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Opening the black box of national systems of entrepreneurship: an application of three-stage DEA on Global Entrepreneurship Index

EDUARDO AVANCCI DIONISIO
UNIVERSIDADE ESTADUAL DE CAMPINAS (UNICAMP)

EDMUNDO INACIO JUNIOR
UNIVERSIDADE ESTADUAL DE CAMPINAS (UNICAMP)

RUY QUADROS
UNIVERSIDADE ESTADUAL DE CAMPINAS (UNICAMP)

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Abstract: Entrepreneurship is one of the key factors contributing to the countries 'economic growths. Implementing National Systems of Entrepreneurship (NSE) strategies to improve a country-level entrepreneurial performance has thus become one of the most important challenges for policymakers. The NSE performance is highly influenced by the complexities of interactions among individuals/entrepreneurs and their institutional context. An evaluation model that go beyond a score aggregate thinking and incorporates the multidimensional aspects of entrepreneurial process is highly needed. This study employed a three-stage Data Envelopment Analysis (DEA) method to measure the country-level efficiency. Our findings show that countries considered world leaders in entrepreneurship, such as the United States, are inefficient at some stages of the entrepreneurial process. Meanwhile, countries like Chile, Estonia and Slovenia are more efficient. Implications of our research encompass the need for policymakers to develop more in-depth knowledge concerning their own NSE.

Keywords: High-impact entrepreneurship. Network DEA. Key-performance indicators.

1 Introduction

Assessing country-level efficiency in terms of entrepreneurship helps the policymakers to identify the best entrepreneurship practitioners for benchmarking and to shed light on ways to improve performance by highlighting the weakness links. However, to obtain effective information for entrepreneurial system policies, it is important to choose an appropriate framework to accommodate the production structure of the entrepreneurial process. As an emerging current of though in entrepreneurship literature, the system of entrepreneurship approach a useful analytical tool for the design of entrepreneurship policies at national our regional level (Qian, Ács, & Stough, 2012).

The National System of Entrepreneurship (NSE) approach was introduced in the 2010s by Ács, Autio and Szerb (Ács, Autio, & Szerb, 2014). It enjoys wide currency in both academic and policymaking context and is considered a useful and promising analytical tool for academic study and for the development of entrepreneurship support policies, fostering and understanding of entrepreneurial processes and its determinants (see Autio, Kenney, Mustar, Siegel, & Wright, 2014; Szerb, Ács, & Autio, 2013; Tasnim & Afzal, 2018). From a general perspective, an NSE results from the interactions between individuals (entrepreneurs or potential entrepreneurs) and their contexts in producing entrepreneurial activity and regulating the entrepreneurial performance and its impacts (Qian et al., 2012). A NSE can defined as "*the dynamic, institutionally embedded interaction between entrepreneurial attitudes, ability and aspirations, by individuals, which drives the allocation of resources through the creation and operation of new ventures*" (Ács, Autio, et al., 2014, p. 479). As Ács and Correa (2014) pointed out the interaction between the population's entrepreneurial intentions/efforts and a favorable environment to entrepreneurship are the basic characteristics of a functional NSE.

With the introduction of NSE, Ács, Autio and Szerb (2014) developed an index methodology, called Global Entrepreneurship Index (GEI) to measure the NSEs interactions among individuals, entrepreneurs and their institutional context, and to identify the bottleneck factors which inhibit the entrepreneurial performance. From a systemic perspective, the GEI reminds policymakers of the need to improve the collaboration among interacting components in the entrepreneurial process and the influence of the entrepreneurial context on the performance and outcomes of new ventures (Ács, Audretsch, Lehmann, & Licht, 2016). As national entrepreneurship policymakers, governments mostly concern themselves with system efficiency as closely related to the entrepreneurial input/output ration and emphasize the effect of public intervention on the NSE efficiency. However, even though the GEI measures entrepreneurial systems, this index was not designed to assess countries 'efficiency in

generating high-impact entrepreneurship through the development of an entrepreneurial friendly environment. This fact represents a challenge to policymakers, mainly in developing countries and/or with scarce resources to develop NSE strategies, with a view to improving the performance of the entrepreneurial activity (Inácio Jr, Dionisio, Fischer, Li, & Meissner, 2020).

Entrepreneurship efficiency is related to the concept of productivity, which is improved when the same amount of entrepreneurial input (IE) generates more entrepreneurial output (OE) or when less IE is needed to produce the same OE. In an output maximization perspective, the concept of efficiency involves "*comparing observed output to maximum potential output obtainable from the input*" (Fried, Lovell, & Schmidt, 2008, p. 7). In this sense, an efficiency NSE operate at their production possibility frontier (PPF) or "transformation curve", which indicates the maximum amount of entrepreneurial output which can be generate with a set of inputs. However, efficiency paths that driving the aggregate levels of competitiveness in systems of entrepreneurship have not received systemic attention from literature. Instead, analytical frameworks are fundamentally derived from the experience of a handful of successful examples, ignoring that this is a typical case in which "one-size-does-not-fit-all" (Roundy, Bradshw, & Brockman, 2018). These shortcomings end up compromising the quality of policymaking processes dealing with the promotion of entrepreneurship. Our inquiry in this article is oriented towards addressing this gap based on the research question: How do countries perform in terms of entrepreneurial systems 'efficiency? Drawing from this approach, we also aim at identifying countries 'distance to the efficiency frontier, through a three-stage Data Envelopment Analysis (DEA) model.

We have conducted research on a sample of 25 countries present on the GEI 2019 report, in order to assess the efficiencies of countries 'entrepreneurial systems. Hopefully, the empirical results of our study can provide useful information as a background implication for policymakers improve the countries' entrepreneurial performance or develop entrepreneurial systems strategies. The remaining of the article is structured as follows. After this introductory argument, Section 2 provides an overview of National Systems of Entrepreneurship (NSEs). Section 3 presents our methodological approach. Empirical findings are explored in Section 4. Section 5 discusses results in light of dedicated literature and implications. Section 6 concludes with final remarks, limitations and suggestions for future research.

2 National system of entrepreneurship in perspective

Within the general framework of entrepreneurial systems, emphasis usually rests on the case of high-impact entrepreneurship (HIE). In addition to contributing to job generation, high-impact firms (HIFs) contribute in a pioneering way to the economy in sectors where technologies and market segments are in the less advanced stages. In these cases, in spite of the uncertainty involved, entrepreneurs often take the lead in setting new technological paths, creating markets and defining technological standards adopted by the users (Ács, 2008; Kenney & Von Burg, 1999; Mcmullen & Shepherd, 2005; West & Bamford, 2005).

Entrepreneurship represents a bridging mechanism between technical knowledge and product and services (Arrow, 1962). In similar vein, Kirzner (Kirzner, 1997) defines the entrepreneur as an individual who explores market opportunities and brings relative balance to markets. Hence, in order to become an entrepreneur, an individual must be able to recognize opportunities to create value to the economic environment (Clarysse, Wright, & Van de Velde, 2011). This can be the result of the lack of quality jobs or existence of latent prospects to improve income (Amit, Muller, & Cockburn, 1995). In order to turn these opportunities into actual entrepreneurial endeavors, attitude and preferences of individuals toward starting their own business must be part of the equation (Ács, Szerb, & Autio, 2015). These matters are often associated with the comprehension of individuals 'identify aspirations, i.e., how they perceive

themselves - and their intrinsic capabilities (Farmer, Yao, & Kung-Mcintyre, 2011). Accordingly, such conditions depend on the development of entrepreneurial spirit and competences, understood as the capacity of individuals to effectively seize opportunities by establishing competitive advantages (Bartelsman, Haltiwanger, & Scarpetta, 2004). A Fundamental issue in this regard concerns educational levels of individuals (Glaeser, 2007).

Although at the micro level, entrepreneurs should not be perceived as isolated units. They frequently tap into networks of peopled organizations to gain access to tangible and/or intangible resources (Dahl & Sorenson, 2012). Alongside these lines, the emergence of an entrepreneurial behavior is also significantly influenced by culture, though social values and norms that can stimulate or inhibit entrepreneurial attitudes and aspirations (Isenberg, 2010). These factors influence the degree of openness of the entrepreneurs to socialize their experiences with other people, an aspect that interferes in the career choice of the individuals (Autio, Pathak, & Wennberg, 2013; Kantis, Federico, & Garcia, 2014). For these reasons, a systemic thinking of the entrepreneurial event becomes inevitable.

Thus, going beyond the focus on the individual and micro-level connections with other agents, literature on entrepreneurship has consistently advanced in terms of understanding the importance of contextual conditions upon entrepreneurial activity (Feldman, 2001; Sternberg, 2009). A first aspect of interest in this discussion concerns the institutional environment, understood as the collective of formal and informal norms which are set to shape the behavior of individuals within socioeconomic systems (Levie & Autio, 2011; Uhlaner & Thurik, 2007).

Firm entry is also associated with the business dynamics of productive structures, such as changes or maturity of technologies, industrial growth (Abernathy & Utterback, 1978; Kenney & Von Burg, 1999), market demand, characteristics of competition (Sorensen, 2007). And availability of complementary resources (Nanda & Sorensen, 2010). These macro conditions are essentially associated with countries 'development levels. Radosevic and Yoruk (2013) identify that gross domestic product (GDP) per capita can promote entrepreneurial straights by affecting qualitative attributes of demand. On the other hand, some authors have perceived that GDP per capita can be negatively associated with overall entrepreneurial activity (Uhlaner & Thurik, 2007; Wennekers, Thurik, Stel, & Noorderhaven, 2007). This is because opportunity cost in the employment-entrepreneurship relationship can be higher, and the presence of highly competitive incumbents can also deter newcomers (Kerr & Nanda, 2011; Ughetto, 2010).

Complementary macro-level elements include openness to foreign markets as a vector of increased competitive pressure (Stam, 2009). Also, credit availability stands for a relevant dimension in defining entrepreneurial context. This goes beyond funding opportunities, as investors often can provide managerial expertise to entrepreneurs (Lerner, 2002).

One last influential aspect concerns science, technology and innovation institutions (e.g., universities, technology transfer offices, R&D institutes, science parks and incubators) and how they influence the development of knowledge-intensive business (Audretsch, Lehmann, Paleari, & Vismara, 2016; West & Bamford, 2005). In fact, processes of knowledge creation and integration represent a fundamental cornerstone of the entrepreneurial activity (Cassia, Minola, & Paleari, 2011). Ultimately, technological systems affect the entrepreneurial context by defining the availability of potentially innovative inputs (Obschonka, Maximilian, Silbereisen, & Cantner, 2012). Also, beyond direct contributions to market agents, these institutions provide resources such as human capital, financing and administrative support in business operations (Cumming & Li, 2013; Grimaldi, Kenney, Siegel, & Wright, 2011) (Wright, Lockett, Clarysse, & Binks, 2006).

Combining micro and macro perspectives, the NSE approach analyzes the development trajectory of dynamic ventures by observing the systemic factors which influence entrepreneurial activity and its impacts (Ács, Szerb, & Autio, 2014). This approach allows the

recognition of problems that inhibit entrepreneurship and the identification of areas that need regulatory intervention (Kantis et al., 2014). In sum, the NSE approach considers the creation of firms as the product of a process influenced by a series of interdependent factors which affect the life cycle of nascent companies (Kantis, Federico, & Menendez, 2012).

Hence, the NSE approach evaluates the developmental trajectories of the HIFs in countries, considering the contextual and individual aspects of entrepreneurship (Ács, Autio, et al., 2014; Ács, Szerb, et al., 2014). Accordingly, this approach goes beyond the "market failure" perspective for policymaking, which are not capable of contemplating the social and systemic aspects that interfere in entrepreneurial activity.

In the NSE approach, opportunities represent the way in which the entrepreneurs allocate resources for productive purposes. Accordingly, NSEs are seen as resource allocation systems, i.e., government institutions and/or specialized organizations provide resources (e.g., human capital, financial services, business services, etc.) to entrepreneurs, and, in turn, these individuals allocate these resources to create new ventures (Ács, Szerb, et al., 2014; Autio et al., 2014). In the context, the GEI (Ács, Autio, et al., 2014; Ács, Szerb, et al., 2014) provides information on the performance of NSEs that go beyond enterprises startups rates or isolated institutional frameworks assessments. The GEI uses the benchmarking approach by key performance indicators (KPIs) to establish the profile of NSEs (Ács, Szerb, Lafuente, & Márkus, 2019). However, this approach is not designed to contemple interaction between factors of production and the productivity or efficiency of analyzed units. Consequently, results can be biased, since the system with the larger scales of values will be considered the benchmark for other countries (Bogetoft, 2012).

Following Kuhlmann (Kuhlmann, 2003) and Inzelt (2004), in order to understand the real performance of a system, it is necessary to evaluate it in a holistic way, rather than quantifying it into specific measures or KPIs. Edquist and Zabala-Iturriagagoitia (2015) argue that performance indices that do not consider the productivity relationship between inputs and outputs provide misleading perspectives on countries 'actual performance. They also affirm that input and output indicators should be considered as two distinct types of indicators.

3 Methodological approach

3.1 Data Envelopment Analysis

When dealing with various inputs that generate outputs, the efficiency literature usually uses Data Envelopment Analysis (DEA) frontier models (Cooper, Seiford, & Zhu, 2011). DEA is a non-parametric method, which through mathematical programming approximates the true, but unknown technology or production possibilities (T) without imposing any weights and restrictions on the variables considered. The main technological assumption of the DEA is that any decision-making unit - DMU (in our case, country) (k) uses $x = (x_1, \ldots, x_i) \in R^i$ inputs to produce $y = (y_1, \ldots, y_o) \in R_+^o$ outputs, and these sets from the technology: $T = \{(x, y)$: x can produce $y\}$. DEA is more sophisticated benchmarking method that provides a set of production possibilities, where efficient DMUs delimit the frontier of efficiency or production. For inefficient DMUs, the DEA estimates the distance from the best practices frontier (efficient DMUs) (Bogetoft, 2012).

The technology in DEA frontiers models has two properties. The first refers to returns to scale. In this study, the modeled technology exhibits Variable Returns to Scale (VRS), because this model captures the technical efficiency, i.e., the short-term results. The second property deals with the model orientation (minimizing input or maximizing output). In this study, the model is oriented to outputs. In the business sector, the notion of efficiency translates into producing more outputs, with minimal inputs allocation (Sengupta, 1987). On the other

hand, in the public sector, human capital and assets tend to be fixed, therefore, policymakers seek to produce as many outputs as possible, using available resources (Fare, Grosskopf, Norris, & Zhang, 1994; Tone & Sahoo, 2003).

$$T(x_k, y_k) = max\theta_k$$

$$\begin{aligned} \text{Subject to: } & \textstyle\sum_{k=1}^{K} \lambda_k y_{k,m} \geq \theta_k y_{k,m} && m = 1,\ldots,m \\ & \textstyle\sum_{k=1}^{K} \lambda_k x_{k,j} \leq x_{k,j} && j = 1,\ldots,j \\ & \textstyle\sum_{k=1}^{K} \lambda_k = 1 \\ & \lambda_k \geq 0 && K = 1,\ldots,k \end{aligned}$$

Where: T: Technology set; K: Number of countries, DMUs k: Counter for countries; x: Input, as a vector; y: Output, as a vector; m: Number of inputs; n: Number of outputs; i: Counter for inputs; j: Counter for outputs

The technology structure in Equation 1 describes how countries (k) allocate their available resources (x= freedom and property, education, country risk, connectivity, corruption, among others), into the maximum possible outputs (y = opportunity recognition, skill recognition, risk perception, know entrepreneur, career status, among others), uses λ as intensity weights to form the linear combinations of the sampled countries (K), and introduces the restriction $\sum_{k=1}^{K} \lambda_i = 1$ to VRS to the technology. The term θ_i is the efficiency score obtained for each country, and for efficiency countries $\theta_i > 1$ and $\theta_i - 1$ points to the inefficiency score. Hence, this technique, when applied in real country configurations, assigns endogenous weights that maximize the overall score of each country, given a set of other observations. In this sense, the assumption of fixed weights for KPIs common to all countries is relaxed and then specific weights that maximize the GEI score for each economy are endogenously determined.

The traditional DEA model consists of a one-stage structure which does not consider the internal operation of the DMUs, such a structure does not allow explicitly expressing the internal processes and the interdependence relationships between variables, which can now be considered as inputs or outputs. Thus, the traditional DEA model is also known as an aggregate model or 'black box'. The three-stage model, proposed by Fried, Lovell, Schmidt and Yaisawarng (2002) to measure the real efficiency of each DMU, through the decomposition of internal processes. This model is indicated for systemic analysis, where output can be used as an input in another production processes, giving rise to new outputs. An illustration of this is the patents that may be the result (output) of expenditures in research and development (R&D), as an input because their acquisition can generate aggregate levels of competitiveness by innovative companies (Azagra-Caro, Lucio, & Gracia, 2003; Zabala-Iturriagagoitia, Voigt, Gutiérrez-Gracia, & Jiménez-Sáez, 2007).

3.2 Method and sample

Our sample encompassed data from the Global Entrepreneurship Index (GEI) 2019 for 25 countries. The GEI approach has been formulated to measures the HIE and to understand the factors and structural aspects that influencing the entrepreneurship (Ács et al., 2019). This index was developed with the purpose of providing comparative analysis on the factors which interfere in the entrepreneurship at country-level (Ács, Autio, et al., 2014).

The GEI is structured around 14 pillars (each pillar or KPI has an institutional variable and individual correspondent that assess the macro and micro levels of entrepreneurship) which

have an impact on NSE performance. These indicators are grouped into three sub-indices: (1) Entrepreneurial attitudes sub-index (ATT); (2) Entrepreneurial abilities sub-index (ABT); (3) Entrepreneurial aspirations sub-index (ASP). Details of sub-indices and pillars are described in Appendix 1. Data for the 25 countries Global Entrepreneurship and Development Institute (GEDI) web page (at http://thegedi.org) and are available in Appendix 2.

We focus on the GEI variables that make up the three GEI sub-indices. We based on previous studies (GEDI, 2014; Inácio Jr et al., 2020) to classify the variables in output, input and input intermediary indicators. These studies classify institutional variables as inputs and individual variables as outputs since institutional variables represent the context in which the entrepreneurial event occurs, whose quality inhibits or drives attitudes towards entrepreneurship and the creation of new businesses and its impacts. Thus, as can be seen in Appendix 1, the start-up skills is made up of the variables 'education' (at the institutional level) and 'skill perception' (at the individual level). The 1st variable represents the quality and size of the higher educational system and the 2nd, the proportion of people who claim to have adequate startup skills. The logic of this pillar is that a high-educated population is a prerequisite for more people to have adequate skills to undertake, i.e. the greater the number with higher education, the greater the number of people with the ability to undertake. However, the risk capital pillar does not follow this logic, the variables depth of capital market (institutional) and informal investment (individual) are classified by GEDI (2014) as inputs, therefore, there is no cause and effect relationship. While the first captures the characteristics of financial instruments to support entrepreneurship, the second refers to the proportion of people who offered funds to an entrepreneur. Thus, we chose to use only the institutional variable, as it is more comprehensive to capture financing for high-impact entrepreneurship.

Thus, using the logic which the institutional variables are input (freedom and property, education, country risk, connectivity, corruption, governance, tech absorption, labor market, compregulation, tech transfer, science, finance and strategy, economic complexity and depth of capital market) and the individual variables are output (opportunity recognition, skill perception, risk perception, know entrepreneurs, career status, opportunity motivation, technology level, educational level, competitors, new product, new technology, gazelle and export), we apply the one-stage DEA VRS model to measure the technical efficiency of the 25 countries selected for their high-performance in the Global Entrepreneurship Index 2019 report: Australia, Austria, Belgium, Canada, Chile, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Israel, Japan, Luxembourg, Netherlands, Norway, Qatar, Slovenia, Sweden, Switzerland, Taiwan, United Arab Emirates, United Kingdom and the United States.

However, the one-stage DEA model shows only the overall efficiency of DMUs, making it impossible to visualize the role of internal processes (intermediaries). It is known that entrepreneurship is a multifaceted and interdependent process, whose performance is highly dependent on the context in which the entrepreneurial activity take place (Ács et al. 2014). Despite this, the entrepreneurial process follows some steps, i.e., the population identifies a business opportunity, create a firm to exploit it and that business can have multiplier effects in the form of innovation, job creation and value generation. However, this flow of linked activities is influenced by the context in which entrepreneurs are inserted, for example, the lack and/or difficulty in accessing venture capital resources can hinder the growth of new companies and consequently their impacts (Kantis et al., 2012). The GEI follows this logic in each of the sub-indexes, the first of which provides a countries' profile on the entrepreneurial behavior of the population and their ability to recognized explore entrepreneurial opportunities, as well as the influences of the context. The 2nd sub-index, measures the characteristics of the new companies and the context in which they are inserted. Finally, the 3rd sub-index measures the impacts of entrepreneurs and the quality of the environment in which they operate.

Thus, to capture the efficiency of NSEs, considering not only the overall efficiency but also the intermediate processes, we use the three-stage DEA model with variable returns of scale (VRS). The reasoning behind the application of the three-stage model is to follow the entrepreneurship processes, from the population's entrepreneurial attitudes to the entrepreneurs' aspirations, considering the influence of the institutional context. Table 1 shows the outputs, original and intermediate inputs.

Table 1 - Indicators in three-stage DEA model

Original input	Intermediate input	Output
Entrepreneurial attitudes stage		
Freedom and property		Opportunity recognition
Education		Skill perception
Country risk		Risk perception
Connectivity		Know entrepreneurs
Corruption		Career status
Entrepreneurial abilities stage		
Opportunity recognition	Governance	Opportunity motivation
Skill perception	Tech absorption	Technology level
Risk perception	Regulation	Educational level
Know entrepreneurs	Labor market	Competitors
Career status		
Entrepreneurial aspirations stage		
Opportunity motivation	Tech transfer	New product
Technology level	Science	New technology
Educational level	Finance and strategy	Gazelle
Competitors	Economic complexity	Export
	Depth of capital market	

Source: The Authors

Stage 1 has as indicators the variables of the ATT sub-index. Thus, the inputs are the institutional variables: Freedom and property, education, country risk, connectivity and corruption. The outputs are the individual variables: Opportunity recognition, skill perception, risk perception, know entrepreneurs and career status. These entry indicators have been selected because they represent the efforts of countries to create an environment that encourages the population entrepreneurial behavior, while output indicators are the results of efforts to create that environment.

Stage 2 was built on the premise that a population with entrepreneurial attitudes is fundamental for the creation of new companies (Ács & Correa, 2014; Bosma & Schutjens, 2011). Thus, the variables opportunity recognition, skill perception, risk perception, know entrepreneur and career status were defined as input variables and the ABT's individual variables (opportunity motivation, technology level, educational level and competitors) was defined as outputs, as they represent the efforts of the population to create new companies. However, the characteristics of entrepreneurial activity at an early stage are influenced by the context, that is, by the institutional variables of the ABT sub-index (governance, tech absorption, labor market and compregulation), these indicators were defined as intermediate inputs, because although they influence the entrepreneurial activity characteristics, they do not have direct effects under the entrepreneurial attitudes of the population. These are national efforts to produce an environment conducive to the creation of new businesses, especially the technology-based business (Bowen & De Clercq, 2008; Kantis et al., 2014; Radosevic & Yoruk, 2013).

Stage 3 was built from the direct link between early-stage firms and the proportion of these firms with high-entrepreneurial aspirations. Opportunity motivation, technology level, educational level and competitors were defined as inputs, as they represent the entry of new

companies with the potential to generate economic impact. Meanwhile, the variables new product, new process, gazelle and export defined as output, represent the real impacts of entrepreneurial activity. However, these impacts are conditioned by the environment in which these companies operate, therefore, the ASP sub-index institutional variables were defined as intermediate, because it mensure the context in which HIFs operate, i.e., it represent the countries' efforts developing an environment conducive to entrepreneurial innovation and growth (Ács, Audretsch, & Lehmann, 2013; Autio et al., 2014).

4 Empirical analysis

This study employed the network DEA model for overall efficiency and the three component efficiencies with the consideration of the interdependent relationship between the three dimensions of entrepreneurship. The overall efficiency is classified into entrepreneurial attitude, activity and aspirations, which is show in the Table 2. The average score of the overall efficiency computed from the network DEA model is 0.42. The only two inefficiency countries are Finland (5.20) and Germany (5.50). Furthermore, the average score of the entrepreneurial attitude, activity and aspirations, which are based on the network relationship, are 16.94, 1.60, and 5.44, respectively. As for the decomposition of overall NSE performance, the attitude stage has a higher average score and more inefficient countries than two other stages. This can be explained which most of countries employ more resources on the development of an environment favorable to entrepreneurship. However, in general, the population has low attitudes toward entrepreneurship.

Table 2 - Countries' efficiency scores

	GEI			Efficiency score of each stage (%)		
Country	Rank	Score	Overall efficiency (%)	Stage 1	Stage 2	Stage 3
United States	1	83.37	0.00	10.70	0.00	0.00
Switzerland	2	77.96	0.00	26.20	3.40	0.00
Canada	3	75.60	0.00	15.80	0.00	0.00
Sweden	4	75.47	0.00	0.00	0.00	17.60
Denmark	5	74.06	0.00	24.20	0.00	17.40
Iceland	6	73.49	0.00	0.00	0.00	0.00
Australia	7	72.51	0.00	30.30	0.00	0.00
United Kingdom	8	71.29	0.00	23.40	0.00	21.90
Ireland	9	70.96	0.00	2.10	0.00	0.00
Netherlands	10	67.79	0.00	20.40	11.30	0.00
Finland	11	66.91	5.20	09.20	9.10	0.00
Germany	12	64.87	5.50	42.50	0.00	8.80
France	13	64.09	0.00	32.80	0.00	14.30
Austria	14	63.46	0.00	26.10	6.50	0.00
Belgium	15	62.98	0.00	62.20	0.00	0.00
Taiwan	16	60.68	0.00	0.00	0.00	0.00
Israel	17	59.08	0.00	0.00	0.00	8.80
Chile	18	58.85	0.00	0.00	0.00	0.00
United Arab Emirates	19	58.80	0.00	0.00	0.00	0.00
Luxembourg	20	58.13	0.00	0.00	0.00	0.00
Qatar	21	57.95	0.00	0.00	09.70	0.00
Norway	22	55.87	0.00	0.00	0.00	47.10
Estonia	23	55.54	0.00	0.00	0.00	0.00
Japan	24	51.72	0.00	97.70	0.00	0.00
Slovenia	25	51.49	0.00	0.00	0.00	0.00
Efficiency score average:			0.42	16.94	1.60	5.44

Source: The Authors

In addition, our empirical exercise indicated the inefficiency score average of the Stage 2 is lowest than two other Stages. This mean that in most countries, although only a low

population proportion shows entrepreneurial behavior, their ventures can be classified as having high-impact potential, as entrepreneurs have received formal higher education, operate in the technology sectors and have introduced unique products and/or services, which have few if any competitors. Finally, the Stage 3 is the second in terms of inefficiency score average (5.44) and with number of inefficient countries (7). Although these countries allocate resources to building an entrepreneurial system suitable for starting high-impact ventures, there is few high-impact firms. Entrepreneurship in countries like France, Sweden, Norway and the United Kingdom is characterized by little technological innovation, low growth expectation and limited internationalization. In Germany and Sweden, the entrepreneurial activity also has low performance, except for some early-stage entrepreneurs who are internationalized.

Finally, we also identified that the United States, although the top of the GEI ranking, presents inefficiency in Stage 1. On the other hand, countries that traditionally are not used as references for the formulation of entrepreneurship policies, such as Iceland, Chile, Taiwan, United Arab Emirates, Luxembourg, Estonia and Slovenia proved to be efficient at all stages. Fact, which makes them references in best practices for the development of entrepreneurial systems strategies.

5 Discussions

The GEI ranks United States, Switzerland, Canada, Sweden and Denmark as world-leaders in NSE's performance. While countries as Iceland, Chile, Taiwan, United Arab Emirates, Luxembourg, Estonia and Slovenia have demonstrated high levels of aggregate productivity or efficiency in the generation of attitudes toward entrepreneurship, entrepreneurial activity and impacts. Compared to the GEI world-leaders, this group of countries represent a sample of NSEs where the results of entrepreneurial systems are greater than resources invested.

Countries are classified by the GEI according to their overall performance, which is obtained by aggregating pillars (both inputs and output variables, which represent the individual and institutional factors). It is widely held in the entrepreneurship literature that institutional context is essential to drive the creation and development of high-impact firms (Ács, Stam, Audretsch, & O'Connor, 2017; Boschma & Martin, 2010; Brown & Mason, 2017; Radosevic & Yoruk, 2013). In reality, institutional context and individuals are relevant (Ács, Autio, et al., 2014). Without individuals 'action, entrepreneurship does not take place. Additionally, impacts arising from entrepreneurial activity will be affected by the appropriateness of context. So, for a country to benefit from the impacts of entrepreneurship, there must be a balance between institutional context and entrepreneurial actions (Ács, Autio, et al., 2014; Bowen & De Clercq, 2008). Both institutional context and individuals are present in the GEI.

However, in the GEI reports, there are a lack of discussions associated with the interdependent relationships between investments (inputs) and results (outputs), which makes it difficult for the reader or policymaker to perceive the need for efficiency in efforts to develop systems of entrepreneurship. Countries with an overall GEI performance close to "100.00" points are considered references, such as the United States, Switzerland, among others, and countries with pillars with a score close to "1.00" are considered as best practices references in specific issues, as product innovation. Thus, when applying an efficiency frontier method, like DEA to the GEI data, dividing institutional and individual variables into inputs and outputs, we identify which entrepreneurship are efficient. Also, when expanding our analysis from the conventional DEA model to a three-stage model, considering the intermediate measures and the interdependencies between variables. We could identify the efficiency of the countries at each stage of the entrepreneurial process. From this approach, we identified that shows general efficiency can be inefficient in some stages.

In this sense, assessing the contribution of each contextual factor to the production of entrepreneurial results is an issue that must be extended to policymaking in less developed economies, which have few resources to promote entrepreneurial system development and, whey they do, are based on anecdotal evidences from countries at the top of the performance index ranking. Also, the use of the three-stages DEA allows us to identify the differences in efficiency in each of the stages. As well minimizing the levels of endogeneity or feedback loops (Godley, Morawetz, & Soga, 2019), present in analytical frameworks which not very flexible (Spigel, 2017). Thus, minimizing the challenges for policymakers to develop supportive policies based on cause and effect relationships and in the multidimensional and multifunctional processes of entrepreneurial systems. A simple illustration can be given by the association between educational levels of the entrepreneurs (as an output indicator) and the educational system (taken an input). This bidirectional causality is reduced by the three-stage model, as output indicators become inputs in subsequent stages. Similar examples of bidirectional causality can be easily drawn from the variables present in Appendix 1.

Finally, our analysis allows us to question the parameters for the benchmarking of entrepreneurship policies which are based on simplistic assessments of aggregated classifications. These scores often address systemic issues from an “additive” perspective, mixing inputs and outputs as similar sets of resources, and without interdependent or correlated cause and effect relationships. Such simplistic views often point to the United States as a benchmark for best practices for other countries to base their own entrepreneurial policies. Even though entrepreneurial activity in this country has been declining in recent decades. Thus, looking more closely at other entrepreneurial systems with higher productivity levels can be a viable option for establishing emerging systems of entrepreneurship.

6 Concluding remarks

The conventional DEA models view DMUs as black boxes which uses a set of inputs to generate a set of outputs and do not take into consideration the intermediate inputs and multidimensional and multifunctions in the entrepreneurial process. As a result, some intermediate measures are lost in the process of changing the inputs to outputs. In this study, we investigated the country-level efficiency though the decomposition of GEI sub-indices in a three-stage DEA model.

The results have direct implications for the assessment of entrepreneurial systems and the entrepreneurship policies designed to boost high-impact entrepreneurship. When policymakers consider the factors that make up NSEs, they must consider the most rational ways of allocating available resources to generate attitudes towards the entrepreneurship and productivity entrepreneurship. Only considering ranking leaders as benchmarks can provide misguided insights formulating supportive policies. As we have shown, the world-leaders in the GEI ranking are not necessarily efficient (not in all stages), a fact which compromises the reproduction of their initiatives in countries which have scarce resources. On the other hand, systemic outputs can be obtained through different configurations, so an inflexible analytical framework based on an “additive" perspective of the entrepreneurial system can limit the adequacy of policies for heterogeneous contexts. In this sense, the efficiency of resource allocation should be incorporate into entrepreneurship supportive policies.

These findings do not go without limitations. First, the very measure of early-stage entrepreneurship used by the GEI to capture the aspirations of entrepreneurial activity in terms of technological innovation and high-growth expectation can limit the assessment of the impacts of entrepreneurship in developing countries, especially those in Latin America, whose ventures tend to have a socioeconomic impact after a few years of trial and error (Kantis, Federico, & Garcia, 2015; Kantis, Ishida, & Komori, 2002) and also tend to show fluctuation in performance trajectory (Garnsey & Heffernan, 2005; Garnsey, Stam, & Heffernan, 2006).

Second, the results of the efficiency analysis portray country-level performance in 2019. Thus, further research is needed to address evolutionary traits of countries 'efficiency performance observed over time. Considering the policy appeal of the entrepreneurial ecosystem concept, as well as impacts arising from related activities, these are issues of utmost importance to advance in both empirical and theoretical terms.

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Appendix 1 – GEI's Sub-Index, pillars and variables

Entrepreneurial attitudes sub-index		
Opportunity perception	Opportunity recognition	It measures people's ability to recognize business opportunities
	Freedom and property	It represents the overall burden of regulation and the capacity of government of enforce contracts
Start-up skills	Skill recognition	It refers to the population that claims to have adequate startup skills
	Education	It measure the quality of education
Risk acceptance	Risk perception	It refers to the population that claims to have not feared of failure
	Country risk	It represents the countries' financial, and macroeconomic climate
Networking	Know entrepreneur	It refers to the population that claims to know an entrepreneur personally
	Connectivity	It measures the urbanization and quality of transport infrastructure
Cultural support	Career status	It measures population cultural support to entrepreneurship as a career choice
	Corruption	It refers the degree of countries' transparency
Entrepreneurial abilities sub-index		
Opportunity startup	Opportunity motivation	It refers to entrepreneurs driven by an opportunity to increase income
	Governance	It refers to administrative burden in paying taxes of the medium-size companies and governmental efficiency
Technology absorption	Technology level	It measures the early-stage firms in medium or high-tech sectors
	Tech absorption	It represents the firms' ability to incorporate new technologies
Human capital	Education level	It refers to firms founded by individuals with high-education
	Labor market	It refers to the legal and regulatory framework of labor market firms' investment in trading and employee development
Competition	Competitors	It captures the level of novelty of a product in a market
	Compregulation	It measures the effectiveness of anti-monopoly policy, and the characteristics of countries' domestic market
Entrepreneurial aspirations sub-index		
Product innovation	New product	It refers to early-stage firms that offer new products to consumers
	Technology transfer	It measures the investment in R&D by business sector and the quality of S&T institutions and industry-university cooperation
Process innovation	New technology	It refers to early-stage firms that using new technologies
	Science	It refers to gross domestic expenditure on R&D as percentage of GDP, the quality of scientific institutions and the availability of scientists and engineers
High-growth	Gazelle	It reflects early-stage firms with a high expectation of job creation
	Finance and strategy	It measures to the availability of venture capital and the ability of firms to pursue differentiation strategies
Internationalization	Export	It measures early-stage firms that reach out to international markets
	Economic complexity	It assesses the accumulation of productive knowledge (capabilities)
Risk capital	Informal investment	It refers to individuals that provided funds for new business
	Depth of capital market	It refers to financial support tools for firms' development

Source: Elaborated by the authors based on Ács, Szerb, Lafuente and Márkus (2019)

Appendix 2 – Sample' row data

Country	Freedom and property	Education	Country risk	Connectivity	Corruption	Governance	Technology absorption	Labor market	Compregulation	Technology transfer	Science	Finance and strategy	Economic complexity	Depth of capital market	Opportunity recognition	Skill perception	Risk perception	Know entrepreneurs	Career status	Opportunity motivation	Technology level	Educational level	Competitors	New product	New tech	Gazelle	Export
Australia	1.0	1.0	1.0	.79	.89	.89	.78	.83	.55	.75	.86	.63	.49	.98	.71	.57	.46	.47	.48	.9	.85	.97	.88	.63	.53	.79	.98
Austria	.87	.87	1.0	.73	.85	.86	.81	.84	.81	.84	.9	.66	.92	.71	.70	.6	.47	.57	.47	.85	.92	.53	.78	.68	.43	.44	.84
Belgium	.89	.96	1.0	.96	.86	.81	.79	.72	.85	.85	.86	.77	.75	.77	.58	.35	.36	.28	.33	.4	.92	.95	.83	.74	.70	.56	.95
Canada	.96	.79	1.0	.80	.93	1.0	.71	.78	.69	.76	.77	.76	.76	1.0	.81	.6	.52	.48	.51	.77	.74	1.0	.91	.75	.57	.73	1.0
Chile	.79	.76	1.0	.74	.79	.79	.63	.62	.41	.52	.44	.59	.48	.81	.91	.83	.74	.72	.59	.66	.61	.74	.97	1.0	.76	.94	.64
Denmark	1.0	.96	1.0	.93	1.0	1.0	.82	.99	.86	.89	.94	.63	.78	.75	.77	.38	.50	.51	.46	1.0	1.0	.98	1.0	.84	.40	.69	.51
Estonia	.90	.82	1.0	.62	.79	.69	.69	.59	.61	.64	.75	.63	.67	.4	.75	.51	.38	.63	.43	.8	.66	.72	.91	.71	.74	.70	.84
Finland	.98	1.0	1.0	.94	1.0	1.0	.87	.64	.68	1.0	1.0	.95	.95	.81	.69	.42	.52	.69	.46	.83	.71	.58	.36	.61	.42	.58	.71
France	.81	.75	1.0	.86	.79	.69	.72	.46	.71	.83	.86	.73	.85	.9	.41	.39	.46	.53	.52	.83	.97	.95	.96	.63	.69	.66	.77
Germany	.95	.84	1.0	.80	.91	.84	.83	.59	.89	.98	.93	.83	1.0	.92	.58	.42	.42	.36	.53	.76	.85	.62	.86	.61	.50	.61	.74
Iceland	.97	.99	1.0	1.0	.89	.94	1.0	.68	.51	.74	.87	.63	.78	.37	.73	.59	.64	.76	.38	1.0	1.0	.60	.88	.71	.64	.76	.99
Ireland	.86	.95	1.0	.57	.84	1.0	.76	.80	.74	.82	.77	.7	.8	.62	.56	.55	.51	.53	.54	.66	.87	1.0	1.0	.75	.72	.9	.88
Israel	.72	.73	1.0	.72	.68	.74	.96	.64	.34	1.0	1.0	.91	.77	.78	.76	.45	.3	.76	.72	.76	1.0	.97	.57	.79	.67	.72	.70
Japan	.84	.76	1.0	1.0	.84	.74	.98	1.0	1.0	.99	1.0	.86	1.0	.96	.14	.12	.43	.24	.2	.63	.94	.91	.32	.73	.60	.98	.59
Luxembourg	.81	.35	1.0	.91	.91	.99	.93	.53	.81	.85	.66	.9	.94	.51	.68	.48	.37	.55	.37	.98	.85	.89	1.0	.96	.79	.49	1.0
Netherlands	.92	1.0	1.0	1.0	.98	.97	.79	.76	.92	.95	.83	.81	.82	.84	.71	.50	.57	.51	.71	.84	.84	.41	.66	.58	.62	.54	.69
Norway	.98	.97	1.0	.74	.98	1.0	.96	.58	.8	.86	.77	.91	.77	.89	.96	.35	.71	.49	.67	.93	.81	.56	.65	.33	.29	.46	.39
Qatar	.67	.35	.44	1.0	.8	.77	.84	.83	.89	.85	.53	1.0	.47	.69	.92	.76	.85	.54	.94	.73	.41	.89	.73	.68	1.0	.90	.71
Slovenia	.66	.87	1.0	.45	.67	.74	.54	.53	.48	.59	.85	.44	.86	.3	.31	.59	.55	.6	.49	.61	.82	.78	.78	.75	.52	.63	.87
Sweden	.95	.78	1.0	.86	1.0	.97	.92	.64	.79	.97	.98	.86	1.0	.86	1	.42	.52	.59	.47	.82	1.0	.82	.92	.64	.58	.60	.83
Switzerland	.87	.87	1.0	.87	.97	.95	.96	.92	.94	1.0	.96	.88	1.0	.88	.65	.51	.63	.44	.34	.81	.9	.73	.75	.68	.50	.59	.93
Taiwan	.82	.88	.79	.78	.69	.73	.74	.58	.81	.88	.86	.84	.76	.89	.5	.30	.53	.55	.62	.98	.61	.99	.27	.94	.55	.98	.62
United Arab Emirates	.58	.41	.61	.99	.79	.82	.96	.91	.89	.72	.51	.93	.46	.77	.66	.78	.41	.48	.7	.89	.47	.98	.42	.81	.98	.94	.85
United Kingdom	.97	.73	1.0	.80	.91	.94	.82	.79	.82	.86	.79	.89	.90	.98	.63	.54	.59	.47	.61	.78	.98	.81	.74	.61	.61	.69	.69
United States	.87	1.0	1.0	.85	.85	.81	.97	1.0	.86	1.0	.95	1.0	.97	1.0	.73	.67	.71	.45	.67	.86	.84	.98	.98	.68	.56	.89	1.0

Source: Global Entrepreneurship Index (Ács et al., 2019)