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Moderate Innovator Trap—Does the Convergence of Innovation Performance Occur in the World Economy?

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Abstract: Based on β and σ convergence analysis, we find a high persistence of innovation gaps for international innovation indices reported by the European Commission. Our research confirms the diverging scientific potential across the analyzed economies. Estimation provides evidence of convergence in the case of R&D expenses and the relative position on the global technological frontier. We propose a simple fixed effect panel regression measuring relative innovativeness potential. Our model suggests that current ranking leaders, i.e., Nordic countries (Sweden, Denmark, and Finland) and Germany, are likely to further outpace the United States. Central and Eastern European countries are achieving the greatest relative gains but are unlikely to exceed 70% of US potential. Peripheral European countries, South Africa, Turkey, and Russia are projected to further lose their innovativeness position despite their weaker initial position.

Keywords: β convergence; σ convergence; innovation; moderate innovators

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1. Introduction

Increasing research interest in the structural changes taking place in the world economy has been observed in the last few years. In particular, the emergence of high- and medium–high-technology industries in emerging markets, like China, attracts the greatest attention. The perspective of global growth convergence has begun to raise questions as developing economies are increasingly based on the use of knowledge. It has been recognized that in order to catch up with the developed world, emerging economies should fully appreciate and strongly support the value of science as a foundation for technological advancement and improved quality of life (Vuong 2018). However, many developing countries face the problem of "resource curse", i.e., overdependence on natural resources endowments, which may lead to the absence of innovations. Moreover, creativity and innovation in business may be concepts that are less widespread within some cultures; for example, a Confucian culture may prevent some ideas from permeating upward, or the willingness to take risks may be limited in some societies (Vuong and Napier 2014b).

Weak innovation capabilities are among the main forces that may lead developing countries to fall into the middle-income trap (Kharas and Kohli 2011; Eichengreen et al. 2012, 2014; Lebdioui et al. 2020). This idea highlights that developing economies have problems exceeding a certain threshold of GDP per capita. The problem is commonly linked with the exhaustion of benefits from imitating the solutions of the developed markets and lack of capacity to provide an innovative solution. On the other hand, the middle-income economies, which achieved rapid convergence progress, are characterized by, among other things, high levels of high-tech exports and patents (Lee 2020). As other studies (Liontakis 2020; Głodowska and Pera 2019) focus on convergence in GDP per capita, the present research goes beyond income convergence and concentrates on the thematic area of convergence in innovation performance in the world economy, trying to provide an answer to the question of whether if countries with a lower level of innovativeness can catch up with innovation leaders?

Because of the complicated nature of innovation, no single universal method to measure the innovativeness of an economy has been elaborated. It is not possible to use a single indicator (like R&D expenditures, number of patents) only, as this would offer a limited view of a broad and complex concept such as innovation. Both the theoretical models and the methods for developing internationally comparable indices to measure innovativeness point out the need for multifaceted measurement of innovativeness. There are different measurement methodologies used in different international comparative studies, out of which one of the most popular was developed in the annually published report entitled the European Innovation Scoreboard (European Commission 2019), in which the Summary Innovation Index (SII) is formulated. This is an example of a composite indicator approach, which reflects both the innovative ability and innovation position of an economy (Kowalski 2020a). The Summary Innovation Index consists of 27 indicators describing, e.g., scientific capabilities, Research & Development expenditure, or intense knowledge-rich activities. The studies analyzing the trends in innovation potential of the European Union countries highlighted the divergence across regions (Archibugi and Filippetti 2011; Kijek and Matras-Bolibok 2018). The objective of this paper is to extend the geographical scope of the research and include other international economies scrutinized by the European Commission, to answer the question, "Is there convergence in the world economy concerning innovation performance of developed and developing countries?"

We propose a simple fixed effect panel regression measuring relative innovativeness potential. Our model suggests that current ranking leaders, i.e., Nordic countries (Sweden, Denmark, and Finland) and Germany, are likely to further outpace the United States. Moreover, Central and Eastern European countries are achieving the greatest relative gains, but are unlikely to exceed 70% of the US potential. On the other hand, peripheral European countries, South Africa, Turkey, and Russia are projected to further lose position compared to other developed economies.

The next sections of this paper present arguments for possible divergence in innovative activities and are structured as follows. Section 2 describes the European Commission Summary Innovation Indices—probably the most comprehensive measure of various aspects of innovations. It also presents the methodology of our research and provides insight into different measurement techniques of convergence. Section 3 summarizes the results of the estimates. Section 4 discusses the results. Finally, Section 5 concludes the paper.

2. Materials and Methods

In this section, we introduce the European Innovation Scoreboard—a ranking proposed by the European Commission to measure the innovative potential of the EU28 economies as well as other international peers (including e.g., United States, Switzerland, Japan, or China).

Innovativeness potential does not have a single measure. The most popular view in macroeconomic theory associates innovation with the presence of national companies on the global technological frontier and achievement of higher labor and multifactor productivity (Cameron et al. 2005; Fu and Gong 2011; Fu et al. 2011). Firm-level studies suggest that convergence is not always the case even in developed economies. While (Cameron et al. 2005) it has been confirmed that the process of catching up exists based on UK industrial firms' data, numerous researchers provide evidence that the technology gap between leading innovators and moderately innovative areas remains persistent in several industries (Iacovone and Crespi 2010; Fu et al. 2011). In a cross-country perspective, less productive firms tend to converge only towards the local (national) frontier rather than the global one (Andrews et al. 2015).

From the perspective of less developed countries, technological catch-up typically relies on Foreign Direct Investments (further FDIs) and their positive spillovers. Theoretically, technological transfer from developed economies with labor turnover on emerging markets should improve human capital and regional potential output. Unfortunately, the

FDIs are not costless and have their limitations. The most crucial barrier visible in the countries lagging behind is the lack of absorptive capacity (Cohen and Levinthal 1990). Firms from developed countries typically shift the production to emerging states only for a product, where technical requirements are only slightly above the current technological frontier of the host economy (Glass and Saggi 1998). Additionally, there is often a conflict of interest between the needs of multinational companies providing capital and the native society's needs. The authors highlight that in-house research and development (R&D) expenditures and motivation systems for domestic investments are required to benefit from foreign capital expenses (Griffith et al. 2003; Crespo and Fontoura 2007).

Another problem is related to the regional system and network connections (Doloreux and Parto 2005). Knowledge-intensive industries are likely to cluster within narrow geographical areas. Numerous authors confirmed that intellectual property (PCT patents) is typically used by firms remaining in geographical proximity to the inventor (Maurseth and Verspagen 2002; Fleming et al. 2007). Finally, more interconnected countries have a greater capability to introduce and export new products (Klinger and Lederman 2006).

The methodology adopted in the European Innovation Scoreboard directly addresses all of these problems. Therefore, we believe that this study should be comprehensive and adequate to perform convergence analysis. The general summary innovation index for a European Union country is a synthetic indicator computed as an average of 27 subcomponents divided into the four pillars. Due to data limitations, indices for international economies contain only 16 subcomponents. The indices are reported annually typically in the middle of the year (June–July).

The first pillar, entitled Framework Conditions, contains 8 indicators for European Union countries and only 4 for international economies. The variables in both groups describe the scientific potential of the society e.g., the number of doctorate graduates, the share of people with tertiary education, as well as research capacity, i.e., international scientific publications and the share of the country's publications amongst the top 10% most cited papers. European indicators additionally account for an innovation-friendly environment, including broadband penetration and opportunity-driven entrepreneurship, cultural diversity (foreign doctorate students), and lifelong learning.

The second pillar, Investment, contains two variables internationally, namely research and development (R&D) expenditure in the business sector and in the public sector. European countries also report three other variables: non-R&D innovative outlays, expansion of venture capital, and availability of ICT training.

The third pillar; Innovation Activities (9 variables within the EU, 8 internationally), is focused on three aspects. The first aspect describes the engagement of Small and Medium Enterprises (SME) in innovative activities. This group consists of two variables—the first describes product or process (PP) innovation, and the second describes marketing or organisational (MO) improvement. The data tables use the acronyms of PP innovators and MO innovators, which are used by the European Commission. European countries report also whether innovative activities were done in-house or outsourced.

The second aspect of the survey promotes cooperation between entities and creating regional networks. The three variables belonging to this aspect describe collaboration of SME enterprises, number of private–public partnership co-publications per thousand inhabitants, and share of collaborative R&D expenses as a percentage of the Gross Domestic Product (GDP).

The third aspect is dedicated to accumulating and using intellectual property rights. The European Commission tracks the number of patent applications under PCT procedure (which stands for Patent Cooperation Treaty), trademarks, and individual design. The number of applications is divided by GDP in Purchasing Power Standard.

Finally, the fourth pillar, Impact, relies strongly on the concept of a technological frontier. This group contains 2 common indicators for international and European Union economies: share of knowledge-intense services in the total services export (further KIS exports) and share of medium- and high-tech products in total goods exports (further

MHT exports). European indicators have an additional 3 measures: first, employment in knowledge-intense activities; second, the employment by fast-growing innovative firms, and third, the frequency of introduction of the innovative products (sales of new-to-market and new-to-firm innovations).

The European Commission transforms each of the variables mentioned and expresses it with a normalized score index, which takes values from 0 to 1. A higher number denotes stronger innovative potential. The descriptive statistics for each subindex are presented in Table 1.

Table 1. European Innovation Scoreboard in 2017—descriptive statistics.

Component	Mean	Min	Max	Std. Deviation
Summary Innovation Index	0.50	0.02	1.00	0.27
KIS Export	0.54	0.00	0.99	0.26
MHT Export	0.40	0.01	1.00	0.27
Private funded public R&D	0.42	0.02	1.00	0.24
Designs	0.35	0.03	1.00	0.31
Trademarks	0.38	0.01	1.00	0.23
PCT patents	0.43	0.00	1.00	0.31
Public-private co-publ.	0.43	0.02	1.00	0.28
R&D exp. business sector	0.47	0.00	1.00	0.26
R&D exp. public sector	0.48	0.00	1.00	0.29
Innovation co-operation	0.44	0.00	1.00	0.30
MO innovators	0.48	0.02	0.96	0.28
PP innovators	0.54	0.06	0.97	0.25
Most cited publications	0.48	0.03	1.00	0.31
International co-publ.	0.54	0.05	1.00	0.29
Tertiary education	0.48	0.00	1.00	0.30
Doctorate graduates	0.50	0.02	1.00	0.27

Indices take values from 0 to 1. The higher number denotes that the economy is more innovative.

The summary innovation index is calculated as an average of normalized scores from 28 indicators for European Union countries and 16 indicators for international economies. We have modified indices for the EU countries to match the indicators from the international database, averaging 16 common subcomponents only. Such transformed indicators were used during all of the estimations.

The overall panel consists of EU27 countries, with other European economies reporting all 28 indicators (United Kingdom, Iceland, Israel, Norway, Switzerland, Turkey) and the group of international economies (Canada, Australia, Japan, United States, China, Brazil, South Africa, Russia, India). The evolution of the summary innovation index and the top-performing economies for each component of the EIS scoreboard was presented in Tables 2 and 3. The research covers the period from 2010 to 2017, and indicators are collected once per annum.

Table 2. European Innovation Scoreboard—Summary Innovation Index.

Country	Index Value		Index Standard Deviation	Position in the Ranking	
	2010	2017	2010–2017	2010	2017
Canada	0.68	0.66	0.01	5	7
Australia	0.60	0.63	0.01	7	10
Japan	0.57	0.58	0.01	12	13
United States	0.56	0.57	0.01	13	14
China	0.36	0.43	0.02	28	23
Brazil	0.30	0.30	0.01	31	32
South Africa	0.27	0.28	0.01	32	35
Russia	0.26	0.28	0.02	37	36
India	0.23	0.24	0.01	39	40
EU	0.54	0.57	0.01	14	15
Belgium	0.58	0.64	0.02	11	9
Bulgaria	0.16	0.22	0.03	43	42
Czech Republic	0.37	0.40	0.01	26	24
Denmark	0.69	0.72	0.01	3	3
Germany	0.68	0.67	0.02	4	6
Estonia	0.42	0.39	0.03	22	27
Ireland	0.50	0.55	0.02	19	18
Greece	0.33	0.35	0.01	29	30
Spain	0.36	0.38	0.01	27	28
France	0.51	0.53	0.01	18	20
Croatia	0.26	0.25	0.02	34	37
Italy	0.38	0.39	0.01	25	25
Cyprus	0.41	0.44	0.01	24	22
Latvia	0.20	0.22	0.01	41	41
Lithuania	0.27	0.34	0.03	33	31
Luxembourg	0.54	0.59	0.03	16	12
Hungary	0.31	0.28	0.01	30	34
Malta	0.26	0.36	0.06	36	29
Netherlands	0.60	0.67	0.03	8	4
Austria	0.59	0.65	0.02	9	8
Poland	0.25	0.25	0.01	38	38
Portugal	0.42	0.39	0.01	23	26
Romania	0.20	0.16	0.02	42	43
Slovenia	0.48	0.51	0.02	20	21
Slovakia	0.26	0.30	0.02	35	33
Finland	0.65	0.67	0.01	6	5
Sweden	0.71	0.72	0.01	2	2
United Kingdom	0.54	0.60	0.03	15	11
Iceland	0.53	0.54	0.02	17	19
Israel	0.59	0.57	0.02	10	16
Norway	0.47	0.56	0.04	21	17
Switzerland	0.80	0.80	0.02	1	1
Turkey	0.22	0.25	0.01	40	39

The index takes values from 0 to 1. The higher number denotes that economy is more innovative.

Table 3. European Innovation Scoreboard in 2017—most innovative countries.

Component	1st	2nd	3rd
Summary Innovation Index	Switzerland	Sweden	Denmark
KIS Export	Ireland	Luxembourg	India
MHT Export	Japan	Hungary	Germany
Private funded public R&D	Malta	Russia	Denmark
Designs	Cyprus	Luxembourg	Malta
Trademarks	China	Sweden	Israel
PCT patents	Japan	Israel	Germany
Public-private co-publ.	United States	Germany	Israel
R&D exp. business sector	Belgium	United Kingdom	Iceland
R&D exp. public sector	Switzerland	Luxembourg	Australia
Innovation co-operation	South Africa	Japan	Belgium
MO innovators	Israel	Brazil	Switzerland
PP innovators	Australia	Sweden	Canada
Most cited publications	Switzerland	United States	United Kingdom
International co-publ.	Australia	Denmark	Sweden
Tertiary education	Canada	Cyprus	Russia
Doctorate graduates	Australia	Slovenia	Switzerland

In the case of equal scores of the top 3 performers in the ranking, the countries were sorted lexicographically.

We aim to determine whether cross-country convergence of innovation occurs. We introduce two measures of concurrences: β and σ (Barro and Sala-I-Martin 1992; Quah 1993). Secondly, we introduce simple relative models distinguishing between in-house innovative capacity and imitations (Griffith et al. 2003).

The most popular concept of convergence (β) assumes that less developed countries/areas are growing more quickly compared to the more affluent peers. Let us denote $innov_t$ as summary innovation index at the time t. We expect to see a positive relationship of average annual change during the period 2010–2017 and starting level $innov_0$ (index value at 2010).

$$\frac{(innov_t - innov_0)}{T} = \delta_0 + \delta_1 * innov_0 \quad (1)$$

where δ_1 should take a negative value if convergence exists. On the other hand, a positive value of this parameter denotes divergence. We will repeat calculations for every single component creating a summary innovation index.

Secondly, we also attempt to use another measure—σ convergence. This indicator assumes that if convergence exists, cross-country standard deviation should diminish over elapsed time. The downward trend should be visible, using the following formula.

$$std(innov_t) = \alpha_0 + a_1 * T \quad (2)$$

We expect the a_1 parameter in Equation (2) to have a negative value; otherwise, divergence occurs. Similarly to the case of β convergence, the estimation will be repeated for all innovation index components.

Finally, the literature on this subject tends to distinguish between the capability of in-house innovation and imitations, we proposed a simple fixed-effects panel model:

$$d\left(\frac{innov_t}{innov_{USA_t}}\right) = \beta_0 + \mu + \beta_1 * \left(\frac{innov_{t-1}}{innov_{USA_{t-1}}} - 1\right) \quad (3)$$

where μ is a cross-country estimated fixed effect, $innov_{t-1}/innov\_USA_{t-1}$—is a relative distance of the country summary innovation index to the United States (selected as a benchmark), β_0 and β_1 are estimated parameters.

This model has a relatively straightforward economic interpretation. Parameters $\beta_0 + \mu$ describe the in-house innovative potential. The negative sum indicates that country is expected to remain in the middle innovation trap, as it is unlikely to catch up with the

United States. β_1 can be identified with the improvement of innovative potential done by imitations. We expect the parameter to be negative. In such cases, countries lying far below the technological frontier are more likely to catch up more strongly (in line with β convergence spirit). Based on this model, we can calculate the steady, state where

$$0 = \beta_0 + \mu + \beta_1 * \left(\frac{innov^*}{innov^*_{USA}} - 1 \right) \quad (4)$$

The result of such exercise should present expected relative performance in case of a scenario of no policy change.

3. Results

This section discusses our findings on innovative capacity convergence. We propose three measures to determine if countries described as moderate innovators are catching up towards the innovation leaders.

The results of β convergence analysis are presented in Table 4. The third column contains estimates of parameter δ_1—the negative values indicate that fewer developed countries are catching up the distance to current leaders. The last column presents whether estimates are statistically significant.

Table 4. β convergence.

	δ_0	δ_1	**T-Statistic (δ_1)**	***p*-Value (δ_1)**	**Significance (δ_1)**
Summary Innovation Index	0.00	0.00	−0.24	0.81	
KIS Export	0.01	−0.03	−2.51	0.02	**
MHT Export	0.01	−0.01	−1.82	0.08	*
Private funded public R&D	0.02	−0.04	−2.46	0.02	**
Designs	0.01	0.00	−0.26	0.80	
Trademarks	0.01	−0.01	−1.38	0.17	
PCT patents	0.00	−0.01	−1.06	0.30	
Public-private co-publ.	0.00	0.00	0.51	0.61	
R&D exp. business sector	0.01	−0.03	−2.30	0.03	**
R&D exp. public sector	0.01	−0.03	−2.57	0.01	**
Innovation co-operation	0.01	−0.02	−1.31	0.20	
MO innovators	0.01	−0.02	−3.18	0.00	***
PP innovators	0.00	0.00	−0.26	0.80	
Most cited publications	0.01	−0.01	−1.74	0.09	*
International co-publ.	0.02	0.02	2.43	0.02	**
Tertiary education	0.01	0.00	−0.71	0.48	
Doctorate graduates	0.02	−0.01	−0.93	0.36	

*** denotes significance at α = 0.01, ** at α = 0.05, * at α = 0.10.

The estimated corresponding to the Summary Innovation Index does not differ from zero, suggesting quite a persistent status quo between innovative potential across the countries. The analysis of subcomponents presents three significant trends: (1) convergence of R&D expenditures in both business and public sector and related to the position of countries' production on the global technological frontier; (2) possible divergence of scientific potential with greater internationalization of research in developed countries; (3) the relatively stable position in case of using intellectual property rights (PCT patents, designs, and trademarks) and SME activities, especially when it comes to product or process innovation.

The results of σ convergence analysis are available in Table 5. The data columns 2–9 contain cross-country standard deviation observed in the subsequent years. Columns 10–11 present the estimated parameters. Column 12 says whether the parameter a_1 is statistically significant.

Table 5. σ convergence.

	Cross—Country Standard Deviation								Parameters		
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	α_0	a_1	**Test**
Summary Innovation Index	0.17	0.17	0.18	0.17	0.17	0.17	0.17	0.17	0.17	−0.18	
KIS Export	0.28	0.28	0.29	0.28	0.28	0.28	0.29	0.27	0.29	−1.64	*
MHT Export	0.27	0.27	0.27	0.26	0.27	0.27	0.27	0.26	0.27	−0.57	
Private funded public R&D	0.28	0.28	0.28	0.31	0.31	0.31	0.30	0.27	0.28	1.89	
Designs	0.22	0.24	0.25	0.25	0.26	0.25	0.24	0.24	0.24	1.28	
Trademarks	0.31	0.32	0.31	0.32	0.31	0.31	0.31	0.31	0.32	−0.90	
PCT patents	0.23	0.24	0.23	0.22	0.23	0.23	0.23	0.23	0.23	0.08	
Public-private co-publ.	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.31	0.29	1.16	**
R&D expenditure business sector	0.28	0.28	0.27	0.27	0.26	0.26	0.28	0.28	0.28	−1.45	
R&D expenditure. public sector	0.27	0.27	0.26	0.26	0.24	0.24	0.26	0.26	0.27	−2.99	
Innovation co-operation	0.27	0.27	0.28	0.28	0.27	0.27	0.28	0.29	0.27	1.99	*
MO innovators	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.30	0.33	−4.10	***
PP innovators	0.26	0.26	0.26	0.26	0.27	0.26	0.27	0.28	0.26	1.95	**
Most cited publications	0.26	0.26	0.27	0.26	0.27	0.26	0.25	0.25	0.27	−1.17	
International co-publ.	0.25	0.27	0.28	0.29	0.30	0.30	0.31	0.31	0.25	8.01	***
Tertiary education	0.29	0.29	0.30	0.30	0.30	0.29	0.29	0.29	0.30	−0.18	
Doctorate graduates	0.27	0.28	0.27	0.27	0.29	0.30	0.30	0.30	0.26	4.94	***

Parameters a_1 were scaled (multiplied by 1000) to visualize whether the trend has an upward or downward slope. *** denotes significance at α = 0.01, ** at α = 0.05, * at α = 0.10.

Similar to the case of β convergence analysis, there is no statistically significant trend for the Summary Innovation Index. The indicator describing the slope of the time trend in a cross-country standard deviation takes a value, which does not statistically differ from 0.

The σ convergence analysis confirms also the divergence of scientific potential—cross-country standard deviation is in an upward trend in case of the indicator describing the number of doctorate graduates in the population and the internationalization of scientific publications. The divergence is also statistically significant in the case of selected SME activities—product and process innovations and international co-operation.

Similarly to the first analysis, there is statistically significant evidence of convergence in marketing and operational innovations and knowledge of intense services export.

Finally, we estimated the simple model of Summary Innovation Index dynamics. Small countries, i.e., those whose population does not exceed 4 million people, were excluded from the sample to eliminate potential outliers. The data for Luxembourg, Malta, Cyprus, Croatia Slovenia, Iceland, and Baltic states (Estonia, Latvia, and Lithuania) were not used during the estimations.

Model parameters are presented in Table 6.

Table 6. Summary Innovation Index Dynamics—Fixed effects model.

Model Parameters				
	Coefficient	**Std. Error**	**t-Statistic**	**Prob.**
Constant	−0.41	0.06	−7.33	0.00
Summary Innovation Index—distance to the US	−0.07	0.01	−7.05	0.00
Model diagnostics				
R-squared	0.55	Mean dependent var		0.00
Adjusted R-squared	0.46	S.D. dependent var		0.03
S.E. of regression	0.02	Akaike info criterion		−4.88
Sum squared resid	0.07	Schwarz criterion		−4.29
Log likelihood	567.98	Hannan-Quinn criter.		−4.65
F-statistic	6.00	Durbin-Watson stat		2.10
Prob(F-statistic)	0			

Periods included: 7, Cross-sections included: 31, Total observations: 217.

Table 7 presents estimated cross-country fixed effects (column 2) and steady states (column 5). Similarly, to the results of β and σ convergence analysis, minor changes are expected.

Table 7. Fixed effects and steady state computations.

	μ	$\beta_0+\mu$	2017 Scores Relative to US	Steady State-Relative to US	Change (pp)
Australia	0.12	0.05	111%	113%	1.6%
Austria	0.13	0.06	115%	115%	0.1%
Belgium	0.11	0.04	112%	111%	−1.4%
Brazil	−0.11	−0.18	52%	56%	3.4%
Bulgaria	−0.18	−0.25	39%	39%	0.0%
Canada	0.14	0.07	116%	118%	1.3%
China	−0.03	−0.10	75%	76%	0.8%
Czechia	−0.05	−0.12	69%	70%	0.9%
Denmark	0.19	0.12	127%	128%	1.7%
Finland	0.15	0.08	117%	118%	1.7%
France	0.04	−0.03	93%	94%	0.3%
Germany	0.15	0.08	117%	120%	3.0%
Greece	−0.10	−0.17	61%	59%	−1.1%
Hungary	−0.13	−0.19	50%	52%	2.3%
India	−0.17	−0.24	42%	42%	−0.1%
Ireland	0.05	−0.02	97%	95%	−1.4%
Israel	0.08	0.01	99%	102%	2.9%
Italy	−0.05	−0.12	69%	70%	1.0%
Japan	0.08	0.01	102%	103%	1.3%
Netherlands	0.14	0.07	118%	117%	−1.0%
Poland	−0.16	−0.23	43%	44%	0.6%
Portugal	−0.06	−0.13	69%	68%	−0.3%
Romania	−0.21	−0.28	29%	32%	3.1%
Russia	−0.15	−0.22	49%	47%	−1.9%
Slovakia	−0.12	−0.19	53%	55%	1.7%
South Africa	−0.14	−0.21	49%	48%	−1.5%
Spain	−0.07	−0.14	66%	65%	−0.8%
Sweden	0.19	0.12	127%	128%	1.7%
Switzerland	0.23	0.16	140%	139%	−1.3%
Turkey	−0.17	−0.24	43%	41%	−2.2%
UK	0.09	0.02	106%	104%	−1.4%

Our model suggests that current ranking leaders i.e., Nordic countries (Sweden, Denmark, and Finland) and Germany are likely to further outpace the United States position in the innovativeness ranking. However, Central and Eastern European countries including Poland, Hungary, Czech Republic, and Romania are achieving the greatest gains but are unlikely to exceed 70% of US potential.

Another interesting example is China—our model indicates nearly stable potential (at 76% of the United States level), after rapid expansion in the years 2010–2014. The European Commission reports constant depression in the export of knowledge-intense serviced export. The construction of ranking is likely to underestimate the innovative potential, e.g., on artificial intelligence related to strategy Made in China 2025 (as technology is utilized in the domestic market only).

On the other hand, peripheral European countries (Greece, Spain Portugal, and Ireland) are projected to lose their innovativeness position. The same problem is related to South Africa, Turkey, and Russia despite their low initial position.

4. Discussion

As the global economy faces many uncertainties and is entering a stage of stagnation, innovation is among the key drivers of sustainable development (Vuong and Napier 2015). There is a strong need to develop innovative production systems, which would go beyond conventional production inputs, namely labor (L) and capital (C), to produce desired outputs, employing a set of creativity methods (Vuong and Napier 2014a). This would increase total factor productivity (TFP), especially in developing countries, as there are large, persistent TFP differences in the world economy (Hsieh and Klenow 2009). TFP differences are large also on the regional level within countries and are strongly related to economic geography and historical development paths, which suggests limited interregional diffusion of technology (Beugelsdijk et al. 2018).

Contrary to the research outcomes for the European Union countries (Archibugi and Filippetti 2011; Kijek and Matras-Bolibok 2018), we found no statistically significant divergence trend for international innovation indices reported based on both β and σ convergence analysis and our fixed-effects model. Still, our research confirmed that technological gaps are persistent, and there are no signs of convergence. Hence, there is no convergence in innovation performance in contrary to income convergence in the world economy as postulated in the so-called convergence hypothesis, which was formulated in neoclassical models of economic growth (Mankiw Gregory et al. 1992; Solow 1956). However, usually, the type of convergence pointed out by these models is conditional convergence, which takes place when different countries tend towards multiple steady states that depend on other variables, including innovation potential.

Based on the subcomponents analysis, we found divergence of scientific potential measured by the number of doctorate students in the population (σ convergence) and international co-publications (both measures). Our research indicates also the problem with the diverging process and product innovations amongst SME enterprises. On the other hand, there are signs of convergence in the case of position on technological frontier and R&D expenses. Both β and σ analysis confirmed the spreading of marketing and operational innovations and knowledge of intense services exports.

Geographical modeling suggests consolidation of division between core and peripheral European Union countries (Magone et al. 2016), as well as North–South division in the global context (Arrighi et al. 2003). The Nordic countries and Germany are expected to increase innovative potential, while peripheral economies are projected to lose the position in comparison with the United States. Similarly, Central and Eastern Europe are expected to develop the fastest, but its potential should still remain significantly below the level of Western economies. Finally, less developed countries like South Africa, Russia, Turkey, or India show limited potential for an increase in technological potential. These findings are consistent with the study (Kowalski 2020b) showing that countries located in the South are usually characterized by developing innovation systems, which are focused not on the generation of technology but rather its absorption from abroad. Although there has been intense international technology transfer in the last few years, accompanied by increasing innovative potential of emerging markets, there is still a persistent divide in the world geography of innovation. Drori (Drori 2010) explains that the global diffusion of digital technology, which took place faster than the diffusion of any technology previously, has been hindered by its uneven distribution worldwide. According to Gouvea and Kassicieh (Gouvea and Kassicieh 2012), there is a growing gap between countries that are able to generate innovation and countries that cannot. Innovation leaders can reshape the nature of competition on a global scale, whereas innovation followers are subject to the rules set up by the innovators. Another study (Veugelers 2016), which was limited to the EU countries, shows that there is a significant divide between member countries with high capacity to innovate and those with low innovation capacity and that the difficult convergence process has been proceeding slowly and unevenly.

5. Conclusions

The research identified a lack of convergence of innovative potential between countries. According to the model, the strong discrepancy between highly innovative North and less developed South of the European Union members is unlikely to vanish in the foreseeable future. The problem is even stronger in the comparison between developed and emerging economies. The uneven innovative potential is likely to limit growth opportunities in the emerging markets and solidify well-known middle-income traps.

Secondly, we identified a strong divergence of scientific and research potential. This phenomenon may result in a problem of the brain drain, i.e., migration of skilled individuals from the peripheral countries to the leading innovation centers to pursue career opportunities. The uneven distribution of skilled cognitive jobs is also likely to result in social tension between the regions—some prelude of this problem was already visible in the USA, where the abandoned rust belt played a decisive role in the election in 2016, or France, where the yellow jackets movement violently protested against inequality.

To prevent such events, governments and international organizations such as the European Union should reconsider implementing deglomeration policies aiming to provide incentives for multinational companies to diversify geographically knowledge-intense activities. So far, such instruments have been applied mostly regionally—for example, in post-war Germany.

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