Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

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To cite this article: Hanns de la Fuente-Mella, Ana María Vallina-Hernandez & Rodrigo Fuentes-Solís (2020) Stochastic analysis of the economic growth of OECD countries, Economic Research-Ekonomska Istraživanja, 33:1, 2189-2202, DOI: 10.1080/1331677X.2019.1685397

To link to this article: https://doi.org/10.1080/1331677X.2019.1685397

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2020, VOL. 33, NO. 1, 2189–2202
https://doi.org/10.1080/1331677X.2019.1685397

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Taylor & Francis Group

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Stochastic analysis of the economic growth of OECD countries

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ABSTRACT

This study examined the determinants of economic development for the 34 member countries of the Organization for Economic Cooperation and Development (OECD) and analysed efficient uses of economic development resource endowments. The methodology included econometric panel data modelling and stochastic frontier analysis, using the Cobb-Douglas production function and trans-logarithmic functional form to analyse data from 2003 to 2012. Economic growth was measured by the gross domestic product (GDP) of each economy. As a result, the determinants of economic development were presented and a ranking of efficiency was obtained for all OECD economies throughout the period of analysis. It was concluded that countries with higher economic growth levels have higher efficiency rankings. For example, countries with higher efficiency rankings were Luxembourg and the U.S.; Chile and Mexico were ranked lower. Finally, there was a positive relationship between growth levels and technical efficiency levels.

ARTICLE HISTORY
Received 12 February 2019
Accepted 5 September 2019

KEYWORDS
Applied economics; stochastic frontier analysis; economic growth

JEL CLASSIFICATIONS
C51; O47; C21; E23; F43

1. Introduction

Economic development is a topic that has been widely studied. Several authors and institutions are dedicated to analysing different models, methodologies and data management to measure development levels of countries and identify their determinants. Two main theoretical approaches are found in the literature: classical and neoclassical, which measure economic growth, as well as other schools of thought that also consider non-economic variables. These are used to design public policies aimed at increasing a population's well-being with a human-centred approach that considers sustainable behaviour as a parameter to ensure development beyond economic growth. Economic growth is still considered necessary in obtaining

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economic development and increasing human productivity (Dang & Sui Pheng, 2015; Ranis, Stewart, & Ramire, 2000; UNDP, 1990).

This study analysed economic growth-related studies that have assessed parameters for measuring development such as education, health and institutions (Altinay & Karagol, 2005). In contrast with previous empirical studies, the value of the econometric strategy is that it does not depend on the scale of the countries, and the use of GDP as a dependent variable eliminates bias due to scale. This research extends the enterprise production function to economies in order to measure their technical efficiency. The generation of goods and services is related to production factors, such as labour and capital. When a country performs better in these dimensions, it improves its ranking compared to the other countries included in the study.

Stochastic frontier analysis methodology used in this study merges ideas from both schools of thought. The Organization for Economic Cooperation and Development (OECD) aims to promote economic growth, prosperity, and sustainable development; thus, it has developed a series of good practice guidelines after gathering statistics so they can be compared. Its 34 member countries have different degrees of economic development, which makes it a good study sample.

In the present study, we assess the technical efficiency of OECD member countries to determine whether higher GDPs imply higher levels of efficiency in their use of resources. Finally, we identify the OECD countries with higher efficiency rankings to compare them to those with lower efficiency rankings.

The conclusions allowed us to infer economic performance, and demonstrated that there are some economies capable of obtaining higher well-being, but are not achieving that goal.

2. Theoretical framework

The approach used in this study focused on a wide range of economic growth determinants. It was geared towards a relative measure rather than an absolute measure of economic performance, considering that many factors interact to attain GDP results (Bodenstein, Faust, & Furness, 2017; De la Fuente, Vallina, & Pino, 2013; Fouquet & Broadberry, 2015; Haavio, Mendicino, & Punzi, 2014).

Authors and institutions were reviewed to build a theoretical framework to classify and define indicators of economic development. The analysis focused on macroeconomic determinants that influence a country's economic performance, for example: income, savings and investment, population growth and unemployment.

GDP is a widely chosen indicator for evaluating the economic behaviour of a country, since it demonstrates income generated by different economic agents. It also measures the cost of goods and services production in the economy, which is measured in terms of factor payments and products produced in each economic sector. Thus, income and expenditure are equal at a macroeconomic level (Dornbusch, Fischer, & Starzt, 2004). The difference between GDP at market value and at factor cost is explained by indirect taxes (Dornbusch, Fischer, & Startz, 2004).

Economic growth can be used as a dependent variable as it enables governments to provide more and better public goods and services, such as education, health services and infrastructure (Acemoglu & Robinson, 2012; Mankiw, 2012). GDP is the market value of all final goods and services produced in a country during a given period (Dornbusch et al., 2004). The GDP adds different types of products together to obtain the value of economic activity at market prices. Its purpose is to include all items produced in the economy and sold on the market. However, certain products are omitted, such as those that are produced and sold illicitly and homemade goods that don't reach the market. This statistic is posted quarterly in order to analyse trends, and is seasonally adjusted to account for seasonal production changes inherent to some goods and services (Dornbusch et al., 2004, Jones, 2015).

According to Chirwa and Odhiambo (2016), the most relevant variables in theoretical models are as follows: investment or increase in physical capital (Solow, 1956; Swan, 1956), savings (Ramsey 1928; Cass 1965; Koopmans 1965), new ideas and learning-by-doing (Arrow, 1962; Sheshinski, 1967; Uzawa, 1965), R&D (Romer, 1986) R&D and non-Pareto optimality in a competitive market, human capital (Lucas 1988), human capital plus investment (Mankiw, Romer & Weil, 1992), R&D and imperfect competition (Romer 1990; Aghion & Howitt 1992; Grossman & Helpman 1991).

Savings and investment are two macroeconomic aggregates that are important to GDP growth in the long run (Dornbusch et al., 2004). These factors relate resource allocation among different periods of time. One method of increasing future productivity is to allocate current resources to increase capital stock, which is accomplished by saving part of their current income to finance investment in order to grow (Cojocaru, Falaris, Hoffman, & Miller, 2016; De Gregorio, 2016). Although there is a demonstrated correlation between growth and investment, causality is uncertain (Cole, 2004). Nonetheless, there is evidence that capital accumulation increases productivity and a consensus that higher investment levels accelerate economic growth. Increasing capital stock raises productivity and accelerates GDP growth. However, for a certain scale, capital shows diminishing returns. Thus, an increase in savings raises productivity and income, but does not necessarily accelerate the growth rate of these variables. Nevertheless, investment in physical capital is important, and countries that save/invest more of their GDP grow faster (Cole, 2004).

Investment is also known as gross capital formation, which is composed of expenditures on fixed assets of the economy plus net change in inventories (Dornbusch et al., 2004). Fixed assets include land improvements, buildings, machinery and equipment purchases, as well as construction of roads, railways, and similar infrastructure. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales. Hence, changes in inventories represent the differences between expected and current expenditure in the economy. Accordingly, gross capital formation contributes to growth through real investment, measured in relation to GDP, which reflects the physical quantity evolution of capital and output (Acemoglu & Robinson, 2015; Sala-I-Martin, Doppelhofer, & Miller, 2004; Simionescu, Lazányi, Sopková, Dobeš, & Balcerzak, 2017).

Chirwa and Odhiambo (2016) define the following as determinants: savings and investment efficiency (Acemoglu & Robinson, 2015; Cole, 2004; Easterly & Wezel, 1989), macroeconomic stability (Fisher 1992), institutions, human capital, international openness and public investment (Acikgoz & Mert, 2014; Barro, 1990, 1999 & 2003; Burnside & Dollar, 2000; Easterly & Levine, 1997; Knight, Loayza, & Villanueva, 1993).

The economic development strategy has other key aspects, including job creation and the improvement of a country's business environment to promote business creation. Both determine the opportunities offered to people by society. New businesses imply job creation, and employment is important for social cohesion, since full employment helps reduce dissatisfaction among the population (Kerr, Kerr, Özden, & Parsons, 2016; Peri, 2016; Stiglitz, 2002).

Other empirical studies consider a variety of parameters such as entrepreneurial culture (Fernández-Serrano, Berbegal, Velasco, & Expósito, 2018), innovation (Fuentes Solis & Ferrada Rubio, 2016; Furman, Porter, & Stern, 2002; González-Cruz & Devece, 2018; Hai, Roig-Dobón, & Sánchez-García, 2016) or entrepreneurship (Gu, Qian, & Lu, 2018).

According to the International Labour Organization (ILO), the conceptual framework for measuring a labour force was adopted by the International Conference of Labour Statisticians in 1982. This Conference defined classification standards according to a person's activity during a short reference period, such as a week or a day, in three exhaustive and mutually exclusive categories: employed, unemployed, and economically inactive. The labour force is composed by those that are employed and unemployed, as they are part of the economically active population that are either working or looking for work. Thus, the criteria to measure a labour force is threefold: to have a job, to be looking for a job or to be available for work. The labour force includes both nationals and immigrants because both produce goods and services that are considered in the GDP (Kerr et al., 2016; Peri, 2016).

The economically active population includes people from 15 to 65 years old if they meet the physical and intellectual conditions to have a job (Dornbusch et al., 2004). The inactive population includes those in the same age range that have no job, are not looking for work and are not available for work (Dornbusch et al., 2004). People under or over the minimum age are passive, as it is assumed that they are not in a proper work condition, or that they have already retired from the work force. Those considered unemployed do not have a job but are either looking for one or are available to take a job offer (Dornbusch et al., 2004).

The unemployment rate is the percentage of the economically active population seeking a job but that are not yet occupied. The unemployment rate is widely used as an overall indicator of a country's economic health (Stiglitz, 2002).

Vergara (2005) includes the participation of women in the labour force as an economic growth indicator, and concludes that low participation has at least two negative consequences. First, the skills of a significant fraction of the population are not utilized. Second, lower income women have lower labour force participation, which deepens income inequality. Aragon-Mendoza, Pardo del Val, and Roig-Dobón (2016) incorporate this gendered perspective with a focus on the creation of quality entrepreneurship.

Another important factor for economic growth is electricity. Electricity plays an essential role in modern life, providing benefits and progress in various sectors such as transportation, manufacturing, mining and communication. Electricity is vital for economic growth and quality of life, not only because it increases productivity, but because it raises energy consumption, which increases exchange opportunities, thus increasing economic welfare (Blazquez-Fernandez, Cantarero, & Perez, 2014; Ciarreta & Zarriaga, 2007; Jumbe, 2004).

Concerning electricity, there are several studies that have established the relationship between energy consumption and economic growth. When a nation uses more energy, production increases, since the use of this energy to operate technology in manufacturing processes increases productivity. In some cases, the availability of electricity enables the incorporation of the above mentioned technology in processes (Acemoglu & Robinson, 2012; De la Fuente et al., 2013; Magazzino, 2014).

3. Econometric strategy

Productivity represents the conversion of the inputs of a process (labour and capital) into desirable outputs (sales, profits, etc.) (Solow, 1956). The term productivity is related to the efficient use of resources when producing a good, and can be defined as the relationship established between production and consumption of productive factors measured in physical units. In the input/output relationship, output can represent any established purpose or anything that the company generates, whereas input can be considered all that is consumed by achieving the output (Diéguez & González, 1994). Gronroos and Ojasalo (2004) defined productivity as the degree of effective transformation of a process' input resources into (i) economic results for the provider of goods/services and (ii) value for consumers.

Technical efficiency involves maximizing the level of output that can be obtained from a given combination of inputs, and indicates the degree of success in the use of productive resources. Therefore, inefficiency is the difference between the observed values of production and the maximum achievable values given a certain technology (Albert, 1998). According to the classic paper of Farrell (1957), the level of efficiency of a company can be viewed from two different measures: (i) technical efficiency, which reflects the ability of a company to achieve maximum outputs depending on a set of inputs; and (ii) allocative efficiency, which reflects the ability of a firm to use inputs in optimal proportions, depending on their respective prices. These two measures are combined to measure economic efficiency (Battese & Coelli, 1992; Coelli, Rao, O'Donell, & Battese, 2005).

Economists typically use an enterprise production function to summarize technically efficient production methods available to each company.

The production function of a firm shows the maximum amount of output that can be obtained with a given number of factors, and shows the results of different technically efficient production methods (Nicholson, 1997).

The production frontier shows the maximum production level regarding technology and resource endowment, which provides the highest level of utility or satisfaction that can be reached, given the resource constrains. The relationship between inputs and output shows the opportunity costs relevant for the economy (Alvarez & Delgado, 2005; Nicholson, 1997).

As the production frontier is the limit of what is possible to produce given the factor endowment, any point situated beyond the boundary is unattainable, while those located inside the frontier represent inefficient situations characterized by idle resources.

There are two alternative methods for estimating production frontiers. One is the Data Envelopment Analysis, a deterministic and nonparametric method that eliminates production function assumptions. The other methodology is the Stochastic Frontier Method, which allows for random shocks even though two alternative production functions are used to estimate the frontier and efficiency ranking. The first method was used by Medved and Kavcic (2012) in a study regarding efficiency in Croatian and Slovenian insurance markets.

The production frontier is modelled under two alternative production functions in the related literature (Aigner, Lovell, & Schmidt, 1977; Nicholson, 1997): the Cobb-Douglas function (Meeusen & van Den Broeck, 1977) and the trans-logarithmic function.

To determine the level or existence of technical inefficiency according to the production models used, a test of technical inefficiency was applied (Coelli, Prasada, & Battese, 1998; Kodde & Palm, 1986).

The selection of the functional form is important when estimating technical inefficiency (Tran & Tsionas, 2009). As in most frontier studies, the Cobb-Douglas model and the trans-logarithmic model are evaluated as a technological representation (De la Fuente, Berné, Pedraja, & Rojas, 2009). In most studies on the manufacturing sector, the trans-logarithmic model is the most popular due to its flexibility (Tran & Tsionas, 2009). The following are general forms of both models after linearization (Eqs. 1 and 2):

[The Cobb-Douglas model]

$$\ln(Y_{it}) = \beta_0 + \sum_{m=1}^{M} \beta_m \ln(X_{mit}) + \upsilon_{it} - \mu_{it}. \tag{1}$$

[The trans-logarithmic model]

$$\ln(Y_{it}) = \beta_0 + \sum_{m=1}^{M} \beta_m \ln(X_{mit}) + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{N} \beta_{mn} \ln(X_{mit}) \ln(X_{nit}) + \upsilon_{it} - \mu_{it}. \tag{2}$$

In both models, Y_{it} is the output of company i during period t; X_{mit} and X_{nit} are the inputs m and n of company i during period t; υ_{it} is the random disturbance assumed as normally distributed, with a zero mean and constant variance; and μ_{it} is a non-observable and non-negative random error associated with technical inefficiency.

4. Results

The present study applied the efficiency analysis to the 34 countries that currently belong to the OECD, using data from 2003-2012.

Table 1. Maximum likelihood estimates of technical efficiency, Cobb-Douglas model.

	Coefficient	Standard-error	t-ratio	*p*-value
β_0	5.67E + 11	1.00E + 00	5.67E + 11	1.21E-35
ln(L)	−3.90E + 09	1.00E + 00	−3.9E + 09	3.73E-29
ln(S)	5.32E + 04	3.23E + 00	16504.12	4.91E-13
ln(K)	3.83E + 08	1.00E + 00	3.83E + 08	3.93E-26
ln(kWh)	2.92E + 00	6.48E-02	45.01	2.41E-05
gamma	9.03E-01	8.86E-03	101.93	2.08E-06
eta	1.95E-02	7.71E-03	2.53	8.54E-02

Efficiency is measured by utilizing the real GDP of each economy in U.S. dollars of 2012 as an output variable measured through purchasing power parity. Inputs are expressed by the following variables: labour, measured as the number of workers in each economy; savings, expressed as gross savings in U.S. dollars; capital, stated as gross capital formation in dollars; and finally, electricity consumption, which measures the production of power plants and cogeneration plants, minus losses in transmission, distribution and processing, plus the consumption of cogeneration plants, (expressed in kWh). The data from the output and input variables were obtained from the statistical database of the World Bank.

To measure the efficiency of OECD member countries, the first functional form used is the Cobb-Douglas, which is expressed as follows (Eq. 3):

$$ln(PIB_{yt}) = \beta_0 + \beta_1 ln(L_{it}) + \beta_2 ln(S_{it}) + \beta_3 ln(K_{it}) + \beta_4 ln(kWh_{it}) + v_{it} - \boldsymbol{u}_{it} \tag{3}$$

where:

PIB_{it}= Gross Domestic Product of country i, for period t.

L_{it}= Number of occupied workers of the labour force in country i, for period t.

S_{it}= National savings of country i, for period t.

K_{it}= Gross capital formation of country i, for period t.

kWh_{it}= Electricity consumption of country i, for period t.

$$\forall\ i = 1, 2, \ldots, \ 34; t = 2003, \ 2004, \ldots, \ 2012$$

while the second is functionally trans-logarithmic, and has the following form (Eq. 4):

$$\begin{aligned} ln(PIB_{it}) = \ & \beta_0 + \beta_1 ln(L_{it}) + \beta_2 ln(S_{it}) + \beta_3 ln(K_{it}) + \beta_4 ln(kWh_{it}) \\ & + \beta_5 ln(L_{it}) ln(S_{it}) + \beta_6 ln(L_{it}) ln(K_{it}) + \beta_7 ln(L_{it}) ln(kWh_{it}) \\ & + \beta_8 ln(S_{it}) ln(K_{it}) + \beta_9 ln(S_{it}) ln(kWh_{it}) + \beta_{10} ln(K_{it}) ln(kWh_{it}) \\ & + \frac{1}{2}\left[\beta_{11} ln(L_{it})^2 + \beta_{12} ln(S_{it})^2 + \beta_{13} ln(K_{it})^2 + \beta_{11} ln(kWh_{it})^2\right] + v_{it} - \boldsymbol{u}_{it} \end{aligned} \tag{4}$$

where, υ_{it} is the random disturbance assumed to be normally distributed, with a zero mean and constant variance; and μ_{it} is a non-observable and non-negative random error associated with technical inefficiency.

The results of the maximum likelihood estimation of the previous Cobb-Douglas model are presented in Table 1. This table shows that, based on the total frontier deviation, 90.3% is due to technical inefficiency, with a technical efficiency that increases over time.

Table 2. Maximum likelihood estimates of technical efficiency translogarithmic model.

	Coefficient	Standard-error	t-ratio	*p*-value
β_0	5.39E + 00	4.51E-01	1.19E + 01	0.001261553
ln(L)	−1.03E-02	2.90E-04	−3.54E + 01	4.96271E-05
ln(S)	4.64E-01	3.21E-02	1.45E + 01	0.000718154
ln(K)	4.89E-03	7.49E-04	6.52E + 00	0.00731463
ln(kWh)	4.88E-01	1.04E + 00	4.69E-01	0.671039447
ln(L)*ln(S)	4.59E-03	1.04E-02	4.42E-01	0.688711587
ln(L)*ln(K)	1.06E + 00	1.03E + 00	1.02E + 00	0.382132206
ln(L)*ln(kWh)	1.06E-02	1.03E-02	1.03E + 00	0.380159582
ln(S)*ln(K)	3.38E-01	3.38E-01	1.00E + 00	0.390932551
ln(S)*ln(kWh)	3.87E-03	3.39E-03	1.14E + 00	0.336863163
ln(K)*ln(kWh)	−2.63E-02	5.97E-02	−4.41E-01	0.689088905
$\ln(L)^2$	−1.81E-04	6.72E-04	−2.69E-01	0.805066677
$\ln(S)^2$	−3.41E-02	5.93E-02	−5.76E-01	0.605125502
$\ln(K)^2$	−4.25E-04	6.53E-04	−6.51E-01	0.561233229
$\ln(kWh)^2$	−5.12E-03	1.89E-02	−2.70E-01	0.804459088
gamma	8.99E-01	1.52E-02	5.91E + 01	1.06666E-05
eta	5.58E-02	7.58E-03	7.36E + 00	0.0051889

The results of the maximum likelihood estimation of the previous trans-logarithmic model are presented in Table 2. This table shows that, based on the total frontier deviation, 89.9% is due to technical inefficiency, with a technical efficiency that increases over time.

To determine whether or not technical inefficiency is present in the former models, the test of technical inefficiency (Kodde & Palm, 1986) was applied. For the Cobb-Douglas function, a likelihood ratio test of 303,605 was obtained with 3 restrictions, and had a critical value of 7.045 with 95% confidence. Therefore, the null hypothesis of no technical inefficiency was rejected, and technical inefficiency was found within the OECD countries.

Regarding the trans-log functional form, a likelihood ratio test of 405.74 was found with 3 restrictions. A critical value of 7.045 with a 95% confidence level was obtained. Thus, as in the Cobb-Douglas function, the null hypothesis of no technical inefficiency was rejected, and technical inefficiency was found within the OECD countries.

These results were used to determine which of the two functional forms better represented the data's behaviour. The generalized likelihood ratio was used, and the null hypothesis indicated that the Cobb-Douglas was the appropriate functional form. The alternative hypothesis stated that the function would be better represented by the trans-log function.

With 10 degrees of freedom, given by the number of parameters in the second order trans-log function, the critical value was 18.31, which resulted in 0.577 according to the Chi-Square table with 95% confidence. This value does not reject the null hypothesis.

Although the most suitable functional form proved to be the Cobb-Douglas function, the efficiency ranking was calculated under both functional forms for comparative purposes (Table 3).

According to the Cobb-Douglas functional form, the U.S.A had the highest level of efficiency, followed by the U.K., France, Italy and Germany. Iceland had lowest level of efficiency within the 34 economies.

Figure 1 demonstrates the evolution of technical efficiency for OECD countries, as measured by the Cobb-Douglas functional form. A growing trend in efficiency was

Table 3. Efficiency results for the OECD member countries (2003–2012).

Trans-log function			Cobb-Douglas function		
1	United Kingdom	0.848	1	USA	0.994
2	Ireland	0.782	2	United Kingdom	0.810
3	Luxemburg	0.779	3	France	0.760
4	Germany	0.769	4	Italy	0.730
5	Italy	0.766	5	Germany	0.682
6	Switzerland	0.755	6	Canada	0.673
7	USA	0.754	7	Japan	0.671
8	France	0.750	8	Spain	0.601
9	Denmark	0.742	9	Australia	0.592
10	Netherlands	0.706	10	Netherlands	0.547
11	Belgium	0.701	11	Switzerland	0.488
12	Japan	0.673	12	Sweden	0.476
13	Austria	0.647	13	Belgium	0.463
14	Sweden	0.629	14	Norway	0.442
15	Norway	0.627	15	Austria	0.416
16	Greece	0.612	16	Greece	0.410
17	Israel	0.597	17	Denmark	0.406
18	Spain	0.589	18	Ireland	0.391
19	Australia	0.566	19	Korea	0.388
20	Finland	0.552	20	Finland	0.341
21	Turkey	0.547	21	Turkey	0.340
22	Canada	0.539	22	Portugal	0.314
23	Portugal	0.528	23	Poland	0.311
24	New Zealand	0.503	24	Mexico	0.290
25	Hungary	0.480	25	Israel	0.272
26	Mexico	0.470	26	Czech Republic	0.234
27	Poland	0.466	27	New Zealand	0.210
28	Chile	0.442	28	Chile	0.210
29	Iceland	0.412	29	Hungary	0.202
30	Slovenia	0.410	30	Slovakia	0.152
31	Slovakia	0.408	31	Luxemburg	0.127
32	Korea	0.399	32	Slovenia	0.095

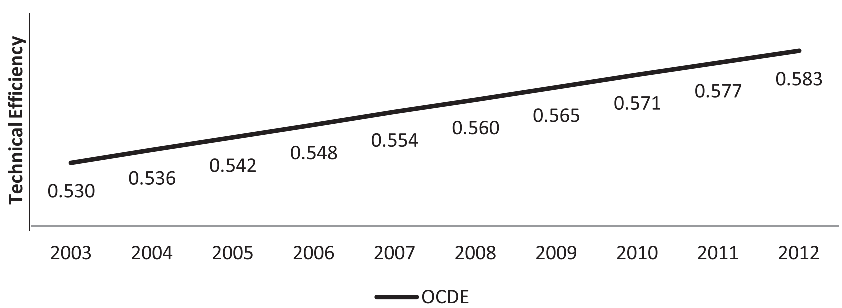

Figure 1. Chart of the evolution of technical efficiency for the OECD member countries (2003–2012).

observed with an average efficiency of 55%. The minimum achieved efficiency was 53% and the maximum achieved efficiency was 58%.

5. Discussion

Inefficiencies were detected in all OECD economies, implying that even advanced economies have room to grow. Nevertheless, average efficiency showed a strong positive trend, even in 2008 despite the Wall Street financial crisis that affected countries around the world.

One surprising result was the inefficiency found in Iceland's economy. This could be explained by the economic crisis of 2008–2010 due to the collapse of its banking system, where the three largest banks in the country declared bankruptcy and their combined debt exceeded more than six times the country's GDP (BBC News, 2009).

Luxembourg was the second most inefficient economy, although it had one of the highest incomes per capita. This could imply that income per capita measurements include bias in well-being.

In addition, Turkey lies in the middle of the ranking list even though it has faced institutional issues such as the coup d'état. Corruption, a variable related to institutions, does not appear to totally explain efficiency, considering that Mexico has a higher ranking than economies with less corruption, such as New Zealand. With that said, the top 15 economies in the ranking belong to countries that are perceived as having strong institutions.

Innovation is thought to be one of the variables that explain development. The top two economies enforce a strong protection of intellectual property rights and an agile patent system, such as the USA. Additionally, Great Britain is a leader in terms of innovation theory and advances in knowledge generation. Nevertheless, South Korea, one of the countries perceived as being very innovative, is ranked 19 of 34 countries. The same can be said about Ireland, whose strategy in recent years has also been strongly centred on innovation. This could imply that innovation and knowledge generation have an accumulative effect.

Germany is another interesting case. It is syndicated as having earned the most within the European Union, yet is the fourth most efficient of the European countries. By contrast, Great Britain is highlighted for its accomplishments in efficiency, although it may be leaving the EU in the short term.

In general, the results comply with the behaviour that was expected: that more advanced economies are more efficient than emerging economies, and that there are factors that must be further analysed, as some aspects had not been examined by previous empirical studies.

6. Conclusions

Technical efficiency is achieved when economies maximize output using all available inputs. Determining a country's level of efficiency provides a valuable insight into economic behaviour, and enables comparisons to other economies. If countries are not using their resources properly, they can make adjustments to increase production and improve efficiency.

The results obtained in this study identified the OECD economies that have idle resources and compares their behaviour to other countries. Countries with lower efficiency rankings have a much greater potential for increasing productivity considering the current combination of productive factors.

Moreover, the study revealed that the top ten most efficient OECD countries are from North America and central Western Europe, as well as Australia and Japan.

These results coincide with their relationship as trade partners. On the other hand, Latin American representatives occupy some of the lower rankings, such as Mexico (24) and Chile (28). Finally, countries with higher levels of efficiency have higher GDPs, and vice versa.

These results should influence public policies to focus on increasing the productivity and competitiveness of individual economies. In terms of the relevant literature, these results demonstrate an alternate method for analysing economic development. The results also provide investors and managers with a new mechanism for evaluating potential for investment, or for examining better business climates, which can influence public policies in other countries.

The objective of this study was to utilize the Stochastic Frontier Methodology to analyse economic performance, and a limitation of the analysis was only using traditional factors of production, labour and capital. However, a second stage of this study will assess other economic growth determinants to widen the scope of the present study. Also, other dependent variables that must be considered in future research are differences between income per capita and GDP, or alternative definitions to measure development growth rather than economic growth.

Future studies should apply the methodology to continental contexts, or regional blocks, i.e., measuring the efficiency of different economies in a continent or region, or to create a world efficiency ranking. It could also be applied to local contexts, measuring the efficiency of different regions/states of a country in order to determine which are the most efficient and to identify specific problems. Studies of this nature will help develop focused public policy, lay out specific conditions, and extend regional growth, in order to work toward more equal conditions and increased efficiency in every country.

Disclosure statement

No potential conflict of interest was reported by the authors.

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