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ON MEASURING COUNTRIES' INNOVATION PERFORMANCE: ORGANISATIONAL LEVEL PERSPECTIVE

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Abstract

Innovation performance of countries is an important input for the governmental policy-making. However, currently popular rankings such as Eurostat's Summary Innovation Index instil one-approach-fits-all perspective by clearly specifying success conditions without considering contingency factors that make each country's situation unique. Our aim is to contrast current approach for innovation performance measurement on both country and organisational levels. We believe that the organisational level perspective can offer an inspiration for a change in the country level indicators themselves. Our study raises several concerns about the current state of the country level innovation measurement, notably exclusion of a higher number of innovation process indicators and omission of specific internal and external factors of measured countries. We propose that indicators accounting for these areas would offer more a realistic and useful picture of innovation performance.

Keywords: innovation performance, measurement, organisation, country, innovation index, contingency approach

INTRODUCTION

The evaluation of innovation performance is necessary for appropriate awareness of the current situation in a given country. When evaluation innovation performance of countries, the European Union works with Summary Innovation Index (SII). SII consists of 27 indicators (Eurostat, 2017a) representing conditions and resources for creation of innovations and economic or other effects of innovations. The resulting composite indicator SII is a simple average of these 27 indicators that is used (besides other data from OECD and Eurostat) for comparison of countries' innovation performance in EIS (European Innovation Scoreboard, Eurostat, 2017a).

The reasoning behind the innovation performance measurement lies in assumed relationship between innovations and competitiveness, or performance respectively. Research focused on innovation–performance relationship and factors moderating this relationship stems mainly from scholars studying organisations or work teams and historically lead to unconvincing or contradicting

results (Rubera and Kirca, 2012). The reasons behind the observed ambiguity of the relationship arguably lie in equifinality of innovation strategies (Calik and Bardudeen, 2016) and in heterogeneity of internal and external factors of organisations used in research (e.g. Vossen, 1998; Thornhill, 2006), articulating the need to consider moderating factors. Contrary to this, on the country level, currently used indicators of innovation performance omit the heterogeneity of countries in e.g. structure of their economies, historical development or national cultures.

As actors in economic and innovation policies actively use these indicators, it is crucial to articulate the influence of specific (exogenous) conditions in which countries exist in order to provide the best possible estimates of real state of innovation performance. The goal of this study is therefore to propose potential directions of changes in innovation performance measurements based on analogy with a measurement on the organisational level.

MATERIALS AND METHODS

Measurement of innovation performance is an important essence of innovation policy. On the country level, it is commonly based on a comparison of numerous science, technology and innovation indicators of particular countries, or by so-called complex composite indicators. The popularity of composite indicators on the country level stems from a complex assessment of innovation performance delivered within a single metric. However, this approach attracts a lot of criticism (Godin, 2003; Grupp and Schubert, 2010). Leaving aside technical processing problems (Grupp and Schubert, 2010), from the theoretical perspective, the selection of composite indicator components in the case of SII is not based on an explicitly defined innovation model that would justify their use and explain relations among components, their weights and impacts on the economic performance (Godin, 2003; Grupp and Mogee, 2004). Furthermore, this approach does not lead to a clear identification of country's strengths and weaknesses and indicators as it lacks economic institutional context (Schibany and Streicher, 2008).

Innovation performance measurement is an important area of research on the organisational level. When searching in Scopus and Econlit databases in November 2017 for articles with keywords "innovation performance management" in the title, only 10% of the results is devoted to the innovation measurement on the country level. The rest of the articles dealing with innovation performance measurement is linked to various types of organisations, mainly enterprises.

Concerning the prevailing research of the innovation measurement on the organisational level, the presented article aims to enrich the critique of innovation performance measurement on the country level and to suggest possible directions for the development of measurement methodology. The basic method used in our work is the comparison of innovation measurement on both organisational and country levels. Based on the background of analogy between organisations and countries.

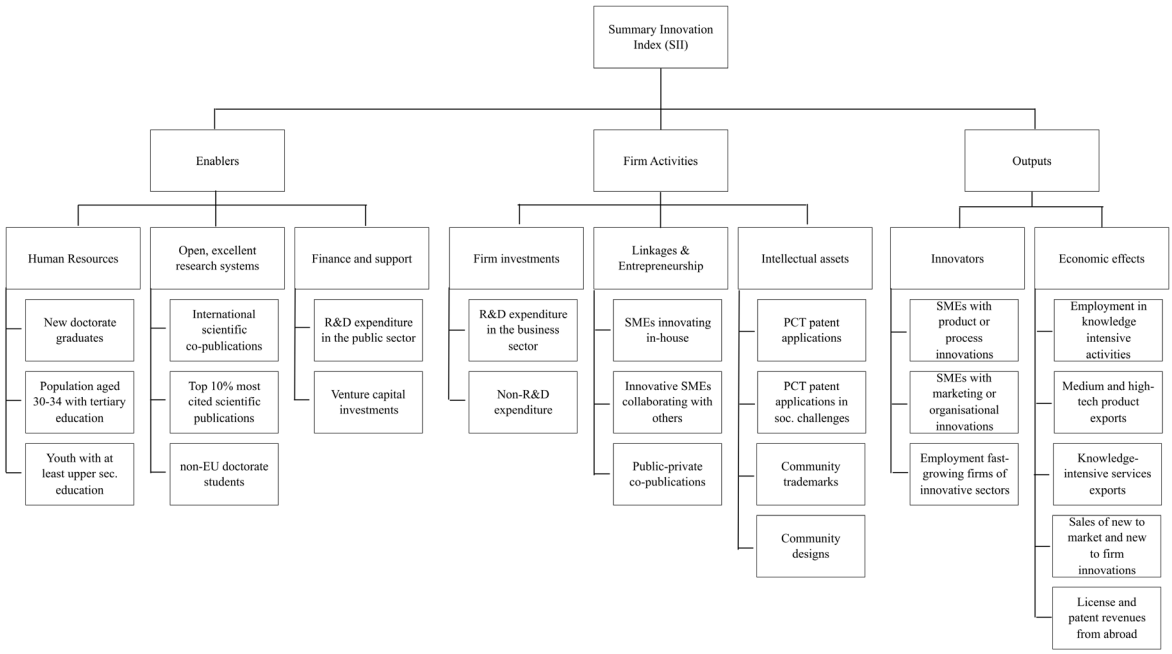
The basic concepts of the proposal are i) the existing measurement frameworks on the country level and ii) methods of measuring innovation performance on the organisational level. The analysed frameworks for measuring innovation performance are Summary Innovation Index (SII) used in the EU and more international Global Innovation Index (GII). However, because of the focus on European countries, we consider SII to be our main object of interest.

Before continuing with the argumentation, we consider important to make a distinction between terms innovativeness and innovation performance. Innovation performance is in the literature used both in a narrower context (outputs of innovation process) and a broader context (being innovative). In this article, we consider innovation performance as any manifestation of a change in an indicator, taking the broader perspective. On the other hand, we consider innovativeness as an ability to realize innovations (Rubera and Kirca, 2012), i.e. ability to use inputs to produce outputs, analogous to absorptive capacity.

RESULTS

National innovation measurement frameworks

Summary Innovation Index is a metric derived by linear aggregation method from a set of components that are grouped into three categories in its 2016's edition: Innovation Enablers, Firm Activities and Innovation Outputs (Eurostat, 2016; see Fig. 1). From the perspective of organisations, Innovation Enablers represent an external environment, the background for future innovations in terms of Human Resources, research systems and finances and support. Firm Activities represent organisational actions related to investment in R & D or other innovation



1: *Summary Innovation Index 2016*
Source: Own adaptation based on Eurostat (2016)

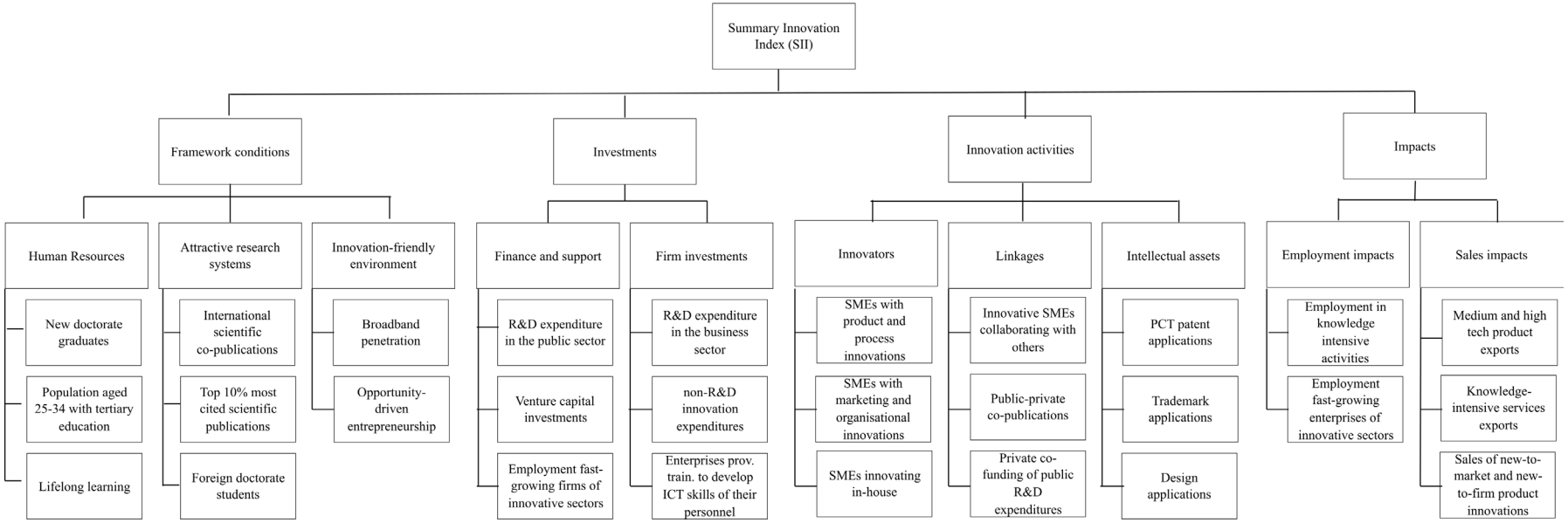
processes, cooperation among organisations and ownership of intellectual assets. Both Innovation Enablers and a part of Firm Activities (investments and intellectual assets) represent inputs for innovation process that are combined and used to produce innovation outputs. The third category, Innovation Outputs stands for the intensity of innovative activities among organisations and economic effects of innovations.

The measurement framework changed in 2017 in the reaction to some criticism. Methodology report itself mentions two of the main critiques we raise towards the framework – lack of underlying theoretical model and not accounting for countries' structural differences (Eurostat, 2017b). The included dimensions have been regrouped (especially enablers), one more dimension Investment has been added, dimension Impact has been split into Employment Impacts and Sales Impacts. These changes lead to the elimination of some indicators and addition of others (Eurostat, 2017a). New indicators are: i) lifelong learning (percentage of population aged 25 to 64 participating in education and training), ii) broadband penetration (share of enterprises with a maximum contracted download speed of the fastest fixed internet connection of at least 100 Mbps), iii) opportunity driven entrepreneurship (share of persons involved in improvementdriven entrepreneurship and the share of persons involved in necessity-driven entrepreneurship), iv) share of enterprises that provide training to develop/upgrade ICT skills of their personnel and v) private co-funding of public R & D as percentage of GDP.

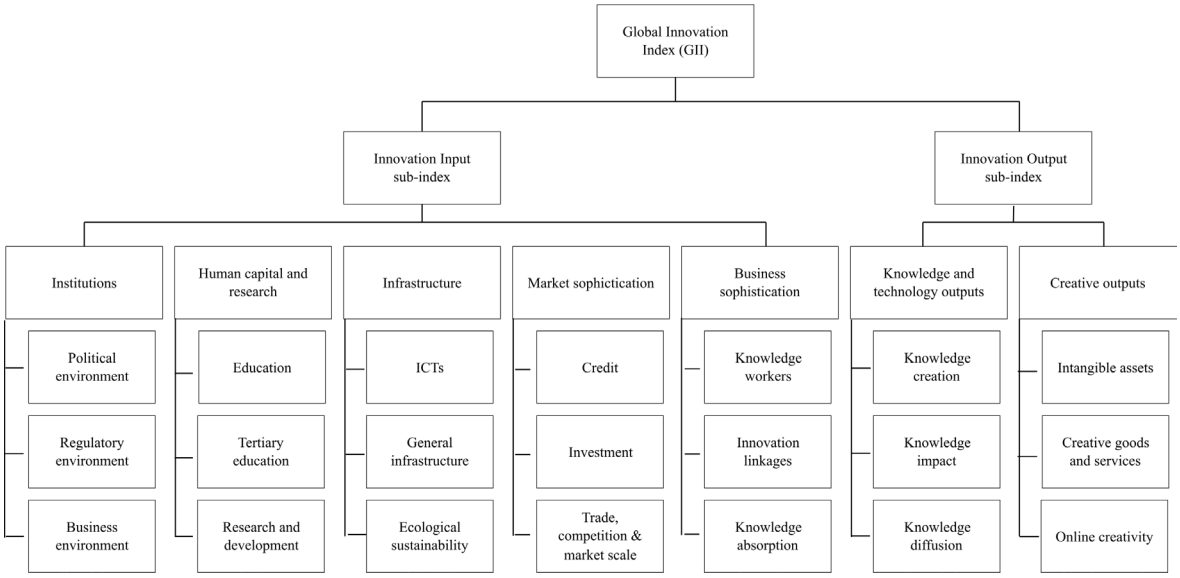
Global Innovation Index is a composite metric derived from a set of components that covers 128 economies in its 2016 edition. GII builds upon two sub-indices (Cornell, 2016), the first representing Innovation Inputs and the second Innovation Outputs. The Innovation Input sub-index consists of five pillars (each further divided into sub-pillars): Institutions, Human capital and research, Infrastructure, Market sophistication and Business sophistication. The Innovation Output sub-index consists of two pillars (each further divided into sub-pillars): Knowledge and technology outputs and Creative outputs. Totally, 82 individual indicators are used in 2016 edition of GII. GII is calculated as a simple average of its two sub-indices. The other measures in GII are calculated as follows: Innovation Input and Innovation Outputs sub-indices as simple average of pillar scores; pillar scores as a weighted average of sub-pillar scores and, finally, sub-pillar scores as a weighted average of individual indicators.

Measurement on the organisational level

Measurement of innovation performance on the organisational level revolves around innovation process, i.e. sequence of activities



2: *Summary Innovation Index 2017*
Source: Own adaptation based on Eurostat (2017b)



3: Global Innovation Index
Source: Own adaptation based on Cornell (2016)

combining innovation resources to create something new. Measurement can be therefore conducted (Carayannis and Provance, 2008): (i) in the beginning of the innovation process as a measure of availability of resources (intellectual, human and technological), (ii) in the course of innovation process in a form of innovation process management indicators and (iii) at the end in terms of outputs that can be both financial (e.g. sales, profits) and non-financial (e.g. patents). This logic applies to the whole range of single indicators, models or composite indicators used in the literature.

From single to multiple indicator measurement

There is a large number of single indicators of innovation performance – R & D expenditure, numbers of product or process innovations, number of patents and their citations etc. (Hagedoorn and Cloodt, 2003). Often, innovation indicators in organisations are tied to R & D expenditure. However, exclusive focus on R & D leads to the omission of other innovation activities (Tadeu and Silva, 2014). R & D expenditure as a single indicator does not cover process of transformation of inputs to outputs and does not show economic and qualitative dimension of innovations and their technological complexity (Coombs *et al.*, 1996; Carayannis and Provance, 2008). Similar to this, measurement based on patents is problematic as economic and technological values may be very different (Santarelli and Piergiovanni, 1996). Moreover, not every part of know-how may be patented and an ability to patent may also depend on a size of an organisation (Carayannis and Provance, 2008). Besides that, patents should be rather considered as indicators of invention rather than innovation (Coombs *et al.*, 1996).

Single indicators are not capturing innovation process in its complex form because they are emphasizing only one partial aspect of innovation. In a consequence, the frameworks of innovation performance measurement emerged covering multiple indicators. Indicators used in these frameworks are integrated into several groups in accordance to innovation process. Davila *et al.* (2013) group them into three categories: (i) inputs representing tangible (people, money, equipment, office space, time) and intangible resources (motivation, culture), (ii) processes representing activities transforming inputs (in this case, the indicators should rather reflect innovative behaviour than economic factors, Tidd and Bessant, 2013) and (iii) outputs representing results of innovation effort. Muller *et al.* (2005) propose another measurement framework including: (i) resources (e.g. percentage of workforce time dedicated to innovation, number of entrepreneurs in an organisation, capital invested in innovation activities, number of new products), (ii) capabilities (e.g. percentage of employees with innovation training, number of innovation tools and methodologies available to employees), (iii) leadership indicators (e.g. percentage of managers with innovation training, time of managers devoted to strategic innovation) and (iv) processes

(e.g. number of ideas, ratio of successful ideas to ideas submitted, average time from idea to commercialization).

Carayannis and Provance (2008) further distinguish among three types of end products of innovation performance: (i) outputs as immediate results of innovations, e.g. new products or patents, (ii) outcomes as mid-term results of innovations, e.g. increase in sales and (iii) impacts as long-term results of innovation, e.g. innovator status. Rubera and Kirca (2012) on the other hand distinguish three different dimensions of innovation performance end products: financial position, market position and created market value.

Composite indicators measurement

Hand in hand with innovation measurement frameworks, numerous authors mention need for a holistic approach to innovation performance measurement (e.g. Hagedoorn and Cloodt, 2003; Carayannis and Provance, 2008; Caetano, 2016). They consider innovation performance to be a system phenomenon rather than a manifestation of isolated factors. Composite indicator can be a way how to overcome the obstacle of single indicators. Moreover, this composite indicator has other advantageous properties such as lower dependence on organisational size (Carayannis and Provance, 2008). Common method to derive such an indicator is a factor analysis used to create a latent variable of innovation performance (Hagedoorn and Cloodt, 2003).

Hagedoorn and Cloodt (2003) include patents, patent citations, R & D expenditure and new product announcements in their composite indicators. However, they also note that resulting latent variable is highly correlated with individual variables and therefore it may be reasonable to use a single indicator. Nevertheless, as they sum up, their findings may be relevant only for hitech industries. Hollenstein (1996) presents other indicators, separate for product and process innovations. He groups 15 variables into three bundles: (i) input-oriented (e.g. investments), (ii) market-oriented (measures connected to sales) and (iii) output-oriented (e.g. number of patents). In the case of product innovations he identifies two factors of innovation performance, on input stage it is a technical dimension and on output stage market dimension.

Carayannis and Provance (2008) define three critical organisational factors that facilitate innovations and create framework for composite measures – posture, propensity and performance. Posture is an organisational position within greater innovation system of its environment and expresses at which point of organisational life cycle, technological lifecycle and competitive landscape the organisation exists. Propensity is an ability to capitalize on a posture – as despite abundancy of resources, an organisation may not be able to produce innovations, if the culture and other intangibles are not prepared. Finally, performance represents results of innovation: output, outcome and impact. Composite measures are represented by input indicators, process and output indicators.

Even in the case of composite indicators that strive for holistic approach to innovation performance measurement, it is important to acknowledge that their findings are often limited to industry and size of studied organisations. Therefore, authors often articulate the need to incorporate environmental, contextual and related conditions. Damanpour (1991) identifies some moderators of the relationship between innovation inputs and outputs, namely industrial sector, type of innovation, stage of adoption, scope of innovation and environmental uncertainty. The choice of indicators should also correspond with innovation strategy, market consequences and operational processes (Tadeu and Silva, 2014). Analogously, some moderators influence relationship between innovation performance and organisational performance. Rubera and Kirca (2012) specify moderators as organisation size, advertising intensity, high-tech versus low-tech industry, Western vs. non-Western countries and conceptualization of innovativeness (i.e. inputs vs. outputs vs. culture, radical vs. incremental innovations). Also, it is worth to mention a national culture as a moderating factor as our study assesses measurement on the country level. For example, customers in short-term oriented countries (Hofstede *et al.*, 2010) adopt innovations faster and that leads innovation performance to appear fast in organisational sales (Rubera and Kirca, 2012). Besides that, there is also a link between an innovation management practice and a national culture (Shane, 1993, van Everdingen and Waarts, 2003).

An incorporation of such variables into innovation–performance relationship follows general suggestion of contingency theories, system approach meaning that change in one part of a system requires change in another part to sustain given performance (Fry and Smith, 1987). Important part of system approach is a principle of equifinality, the assumptions that there exist

several different ways how to achieve the same result (Donaldson, 2001).

Process approach to measurement

Metrics of innovation process (Muller *et al.*, 2005; Carayannis and Provance, 2008), this acceptance obscures a comprehensive perspective on how firms can influence their innovation capacity and resulting performance. This paper proposes a '3P' construct of innovation measurement that simultaneously considers the Posture, Propensity and Performance related to a firm's innovation capabilities. We propose and provide empirical support showing that robust measurement of the performance implications of innovation requires the consideration of input, throughput and output factors simultaneously. Single or more limited indicators do not offer the degree of fine-tuning to a firm's innovation system that managers require. Thus, we propose the development, and future research into contingent variations, of a Composite Innovation Index (CII appear within above mentioned frameworks of innovation performance measurement). Broadly speaking, the organisation process is a logical sequence of activities consuming resources to transform an object (mental or physical) in order to attain specific measurable result for internal or external customers (Rolstadås and Andersen, 2012). Process approach therefore focuses on an organisation ability to transfer inputs into outputs that we define as innovativeness in the introduction. The innovativeness is actually an analogy of absorptive capacity as a capacity to assimilate and replicate new knowledge obtained from external resources (Cohen and Levinthal, 1990), i.e. transform potential absorptive capacity into realized absorptive capacity (Zahra and George, 2002). Absorptive capacity (the realized one) is often measured by R & D intensity calculated as the ratio of R & D expenditure to sales (Cohen and Levinthal, 1990). The innovation process contains activities like idea generation, development of concepts, development of prototypes, testing, production, commercialization etc. These activities are sometimes assessed in process approaches together with a management practice of innovation (e.g. Tadeu and Silva, 2014). In order to measure innovation performance from the innovation process perspective, so-called innovation audits are used. An innovation audit is defined by an intention to investigate and improve an organisation's capabilities to innovate and perform innovation processes (Björkdahl and Holmén, 2016). Innovation scorecards are important analytical tools evaluating innovation performance in several dimensions. Although models behind them and corresponding dimensions are various (Burgelman *et al.*, 1988; Tang, 1998; Chiesa *et al.*, 1996; Tidd and Bessant, 2013), the core is always defined by comparisons with the best practice that is not considered the same for every organisation. Carayannis and Provance (2008) define two groups of innovation process variables – innovation management (definition of innovation strategy, clear regulation of idea evaluation, profitability analysis implementation, ex-post analysis of innovation projects) and project management (implementation of project management, controlling of project implemented, involvement of marketing, development of the project).

An important part of the process approach of innovation performance measurement is Balanced or Innovation Scorecard framework. The framework draws upon organisational and innovation strategies and in its focus on innovations it tries to comprehensively capture innovation management and measurement (Davila *et al.*, 2013; Zizlavsky, 2016). Besides financial indicators, it also make use of non-financial indicators and broader linkages such as strategy (Kaplan *et al.*, 2007).

Critique of current approach to measurement on the organisational level

Carayannis and Provance (2008) summarize weaknesses of current approaches to innovation measurement on the organisation level – excessive focus on manufacturing sector and product innovations, while ignoring process measures. In addition, indicators do not consider differing size, goals and activities of organisations. In relation to Dewangan and Godse (2014), they articulate the need for multidimensional measurement in individual stages of innovation process, taking into account stakeholders and reflection of causal relations among components. In parallel with this, such a measurement should be easy to implement. Muller *et al.* (2005) emphasize distinctiveness of individual organisations that leads to a need to create a comprehensive set of indicators, re-evaluate current indicators, avoid complex metrics, include at least some customer driven indicators (such as sales) and match the set with methodology. Also, short-termism in measurement should be avoided (Birchall *et al.*, 2011).

While deciding which indicators of innovation performance to use, there are several decision that has to be made and that impact how a measurement system looks like (Calik and Bardudeen, 2016).

These decisions involve (i) whether to measure inputs, process or outputs, (ii) what types of innovation to measure (product, process, etc.), (iii) whether sustainability aspect – economic, environmental, societal – should be included, (iv) whether to measure perceptual or hard data, (v) on which level of detail to measure and (vi) how short-term and long-term aspects of innovation are covered. There is no single agreement what should be measured and how (Birchall *et al.*, 2011). Still, there is a consensus among authors that it is important to select the indicators carefully (Muller *et al.*, 2005).

DISCUSSION

When looking at individual indicators within SII 2016, we notice that the complex assessment of inputs through processes to outputs only seemingly offers broad perspective. For example, innovation processes (that ought to be contained in Firm activities category of SII) are in reality covered only by two components, "SMEs innovating in-house" and "Innovative SMEs collaborating with others". The other components in the category are more connected with inputs (Firm investments subcategory) and outputs (Intellectual assets subcategory, Public-private co-publications). By this, they actually strengthen the other two categories of SII – Enablers and Outputs – and overweight the static view of innovation performance at the expense of its dynamic part, i.e. innovativeness.

Process indicators consider the existence of an innovation management practice. The easiest way to support the role of process in indicators without requiring new data to be collected is to measure innovation process efficiency. This can be done by including any meaningful ratio of innovation inputs to innovation outputs. Besides that, more can be done by adding new process related variables such as quality of innovation strategy and its implementation (compared to a given benchmark of best practice) etc. Innovated SII 2017 is intended to be the response to raised criticism (Eurostat, 2017b). We acknowledge that some progress is made, e.g. the whole dimension Innovation-friendly Environment can be connected with propensity (an elementary precondition of innovation performance and involves innovative culture and intangibles supporting innovation) from Carayannis and Provance's (2008) 3P model. However, we argue that these changes are rather a minor evolution and do not respond to our critique.

We believe that innovation performance measurement deserves more significant changes that would encompass broader context and specified causal relationships including moderating variables as any relations should be considered in their situational contexts (Bukh and Malmi, 2005). Taking into account heterogeneity of countries (caused by differences in national cultures, economy structures and more generally institutions) we question whether one-fits-all indicators should be used for all countries. Varying weights of components across groups of similar countries can be the way to solve the problem. That is similar to the organisation process approach that takes organisations as unique entities (e.g. Carayannis and Provance, 2008).

As innovation process is a sum of numerous decisions resulting in equifinality of innovation performance (Calik and Bardudeen, 2016) it is not reasonable to omit the context. Even if we take a fundamental causal relationship between innovation and performance, the results are ambiguous without taking other factors into consideration. The differences based on an organisation size (e.g. Vossen, 1998) or knowledge assets (Thornhill, 2006) indicate that there is a certain level of heterogeneity and organisations need to be studied either in smaller homogenous clusters (Birley and Westhead, 1990) or while carefully controlling for these internal influences.

If we note factors that may be reflected at the country level as well – factors like national culture (collectivism or individualism; Rosenbusch *et al.*, 2011) or dynamism and institutional support (Li and Atuahene Gima, 2001) point out to the fact that innovation strategies of entities need to be adapted to their surrounding environment. We believe that the reasoning behind innovation performance indicators on the country level should correspond to the same logic of contingency theory approach. This approach should be therefore preferred and necessary condition for studying this relationship to clearly distinguish what kind of innovation performance is actually important for the country as such.

CONCLUSION

Composite indicators are aggregate multidimensional means to assess innovation performance of countries. As the indicators use the same criteria for all the countries involved, they inherently omit broader context in which each country exists. By taking inspiration in the organisational level measurement of innovation performance our study raises several concerns about such an approach. We suggest that current indicators lack a sufficient number of process indicators and more important, we propose that varying weight of indicators should be applied in order to take specific conditions of countries into account.

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