ENTREPRENEURSHIP IN THE RAW MATERIALS SECTOR

PROCEEDINGS OF THE LIMBRA INTERNATIONAL SCIENTIFIC CONFERENCE

EDITED BY
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Preface

LIMBRA ('Decreasing the negative outcomes of brain drain in the raw materials sector') is a project funded by EIT RawMaterials. Our primary goal is to generate new entrepreneurial ideas in the raw materials sector, and to encourage engineering students graduating in raw materials-related programmes to start their own businesses. Additionally, it was also part of LIMBRA's mission to engage in wider society learning, and so make efforts to increase the general public's awareness about issues that are closely related to raw materials and natural resources: climate change, critical raw materials, and sustainable living.

The LIMBRA team is made up of four universities from the Visegrad countries (University of Miskolc, as leader, and AGH Krakow – University of Science and Technology, Technical University of Kosice, and Technical University of Ostrava as partners), and the Bilbao-based Tecnalia, one of Europe's leading centres of applied research and business incubation. Over the past three years our team has started several initiatives to achieve the LIMBRA goals: we have developed study materials to enhance the soft and business skills of engineering students; we have held summer schools where our study materials were deployed; we held real-life problem solving events; our expanded team conducted a comprehensive market research in order to detect market niches and business ideas in the raw materials sector; we developed materials and provided a platform for speeches directed at the wider public in order to increase awareness about such topics as energy decoupling, the role of critical raw materials, sustainability, and green growth; and we started a mentoring programme within which 20 business ideas connected to raw materials have been developed.

The conference titled Entrepreneurship in the Raw Materials Sector held on 24th November 2021 served as a summary and conclusion of our activities. Given the diversity of the LIMBRA initiatives, the conference also embraced a wide variety of topics. Some papers address macroeconomic issues such as green growth; several papers concentrate on the raw materials markets, and some of them raise specific business problems that can lead to the generation of new business ideas; a couple of papers deal with issues related to entrepreneurship training, and mentoring; and a good number of papers investigate topics related to entrepreneurship. Many of the papers are based on experience coming from LIMBRA activities (our real-life problem-solving events, our market research, and the entrepreneurship mentoring programme), and many others serve as good additions to our team's achievements.

Once again, we express our gratitude to EIT RawMaterials for the generous funding the LIMBRA team received during the 2019 – 2021 period. This proceeding offers a good summary of our approach, and our results: identify the critical trends in the macroeconomic environment; learn about the specifics of the raw materials markets; develop new business ideas, and rely on your local ecosystem for extra knowledge, mentoring, and help; and finally, "Become a stay-at-home entrepreneur" who contributes to the development of the community.

Miskolc, 28 November 2021
Zoltán Bartha, Project Manager


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Technical program committee

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The conference was carried out in the project entitled 'LIMBRA Decreasing the negative outcomes of brain drain in the raw material sector - EIT RawMaterials Project.'


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Top OECD performers in green growth—an FOI model analysis

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ABSTRACT: With rising concerns about climate change, the issue of green growth have been growing in importance. The aim of this study is to establish a measurement method for green growth, and to identify the best performing countries in this field. The Future, Outside, and Inside (FOI) development model was used to measure the performance of the 38 OECD countries. Based on their 2019-20 scores, the countries that are top performers in green growth are the members of the so called Welfare-participatory cluster (Austria, Denmark, Finland, Germany, Ireland, Israel, New Zealand, Norway, Sweden), and two outliers (Iceland, and Luxembourg).

1 INTRODUCTION

As the topic of human-induced climate change came more and more to the forefront of public debate, the area that is often summarized as green growth, energy transition or (energy and/or growth) decoupling became one of the main research problems in economics. A ProQuest database search for content published in 2021 provides 589,822 hits for green growth (14% of the all-time value), 372,172 ones for energy transition (15%), and 19,408 ones for decoupling (10,5%). These abstractions refer to very similar concepts. Green growth is defined as "fostering economic growth and development, while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (OECD 2011, p. 9); energy transition refers to the transition from fossil fuels to renewable energy (Quitzow et al. 2019); while according to the OECD "decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force (e.g. GDP)" (OECD 2002, p. 4). The big question is, whether green growth is happening, if the transition is happening quickly enough, and what are the policies that can facilitate the process.

This paper focuses on the OECD countries, uses the FOI model (Bartha & Gubik 2014) to evaluate their performance in the three main pillars of development (Future, Outside, and Inside potential), and investigates how green growth fits into the development model of the OECD countries. This study aims to answer two main questions: Is there a green growth pattern emerging among the OECD countries; and Which OECD countries perform the best in green growth? The contribution of this study is the following:

1. By measuring the Future, Outside and Inside potential of the OECD countries, and conducting a cluster analysis based on the FOI indices, it shows the different development paths these countries are on.
2. By investigating the variables correlated with the FOI indices, and conducting a factor analysis among them, it identifies a Green growth factor of the Future potential.
3. Finally, by comparing the average Green growth factor scores of the different OECD clusters, it identifies the group of countries that have done the best so far at achieving sustainable development.

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The rest of the study is structured as follows: section 2 provides a short literature review of the empirical results on the topic of green growth; section 3 introduces the FOI model, and the method and sources of calculating the FOI indices; section 4 presents the results of the calculations and offers a discussion of the results; section 5 concludes the study.

2 LITERATURE REVIEW

Although the literature on green growth is very rich, most of the studies focus on either individual countries, or certain sectors/industries of selected countries. In this review I focus on studies conducted on macroeconomic indicators of the OECD countries.

Szita (2014) in an early study calculates a Greening index for the 34 OECD members. Based on the data available for the early 2010s, she finds that the following countries can be considered as green: Austria, Denmark, Norway, Sweden, Switzerland, Japan, and Iceland.

Chakraborty & Mazzanti (2021) test 33 countries that are now all members of the OECD for the 1971-2015 period. They use methodologies that consider cross-sectional dependence and find that there is a significant positive relationship between per capita economic growth and per capita renewable electricity consumption. Higher per capita growth rates seem to go together with higher rates of renewable energy consumption, but the authors could not detect any Granger causality between the two variables (despite trying many specifications).

Gavurova et al. (2021) include all current 38 OECD members in their analysis. They select 15 indicators related to green growth, calculate an average for period 1 (2000-2009), and period 2 (2010-2019) and compare them. The authors find that overall, there is an improvement from period 1 to period 2. A cluster analysis is also conducted, splitting the countries into 6 (period 1), and 7 (period 2) clusters according to the indicators. The countries' cluster placement more or less corresponds to their development level.

Wang et al. (2019) conduct a dynamic panel regression analysis based on the data of the industrial sector of 24 OECD countries for the 2004 and 2010 period to test the impact of environmental regulation policy on green productivity growth. They find an inverted U-shaped relationship, so environmental regulation seems to hurt productivity growth after a certain stringency level. After decomposing the productivity growth, the catching-up effect is found to be the primary source of green productivity growth, which partially explains why some of lesser developed countries (the Czech Republic, Korea, Poland, and the Slovak Republic) of the OECD have the highest green total factor productivity growth. The other group of countries doing well in green productivity growth consists of Finland, Sweden, and France.

Shen et al. (2017) also measure green productivity growth, using a sample of 30 OECD countries over the period of 1970 – 2011. Their results show that green productivity has grown faster than the traditional Total Factor Productivity (TFP) would suggest, because carbon emission drops in periods of downturn. Improvements in technical and structural efficiency contribute to green growth from 1971 – 2000, which is in line with the results of Wang et al. (2019) who also found technical efficiency as the main driver, but for the remainder of the period technological progress seems to have the strongest impact. Shen et al. only provide data for three groups of countries (OECD Americas, OECD Asia-Oceania, and OECD Europe); out of these three groups OECD Europe has the lowest trend in carbon emissions, but this is also the region that grows the slowest over the inspected period.

Huang et al. (2021) take a slightly different approach and focus on the so called 3E trilemma (achieving energy security, economic development, and environmental protection at the same time). The authors set up a complex measurement method based on several indicators and use a sample of 34 OECD countries over the 2000 to 2015 period to test the relationship among the three pillars of the trilemma. Huang et al. could not detect a significant relationship between energy security and decoupling, but they find a group of five countries that have done well both in energy security and in decoupling economic growth from carbon emission. Australia, Switzerland, Germany, Denmark, and Sweden are the five members of this group.

Ates & Derinkuyu (2021) incorporate a number of indicators in their analysis, measuring the economic, social, and environmental aspects of the OECD countries. The authors create a single indicator by synthetizing the different variables using multivariate I-distance approach, and find that Sweden, Luxemburg, Norway, and Denmark are the top performers in green growth.

3 DATA AND METHODS

3.1 *Data and sources*

My analysis included a sample of 38 OECD countries and incorporated a total of 95 variables measuring the level of socio-economic development. The latest available data was used, which means that most of the values belong either to 2020 or 2019.

The data was obtained from the following sources:

1. OECD.Stat: https://stats.oecd.org/
2. WEF Global Competitiveness Report (Schwab 2019)
3. IMF World Economic Outlook Database, April 2021 Edition: https://www.imf.org/en/Publications/WEO/weo-database/2021/April
4. World Bank Doing Business database: https://www.doingbusiness.org/en/doingbusiness
5. Solability Sustainable Intelligence: https://solability.com/
6. WHO the Global Health Observatory: https://www.who.int/data/gho/data/indicators
7. Global Footprint Network: https://www.footprintnetwork.org/
8. Trading Economics: https://tradingeconomics.com/
9. ETS TOEFL results: https://www.ets.org/

3.2 *Method: The FOI model*

This study uses the FOI model to evaluate the development paths taken by the OECD countries and then identifies a Green growth factor that is correlated with the Future potential, the first of the three pillars of FOI. A detailed description of the method is available in Bartha & Gubik (2014), here only a short summary is provided.

The FOI model is developed on the assumption that three main dimensions determine the development path of economies. The future potential considers the long-term competitiveness of the economy; the outside potential determines the current world market position of the economy; while the inside potential summarizes factors that are crucial for the current well-being of the community. The FOI model assigns several variables to each of the three potentials and following some transformations (all variables are recoded to a 1-7 scale using a minmax method) they can be used to calculate the F, O, and I indices. Table 1 shows all the variables used for the calculation of the three indices.

Once the FOI indices are obtained SPSS is used to derive clusters of OECD countries and factors of the F, O, and I potentials. The hierarchical cluster analysis generates clusters of the 38 countries according to their F, O, and I indices and these clusters can be interpreted as different development strategies or paths. During the factor analysis I select a large number of variables that are correlated with one of the three indices and generate 2 factors for each index. These factors can then be used to provide a more sophisticated description of the OECD clusters. Green growth is one of the factors being connected to the F index.

4 RESULTS AND DISCUSSION

The F, O, and I indices of the OECD countries are included in Table 2. All components were transformed to a 1-7 scale, where 1 is the worst, and 7 is the best value of the indicator. In this

Table 1. Variables used to calculate the F, O, and I indices.

Index	Variables
F-index	1. Global Sustainable Competitiveness Index (Solability, 2020)
	2. Cooperation in labour-employer relations (WEF-GCI, 2019)
	3. Flexibility of wage determination (WEF-GCI, 2019)
	4. Electricity supply quality (WEF-GCI, 2019)
	5. Total expenditure on educational institutions (OECD, 2017)
	6. Elderly (65 and above) population (OECD, 2020)
	7. Renewable energy (OECD, 2019)
	8. Life expectancy at birth (OECD, 2020) & Healthy life expectancy (WHO, 2019)
	9. Ecological Footprint (GFT, 2020)
	10. R&D expenditures & Patent applications (WEF-GCI, 2019)
	11. 15-year-old students who are not low achievers (OECD, 2018)
O-index	1. Exports+Imports/GDP*2 (OECD, 2020)
	2. Country credit rating (TE, 2020)
	3. Soundness of banks (WEF-GCI, 2019)
	4. Exchange rate stability (IMF, 2019)
	5. TOEFL iBT® Total and Section Score Means (ETS, 2019)
I-index	1. Budget transparency & Burden of government regulation (WEF-GCI, 2019)
	2. Better life index (OECD, 2018)
	3. General government revenue (IMF, 2020)
	4. Assets in pension funds and all retirement vehicles (OECD, 2020)
	5. Gross domestic product per capita & Gross domestic product percent change (IMF, 2020)
	6. Financing of SMEs (WEF-GCI, 2019)
	7. Labour market Flexibility (WEF-GCI, 2019) & Labour force (OECD, 2020)
	8. Ease of finding skilled employees (WEF-GCI, 2019)

Source: own work based on Bartha & Gubik 2014

paper I focus on the F-index, since it is correlated with many of the variables that are typically used to measure green growth.

After the indices were calculated, I checked the bivariate correlation between the index values and the 90+ variables included in my database. Initially, all variables that were correlated to the index on at least 5% significance level were included in a factor analysis using principal components as an extraction method, and varimax for rotation. Some of the variables were correlated to more than one of the indices, so as I proceeded with the iterations, I aimed at including the variables in only one of the factors. The final iteration for the variables correlated to the F-index ended up with two factors (Table 3.), with a KMO value of 0.71. The two factors explain 57.8% of the total variance, which is not great, but acceptable. I also calculated a factor score for the Green growth factor using the regression method; the score for Costa Rica and Switzerland is missing, because no data was available for these countries in at least one of the variable categories included in the factor.

The cluster analysis was the next step. Countries were sorted according to their F-, O-, and I-index values, hierarchical cluster analysis was applied and between-group linkage was used as the cluster method. I intentionally went for a high number of clusters (11), so that smaller nuances could be detected as well. Table 4 contains the different clusters that were derived, and Figure 1 shows their position along the Future, Outside, and Inside dimensions.

Table 4 also includes the Green growth factor score for the 11 different clusters. Clearly, green growth performance is very heterogeneous even among the most developed countries. Countries in the Welfare-participatory cluster, and some other outliers do relatively well, while the Market-oriented and Statist clusters perform poorly.

The difference between cluster 1 and 2 is particularly striking, as these two clusters (with the exception of three outlier countries: Luxembourg, Iceland, and Switzerland) are typically the top performers in almost all other factors. They have the best scores in both factors of the

Table 2. The F-, O-, and I-index of the OECD countries in 2020.

Country	F-index	O-index	I-index
Australia	3.80	5.34	4.63
Austria	4.42	5.08	3.92
Belgium	3.82	4.87	3.59
Canada	4.00	4.93	4.64
Chile	3.65	3.90	3.78
Colombia	3.17	2.68	3.12
Costa Rica	3.31	3.65	1.96
Czech Republic	3.75	4.18	3.25
Denmark	4.92	5.01	4.71
Estonia	4.16	4.73	3.61
Finland	4.63	5.07	4.95
France	4.16	4.30	3.53
Germany	4.36	4.70	4.49
Greece	3.29	2.86	1.94
Hungary	3.08	4.40	2.61
Iceland	5.34	4.23	4.96
Ireland	4.27	4.60	4.95
Israel	4.52	4.59	4.10
Italy	3.54	3.53	2.66
Japan	4.67	3.72	4.11
Korea	4.30	4.28	3.77
Latvia	3.51	4.21	3.40
Lithuania	3.63	4.34	3.62
Luxembourg	3.80	6.11	4.61
Mexico	3.04	4.12	3.26
Netherlands	4.27	5.27	5.33
New Zealand	4.54	5.08	4.78
Norway	4.70	4.87	4.86
Poland	3.69	4.00	3.12
Portugal	3.93	3.67	3.14
Slovak Republic	3.40	4.76	2.92
Slovenia	3.99	4.49	3.20
Spain	3.17	4.02	3.14
Sweden	4.93	4.93	4.56
Switzerland	5.19	5.39	5.65
Turkey	3.14	3.16	3.07
United Kingdom	3.85	5.33	4.66
United States	3.89	5.39	5.30

Source: own calculations

Inside potential (Human capital and Governance), as well as in the only clearly distinguishable factor of the Outside potential (FDI readiness).

In fact, Cluster 1 (Market-oriented) and Cluster 2 (Welfare-participatory) are very similar to each other in almost every aspects of the FDI model (see Figure 1.). Their Outside and Inside potentials are similar (with the Market-oriented countries having a slightly higher average in the O-index, and the Welfare-participatory countries a slight edge in the I-index), and they are top performers in Future potential (where the Welfare-participatory cluster has a considerable, 0.6-point edge).

When looking for differences, we can check the FDI readiness factor (variables correlated with the O-index), where Cluster 1 has a score of 0.83, while Cluster 2 only scores 0.53, but both of these values are way higher than the factor score of any other multi-country cluster, and they are at the same level as Luxembourg (0.73, very close to Cluster 1's average), and Switzerland (0.54, almost identical to Cluster 2's average).

Table 3. The two factors of the future potential (rotated components matrix).

Factor	Variable	Component 1	Component 2
Government quality	Efficiency of legal framework in settling disputes	0.921	0.21
	Property rights	0.902	0.29
	Government ensuring policy stability	0.833	0.299
	Strength of auditing and accounting standards	0.83	0.155
	Share of population with tertiary education	0.787	0.022
	Patent applications per million pop.	0.762	-0.159
	Incidence of corruption	0.756	0.312
	R&D expenditures	0.746	-0.109
	Life expectancy at birth	0.638	0.363
	Contracting with Government	-0.518	0.19
	Total expenditure on educational institutions	0.442	0.167
Green growth	Production-based CO2 productivity	0.02	0.713
	Emissions priced above EUR 30 per ton of CO2	0.109	0.707
	Renewable energy	0.072	0.685
	Population connected to public sewerage	0.068	0.595

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 3 iterations.

Source: own calculations

Table 4. Clusters according to their FOI-indices.

Nr.	Name	GG fac. score	Members
1	Market-oriented	-0.47	Australia, Canada, Netherlands, United Kingdom, United States
2	Welfare-participatory	0.60	Austria, Denmark, Finland, Germany, Ireland, Israel, New Zealand, Norway, Sweden
3	Statist 1 (welfare)	-0.52	Belgium, Estonia, France, Korea, Slovenia
4	Statist 2 (protectionist)	-0.04	Chile, Czech Republic, Italy, Latvia, Lithuania, Mexico, Poland, Portugal, Spain
5	Laggard 1 (rising)	-0.49	Colombia, Turkey
6	Laggard 2 (falling)	0.18	Costa Rica, Greece
7	Statist 3 (open)	-0.65	Hungary, Slovak Republic
8	Iceland	2.34	Iceland
9	Japan	-1.45	Japan
10	Luxembourg	1.08	Luxembourg
11	Switzerland	n/a	Switzerland

Source: own calculations

Based on all the FOI-related calculations, the Market-oriented and the Welfare-participatory countries have the best indicator values within the OECD (again, three, similarly well-performing outliers need to be mentioned here: Iceland, Luxembourg, and Switzerland). They have the highest factor score in Human capital development and Governance (the Market-oriented group having a slight, 0.1-point edge); they also have the highest factor score in FDI readiness (the Market-oriented group leading by about 0.3); and they have the highest F-index as well (although the lead of the Welfare-participatory group is considerable in this area, and the Market-oriented cluster is overtaken by the Statist 1 group as well). So, the only clear difference among the top performers comes from the Green growth factor: the Welfare-participatory countries are on the top of the list (if we disregard Iceland and Luxembourg),