RELISE

OPENING THE BLACK BOX OF ENTREPRENEURIAL SYSTEMS: AN APPLICATION OF THREE-STAGE DEA ON GLOBAL ENTREPRENEURSHIP INDEX[1]

ABRINDO A CAIXA PRETA DOS SISTEMAS EMPREENDEDORES: UMA APLICAÇÃO DA DEA DE TRÊS ESTÁGIOS NO GLOBAL ENTREPRENEURSHIP INDEX

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ABSTRACT

Entrepreneurship is one of the key factors contributing to the countries' economic growth. 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 goes 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: productive entrepreneurship, network DEA, key-performance indicators.

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RESUMO

O empreendedorismo é um dos principais fatores que contribuem para o crescimento econômico dos países. A implementação de estratégias de Sistemas Nacionais de Empreendedorismo (NSE) para melhorar o desempenho empreendedorl em nível nacional tornou-se, portanto, um dos desafios mais importantes para os formuladores de políticas. O desempenho do NSE é altamente influenciado pelas complexidades das interações entre os indivíduos/empreendedores e seu contexto institucional. Um modelo de avaliação que vá além de um pensamento agregador de pontuação e incorpore os aspectos multidimensionais do processo empreendedor é altamente necessário. Este estudo empregou um método de Análise de Envoltória de Dados (DEA) de três estágios para medir a eficiência em nível de país. Nossos achados mostram que países considerados líderes mundiais em empreendedorismo, como os Estados Unidos, são ineficientes em algumas etapas do processo empreendedor. Enquanto isso, países como Chile, Estônia e Eslovênia são mais eficientes. As implicações de nossa pesquisa abrangem a necessidade de os formuladores de políticas desenvolverem um conhecimento mais aprofundado sobre seu próprio NSE.

Palavras-chave: empreendedorismo produtivo, DEA network, indicadores-chave de desempenho.

INTRODUCTION

Assessing country-level efficiency in terms of entrepreneurial activity 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 (DIONISIO; INÁCIO JR.; FISCHER, 2021). 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 thought in entrepreneurship literature, the systems of entrepreneurship approach is a useful tool for the design of entrepreneurship policies at national or regional level (QIAN; ÁCS; STOUGH, 2015).

The National Systems of Entrepreneurship (NSE) approach was introduced in the 2010s by Ács, Autio, and Szerb (2014). It enjoys wide currency

in both academic and policymaking context and is considered a useful tool for academic study and for the development of entrepreneurship policies, fostering and understanding of entrepreneurial processes and its determinants (AUTIO et al., 2014; TASNIM; AFZAL, 2018). From a general perspective, an NSE is the interactions between individuals (entrepreneurs or potential entrepreneurs) and their contexts in producing productive entrepreneurship and regulating entrepreneurial performance and its impacts (QIAN; ÁCS, 2013). With the introduction of NSE approach, Ács, Autio, and Szerb (2014) developed an index, called Global Entrepreneurship Index (GEI) to measure the NSEs interactions among individuals (entrepreneurs) and their 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 et al., 2016). National entrepreneurship policymakers and governments mostly concern themselves with system efficiency as closely related to the entrepreneurial input/output ration and emphasize the effect of public intervention of the NSE efficiency. However, even though the GEI measures entrepreneurial systems, this index was not designed to assess countries' efficiency in generating productive 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 (INACIO JUNIOR et al., 2021).

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 et al., 2002, p. 7). In this sense, efficient NSEs 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 drives the aggregate levels of competitiveness in entrepreneurial systems 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; BRADSHAW; BROCKMAN, 2018). These shortcomings end up compromising the quality of policymaking processes dealing with the promotion of entrepreneurship. Our inquiry in this paper 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’ entrepreneurial systems performance, 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, 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.

This paper is structured as follows. After this introductory argument, the second secontion provides an overview of National Systems of Entrepreneurship (NSEs). The third section presents our methodological approach. Empirical findings are explored in the fourth section, and the fifthsection 5 discusses results in light of dedicated literature and implications. The final section concludes with remarks, limitations, and suggestion for future research.

NATIONAL SYSTEM OF ENTREPRENEURSHIP IN PERSPECTIVE

Within the general framework of entrepreneurial systems, emphasis usually rests on the case of productive entrepreneurship. In addition to contributing to job generation, high impact firms contribute in a pioneering way to the economy in sectors where technologies and market segments are in the less advanced stages. In these cases, despite 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, 2006; WEST; BAMFORD, 2005).

Entrepreneurship represents a bridging mechanism between technical knowledge and product/services (ARROW, 1962). In a similar vein, Kirzner (1997) defines the entrepreneur as an individual who explores market opportunities and brings relative balance to markets. Hence, 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, attitudes, and preferences of individuals toward starting their own business must be part of the equation (ÁCS; AUTIO; SZERB, 2014). These matters are often associated with comprehending of individuals' 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 competencies, understood as the capacity of individuals to effectively seize opportunities by establishing competitive advantages (BARTELSMAN; HALTIWANGER; SCARPETTA, 2004).

However, 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, through 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 with the career choice of the individuals (AUTIO; PATHAK; WENNBERG, 2013; KANTIS; FEDERICO; GARCÍA, 2020). For these reasons, a systemic thinking of 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), 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 intentions 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 et al., 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).

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; AUTIO; SZERB, 2014). This approach allows the recognition of problems that inhibit entrepreneurship and the identification of areas that need regulatory intervention (KANTIS; FEDERICO; GARCÍA, 2020). In sum, the NSE approach considers the creation of firms as the product of a process influence by a series of interdependent factors which affect the life cycle of early-stage entrepreneurs (APARICIO; URBANO; GÓMEZ, 2016).

Hence, the NSE approach evaluates the developmental trajectories of the productive entrepreneurship in countries, considering the contextual and individual aspects of entrepreneurship (ÁCS; AUTIO; SZERB, 2014; NICOTRA et al., 2018). Accordingly, this approach goes beyond the “market failure” perspective for policymaking, which is not capable of contemplating the social and systemic aspects that interfere 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, financing, supportive services, etc.) to entrepreneurs, and, in turn, these individuals allocate these resources to create new ventures (STAM; VAN DE VEN, 2021). In the context, the GEI provides information on the performance of NSEs that go beyond startups rates or isolated institutional frameworks assessments. The GEI uses the benchmarking approach by key performance indicators (KPIs) to establish the profile of NSEs (LAFUENTE; SZERB; ÁCS, 2016). However, this approach

is not designed to consider complete interaction between factors of production and the 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 (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.

RESEARCH DESIGN

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 a 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, i.e., 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 et al., 1994; TONE; SAHOO, 2003).

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.

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

Subject to: $\sum_{k=1}^{K} \lambda_k y_{k,m} \geq \theta_k y_{k,m}$ $\quad m = 1, \ldots, m$

$\sum_{k=1}^{K} \lambda_k x_{k,j} \leq x_{k,j}$ $\quad j = 1, \ldots, j$

$\sum_{k=1}^{K} \lambda_k = 1$

$\lambda_k \geq 0$ $\quad K = 1, \ldots, k$

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 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 was 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; FERNÁNDEZ DE LUCIO; GUTIÉRREZ GRACIA, 2003; ZABALA-ITURRIAGAGOITIA et al., 2007).

Method and sample

Our sample encompassed data from the Global Entrepreneurship Index (GEI) 2019 for 25 countries. The GEI approach has been formulated to measure

the productive entrepreneurship and to understand the factors and structural aspects that influence entrepreneurship (ÁCS et al., 2019). This index was developed with the purpose of providing comparative analysis on the factors which interfere in entrepreneurship at country-level (ÁCS; AUTIO; SZERB, 2014).

The GEI is structured around 14 pillars (KPIs) 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). The 1st sub-index is composed of five pillars that assess the population's attitudes toward entrepreneurship, through the combination of individual variables that quantify the proportion of the population that has entrepreneurial intentions and institutional variables that reflects the possibilities and opportunities to undertake, as well as a country's socioeconomic climate. The 2nd sub-index is composed of four pillars which show a profile of early-stage firms, though the combination of individual variables that measures the new firms in terms of technological intensity, motivation, and product and/or service uniqueness, and institutional variables that reflect the business environment. The 3rd sub-index has five indicators that measure the performance of the entrepreneurial activity, i.e., the individual variables measure new firms in terms of technological innovation, growth and internationalization efforts, while institutional variables capture the context characteristics that affect the emergence of high-impact entrepreneurship, such as availability of venture capital and the quality of the innovation systems. Details of sub-indices and pillars are described in Appendix 1. Due to the restriction of pages, it was decided to mention only the variables used to measure the efficiency score of each country. The collected data is publicly available on the Global Entrepreneurship and Development Institute (GEDI) web page at http://thegedi.org.

For our inquiry, we divided GEI variables into input and output indicators, following Bogetoft's (2012, p. 51) definitions: "production theory defines the inputs as resources expended and outputs as the outcome of the process that has an external value". According to this reasoning, NSEs inputs refer to resources that influences the attitudes toward entrepreneurship, and the creation and development of new business. In its turn, NSEs outputs refer to the performance and impacts of new business. We focus on 27 variables of the three dimensions of GEI. To classify individual and institutional variables into input and outputs indicators, we rely on the previous studies (GEDI, 2015; INACIO JUNIOR et al., 2021). In addition, the three-stage DEA or network DEA allows the classification of indicators as intermediate inputs and/or outputs (BOGETOFT, 2012). This approach allows the observation of the entrepreneurship event as an interdependent or multidimensional phenomenon instead of a linear process. 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: GEI 2019 report
Note: Elaborated by Authors

The 1st Stage consists of all variables of attitudes sub-index. Institutional/contextual variables influence the population's ability to recognize opportunities to undertake, as well as their startup skills, risk perception and recognition and appreciation of entrepreneurs. Therefore, a favorable environment for entrepreneurship affects the presence of entrepreneurial behavior in the country population (KANTIS; FEDERICO; GARCÍA, 2020).

A population with entrepreneurial attitudes is a prerequisite for the entrepreneurial event, i.e., creation of new innovative and/or technology-based firms. However, these firms appear in contexts favorable to innovation, where there are supportive policies and regulations favorable to entrepreneurship, and a business structure whose history is one of absorbing technology and investments in the formation of human capital (BOWEN; DE CLERCQ, 2008; QIAN; ÁCS, 2013). Thus, we define the five outputs of Stage 1 in input indicators of Stage 2 and add the four variables of the ABT sub-index as intermediate input (governance, tech absorption, regulation and labor market) and, finally, we define the opportunity motivation, technology level, educational level and competitors as outputs.

Innovative and/or technology-based firms are those which have the potential to become HIFs. However, its growth depends on an innovative environment, the S&T infrastructure, the existence of financing mechanisms and the productive structure (BOWEN; DE CLERCQ, 2008; KANTIS; FEDERICO; GARCÍA, 2020; RADOSEVIC; YORUK, 2013). In this sense, we define the four outputs of Stage 2 in input indicators of Stage 3 and apply the five original variables of the ASP sub-index as intermediate inputs, finally, we define the new product, new technology, gazelle, and export as outputs.

In addition the overall efficiency is calculated used all institutional variables (freedom and property, education, country risk, connectivity, corruption, governance, tech absorption, regulation, labor market, tech transfer, science,

finance and strategy, economic complexity and depth of capital market) as input indicators, while 13 of 14 individual variables (opportunity recognition, skill recognition, risk perception, know entrepreneurs, career status, opportunity motivation, technology level, educational level, competitors, new product, new technology, gazelle and export) as output indicators. The informal investment variable was not used in the overall efficiency model and the three-stage DEA because it has no input-output relationship with its institutional variable “depth of capital market” (see GEDI, 2015).

Finally, to measure efficiency of each Stage and overall performance we use the Variable Returns to Scale (VRS) in a sample of 24 countries and SAR Taiwan selected by high-performance in 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, United Arab Emirates, United Kingdom and United States.

EFFICIENCY ANALYSIS

Table 2 shows countries’ overall inefficiency in column four. Countries with inefficiency scores above 0.000%, like Finland (5.200) and Germany (5.500) are considered inefficient. From column five through six, Table 2 shows the inefficiency scores for each of the entrepreneurial systems components. Each of the components represents one of the resource allocation stages of entrepreneurial systems. The first stage refers to entrepreneurial attitudes. At this stage, inefficiency rates range from 2.100 to 97.70%. Although these rates are quite different, countries with scores above 0.000% are considered inefficient. Fourteen NSEs are in this situation, they are Ireland (2.100%), Finland (9.200%), United States (10.70%), Canada (15.80%), Netherlands (20.40%), United Kingdom (23.40%), Denmark (24.20%), Austria (26.10%), Switzerland (26.20%),

Australia (30.30%), France (32.80%), Germany (42.50%), Belgium (62.20%), and Japan (97.70%).

Table 2 – Countries' efficiency scores

	GEI		Overall inefficiency	Inefficiency score of each stage (%)		
Country	Rank	Score	(%)	Stage 1	Stage 2	Stage 3
United States	1	83.37	0.000	10.70	0.000	0.000
Switzerland	2	77.96	0.000	26.20	3.400	0.000
Canada	3	75.60	0.000	15.80	0.000	0.000
Sweden	4	75.47	0.000	0.000	0.000	17.60
Denmark	5	74.06	0.000	24.20	0.000	17.40
Iceland	6	73.49	0.000	0.000	0.000	0.000
Australia	7	72.51	0.000	30.30	0.000	0.000
United Kingdom	8	71.29	0.000	23.40	0.000	21.90
Ireland	9	70.96	0.000	2.100	0.000	0.000
Netherlands	10	67.79	0.000	20.40	11.30	0.000
Finland	11	66.91	5.200	9.200	9.100	0.000
Germany	12	64.87	5.500	42.50	0.000	8.800
France	13	64.09	0.000	32.80	0.000	14.30
Austria	14	63.46	0.000	26.10	6.500	0.000
Belgium	15	62.98	0.000	62.20	0.000	0.000
Taiwan	16	60.68	0.000	0.000	0.000	0.000
Israel	17	59.08	0.000	0.000	0.000	8.800
Chile	18	58.85	0.000	0.000	0.000	0.000
United Arab Emirates	19	58.80	0.000	0.000	0.000	0.000
Luxembourg	20	58.13	0.000	0.000	0.000	0.000
Qatar	21	57.95	0.000	0.000	9.700	0.000
Norway	22	55.87	0.000	0.000	0.000	47.10
Estonia	23	55.54	0.000	0.000	0.000	0.000
Japan	24	51.72	0.000	97.70	0.000	0.000
Slovenia	25	51.49	0.000	0.000	0.000	0.000
Efficiency score average:			0.420	16.94	1.600	5.440

Source: GEI report (2019)
Note: Elaborated by Authors

Regarding the second stage, called entrepreneurial skills - which is related to technology-based entrepreneurial activity and the uniqueness of the products offered by early-stage entrepreneurs - only five inefficient countries were identified: Switzerland (3.400%), Austria (6.500%), Finland (9.100%), Qatar (9.700%), and Netherlands (11.30%). At this stage, inefficiency rates vary as little as 3.400 to 11.30%. The third stage entitled entrepreneurial aspirations refers to entrepreneurial innovation. At this stage, inefficiency rates range from 8.800 to 47.10%. Unlike the previous stage, in stage 3, more inefficient countries (7) were

identified, namely Germany (8.800%), Israel (8.800%), France (14.30%), Denmark (17.40%), Sweden (17.60%), United Kingdom (21.90%), and Norway (47.10%).

Table 2 also shows the average inefficiency scores for each of the entrepreneurial systems stages (Stage 1: 16.94%; Stage 2: 1.600%; Stage 3: 5.440%). We identified that the average inefficiency rate for stage 1 is higher than the scores for the other stages. This indicates that most entrepreneurial systems are characterized by low attitudes towards entrepreneurship. On the other hand, the low inefficiency rates of the other stages indicate that most of the analyzed systems are efficient in terms of resource allocation for the creation of productive entrepreneurship, characterized by technological intensity, technological innovation, and growth in terms of number of employees.

However, in individual terms, when we analyze stage 3, according to the GEI database that was used in this research, we identify that the entrepreneurial systems of France, Sweden, Norway, and the United Kingdom are characterized by few early-stage entrepreneurs that introduced innovative technologies, with expectations of growth and low entry into the foreign market in terms of exports. In Germany and Sweden, entrepreneurial activity is also underperforming, but some early-stage entrepreneurs have accessed foreign markets.

Finally, we identified that the United States, despite constantly leading the rankings of the GEI annual reports, is inefficient in Stage 1, that is, in terms of resource allocation to boost attitudes in favor of entrepreneurship. In addition, we identified that countries that are traditionally not associated with centers of entrepreneurship, such as Iceland, Chile, United Arab Emirates, Luxembourg, Estonia, Slovenia, and the Chinese province of Taiwan, were efficient in all stages of entrepreneurial systems.

DISCUSSION

The GEI ranks the United States, Switzerland, Canada, Sweden, and Denmark as world leaders in terms of high-performance entrepreneurial systems. However, our empirical exercise showed that the entrepreneurial systems of Iceland, Chile, Taiwan, United Arab Emirates, Luxembourg, Estonia, and Slovenia are efficient in allocating resources to build an environment that stimulates attitudes in favor of entrepreneurship. Although not all entrepreneurial intentions turn into entrepreneurial actions, the lack of entrepreneurial attitudes undermines the existence of future and/or potential entrepreneurs (KANTIS; FEDERICO; GARCÍA, 2020). For, in societies where entrepreneurship is devalued as a career choice or where the opportunity cost of leaving a job to undertake is very high, they tend to show low rates of entrepreneurial activity (AMIT; MULLER; COCKBURN, 1995; DARNIHAMEDANI et al., 2018), a fact that can harm the strengthening of entrepreneurial systems in terms of the flow of information and distribution and/or recycling of resources for productive purposes (SPIGEL; VINODRAI, 2020).

Countries are classified by the GEI according to the overall performance of their respective entrepreneurial systems, which is obtained by aggregating indicators (both input variables and output variables, which represent individual and contextual factors of entrepreneurship). There is a consensus in the literature on entrepreneurship that the entrepreneurial context affects the existence of productive entrepreneurship (ÁCS et al., 2017; AUTIO et al., 2014; BROWN; MASON, 2017; ROUNDY; BRADSHAW; BROCKMAN, 2018; STAM; VAN DE VEN, 2021). However, both the context and the individuals are relevant to the functioning of entrepreneurial systems, because, without the action of individuals, entrepreneurship does not occur (ÁCS; AUTIO; SZERB, 2014; KANTIS; FEDERICO; GARCÍA, 2020; STANGLER; BELL-MASTERSON, 2015). On the other hand, without an entrepreneurship-friendly context, i.e., one that offers

resources, especially financial resources, productive entrepreneurship does not take place (AUDRETSCH et al., 2016; DUTTA; MEIERRIEKS, 2021; FLORIDA; MELLANDER, 2016; FREILING; BARON, 2017; GIRAUDO; GIUDICI; GRILLI, 2019). In this sense, for entrepreneurial activity to become productive, i.e., to contribute to the transformation of knowledge into innovations and to job creation, there must be both a favorable entrepreneurial context and actions in favor of productive entrepreneurship (AUTIO et al., 2014; NICOTRA et al., 2018).

Although the GEI was developed from the systemic perspective of entrepreneurship, i.e., considering the interactions between individuals (entrepreneurial action) and their respective contexts, the index lacks discussions on the dynamics of entrepreneurial systems in terms of the efficiency allocation of available resources in the context for productive entrepreneurship purposes. This occurs, above all, because the GEI uses the variable interaction method, i.e., it builds its indicators from the multiplication of a contextual variable and an individual one (entrepreneurial action). The indicators are used to comparatively analyze the performance of entrepreneurial systems, e.g., to compare the performance of countries in terms of product innovation. However, as it is an aggregate measure, this way of constructing the indicators leads to misinterpretation, making it impossible to identify the quality of the context and/or entrepreneurial action. Furthermore, as both context variable (inputs) and individual variables (outputs) are aggregated into a single indicator, it is not possible to assess the efficiency of entrepreneurial systems in terms of resources allocation.

When we split the GEI's contextual and individual variables into inputs and outputs and apply an efficiency frontier method such as DEA, it allowed us to identify which entrepreneurial systems are efficient. However, as the GEI is an entrepreneurship index that measures the quality of systems through the aggregation of three subindices, applying a conventional DEA model would not

be adequate to assess the efficiency of the three dimensions that make up an entrepreneurship system, therefore, in systems where multiple inputs generate multiple outputs, it is more appropriate to use a DEA network model. Given this limitation, we applied the three-stage DEA network model, considering intermediate measures and interdependencies between variables. We managed to identify the efficiency of the countries in each stage of the entrepreneurial process. From this approach, we identified that entrepreneurial systems that presented global efficiency may be inefficient in some stages.

The three-stage approach allows for identifying the contribution of each contextual factor to the production of productive entrepreneurship results. This is an issue that should be extended to the formulation of policies to support entrepreneurship, especially in infant and/or immature systems, which have few resources to promote the development of the entrepreneurship system and, when they elaborate entrepreneurship policies, they do, based on anecdotal accounts of mature entrepreneurial systems, such as that of the United States and other countries at the top of the GEI ranking. In addition, the three-stage DEA allows for identifying efficiency differences in each of the stages, as well as minimizing endogeneity levels or feedback loops (GODLEY; MORAWETZ; SOGA, 2019), present in inflexible analytical frameworks (SPIGEL, 2017). For example, the GEI has variables that measure similar aspects of the quality of a system, such as the quality of the education system, in terms of higher education enrollment rates and the proportion of entrepreneurs with tertiary education. The education system is defined by the GEI as an input for the generation of outputs in terms of individuals with perceived entrepreneurial skills (GEDI, 2015). However, the educational system also generates entrepreneurs with tertiary education, who are more likely to develop innovative ventures (ASTEBRO; BAZZAZIAN; BRAGUINSKY, 2012; COLOMBO; PIVA, 2020; HUYNH et al., 2017; MAYHEW et al., 2012; MORAES et al., 2021). In this sense, the level of education of entrepreneurs can be seen

as a system's output and at the same time as an input, as entrepreneurs with tertiary education are often responsible for the development of productive enterprises (MAYHEW et al., 2012; WALTER; BLOCK, 2016). In this sense, the three-stage DEA, by considering the duality of factors and using output variables as input variables in subsequent stages, minimizes the challenges for policymakers to develop entrepreneurship policies based on cause-and-effect relationships and processes multidimensional aspects of entrepreneurial systems.

Finally, our study allows us to question entrepreneurship indices, such as the GEI, which are based on aggregated indicators and classify economies from an additive perspective, mixing inputs and outputs, without considering interdependent cause-and-effect relationships. This form of classification points to countries with the highest scores in all indicators as references for best practices in entrepreneurship systems. However, by disregarding the efficiency relationships between contextual resources and entrepreneurs, these indices often point to the United States as a reference for an entrepreneurial system, as this country has a favorable context for entrepreneurship, however, entrepreneurial activity has been decreasing in recent decades. In this sense, looking at the efficiency relationships between the systems is relevant to identify systems that, even with few resources, manage to obtain high levels of entrepreneurial output.

CONCLUSION

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 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 through 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 productive 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 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; GARCÍA, 2020; 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)