditure the more improvement on the efficiency of patents, and that private companies and universities are a major part of the national R&D effort. Kapetaniou et al. (2018), on the other hand, stated that the public funding of R&D activities has been greater than that of the private sector. Loikkanen et al. (2009) noticed that private and public R&D investments have been used as input data for developing an IS. Simmie et al. (2004) found evidence that behind the strong performance in high-tech companies is the expenditure in R&D activities, while Wu and Fan (2010) considered expenditure and performance on R&D as measures of ISP.

4.4 Financing

Cirillo et al. (2019) found in a literature review that financing innovation is one of the key factors that influence ISP. Lundvall (2007), Scheel (2002) and Solleiro and Castanon (2005) identified financial markets and programs as key success factors, while Van Lancker et al. (2016) and Spencer (2003) stated that the commercial success of innovative products depends on firm's financial strength.

According to Alkemade et al. (2007) and Guan and Chen (2012), an important factor in exploring tech problems is the venture capital industry. Fernandez-Serrano et al. (2019) found that the RIS development level capture the economic structure of the regions, as high-developed regions present a better economic environment for innovation. Wonglimpiyarat (2011) concluded that financial policies are vital in promoting industry performance.

4.5 Institutions

Cirillo et al. (2019) indicated that ISP is affected by both formal and informal institutions, and Jenson et al. (2016b) and Trigkas et al. (2012) remarked that the sectoral approach indicates that institutions are a key part of ISP. Kieft et al. (2018), Samara et al. (2012) and Mowery (2011) established that institutions are a key part of a NIS and the greatest impact on IP is produced by the NIS institutional conditions.

Fernandez-Serrano et al. (2019) indicated that entrepreneurs' characteristics condition the way in which institutions interact in RIS. Kapetaniou et al. (2018) concluded that institutions align the NIS with financial allocation and according to Santos (2006), the participation of the institution involved in a RIS determines the effectiveness of the absorption, creation and diffusion of new technologies. He et al. (2018) said that institutions, especially policy, should encourage local governments to compete in their R&D investment levels as it impacts the efficiency of the IS. Many authors also pointed out the importance of informal institutions, like unwritten rules, values and culture for ISP (e.g., Hermans et al., 2015; Lamprinopoulou et al., 2014).

4.6 Policies

According to Mowery (2009), the structure of a NIS is the result of policy decisions, but its performance depends on the actions of private companies that can reinforce or offset the effect of those policies. Samara et al. (2012) recognised that the regulatory framework is a key driver of competitiveness. Solleiro and Castanon (2005) described as public policy instruments the promotion of financial flows for R&D activities, the regulatory environment for intellectual property, standardisation and sectoral specific programs. Governments also guarantee the stability of institutional configuration. Accordingly, Bartels et al. (2012), Castro-Martínez et al. (2013) and Guan and Chen (2012), stated that government should be in the 'fostering innovation' business establishing and managing policies that cradle NIS especially the ones that guarantee knowledge transfer within market conditions. Brown (2016) reached a similar conclusion regarding the government's role in promoting universities' knowledge generation and transferring. However, not all governments should foster an IS in the same way (Chang and Shih, 2004), as there exist different successful configurations for the design of NISs (Cirillo et al., 2019). According to Mowery (2009), the NIS structure is the result of policy decisions, remarking the importance of a regulatory perspective tackling the liberating, as well as the controlling, dimensions of regulatory activity.

4.7 Infrastructure

Jenson et al. (2016b), Scheel (2002) and Van Lancker et al. (2016) identified infrastructure as one of the key success factors for ISP. The infrastructure contains aspects as financial, government support, research and technology, training and education, technological entrepreneurship, and consulting, besides physical infrastructure. Liu et al. (2018) pointed out the importance of the industrial development environment for innovation efficiency, including the regional development conditions and the regional consumption potential.

4.8 Management

Entrepreneurial activities and technology management are important to enhance ISP (Alkemade et al., 2007; Markard and Truffer, 2008; Scheel, 2002; Theeyattuparampil et al., 2013). Mowery (2009) analysed the importance of managerial decisions that can reinforce or offset the effect of public policies. Fernandez-Serrano et al. (2019) agreed that the personal characteristics of entrepreneurs influence IP. Loikkanen et al. (2009) found that the indicators of a knowledge society are focused on entrepreneurship and venturing, while Wu and Fan (2010) mentioned that the climate for entrepreneurial behaviour is a variable that affects NISs.

4.9 Market orientation

Bartels et al. (2012) and Cirillo et al. (2019) identified that the structural dynamics of the market and the market formation, are factors that determine the behavioural dynamics of the NIS. Lundvall (2007) established the importance of product markets to foster ISP, a result shared by Spencer (2003). Samara et al. (2012) concluded that the effectiveness of market processes depends on the regulatory framework. Market orientation, though, does

not guarantee that every actor will benefit from the system. Simmie et al. (2004) noticed that networked systems grow faster than market-oriented systems. Van Lancker et al. (2016) stated the importance that inventions turn into marketable products to be considered successful.

4.10 Absorptive capacity

Brown (2016) identified in the literature that a low level of absorptive capacity of firms from universities affects their productivity. Castro-Martínez et al. (2013) agreed, stating that the absorptive capacity is key to the success of the interaction; while Kallio et al. (2010) said that the absorptive capacity of a RIS requires the right people in the right place and the innovation environment.

For instance, the technology gap theory predicts that most labour productive firms are those importing the most advanced technologies (Fernández and Gavilanes, 2017), although De Marchi and Grandinetti (2017) concluded that the lack of absorptive capacity in developing countries may affect their IP levels, as importers may use foreign technology inexpertly and fail to apply it.

Other IP drivers identified in the literature were:

a Adaptive capacity: Simmie et al. (2004) proposed adaptive capacity as the key variable of a local IS, a term not usually found in literature, and that the most successful ISs are those able to deal with external shocks.

b Designs: Bartels et al. (2012) found that the design of prototypes is a key component for innovation success. Desai (2013) stated that designs, patents, and publications influence learning and innovation processes.

c Diffusion of technology: Tigabu et al. (2015) mentioned that literature has contextualised the adoption and diffusion of new technologies as part of the innovation process.

d Technology transfer: Tigabu et al. (2015) noticed that technology transfer results in further development of technology, a result also found by Wu and Fan (2010).

e Specialisation: Samara et al. (2012) stated that IP relies on intangible assets as the economy moves to specialised activities. Market specialisation was also mentioned by Azimi (2019); nevertheless, according to Mowery (2011), there is no clear relation between specialisation and IP.

f Social capital: Aragón et al. (2019) point that bonding and bridging connectors to bind and share information and capabilities among different groups of agents within a RIS generate a virtuous spiral dynamic that nurtures innovation.

g Management: De Oliveira et al. (2019) said that organisational strategy and policies should aim to support the IP, especially by offering collaborative structures that harness the opportunities to identify and absorb external and internal knowledge and innovate.

h Resource endowments: Markard and Truffer (2008) established that resource endowments are indicators for the innovation potential at the firm level. Key resources include financial capital, human capital, and complementary assets such as network infrastructure.

5 ISP outputs

According to Hekkert et al. (2007), to figure out what the crucial IP measures are one must begin by understanding the IS functions. Hekkert et al. (2007) proposed that the IS functions can be classified into:

a knowledge development

b knowledge diffusion

c guidance in research, exploration and selection

d entrepreneurial activity

e market formation

f resource mobilisation

g creation of legitimacy.

Other authors that adopted this function as a guiding axis when studying the IP of an IS were Azad et al. (2019), Bergek et al. (2018), Karanasios and Parker (2018), Reichardt et al. (2016), Sawulski et al. (2019), Vidican et al. (2012) and Wieczorek et al. (2015).

Many articles have focused on translating each of these functions to a certain technology or a specific industrial sector, such as the case of Kılkıs (2016) and Wesseling and Van der Vooren (2017). For instance, Kılkıs (2016) adds knowledge production (publications), technological innovation (patents), and system efficiency as useful factors to assess the maturity of the IS.

According to Nooteboom (2000), to assess the implications of IP, one should consider the different types, levels and degrees of innovation:

a types: product, process; technological, commercial, organisational and institutional innovation

b levels: within a team, in the firm, on the level of an industry or an entire economic system

c degrees: incremental or radical, new to a firm, industry or the world.

For a better understanding of the IP, the Oslo Manual (OECD/Eurostat, 2018) suggests considering both quantitative and qualitative measures. For qualitative measures, it is pertinent to clarify that in cases in which ordinal data is obtained, it is possible to organise and use this information for econometric analysis. However, there is also space for the use of unstructured qualitative data, which allows for a more in-depth analysis in certain aspects and even to identify emerging foci of importance (e.g., Jenson et al., 2016a; Ruckstuhl et al., 2019).

90% of the articles addressed IP from a quantitative perspective. Metrics associated with ISP, also known as output indicators (Miremadi et al., 2018), and the various ways in which these factors have been classified and analysed are presented. Measuring the ISP can serve as an important tool for policymakers to identify best practices and provide aid to the implementation of policies intended to support innovation as it can be used to simulate actions and strategies (Hajek et al., 2019).

According to Miremadi et al. (2018), a valid performance indicator must meet four criteria:

a understanding, the indicator cannot be hard to comprehend

b availability, the existence of detailed information and the access to it

c relevance

d measurability, indicators must be available in numerical terms.

Miremadi et al. (2018), made one of the most complete lists of performance indicators for technological ISs.

5.1 Innovations produced

This variable refers to the volume of innovative products produced (Vechkinzova et al., 2019). Traditionally, this variable included four types of innovation activities which are:

a introduction of new products

b introduction of new production processes

c entrance into new markets

d changes in the internal organisation (Fernández-Esquinas et al., 2016).

The Oslo Manual [OECD/Eurostat, (2018), p.20] reduced these four dimensions in two, describing innovation as "a new or improved product or process that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)." New organisational structures and marketing methods were contained in process innovation.

Kuştepeli et al. (2013) used as indicators of innovativeness, the new or significantly improved:

a products and services

b production processes, components, or materials

c strategies

d organisational structures

e market concepts.

In this aspect, Gokhberg and Roud (2016), made a distinction among international innovators and national innovators, international imitators and national/local imitators and technology adopters (when external organisations develop the innovations). The first two classifications are based on the extension of the markets covered by the innovative organisation while, in the second classification, the word 'imitator' means that the organisations develop innovations in-house, although the resulting outputs are similar to already existing ones. Jenson et al. (2020) also used this measure, named as innovation outcomes, when analysing the IP.

5.2 Commercial performance

Carayannis et al. (2016), Choi and Zo (2019), Morero (2010) and Simmie et al. (2004) used commercial performance as a measure of an ISP. Castro-Martínez et al. (2013) and

Spencer (2003) stated the importance of achieving commercial success to evaluate the ISP. Samara et al. (2012) included new sales in markets and by firms as a measure of ISP. Unger (2000) concluded that innovative product sales are a direct measure of the output of innovation. Alcorta and Peres (1998) concluded that participation in the international market is a measure of success. Lau and Lo (2015) used company's annual sales growth rate and sales of new products as indicators of IP, while Oberg (2019) used the number of ideas being commercialised. Governments must assume a leading role in terms of strategy and funding as breakthroughs in certain strategic technologies might not ever produce profits by themselves, even though they bring important contributions to the society and economy overall (Bazavan, 2019).

5.3 Economic performance

Many authors considered economic performance as a measurement of IS performance, commonly relating innovation rates with variables as profits, annual turnover, sales performance and sales growth (e.g., Bartels et al., 2012; Cirillo et al., 2019; Hajek et al., 2019; Kostić and Květoň, 2020; Lau and Lo, 2015; Lundvall, 2007; Trigkas et al., 2012; Tulum and Lazonick, 2018).

Economic indicators are sometimes correlated with a size-related factor, such as gross domestic product (GDP) or population and will then be valid for cross-country comparisons (Miremadi et al., 2018); while some performance indicators such as national wealth (GDP per capita), are used to compare ISs (Katz, 2006). Pugliese et al. (2019) use a proxy for economic production of innovation based on the monetary value of the overall export of a country for a product during a year; while Rypestol and Aarstad (2018) considered growth and development as desirable metrics to measure IP.

The term competitiveness can be applied at the firm, country, or region level. When talking about performance at a firm level it is usually called firm competitiveness. Květoň and Horák (2018) and Qu et al. (2017) measured it by the return on assets, and Fernández and Gavilanes (2017) used labour productivity, measured as the natural logarithm of firms' total sales divided by the number of employees. Yi and Fengyan (2015) focused on a firm's new product sales and new product output value, as IP measures, while Wieczorek et al. (2015) focused on entrepreneurial activities, which include exploring and exploiting business opportunities based on new technologies and applications.

Kuştepeli et al. (2013) measured IP as an attribution of the percentage of the turnover of the firm, including new slightly or dramatically improved products and services, whereas Toshevska-Trpchevska et al. (2019) considered the costs of the innovation process and then estimated the effectiveness of the effort leading to productivity gains.

In relation to economic performance, many authors measure IP in terms of the royalties and licensing fees derived from innovations made by the organisation (e.g., Hu et al., 2014; Chen et al., 2011; Brown, 2016). When analysing performance at the national level, Lu et al. (2014) stated that NISP should be reflected on economic efficiency, including GDP, PPP, and productivity measured as the difference between real output value and real input value. According to Zabala-Iturriagagoitia et al. (2007), the European Innovation Scoreboard 2002–2003 includes regional GDP per capita as one of the main outputs of an IS to compare IP, which produces a very biased picture of the reality; as it shows regions with the biggest investment as leaders, while regions that may have great potential are ignored.

5.4 Patents

Patents are the most used metric for assessing IP, 44% of articles consulted used them. Chen et al. (2011) used patents, royalties, and the number of journal articles as measures of ISP. Cirillo et al. (2019) stated that patents are a hard measure of ISP and proposed the use of surveys to overcome the difficulty of measuring the soft part. Samara et al. (2012) identified patents as a measure of technological performance, as well as trademarks, product sales and manufacturing employment. Nevertheless, Alcorta and Peres (1998) warned that patents are affected by countries' legislation, and as not all inventions are patented, patents are only a partial indicator of performance. In the same line, Janger et al. (2017) said that patents should not be used as an innovation output indicator as they do not imply actual innovations. Tylecote and Conesa (1999) said that only technological performance could be measured through patents.

Other authors that consider patents as an important ISP indicator are Carayannis et al. (2016), Carrincazeaux and Gaschet (2015), Chen and Guan (2012), Corrocher and Cusmano (2014), Fritsch and Graf (2011), Fukugawa (2016), Hajek et al. (2014), Jiao et al. (2016), Katz (2006), Kou et al. (2016), Lee et al. (2016), Lenger (2008), Li (2015), Matei and Spircu (2012), Pan et al. (2010), Rodriguez-Pose and Crescenzi (2008), Russu (2018), Suzuki et al. (2015), Wong et al. (2018) and Zemtsov and Kotsemir (2019).

5.5 Publications

Guan and Chen (2012) and Wu and Fan (2010) used international scientific papers and publications as a proxy for innovative output, as well as the added value of industries and exports as a proxy for the commercial profits. Alkemade et al. (2007) stated that publications reflect diffusion of technological knowledge and therefore are an indicator for IP. Also, Sawulski et al. (2019) and Nwagwu (2008) focused on universities functioning in a knowledge-based economy, using the number of publications as a measure of IP. Other authors that included papers and scientific journal articles, as measures of IP, were Chen et al. (2011), Hu et al. (2014), Pan et al. (2010), Pugliese et al. (2019), Schmid and Wang (2017), Van Looy et al. (2006) and Wang et al. (2015, 2016). Carayannis et al. (2016) placed publications and patent applications in the intermediate level for the ISP, clarifying that outputs are only those things related to most tangible results, and Oberg (2019) concluded that researchers focus on publishing rather than on selling their ideas.

5.6 Knowledge transfer

Jespersen (2018) defined the IS outcome as the sum of knowledge learned from the crowd and knowledge from internal R&D. Entrepreneurial activities include exploring and exploiting business opportunities based on new technologies and applications, as this creates opportunities to learn about the functioning of new products, processes or services after exposure to market dynamics (Wieczorek et al., 2015).

6 Future research

Future research should explore the role of the government in implementing innovation-related policies for the ISP, and at the organisational level, how firms' strategies are influenced by an IS and should focus on how the organisational IS influences the performance of the micro-level and higher system levels.

It is also important to better understand the role of qualitative measures and how to adequately apply them, as very few articles found addressed this issue, and there are no clear guidelines for their application and analysis.

In accordance with Cirillo et al. (2019), several measurements are necessary, and it is important to construct composite indicators to measure ISP, also considering the importance of efficiency when comparing different ISs (e.g., inputs versus outputs). Sustainable development is a crucial factor when studying ISP, as innovation must contribute to sustainable cities, responsible consumption, cleaner production and climate action (Gregersen and Johnson, 2021). The advancement of the measurement of ISP must include indicators of how the ISs perform in relation to sustainability and how this performance could be assessed.

Additionally, future research should advance in the development of comparable measurement among countries, as multiple conditions are necessary for ISs success. There is also a need to analyse if all performance drivers and outputs are independent or they could be better classified in tiers. For example, if the interaction is worthless without knowledge generation. It must be considered that the use of statistical data is not the same as having indicators for ISP. Unless the desirable levels for different types of ISs are better understood there will basically be some evidence of the ISP but not necessarily indicators for it.

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