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An empirical investigation of country level efficiency and national systems of entrepreneurship using Data Envelopment Analysis (DEA) and the TOBIT model

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Abstract

The goal of this paper is to investigate effects of national systems of entrepreneurship on the country level efficiency, on addition we find what macro factors affect efficiency as well. From a comprehensive database of 59 countries using GEM, WDI, WCI for 2018 using data envelopment analysis (DEA) we find the results support the theoretical grounding of Global Entrepreneurship Index (GEI) hypothesis. The GEI methodology has been designed to capture the core features of the National Systems of Entrepreneurship theory. It approaches country-level entrepreneurship as a systemic phenomenon, which is driven by the interaction between individual-level actions and country-level framework conditions. While discussing country level framework, we have depicted key macroeconomic indicators in the analysis along with GEI index. The DEA analysis followed this framework to assess the performance of the study countries. Though inefficiency widely varies across countries, while the group of factor-driven countries is the most inefficient while innovation-driven economies are the most efficient ones. Subsequently, we apply the Tobit model to explain efficiency. Based on the Tobit regression model, the DEA VRS technical efficient score could be improved through GDP per capita and social capital. From policy perspective, to promote economic growth policy makers should consider national systems of entrepreneurship as their priority so that entrepreneurs can allocate resources in the economy effectively.

Keywords: Global entrepreneurship index 9GEI), Efficiency, Data envelopment analysis (DEA), Tobit model

Introduction

The simple correlation between research and development (R&D) expenditure and gross domestic product (GDP) growth reveals no systematic relationship of country level knowledge diffusion. Both Solow and new growth theory seems to offer no adequate explanation as to why countries with large R&D stocks grew slowly (such as Sweden), while other countries less endowed with knowledge—such as Denmark—experienced persistent and high growth rates (Barro, 1991). We believe that the ambiguous empirical support for endogenous growth models raise the issue of entrepreneurship concept as the key element of discussion in modern production function. To address this gap and to provide a coherent theoretical grounding for the Global Entrepreneurship Index (GEI) approach, we have advanced the theory of National Systems of Entrepreneurship using Data Envelopment Analysis (DEA)- a non-parametric empirical methodology.

Generally speaking, the country level productivity differences occur from both technology gaps and differences in efficiency (Fare et al., 1994; Boussemart et al., 2003; Mahlberg and Sahoo, 2011). From an economic perspective, Debreu (1951) introduced efficiency as it is related to the coefficient of resource utilization in terms of input usage or output production. Further Farrell (1957) developed the thought and, according to him efficiency is denoted by a distance function, which captures efficiency differences that is initiated in factors other than differences in technology.

Efficiency is a significant concept in economics. For example, in the field of economic growth technology and efficiency are combined used to evaluate productivity: In an economy how effectively given technology and factors of production are actually used is measured by efficiency.

The link between efficiency measures based on distance functions and economic theory now appears more apparent: if existing input factors are not combined efficiently a country will not be on the production possibilities frontier, regardless of the amount and quality of production factors of that country such as physical capital and labor. Even though there exists a large literature on distance functions now (see e.g., Cooper et al., 2011), to the best of our knowledge, the analysis on the impact of entrepreneurship in determining territorial efficiency remains empirically sparse beyond the simple correlation analysis between GDP and R&D expenditure.

By connecting knowledge diffusion and entrepreneurship in endogenous growth models (Braunerhjelm et al., 2010; Acs et al., 2009a, b) this paper seeks to gain a deeper understanding of efficiency differences at country level using National Entrepreneurship System (NES) concept.

The purpose of this paper is to analyze three issues. First, we analyze the effects of national systems of entrepreneurship on country-level efficiency. Second, we search whether efficiency is affected by corruption level of the country for implementing national system of entrepreneurship. Third, we scrutinize the relationship between efficiency and certain variables those are related to the regulatory environment to create and run a business and to the social capital networks (Morck et al., 2004).

This is an empirical application on international sample of 59 countries for 2018 and we use input data from the Global Entrepreneurship Index (GEI)—which captures the multidimensional nature of the country's entrepreneurship ecosystem—and macroeconomic data from the World Bank databases. To directly test the efficiency analysis using the GEI indicators in the production function, we use a Data Envelopment Analysis (DEA) frontier method. DEA is a non-parametric technique that yields a production possibilities frontier through linear programming (Cooper et al., 2011). For the applications in diverse and heterogeneous contexts analysts use DEA models for its flexible nature (Grifell-Tatje´ and Lovell, 1999; Epure and Lafuente, 2015). The second stage proposes a Tobit regression that demonstrates the effect of different macro variables in a country's obtained efficiency scores from DEA.

The results indicate that inclusion of the national system of entrepreneurship to the model contributes to explain efficiency differences significantly. Our findings support that entrepreneur centric development is the key for knowledge production and diffusion of the countries. Among the analyzed countries, we find that inefficiency is greater in less developed countries and we cannot come to a clear conclusion about the corruption ranking and the efficiency of the countries while explaining NES. Although inefficiency widely varies across countries, GDP per capita and social capital contribute positively to reduce inefficiency which is reported in TOBIT analysis results.

The following section presents the theoretical underpinning. Literature review section. Methodology section describes the data, country selection and the methodological approach. Data and Variables section presents the empirical findings, and Country selection section provides the discussion and concluding remarks.

Theoretical underpinning and hypothesis formulation

Romer (1990) and Aghion and Howitt (1992) discussed the more recent advance endogenous growth theory that has been based on the emergence of research and development-based models of growth in their seminal papers. The role of technological progress in the growth process is explained explicitly in these economic models. In R&D based models technology which is treated as an endogenous variable is the primary determinant of growth. The ideas of the traditional inputs of physical capital and labor are enhanced by these models. The traditional neoclassical growth model is the starting point for any study of economic growth, which is constructed by Solow (1957). Solow incorporates technological knowledge but assumes it as exogenous which is not the outcome of activity in an economy, it comes from outside and it impacts the efficiency of labor. According to Solow as technology is given accumulation of capital was crucial and central to a country's growth rate. The part of growth that capital and labor increases could not explain was the residual that accrued from technology change. Cobb-Douglas production function is the simplest version of the Solow-Swan model:

$$Y = K^{\alpha}\left(AL^{1-\alpha}\right), 0 < \alpha < 1$$

Here Y, K, L are output, capital and labor respectively. 'A' is exogenous technological knowledge improving productivity of labor. Because technology comes outside the economy the Solow growth model assumes constant returns to scale and diminishing marginal returns to capital. The diminishing marginal returns to capital are continually offset by technological progress so the growth rate of output per person does not fall to zero. Solow exhibits that when they exactly offset each other the economy approaches a steady state and the output/ capital ratio is constant and growth rate is zero. The only parameter affecting the growth rate and breakdown the steady state is the exogenous rate of technological progress. Realizing the importance of technology in growth and assuming that technological changes occur within the economy, the endogenous growth theory was introduced. The endogenous growth models developed by Romer (1990) and Aghion and Howitt (1992) (commonly referred as Schumpeterian growth theory) enhanced the idea of Solow (Aghion and Howitt, 1992) by introducing human capital and technological innovation were central notions in their theory, which posited that human capital exhibits increasing returns and that well-educated individuals tend to invent new things. Attempts to take advantage of those new things (i.e., technological advances) are what drive economic growth. Interestingly, they also used the term "entrepreneur," although not to refer to individuals who start new firms but to inventors who create and exploit technological advances (Pekka et al., 2013).

(Abdih and Joutz, 2006, p. 244) states that the other source of productivity differences come from efficiency rather than only stock of R&D workers and technological advancement. Thus, we can measure productivity, P as

$$P = T \times E \tag{3}$$

T is a measure of technology, and E is a measure of efficiency. Wide differences in the level of both technology and productivity are shown in country-level data. To measure the differences due to differences in technology and the differences in efficiency let's propose the case of two hypothetical countries (X and Y) where country X is B years behind country Y technologically. Mathematically: $T_{2018,\ X} = T_{2018-B,\ Y\_}$. Let g be the growth rate of technology in country Y we can write:

$$T_{2018,X}/T_{2018,Y} = (1+g)^{-B}$$

So to measure the differences in efficiency between two countries the equation will be:

$$P_X/P_Y = (T_X/T_Y) \times (E_X/E_Y)$$

Unless the gap in technology is extremely large the differences in productivity will result from efficiency differences. The efficiency gap would continue to remain larger when we increase the number of years in the technology gap. How the production factors and technology are combined are shown by these efficiency differences. So basically, efficiency differences come from differences in institutions as they set the rules of the game and from entrepreneurship that responds to these incentives,

$$E = F \times A^*,$$

Where E is efficiency, F is institutions and A* is entrepreneurship by individuals. And now we develop a methodology which measures institutions and agency as they may affect productivity across countries from a systems perspective where$A = T \times NSE$, where NSE measures the national system of entrepreneurship.

The national systems of entrepreneurship (NSE) refer to the joint effect of individual entrepreneurial initiatives and the structure in which these initiatives function. According to the definition, the 'National Systems of Entrepreneurship are the dynamic, institutionally static interaction between entrepreneurial attitudes, abilities, and aspirations by individuals, which drives the allocation of resources through the creation and operation of new ventures' (Acs et al., 2014, p. 479).

The analysis of the NSE highlights on numerous inter-linked effects connected to territorial economic performance. First, the NSE portrays the territory's capacity to mobilize available resources to the market through new business formation processes, in the form of interactions between individuals' attitudes, aspirations, and abilities. Second, the NSE represents the interactions between entrepreneurial human capital and accumulated knowledge and the multidimensional economic, social, and institutional frameworks in which individuals develop their entrepreneurial activity. Finally, the NSE contributes to understand the territorial economic productivity through the efficient allocation of resources in the economy driven by entrepreneurial activity (Acs et al., 2014).

The national systems of entrepreneurship acknowledge that entrepreneurship is a vital component present in any economy. Therefore, the national systems of entrepreneurship help not only to increase the analysis of the factors that contribute to explain economic performance, but also to offer policy makers with valuable information on the economic contribution of entrepreneurship.

Based on the above theoretical arguments we hypothesize:

For modeling the country's technological contribution to explain efficiency differences across countries, the inclusion of the national system of entrepreneurship relative to model specifications that do not incorporate national systems of entrepreneurship in the country's production function.

Literature review

National systems of entrepreneurship

Since the day of Schumpeter (Schumpeter, 1934) economists have agreed that entrepreneurship matters for economic development. Entrepreneurs, according to Schumpeter the 'agents of creative destruction', generate a whole array of economic benefits ranging from innovation (Acs and Audretsch, 1988) to job creation (Blanchflower, 2000; Parker, 2009) to productivity (van Praag, 2007) to, e.g., facilitation of technology transfer and knowledge spill-overs from research to industry (Acs et al., 2009a, b). Even though entrepreneurship plays crucial role in economic development and in spite of years of research the measurement of entrepreneurship in country level is a complex challenge (e.g. Djankov et al., 2003; Reynolds et al., 2005). 'National Systems of Entrepreneurship' is the notion to fight with this challenge.

National Systems of Entrepreneurship are fundamentally resource allocation systems which emphasize the connections between individuals and their institutional settings in producing entrepreneurial action and regulating the quality and outcomes of this action. By definition National Systems of Entrepreneurship recognize that 1. Entrepreneurship fundamentally works at individual-level; where through the creation of new firms it mobilizes resources for opportunity pursuit for the country; 2. When entrepreneurship works at complex population-level, it interacts between attitudes, aspirations, and ability; which is surrounded by a multidimensional economic, social, and institutional context; 3. Entrepreneurship drives economic productivity through allocating the resources in an efficient way.

Combining these we can define National Systems of Entrepreneurship:

> 'A National System of Entrepreneurship is 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' (Acs et al., 2013).
>
> To measure country-level entrepreneurship a systemic approach is needed which allows system components to interact to produce system performance. This indicates that poorly performing system components i.e. bottleneck factors can hinder system performance. Following these principles, Global Entrepreneurship Index (GEI) is used to measure county-level entrepreneurship which reflects the various aspects of the dynamic interaction that drives productive entrepreneurship in a given country (Acs et al., 2013).

Methodology

DEA

Data Envelopment Analysis (DEA) which is originally developed for performance measurement is a linear Programming technique applied in economics and other related sciences. It is effectively used to assess the relative performance or technical efficiency of a set of firms (in DEA, it calls decision making units) using variety of inputs and outputs. DEA is a non-parametric approach that determines efficiency levels by doing linear programming for each unit in the sample. The efficiency level of the decision-making units (DMU) are calculated by comparison with the best producer in the sample to derive compared efficiency. DEA approach calculates a single relative ratio for each DMU (e.g. here an individual country), by comparing total weighted outputs to total weighted inputs and the distinctive feature is proposition of any specific functional form is not required. As described in original Charnes, Cooper and Rhodes model, the DEA efficiency value ranges between 0 to1. Two types of DEA models are basically widely used by operational researchers, namely the input-oriented (focused on cost minimization) and the output-oriented (focused on output maximization) models. According to the evidence research results are not sensitive to which of the models is being used. DEA requires a linear programming model to be formulated and solved for each DMU thus it seems to be a tedious job. But now analysts can estimate the efficiency scores for all DMUs in one DEA model that eliminates any potential human error by using software such as IDEAS, DEA-Solver, DEAP and EMS (Afzal & Lawrey, 2012).

Theoretical note of DEA

DEA is based on Technical Efficiency (TE) or the performance efficiency concept, which can be expressed as:

Technical efficiency $TE = \frac{\sum WO}{\sum WI.}$

Here WO = weighted output, WI = weighted input

Mathematically, we can formulize the above relation as:

$$E_k = \frac{\sum_{j=1}^{M} P_j O_{jk}}{\sum_{i=1}^{N} Q_i I_{ik}}$$

E_k TE for the DMU_k (between 0 and 1)

K Number of DMU_k, in the sample

N Number of inputs used ($i = 1, L, N$)

M Number of outputs ($j = 1, L, M$)

O_{jk} The observed level of output j from DMU_k

I_{ik} The observed level of input i from DMU_k

Q_i The weight of input i

P_j The weight of output j

Now the following problem must be solved to measure TE_k for DMU_k using linear programming:

Max TE_k

Subject to $E_k \leq 1$, $k = 1, 2, L, K$

Where using given inputs TE_k is maximizing outputs or for a given level of outputs TE_k is minimizing inputs. To overcome difficulties associated with nonlinear (fractional) mathematical programming in above problem Charnes, Cooper and Rhodes (1978) established a mathematical transformation called the CCR model (the initials of their names), where they developed a linear version under constant-returns-to-scale (CRS).

The formula of modified linear programming is:

$$\text{Max}\sum\nolimits_{j=1}^{M} P_j O_{jk}$$

S.t.

$$\begin{aligned} \sum_{i=!}^{N} Q_i I_{ik} &= 1 \\ \sum_{j=1}^{M} P_j O_{jk} &\leq \sum_{i=!}^{N} Q_i I_{ik} \\ P_j Q_i &\geq \varepsilon > 0 \\ \varepsilon &> 0 \end{aligned}$$

The above procedure can also be performed using input weights Q_i and variable I_{ik} and subject the formula to an output constraint under CRS. The optimization procedure in DEA ensures that while maintaining equity for all other DMUs the particular DMU (in our study the countries) being evaluated is given the highest score possible by maximizing its relative efficiency ratio.

DEA counts relative efficiency scores directed by the benchmark of unity (100%) as the highest score possible for one or more DMUs. Banker, Charnes, and add the modification into the original CCR model by developing the concept of variable returns to scale (VRS) and argue that, if the sum of weights of inputs and outputs in the CCR model adds up to more than 1, the scale size of DMU is decreasing returns to scale. A DMU should decrease in size or reduce the excess use of inputs in order to achieve CRS or optimum productive size. However, if the value is less than 1, a DMU has increasing returns to scale and should expand or increase its use of productive resources to achieve the most productive size. This modification in DEA is called the BCC model, named after Banker, Charnes and Cooper (Afzal, 2014).

Advantage of using non-parametric analysis

We use non-parametric analysis because1 it measures technical efficiency, scale efficiency, allocative efficiencies, technical change and TFP change, technological efficiencies changes without any fixed functional form. In this process DMUs are not assumed to be efficient in advance. It is analysis strong in measuring efficiency measurement of multiple outputs but weak in measuring noise in the analysis like parametric models. Function type and distribution type is not needed in this process for analysis (Afzal and Manni, 2013).

Data and variables

The functional formula use in our analysis is a production function such as

$$Y = f(X, Z, W)$$

Here Y = output, for our analysis we consider real GDP as proxy

X, Z, W = inputs, here inputs are labor force, GCF, GEI are the proxies.

we have used data from several sources for the proxy variables use in the functional model. In this paper we took gross capital formation, labor force and Global Entrepreneurship index score (GEI) as input variables and Gross Domestic Products (GDP) as output variable. Data on the macroeconomic figures were obtained from the World Bank databases. And to measure entrepreneurial activity we used the GEI scores 2018.

In our study DEA model specification used to calculate the world frontier defines an aggregate output (gross domestic product) that is produced by three inputs- labor, capital, and the national systems of entrepreneurship.

Table 1 presents the descriptive statistics for the input–output set. We have taken the 'ln' values of the variable to measure the growth rate. The statistics shows the averages and standard deviations of the variables that expose each dimension under study. As we can see, the ln GEI has the lowest standard deviation that means data spread is not high and it is reliable to take it as an input variable.

The gross domestic product (GDP) for the year 2018 is expressed at 2011 prices in millions of PPP International US dollars. Labor defines the country's number of employees (expressed in millions of workers). Capital is measured as the gross capital formation, which represents the outlays on additions to the economy's fixed assets (public infrastructures, and commercial and residential buildings) plus net changes in the level of inventories held by firms in the economy.

The Global Entrepreneurship Index is a combined indicator of the condition of the entrepreneurship ecosystem in a given country. Both the quality of entrepreneurs and the extent and depth of the supporting entrepreneurial ecosystem are measured by GEI. Depending upon 14 pillars GEI score calculates three levels of scores for a given country: the overall GEI score, scores for Individuals and Institutions, and pillar level scores (which measure the quality of each of our 14 components, see more detail Acs et al., 2014).

Table 1 Descriptive statistics for the selected input–output set

Variable	Description	Mean	Std. Dev.	Min	Max
Gross domestic product (GDP)	GDP equals the gross value added by the country producers plus product taxes and minus subsidies not included in the value of the products.	26.59563	1.51588	23.69311	30.47631
Labor force	Labor force comprises the economically active population: people over 15 years old who supply labor for the production of goods and services.	15.94763	1.372452	13.44752	18.90415
Gross capital formation (GCF)	GCF consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.	24.58853	1.685187	20.48996	28.93274
GEI index	Index that measures the country's the quality and dynamics of entrepreneurship ecosystems	3.629607	0.518262	2.4681	4.426044

Source: Author calculation
Note: ln values of the variables are taken to measure growth rate. i.e. ln GDP, ln labor force, ln GCF, ln GEI

Table 2 Country classification

Country name	Country Level	Economic development level	Corruption ranking
Austria	1	innovation	16
Belgium	2	innovation	16
Croatia	3	efficiency	57
Denmark	4	innovation	2
Estonia	5	innovation	21
Finland	6	innovation	3
France	7	innovation	23
Germany	8	innovation	12
Greece	9	efficiency	59
Hungery	10	efficiency	66
Ireland	11	innovation	19
Israel	12	innovation	32
Italy	13	efficiency	54
Latvia	14	efficiency	40
Lithuania	15	efficiency	38
Macedonia FYR	16	efficiency	107
Netherlands	17	innovation	8
Norway	18	innovation	3
Poland	19	efficiency	36
Portugal	20	efficiency	29
Romania	21	efficiency	59
Russia	22	efficiency	135
Slovak Republic	23	efficiency	54
Slovenia	24	efficiency	34
Spain	25	efficiency	42
Sweden	26	innovation	6
Switzerland	27	innovation	3
Turkey	28	efficiency	81
United Kingdom	29	innovation	8
Argentina	30	efficiency	85
Brazil	31	factor	96
Chile	32	innovation	26
Colombia	33	efficiency	96
Costa Rica	34	efficiency	38
Ecuador	35	factor	117
El Salvador	36	factor	112
Mexico	37	efficiency	135
Panama	38	efficiency	96
Peru	39	efficiency	96
United States	40	innovation	16
Uruguay	41	efficiency	23
Bangladesh	42	factor	143
Iran	43	factor	130
Japan	44	efficiency	20

Table 2 Country classification *(Continued)*

Country name	Country Level	Economic development level	Corruption ranking
Korea	45	efficiency	51
Malaysia	46	efficiency	62
Pakistan	47	factor	117
Singapore	48	innovation	6
Thailand	49	efficiency	96
Algeria	50	factor	112
Angola	51	factor	167
Botswana	52	factor	34
Ghana	53	factor	81
Malawi	54	factor	122
Namibia	55	efficiency	53
South Africa	56	efficiency	71
Tunisia	57	efficiency	74
Uganda	58	factor	151
Zambia	59	factor	96

Country selection

This is an international analysis so we computed data for 59 countries. We have categorized the countries by their economic development level and corruption ranking (Table 2). According to Global Entrepreneurship (GEM) data we have classified economies in: innovation driven country, efficiency driven country, factor driven country. The GEM is the world's foremost study of entrepreneurship. The corruption ranking is taken from Corruption Perceptions Index 2017 done by transparency international. The index ranks countries and territories by their perceived levels of public sector corruption according to experts and business people and the lowest ranking country means that country is cleaner or less corrupted.

Result and discussion

To test hypothesis, we assessed the influence of introducing the GEI index in the countries' efficiency by examining the DEA model that considers GDP a function of labor and capital and the model that includes the GEI index in the production function. From the direct comparison between these two DEA models we can measure the significant inefficiency changes causes by the introduction of the GEI index in the model. The result found without introducing GEI in the model is shown in Table 3 and introducing GEI is shown in Table 4. As we explain before, this study interested to check how efficiency changes in conventional production function after introduction of entrepreneurship index.

The result shows significant differences after introducing GEI in the model for several countries. For example, before introducing GEI Croatia was inefficient with inefficiency rate 0.6235% but after the introduction of GEI Croatia becomes fully efficient. Just like Croatia, Bangladesh, Macedonia, El Salvador, Panama, Iran, and Algeria become fully efficient after introducing GEI in the model. But for Bangladesh it is not a minor change because Bangladesh improved from inefficiency rate 2.8898% to 0. So, entrepreneurship

Table 3 Inefficiency score of the analyzed countries (without introducing GEI)

DMU	Country name	Rank	VRS_TE	Inefficiency
1	Austria	46	0.985116	1.4884
2	Belgium	41	0.987946	1.2054
3	Croatia	27	0.993765	0.6235
4	Denmark	45	0.985164	1.4836
5	Estonia	1	1	0
6	Finland	47	0.984988	1.5012
7	France	36	0.991335	0.8665
8	Germany	22	0.995725	0.4275
9	Greece	1	1	0
10	Hungary	25	0.994447	0.5553
11	Ireland	11	1	0
12	Israel	51	0.982227	1.7773
13	Italy	20	0.99714	0.286
14	Latvia	8	1	0
15	Lithuania	1	1	0
16	Macedonia FYR	16	0.998752	0.1248
17	Netherlands	34	0.991596	0.8404
18	Norway	23	0.995394	0.4606
19	Poland	18	0.997675	0.2325
20	Portugal	31	0.992231	0.7769
21	Romania	35	0.991518	0.8482
22	Russia	1	1	0
23	Slovak Republic	33	0.991719	0.8281
24	Slovenia	1	1	0
25	Spain	32	0.991848	0.8152
26	Sweden	49	0.984151	1.5849
27	Switzerland	40	0.988163	1.1837
28	Turkey	24	0.995054	0.4946
29	United Kingdom	28	0.99363	0.637
30	Argentina	37	0.990391	0.9609
31	Brazil	26	0.99429	0.571
32	Chile	42	0.987278	1.2722
33	Colombia	50	0.98326	1.674
34	Costa Rica	53	0.979542	2.0458
35	Ecuador	56	0.973254	2.6746
36	El Salvador	17	0.998689	0.1311
37	Mexico	39	0.989909	1.0091
38	Panama	57	0.972055	2.7945
39	Peru	52	0.981764	1.8236
40	United States	1	1	0
41	Uruguay	48	0.984567	1.5433
42	Bangladesh	58	0.971102	2.8898
43	Iran	19	0.997267	0.2733
44	Japan	38	0.98996	1.004

Table 3 Inefficiency score of the analyzed countries (without introducing GEI) *(Continued)*

DMU	Country name	Rank	VRS_TE	Inefficiency
45	Korea	44	0.985844	1.4156
46	Malaysia	21	0.99701	0.299
47	Pakistan	13	1	0
48	Singapore	1	1	0
49	Thailand	29	0.993176	0.6824
50	Algeria	43	0.986613	1.3387
51	Angola	14	1	0
52	Botswana	9	1	0
53	Ghana	54	0.978255	2.1745
54	Malawi	15	1	0
55	Namibia	12	1	0
56	South Africa	30	0.992991	0.7009
57	Tunisia	10	1	0
58	Uganda	55	0.973639	2.6361
59	Zambia	59	0.966506	3.3494

Source: Author calculations

can draw a significant effect on Bangladesh economy. Other than this many more countries like Hungary, Italy, Norway, Slovak Republic, Argentina, Costa Rica, Ecuador, Mexico, Uruguay, Japan, Malaysia, Uganda and Zambia show slight improvement after putting GEI in the model. Though the change is very small it should not be ignored. However, when we try to relate the countries' corruption ranking to the result picture becomes gloomy. For example, if we take Bangladesh we can see that Bangladesh is a highly corrupted but fully efficient country. On the other hand, take Norway which is least corrupted country is inefficient with 0.3056%. Thus, without surveying the relevant factors it is tough to make conclusion about direct relation between corruption and efficiency. When we focus on the types of the country it is clear that innovation driven countries are more efficient than the others in general because they utilize their knowledge and R&D stock efficiently for producing entrepreneurship environment in the country. The efficiency results after inclusion of GEI in the model for analyzed countries are shown in the radar diagram 1.

TOBIT analysis

At this stage we run a TOBIT regression to further analyze how country-specific factors which are not connected to DEA scores—relate to efficiency. Table 5 presents the descriptive statistics of the variables. The first variable is the gross domestic product per capita in 2018 (expressed at 2011 prices in PPP International US dollars) which measures the country's economic welfare. The second variable is the social capital index which measures the strength of the countries' social cohesion, social engagement, as well as the performance of community and family networks, with higher values indicating greater level of social capital. Social capital refers to the internal social and cultural coherence of society, the norms and values that govern interactions among people and the institutions in which they are embedded. These interactions are the basis of

Table 4 Inefficiency score of the analyzed countries (after introducing GEI)

DMU	Country name	Rank	VRS_TE	Inefficiency
1	Austria	50	0.985116	1.4884
2	Belgium	45	0.987946	1.2054
3	Croatia	1	1	0
4	Denmark	49	0.985164	1.4836
5	Estonia	1	1	0
6	Finland	52	0.984988	1.5012
7	France	41	0.991335	0.8665
8	Germany	30	0.995725	0.4275
9	Greece	1	1	0
10	Hungary	29	0.996149	0.3851
11	Ireland	23	1	0
12	Israel	56	0.982227	1.7773
13	Italy	24	0.999734	0.0266
14	Latvia	1	1	0
15	Lithuania	1	1	0
16	Macedonia FYR	17	1	0
17	Netherlands	39	0.991596	0.8404
18	Norway	28	0.996944	0.3056
19	Poland	26	0.997675	0.2325
20	Portugal	37	0.992231	0.7769
21	Romania	40	0.991518	0.8482
22	Russia	1	1	0
23	Slovak Republic	36	0.992272	0.7728
24	Slovenia	1	1	0
25	Spain	38	0.991848	0.8152
26	Sweden	53	0.984151	1.5849
27	Switzerland	44	0.988163	1.1837
28	Turkey	32	0.995054	0.4946
29	United Kingdom	33	0.99363	0.637
30	Argentina	25	0.998383	0.1617
31	Brazil	1	1	0
32	Chile	46	0.987278	1.2722
33	Colombia	54	0.98326	1.674
34	Costa Rica	51	0.985039	1.4961
35	Ecuador	47	0.986988	1.3012
36	El Salvador	1	1	0
37	Mexico	43	0.990135	0.9865
38	Panama	22	1	0
39	Peru	57	0.981764	1.8236
40	United States	1	1	0
41	Uruguay	42	0.990861	0.9139
42	Bangladesh	1	1	0
43	Iran	1	1	0
44	Japan	31	0.995091	0.4909

Table 4 Inefficiency score of the analyzed countries (after introducing GEI) *(Continued)*

DMU	Country name	Rank	VRS_TE	Inefficiency
45	Korea	48	0.985844	1.4156
46	Malaysia	27	0.997135	0.2865
47	Pakistan	1	1	0
48	Singapore	1	1	0
49	Thailand	34	0.993176	0.6824
50	Algeria	18	1	0
51	Angola	1	1	0
52	Botswana	19	1	0
53	Ghana	58	0.978255	2.1745
54	Malawi	1	1	0
55	Namibia	20	1	0
56	South Africa	35	0.992991	0.7009
57	Tunisia	21	1	0
58	Uganda	55	0.982675	1.7325
59	Zambia	59	0.966943	3.3057

Source: Author calculations

national systems of entrepreneurship. Social capital sticks the societies together and without which there can be no economic growth or human wellbeing. Without social capital, society at large will collapse so efficiency cannot be attained. The last variable is the unemployment rate which is used to evaluate the quality of countries' entrepreneurial activity.

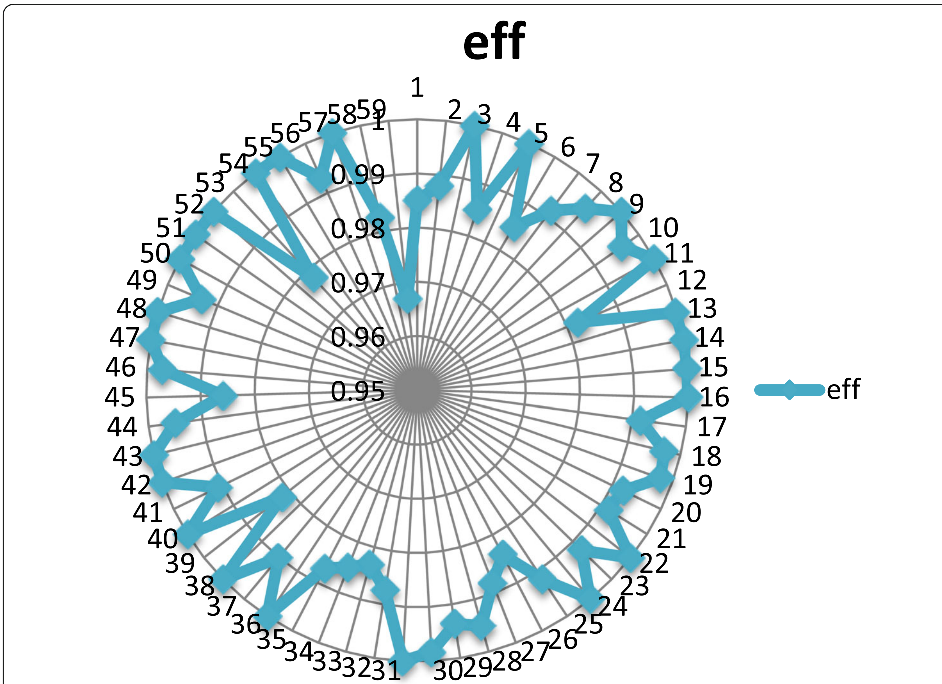

Diagram 1 The efficiency results after inclusion of GEI

Table 5 Descriptive statistics of the input-output variables

Variable	Mean	Std. Dev.	Min	Max
GDP per capita, PPP (constant 2011 international $) (gdppc)	9.885019	0.87854	6.990489	11.3
Social capital index (sci)	3.842056	0.873014	1.386294	4.93
Unemployment rate (uer)	1.883003	0.637826	0.079735	3.32

Source: Author calculations
Note: 'ln' values of the variables are taken to measure growth rate

To attain the analysis, we propose TOBIT regression model which further investigate the effects of our sample variables on the DEA VRS technical efficiency results. We used the Tobit model to determine the effect of influential variables on the country's DEA efficiency score because this model deals with a number of dependent variable values clustered at a limiting value. This approach applies DEA and used in the literature.

The Tobit model which is also known as the truncated or censored regression analysis Model can be formed like:

$$Y_t = X_t\beta + \mu_t \; if \; X_t\beta + \mu_t > 0 = 0 \; if X_t\beta + \mu_t \leq 0 \; t = 1, 2, \ldots, N$$

Here N represents the number of observations; Y_t is the dependent variable, Xt is the vector of independent variables, β is a vector of unknown coefficients and μt is the independently distributed error term assumed to be normal with a zero mean and constant variance N (0, σ2). The inefficiency score is defined as the following:

Inefficiency score = 1− efficiency score (from DEA VRS efficiency results).

The technical efficient function of the country level efficiency is written as:

$$\mathrm{Ei} = \alpha + \beta_1 gdppc + \beta_2 sci + \beta_3 uer + \mu_i$$

Here Ei indicates the DEA VRS technical efficiency scores, gdppc, sci, uer are the independent variables (GDP per capita, Social capital index, Unemployment rate), i indicates the number DMUs, α indicates a constant term, β_1– β_3 indicates the coefficients of independent variables and μ indicates an error term μ~N(0, σ2) (Afzal, 2014).

The empirical results analyzed from Tobit regression model are reported in Table 6. According to the analysis social capital index is statistically significant at 5% level, while other variables depict insignificant results at the 5% level. Although GDP per capita is not statistically significant it comes with expected sign. Even though unemployment rate is a vital variable that affects efficiency but, in this model, it is insignificant with the wrong sign, which may be because of an endogeneity problem. The variables that come with the positive sign mean that they affect the efficiency of the country positively.

Our analysis reports that when GDP per capita (gdppc) rises 0.01%, the efficiency scores would increase to 100%, meaning GDP per capita can positively and significantly

Table 6 TOBIT regression results

Variable	Coefficient	Std. Error	T	*P* > |t|
gdppc	0.001325	0.002333	0.57	0.572
sci	0.005399	0.001998	2.7	0.009
uer	0.004309	0.002398	1.8	0.078
constant	0.960959	0.028952	33.19	0.000

Source: Author calculation

improve the efficiency scores of a country. The 0.05% increase in the social capital (sci) can increase the country level efficiency score to 100% in our study countries. Social capital is a favorable indicator to make a country efficient.

In conclusion, based on the Tobit regression model, the DEA VRS technical efficiency score of inefficient countries could be improved through increasing GDP per capita and social capital. Hence, from our analysis, these variables have a direct effect on increasing the technical efficiency score of inefficient countries.

Conclusion and policy suggestions

Our paper analyzes the efficiency hypothesis of the knowledge spillover theory of entrepreneurship. Although social and economic advantages resulting from entrepreneurship is acknowledged by policy makers, the analysis of the relationship between the country's entrepreneurship system and economic efficiency remains sparse. In this context this study contributes to understand how countries capitalize on their entrepreneurial system.

Specifically, this study relies on the comprehensive efficiency analysis of 59 countries through a non-parametric technique—DEA. Including the national systems of entrepreneurship as input in the traditional production function, we explain efficiency differences across the analyzed economies. And by using tobit model we scrutinized what macro factors affect efficiency generally.

Results indicate that country-level efficiency significantly increases from incorporating countries' entrepreneurial system in the model. Additionally, though inefficiency widely varies across countries, the group of factor-driven countries is the most inefficient while innovation-driven economies are the most efficient ones. And country level efficiency is affected by GDP per capita and social capital.

The result of the study interprets the benefits of national systems of entrepreneurship. Therefore, from policy perspective, policy makers should shift from an excessive focus on physical capital and labor towards emphasizing more on the national systems of entrepreneurship process. The effective exploitation of knowledge is the key point for entrepreneurship so policy makers need to enhance the way through which the national systems of entrepreneurship channel knowledge to the economy and create economic growth in the long-run.

Though the cross-sectional nature of the study calls for obvious caution when interpreting and generalizing its findings, it rather can represent avenues for future research than counted as limitation.

Abbreviations

DEA: Data Envelopment Analysis; DMU: Decision Making Units; GEI: Global Entrepreneurship Index

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