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AUTHORS	Maxim Polyakov Igor Khanin Vladimir Bilozubenko Gennadij Shevchenko Maxim Korneyev

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Maxim Polyakov (the USA), **Igor Khanin** (Ukraine), **Vladimir Bilozubenko** (Ukraine), **Gennadij Shevchenko** (Ukraine), **Maxim Korneyev** (Ukraine)

DIFFERENTIATION OF INNOVATION ECOSYSTEMS OF THE COUNTRIES BEING THE GLOBAL INNOVATION INDEX LEADERS IN THE GLOBAL COMPETITIVE CONTEXT

Abstract

Innovations have become pivotal for the growth and competitiveness of national economies. Generating innovations necessitates a comprehensive ecosystem as a set of conducive conditions. With competition intensifying and focusing on innovation, countries increasingly prioritize the enhancement of their innovation ecosystems. The foundation for this lies in international comparisons, particularly among countries that are global leaders, as it aids in identifying their specific characteristics and advantages. The aim of the study is to differentiate the innovation ecosystems of world-leading countries by highlighting the indicators in which they differ the most.

The paper covered the top 15 countries according to the Global Innovation Index, each characterized by 23 indicators in their innovation ecosystems. In the first stage, using mathematical processing (the k-means method), the countries were divided into six clusters. Then, to find the parameters that differentiate the obtained clusters, a classification analysis was conducted (the "decision tree" method), resulting in 11 indicators that, in various pairwise combinations, most differentiate the analyzed countries. These indicators reflect the features and most important advantages (or weaknesses) of each innovation ecosystem and are also priorities for increasing the parameters of these ecosystems to improve the position of countries. It is advisable to use these indicators to form state innovation policy.

Keywords innovation ecosystems of countries, indicators, clustering, classification analysis, differentiation

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Maxim Polyakov, Doctor of Economics, Associate Professor, Noosphere Ventures Inc., the USA.

Igor Khanin, Doctor of Economics, Professor, National University of Water and Environmental Engineering, Ukraine.

Vladimir Bilozubenko, Doctor of Economics, Professor, University of Customs and Finance, Ukraine.

Gennadij Shevchenko, Candidate of Technical Science, Associate Professor, Association Noosphere, Ukraine.

Maxim Korneyev, Doctor of Economics, Professor, University of Customs and Finance, Ukraine. (Corresponding author)

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INTRODUCTION

Innovation involves transforming ideas into new (improved) products and services, perceived by the market, or the creation of business models and technological and managerial processes that enhance economic efficiency. As economic systems have evolved, innovation has become one of the most significant factors for the growth and development of national economies. The significance of innovation, and therefore innovation opportunities for countries, is growing on the one hand due to technological and economic transformations observed today, such as digitization, industrial revolutions, transition to a green economy, and so on. On the other hand, it is also due to the continuous intensification of global competition. The competitiveness level of countries and their positions in the global economy significantly depend on the success in developing and adopting innovations.

Given this, governments purposefully support innovation activity in the economy to create the most favorable conditions, considered together as a specific ecosystem. The quality of this ecosystem determines the stability of reproduction, the scale, and the results of innovations. With the intensification of competition, each country naturally aims to enhance its innovation ecosystem, necessitating comprehensive diagnostics and the selection of crucial parameters for efficiency in these conditions. Ultimately, these parameters will contribute to securing a higher position for the country in the global innovation race. The identification of these critical parameters for enhancing a specific country's innovation ecosystem should rely on international comparisons. Given the nature of global competition in innovation, it is advisable to compare the innovation ecosystems of countries that are global leaders with more advanced innovation development models. Countries' leadership in innovation can be assessed using the Global Innovation Index (GII), the most authoritative rating for evaluating the efficiency of countries' innovation ecosystems.

Considering the escalating global competition, a crucial scientific and practical task is to differentiate the innovation ecosystems of world-leading countries. Specifically, this involves identifying the indicators of innovation ecosystems that differentiate countries in a particular group the most. Such a comparison will demonstrate the structural features of their innovation ecosystems, as well as the strengths and weaknesses of individual countries in innovations.

1. LITERATURE REVIEW

In the knowledge economy, intellectual leadership has become crucial for achieving top positions in competitive battles. This entails high quality and efficiency in utilizing intellectual resources, where the most intense competition is observed (Kalenyuk et al., 2018). This has elevated to the national level, creating a new paradigm of global competition, which increasingly focuses on innovation. Innovations are increasingly pivotal for the growth and development of national economies (Maradana et al., 2019; Kuzkin et al., 2019), as well as for bolstering the global competitiveness of countries and specific economic sectors (Marčeta & Bojnec, 2020; Shkolnyk et al., 2019), especially in the high-tech sector (Braja & Gemzik-Salwach, 2020).

The economic successes of the world's leading countries are largely due to their creation of a conducive environment for generating and implementing promising innovations. This focus highlights the importance of the quality and efficiency of national innovation ecosystems (alongside the concept of national innovation systems), which are viewed as a complex of various factors and conditions necessary for innovation to emerge (Granstrand & Holgersson, 2020; Gontareva et al., 2022; Marcon et al., 2024). Innovation ecosystems consist of various components. This makes them complex and influences approaches to their parametric description and quantitative assessment. Therefore, the structure and functions of innovation ecosystems are characterized by a diverse set of specific indicators that describe and allow for a quantitative assessment of various aspects of the functioning and efficiency of these ecosystems. Such a synthetic approach requires continuous multidimensional analysis of the characteristics of innovation ecosystems.

Given that the main functional blocks of innovation ecosystems and the macroprocesses they reproduce are similar in different countries, even considering possible configurations, there is an opportunity for corresponding international comparisons, especially parametric ones (Reiter et al., 2024; Paasi et al., 2023). The necessity for such comparisons arises from the intensifying global competition in innovation. Within this framework, comparisons enable identifying and assessing disparities in innovation ecosystems, the determination of their specific national traits (or similarities), and the strengths and weaknesses of individual countries across diverse indicators or specific qualitative features. Given the multitude of indicators that characterize innovation ecosystems, their parametric comparison (or juxtaposition) becomes a complex scientific and practical endeavor.

The challenges of promoting innovation are especially pertinent for developing countries, which are establishing their innovation ecosystems in a complex competitive environment (Mokhtari

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Moughari & Daim, 2023). Given the importance of innovations for the modern economy, enhancing innovation ecosystems is crucial for overcoming global economic disparities, primarily driven by variations in countries' innovation capabilities (Mohamed et al., 2022). It is precisely the ability to create and adopt innovations that generates a technological gap between developed countries (technology producers) and developing ones (technology exporters), which grows and increases economic asymmetry (Gebrerufael, 2021).

The problem of the innovation (technological) gap in the global economy has other manifestations. In particular, this applies to the gap between leading players, such as the EU and China, where competition is also intensifying (Kowalski, 2021). In recent years, considerable attention has been directed toward China's advancements, as it acknowledges the economic and geopolitical importance of technology, aiming to secure a leadership position in the global economy. The escalating competition between the US and China is increasingly shifting toward innovation (Choi, 2023), evolving into a technological war (Sun, 2019; Zhuravka et al., 2021) with geopolitical implications that affect other nations (Wong, 2022). This shift in the global competitive landscape, marked by heightened innovation rivalry, further emphasizes the need for countries to address the issues of improving conditions for generating and adopting innovations. This requires comparing the innovation ecosystems of individual countries, considering various aspects, parameters, and operational outcomes (Ituarte, 2020). Such comparisons enable evaluating their positions and identifying their unique characteristics, strengths, and weaknesses as competitors. International comparisons provide the basis for identifying areas to enhance a specific innovation ecosystem and the parameters that need strengthening to narrow the gap with other countries.

The innovation gap can be analyzed within the context of country unions, particularly the EU. The differences among its member countries in innovation create the challenge of convergence, which involves raising the level of development of lagging countries (Aytekin et al., 2022). Without this, achieving global competitiveness and leadership for the entire EU would be unattainable, so special attention is paid to supporting science and innovation, in addition to the efforts of individual member countries. From the EU's perspective, enhancing the level of innovation development and the efficiency of innovation ecosystems involves bridging the gaps between member countries within the union and overcoming the EU's lag behind other global players in various innovation development areas (Kowalski & Rybacki, 2021; Xu et al., 2023). This requires corresponding international comparisons, partially implemented through the European Innovation Scoreboard (Zabala-Iturriagagoitia et al., 2021), but can be complemented by the approach used in this paper.

International comparisons of innovation ecosystems, including the state of all its components, allow attention to be focused on specific, most priority indicators (Kang et al., 2019). The main approaches to defining and assessing such indicators are based on statistical methods of measuring innovation activity, utilizing well-known sets of parameters common in national and international statistics (Paredes-Frigolett et al., 2021). The most common ranking for assessing the efficiency of countries' innovation ecosystems is the Global Innovation Index (GII), which is published by the World Intellectual Property Organization (WIPO) and covers a large amount of up-to-date data on various aspects of countries' innovation potential and the results of its utilization. The GII indicators can be used to assess the potential, performance, dynamics, and structural features and conduct qualitative comparative analysis of countries' innovation ecosystems (Yu et al., 2021; Brás, 2023; Nasir & Zhang, 2024).

The recent research review highlights a strong focus on innovation development and the establishment of effective national innovation ecosystems. Part of defining priority areas and developing corresponding measures indeed involves international comparisons. However, there are gaps in justifying the differentiation of countries' innovation ecosystems, especially when comparing the ecosystems of specific groups of countries overall using a set of indicators, and identifying the indicators where these countries differ the most. These indicators are crucial for determining the positions (whether leading or lagging) of countries within the specific group. They signify the competitive advantages of countries in various parameters and can be seen as pivotal factors in ensuring the effectiveness of national innovation ecosystems within the global competition landscape. Conducting this analysis on countries that serve as global innovation leaders is immensely valuable, not just for the leaders themselves as direct competitors, but also for countries that follow their lead, including developing countries.

This study aims to justify and conduct the differentiation of the innovation ecosystems of world-leading countries by comparing these ecosystems using a set of indicators and identifying the parameters in which countries differ the most.

2. METHODS

To conduct the research, a set of 23 indicators (Table 1) characterizing the innovation ecosystems of countries and included in the GII for evaluating their effectiveness was compiled. These indicators constitute a dataset for further research.

Table 1. List of indicators characterizing the innovation ecosystems of countries

Source: Global Innovation Index 2023 (WIPO, 2023).

Variable	Indicator
x_1	Expenditure on education, % GDP[1]
x_2	Tertiary enrolment, %gross
x_3	Graduates in science and engineering, %
x_4	Researchers, FTE[2]/million population
x_5	Gross expenditure on R&D, % GDP
x_6	Global corporate R&D investors, top three global companies, million USD
x_7	Venture capital investors, deals/billions PPP$ GDP[3]
x_8	Venture capital recipients, deals/billions PPP$ GDP
x_9	Knowledge-intensive employment, %
x_{10}	GERD[4] performed by business, % GDP
x_{11}	GERD financed by business, %
x_{12}	University-industry R&D collaboration[5]
x_{13}	GERD financed by abroad, % GDP
x_{14}	Joint venture/ strategic alliance deals/billions PPP$ GDP
x_{15}	Patent families/ billions PPP$ GDP
x_{16}	Intellectual property payments, % total trade
x_{17}	High-tech imports, % total trade
x_{18}	Patents by origin/billions PPP$ GDP
x_{19}	PCT patents by origin/billions PPP$ GDP
x_{20}	Scientific and technical articles/billions PPP$ GDP
x_{21}	Citable documents H-index
x_{22}	Software spending, % GDP
x_{23}	High-tech manufacturing, %

Note: [1]Gross Domestic Product; [2]Fulltime Equivalent; [3]GDP based on Purchasing Power Parity, billions of dollars; [4]Gross expenditure on Research and Development; [5]a survey question.

The analysis covers the top 15 most innovative countries in the world according to the GII, namely Switzerland, Sweden, the United States, the United Kingdom, Singapore, Finland, the Netherlands, Germany, Denmark, the Republic of Korea, France, China, Japan, Israel, and Canada. Comparing the indicators of the innovation ecosystems of these leading global players is valuable not only for them but also for their followers at different levels.

While assessing the established set of indicators, it is crucial to note their heterogeneity, specificity, and collective ability to cover various aspects and functions of a country's innovation ecosystem. The set avoids indicators that duplicate or negate each other. Possible correlations and mutual influences among these indicators are not considered; each indicator is assumed to hold equal significance and impact on the efficiency of the country's innovation ecosystem. From a variability perspective, all indicators aim to maximize without a saturation point or minimum requirement. Overall, the obtained set of indicators satisfies the conditions of consistency, completeness, and diversity in describing the properties of complex objects like countries' innovation ecosystems. Therefore, it is suitable for the intended international comparisons.

The analysis consists of two stages. The first stage involves dividing the set of countries into clusters as relatively homogeneous groups. The indicators listed in Table 1 create a feature space for clustering. Initially, it is crucial to evaluate the feasibility of grouping the chosen set of countries into clusters based on the compiled dataset. This process utilizes 3D visualization, employing a specialized information tool available on the ScienceHunter web portal. Afterward, it is advisable to determine the optimal number of clusters based on constructing a dendrogram and calculating specific indices (Sum of Squared Errors Index, Davies-Bouldin Index, Trace Index, Calinski-Harabasz Index, Dunn Index, and PBM Index). Suitable tools are also available on the ScienceHunter web portal.

Given the nature of the data, clustering is performed using the widely recognized k-means method (metric – Euclidean distance), com-

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monly used in economic research and efficient when objects in the dataset form compact clusters that are well separated from each other. Tools for these calculations are available on the ScienceHunter web portal.

The second stage is extraction of the indicators that most distinctly characterize the obtained clusters and, consequently, the countries within the studied set. For classification, the dataset undergoes mathematical processing using the logical-combinatorial method of "decision tree" (Vasylenko & Shevchenko, 1979). This method identifies relatively small combinations of indicators with maximum, ideally absolute, separation ability. These combinations indicate the most significant differences between clusters, thereby determining the differentiation between countries. Considering the classification task's nature, the indicators that most strongly differentiate the clusters can be considered as key factors in positioning countries and assessing the effectiveness of their innovation ecosystems.

The basis for the classification analysis is the sampling set, formed by an array of empirical data constructed according to the list provided in Table 1, with countries divided into clusters as a result of clustering. The assessment of the separation ability (quality) of the entire sampling set and each of the indicators, followed by the identification of a specific combination (or combinations) of indicators with maximum separation ability, is conducted using a special tool available on the ScienceHunter web portal. The separation ability of the sampling set and each of the included indicators is evaluated using the formula:

$$V\left(x_{i1},...,x_{ij}\right)=\frac{1}{k}\sum_{\Delta\in\Gamma}\max_{Y}\left(\frac{m_{\Delta Y}}{m_Y}\right), \qquad (1)$$

where k is the number of classes (clusters), m_Y is the number of objects belonging to class (cluster) Y, $\Delta=t_{i1},t_{i2},...,t_{ij}\left(0\le t_{ij}\le k_{ij}-1\right)$, $j=1,...,\Gamma$ means the arbitrary set of parameter values $x_{i1},...,x_{ij}\left(1\le\Gamma\le n\right)$, $m_{\Delta Y}$ denotes the number of sampling sets of the m class, for which the relation $x_{ij}=t_{ij}\left(j=1,...,\Gamma\right)$ is performed, t_{ij} are the values of parameters x_{ij} in the set of Δ, Γ means variety of all sets of parameter values $x_{i1},...,x_{ij}$.

In case of complete separation of classes, this evaluation reaches its maximum value, which is one (Vasylenko & Shevchenko, 1979). This evaluation is calculated directly from the sampling set. If, as a result of the calculations, several groups of indicators with sufficiently high separation ability are identified, it is possible to choose one main group (with the maximum separation ability) or combine the groups of indicators into a single list, eliminating duplicates.

3. RESULTS

The empirical data array for the 15 GII-leading countries was built based on the feature space (Table 1). Using 3D visualization, the optimal number of clusters to divide this set of countries according to the obtained dataset is six. This specific number was chosen for mathematical processing. The clustering results are presented in Table A1 (Appendix A).

Cluster I comprises 9 countries with the highest level of innovation ecosystem efficiency: Switzerland, Sweden, the United States, the United Kingdom, Finland, the Netherlands, Germany, Denmark, and France. With a certain hierarchy, these countries were found to be very close in a specific set of indicators and consequently ended up in the same cluster. Therefore, the innovation ecosystems can be considered relatively similar compared to those of countries in other clusters. The hierarchy based on the GII ranking is preserved in Table A1 (Appendix A) (except for Singapore and the Republic of Korea, which are in other clusters). Within Cluster I, there are leaders in specific indicators, including: x_1, x_4, x_9 – Sweden; x_2, x_{13} – Finland; x_3 – Germany; x_5, x_6, x_{10}, x_{11}, x_{12}, x_{17}, x_{22} – the United States; x_7, x_8, x_{15}, x_{18}, x_{19}, x_{23} – Switzerland; x_{14} – Switzerland, Sweden, the United States, the United Kingdom, and Finland have equal values; x_{16} – the Netherlands; x_{20} – Denmark; x_{21} – the United States and the United Kingdom. Thus, this study can assess the level of development, scale, and absolute efficiency of the innovation ecosystem. Countries in Cluster I have certain advantages over the countries in other clusters, which also demonstrates their specificity as global leaders.

Cluster II includes the Republic of Korea and Japan. The Republic of Korea dominates Japan in 13 indicators; however, these countries were found to be close in the structure of parameters of the innovation ecosystem compared to other countries and formed a single group, hence they can be considered relatively similar. Cluster II falls short of the maximum values of Cluster I in most indicators, but it exceeds the minimum values of Cluster I indicators. Therefore, the Republic of Korea and Japan do not significantly lag behind the average level of development and effectiveness of the innovation ecosystems of Cluster I countries. They have certain structural differences in indicators, which highlight the specificity of the innovation ecosystems of these countries.

Each of the subsequent four clusters consists of a single country (Singapore, China, Israel, and Canada), reflecting significant peculiarities and structural differences from countries in Clusters I and II, as well as among themselves. Singapore, included in Cluster III and ranked 5th in the GII, appeared to be somewhat distinct in the 3D visualization from Cluster I. Singapore not only keeps pace but even surpasses the average levels of indicators in Clusters I and II in numerous aspects, indicating its competitive edge rather than lagging behind, given the country's size and the unique characteristics of its innovation ecosystem. When compared to other countries forming distinct clusters, Singapore holds advantages over China in 12 indicators, over Israel in 10 indicators, and over Canada in 14 indicators.

China has only one absolute maximum among the indicators of the analyzed set of countries and five absolute minimums. Additionally, China exceeds the average values of Cluster I in 7 indicators, the Republic of Korea and Japan in 9 different indicators each, and Singapore, Israel, and Canada in 11 different indicators, indicating the formation of its competitive advantages. Overall, China is evolving into one of the global innovation leaders, as evidenced by its distinct innovation ecosystem compared to other leading countries. Israel also formed a separate Cluster V due to significant structural differences, although in most indicators, it could compete with countries in Clusters I and II. This further confirms the specificity of Israel and its innovation ecosystem. The country has a developed science and high-tech sector, but due to its small size, it naturally may lag behind in certain innovation indicators, especially those dependent on the scale of the economy. Canada formed a separate Cluster VI and has the lowest GII ranking in this set. However, Canada surpasses or slightly lags behind countries in Clusters I and II in several indicators, with only five indicators showing an absolute minimum.

Thus, clustering revealed the general differences in the innovation ecosystems of world-leading countries, as well as the similarities among countries in Clusters I and II. The clustering results have their specificities, as all the countries selected for analysis are global innovation leaders and have significant individual advantages, including in comparison with each other. The division into clusters was not only based on the level of indicators but also heavily influenced by the structural features of the innovation ecosystems in this feature space. Therefore, clustering has demonstrated the specificity of the innovation ecosystems of countries, especially those identified as separate clusters. In a specific manner, the division into clusters characterizes the global geography of innovation, focusing on the concentration of corresponding potential and activity. This lays the groundwork for in-depth research into specific groups of countries to compare the clusters and determine the advantages of individual leading countries. The distribution among the first, second, and other clusters provides a relative assessment of the efficiency level of countries' innovation ecosystems, highlighting the need to focus on key indicators for differentiation.

Having divided the countries into clusters (classes), a classification analysis was conducted on the obtained sampling set. The assessment of its quality, i.e., the cumulative separation ability, showed a maximum of 100%, indicating the ability for complete differentiation of the clusters. With this in mind, combinations of indicators were selected, whose separation ability was either absolute or close to it. Considering the specificity of the dataset, the maximum possible number of features (indicators) in the specified combinations was set to three, which proved to be sufficient for the full distribution of classes. As a result of using the specialized computational tools provided on the ScienceHunter web portal, 10 combinations of indicators with absolute separation ability were obtained:

1) "x_1 – x_2": "Expenditure on education" (% GDP) – "Tertiary enrolment" (% gross);

2) "x_1 – x_5": "Expenditure on education" (% GDP) – "Gross expenditure on R&D" (% GDP);

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3) "x_1 – x_{10}": "Expenditure on education" (% GDP) – "Gross expenditure on R&D performed by business" (% GDP);

4) "x_1 – x_{11}": "Expenditure on education" (% GDP) – "Gross expenditure on R&D financed by business" (%);

5) "x_1 – x_{14}": "Expenditure on education" (% GDP) – "Joint venture/strategic alliance" (deals/billions PPP$ GDP);

6) "x_2 – x_8": "Tertiary enrolment" (% gross) – "Venture capital recipients" (deals/billions PPP$ GDP);

7) "x_2 – x_{15}": "Tertiary enrolment" (% gross) – "Patent families/ billions PPP$ GDP;"

8) "x_2 – x_{20}": "Tertiary enrolment" (% gross) – "Scientific and technical articles/billions PPP$ GDP;"

9) "x_2 – x_{22}": "Tertiary enrolment" (% gross) – "Software spending" (% GDP);

10) "x_2 – x_{23}": "Tertiary enrolment" (% gross) – "High-tech manufacturing" (%).

All indicators are key factors by which the innovation ecosystems of the analyzed countries currently differ the most, further substantiating their differentiation. Considering indicator duplication and assuming their equal significance, these indicators can be consolidated into a single list (Table 2).

The selected indicators play a crucial role in differentiating between countries and illuminating their strengths and weaknesses. Each indicator's value assists in evaluating the leading country's most significant advantage over others, as well as potential weaknesses. Viewing these indicators as key factors in the efficiency of innovation ecosystems and countries' positioning in the global landscape, the study explores the importance of each.

x_1 *"Expenditure on education" (% GDP)* assesses the level of funding for the entire education system in a country, which is one of the main prerequisites for building its innovation potential. This becomes particularly important due to the increasing significance and demand for education in the modern economy, underpinning the universal value of the indicator repeated in five combinations. This confirms that the innovation race among leaders largely occurs at the level of basic conditions for generating innovations related to human development.

Table 2. Selected indicators and their values

Countries	Selected indicators (the numbering corresponds to Table 1)										
	x_1	x_2	x_5	x_8	x_{10}	x_{11}	x_{14}	x_{15}	x_{20}	x_{22}	x_{23}
Cluster I:											
Switzerland	5.1	65.3	3.2	0.3	2.2	64.7	0.2	8.6	43.3	0.7	67.3
Sweden	7.6	84.5	3.3	0.2	2.4	62.4	0.2	7.0	41.3	0.6	47.4
The United States	5.0	87.6	3.5	0.3	2.7	67.9	0.2	3.3	14.1	1.0	42.4
The United Kingdom	5.2	69.5	2.9	0.3	2.1	57.5	0.2	1.9	32.0	0.7	42.9
Finland	6.4	95.0	3.0	0.2	2.1	56	0.2	6.1	42.5	0.6	38.1
The Netherlands	5.2	92.0	2.3	0.1	1.5	56.9	0.1	4.4	31.7	0.7	47.4
Germany	5.1	73.0	3.1	0.1	2.1	62.6	0.1	5.0	20.5	0.6	52.9
Denmark	6.9	82.8	2.8	0.2	1.7	59.6	0.1	4.9	47.9	0.5	50.5
France	5.4	69.3	2.2	0.2	1.5	56.8	0.1	2.9	18.6	0.7	48.8
Max for Cluster I	7.6	95	3.5	0.3	2.7	67.9	0.2	8.6	47.9	1	67.3
Average for Cluster I	5.8	79.9	2.9	0.2	2.0	60.5	0.2	4.9	32.4	0.7	48.6
Min for Cluster I	5	65.3	2.2	0.1	1.5	56	0.1	1.9	14.1	0.5	38.1
Cluster II:											
The Republic of Korea	4.7	102.5	4.9	0.0	3.9	76.1	0.0	12.5	24.5	0.2	56.2
Japan	3.2	65.3	3.3	0.1	2.6	78.1	0.0	13.0	13.5	0.3	54.6
Average for Cluster II	3.9	83.9	4.1	0.05	3.25	77.1	0	12.8	19	0.25	55.4
Cluster III: Singapore	2.5	93.1	2.2	0.9	1.4	58.3	0.2	2.6	21.0	0.2	78.5
Cluster IV: China	3.5	63.6	2.4	0.1	1.8	77.5	0.0	1.7	21.9	0.4	48.5
Cluster V: Israel	6.1	61.1	5.6	0.7	5.1	40.0	0.3	4.9	29.5	0.2	38.0
Cluster VI: Canada	4.8	79.5	1.6	0.4	0.9	44.1	0.3	2.0	30.3	0.7	34.7

x_2 *"Tertiary enrolment"* (*% gross*) assesses the proportion of the population enrolled in universities and, consequently, covered by tertiary education. This underscores the high significance of the higher education system, which creates essential conditions for generating innovations. Beyond its general educational functions, higher education is associated with the professional orientation, training, and qualification selection of individuals. Higher education is one of the most crucial components of a country's innovation ecosystem and a sphere of strategic global competition. This indicator was repeated in six combinations and was universal for all countries.

x_5 *"Gross expenditure on R&D" (% GDP)* assesses the level of funding for the R&D sector, reflecting its scale and the corresponding ability to generate new knowledge, which serves as the basis for innovation. This indicator is fundamental and universal in assessing the level of development and efficiency of innovation ecosystems, making it a subject of global strategic competition.

x_8 *"Venture capital recipients" (deals/billions PPP$ GDP)* assesses the scale of venture capital acquisition in the economy, reflecting innovative activity and business effectiveness. The inclusion of this indicator among the key factors of innovation ecosystem efficiency is logical, given the significant and diverse role that venture capital plays in innovation generation. It facilitates the implementation of risky innovation projects and the establishment of new enterprises. However, despite its importance, this indicator is not universally applicable even for global leaders, as the structure of the market and the functions of venture investing have considerable national specificity.

x_{10} *"Gross expenditure on R&D performed by business" (% GDP)* assesses the scale of total expenditure on business R&D at the economic level, as it is one of the primary drivers of innovation development and utilization. This indicator may encompass various sources of business funding, focusing on R&D as a manifestation of innovative activity. The indicator holds universal significance for all countries.

x_{11} *"Gross expenditure on R&D financed by business" (%)* assesses the scale of gross expenditures on R&D, which businesses provide as part of the total R&D funding at the national economic level. This indicator focuses on businesses as a source of R&D funding, reflecting their innovative activity. It holds universal significance for all countries. Indicators x_{10} and x_{11} are closely related, hence their appearance in two different interchangeable combinations that distinguish the countries in the studied set.

x_{14} *"Joint venture/strategic alliance" (deals/billions PPP$ GDP)* assesses the scale of joint ventures (where a single legal entity is established through a merger) and strategic alliances (where parties work together without establishing a legal entity) in the field of innovation. This indicator directly characterizes the intensity of business collaboration at the national economic level, as manifested in relevant agreements. Collaboration is often a practical and necessary measure for exploring and advancing innovations into markets, as partners combine their capabilities and resources, increasing the likelihood of success. For the selected leading countries, this indicator holds universal significance, while for others, its significance may vary depending on the quality of the business environment.

x_{15} *"Patent families/billions PPP$ GDP"* is one of the key metrics for characterizing the performance of innovation processes at the national economic level. Considering the existence of various types of patent families, this indicator overall reflects the protection of a specific invention in more than one country, which must be taken into account in the context of global competition and the assessment of countries' positions. Therefore, it is logical that this indicator differentiates leading countries, holding universal significance for them. For other countries, it is also important, but its significance may vary depending on the specifics of the country's (business) development strategy in the global economy.

x_{20} *"Scientific and technical articles/billions PPP$ GDP."* This indicator is one of the key metrics for evaluating overall scientific and technical performance relative to the scale of the national economy, encompassing scientific activities across various sectors and fields of knowledge and technology. It holds universal significance for all countries, particularly for leading countries whose innovation race extends into the realm of acquiring new knowledge.

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x_{22} *"Software spending" (% GDP)* assesses the scale of total expenditures on software, including the cost of purchased or leased packaged software such as operating systems, database systems, programming tools, and utilities. The indicator has become extremely important in the era of building a digital economy and is one of the main metrics characterizing countries' positions in the realm of digital transformations, which stimulate and create a new sphere for innovations. The intensification of competition among leading countries in the digital sphere is natural; thus, on a global scale, this indicator gains increasingly universal significance. However, it may have national specifics depending on the software acquisition model and the speed of digital transformations.

x_{23} *"High-tech manufacturing" (%)* assesses the scale of the high-tech sector by determining the share of total high-tech and medium-high-tech products in the overall manufacturing output based on relevant international classifications and standards. The indicator is critical as it reflects the effectiveness of innovations in the economy, focusing on the technology that is at the cutting edge and particularly crucial for economic growth. The indicator acquires universal significance for all countries, especially in the context of the Fourth Industrial Revolution, characterized by active innovation adoption and fundamentally reshaping global competition.

The selected indicators serve as benchmarks both for the leading countries themselves and for all other countries, usually taking into account the correlation of their goals and potential. From the perspective of a particular country, the selected indicators can be viewed as:

1) factors for accelerated development, improvement, and increased efficiency of the innovation ecosystem;

2) key factors that determine the architecture of leadership or lagging behind in a specific set of countries, and thus form the basis for creating advantages in innovation ecosystems and increasing the overall competitiveness of countries.

Given the above, the selected indicators should be considered as priorities for enhancement from the perspective of rapidly improving the promising competitive positions of a certain country. This encourages a reconsideration of current resource allocation methods within innovation policies, allowing for increased rationality. Governments gain a basis for concentrating resources on enhancing the more critical indicators of their innovation ecosystem, as determined against international comparisons. The proposed approach can also offer insights into the constraints of a particular innovation ecosystem and suggest potential pathways for its improvement by changing certain structural parameters. This can facilitate the formulation of a more effective government innovation policy targeted at addressing specific challenges. To substantiate strategic decisions, this approach should be implemented based on a dynamic approach and supplemented with other aspects of researching innovation ecosystems.

4. DISCUSSION

The rationale for differentiating the innovation ecosystems of world-leading countries through the identification of key indicators where these countries differ significantly deepens our understanding of the structural differences in their innovation ecosystems. It demonstrates the specificity of national innovation development models. These results provide specific empirical assessments of the differentiation of countries in innovation and lay the groundwork for a deeper comprehension of countries' advantages and disadvantages in the global competitive landscape. Understanding the specificity of innovation ecosystems necessitates further specialized research, encompassing institutional conditions, civilizational factors, and blocks of countries' innovation systems.

The use of the proposed approach allows for selectively enhancing individual indicators, improving the functional properties and components of the country's innovation ecosystem. Similarly, this approach can be applied at the level of economic sectors to manage science, education, and high-tech industries through comparisons with other competitor countries. Therefore, the practical application sphere of this approach and the obtained results could primarily involve the development of state innovation policy to increase its alignment with external conditions and more effectively allocate resources. In the long-term application of this approach, it offers the opportunity to fine-tune priorities and target indicators of innovation policy within a comprehensive strategy, considering the demands of global competition. Beyond addressing the challenges of enhancing countries' innovation competitiveness, this approach opens avenues for uncovering new empirical patterns in innovation development, which could hold theoretical significance.

The developed approach can complement existing methodologies of international comparative analysis, benchmarking, and various innovation rankings (Ituarte, 2020; Polyakov et al., 2020; Yu et al., 2021; Brás, 2023; Nasir & Zhang, 2024). Focusing on global competition, which creates the external context for all countries, this approach can be used to identify specific advantages and weaknesses of countries, focusing on key drivers for increasing competitiveness (Marčeta & Bojnec, 2020; Braja & Gemzik-Salwach, 2020; Mokthtari Moughari & Daim, 2023). It seems useful to apply the proposed methodological approach, in addition to the sphere of innovations, to assess other components of national economic competitiveness (Okunevičiūtė Neverauskienė et al., 2020). Thus, it will serve as a basis for preparing practical recommendations for state innovation policy (as well as policy at the EU level) to deliberately improve the country's positions in the Global Innovation Index (GII) or competitiveness rankings such as the World Competitiveness Ranking calculated by the IMD Business School.

In addition to competitiveness, the primary application of the proposed approach is to enhance innovation ecosystems (or national innovation systems). This primarily enables a deeper comparison of innovation ecosystems across a wide range of indicators and facilitates the exploration of various aspects of their differentiation, which complements various research endeavors (Kang et al., 2019; Zabala-Iturriagagoitia et al., 2021). To some extent, the approach can also be used to assess the quality, efficiency, and dynamics of the development of a specific country's innovation ecosystem through international comparisons (Jurickova et al., 2019). In conjunction with other methodologies, this approach lays the foundation for tackling more complex challenges related to enhancing innovation ecosystems and developing high-tech sectors within countries (Paredes-Frigolett et al., 2021). This will contribute to overcoming the problem of innovation and overall economic lag of countries (Aiyedogbon et al., 2022; Kowalski, 2020) and increasing the level of convergence among EU member states or candidate countries (Aytekin et al., 2022; Kowalski & Rybacki, 2021). Taking into account the above, the proposed approach can become part of special strategic programs for the development of national economies, following the leaders ("catch-up development"), aiming to achieve a rapid technological leap (Gebrerufael, 2021; Petrushenko et al., 2022).

CONCLUSION

Considering the transformation of innovations into one of the most important factors of growth, development and competitiveness of national economies, there is a need to continuously improve the conditions for innovation activities. In the global competitive context, this requires comparing the innovation ecosystems of different countries, including world leaders, in order to identify their features, strengths and weaknesses. This enables a more rational orientation of the state innovation policy and improves the efficiency of innovation ecosystems. In this regard, the purpose of this study is to substantiate and differentiate the innovation ecosystems of the world's top countries based on a set of indicators that characterise them and to identify the parameters that make these countries most different. Based on the GII, a dataset of 23 key indicators characterising the innovation ecosystems of 15 leading countries was selected. At the first stage, these countries were divided into six clusters using the k-means method, demonstrating the similarity of the innovation ecosystems of cluster I (Switzerland, Sweden, the USA, the UK, Finland, the Netherlands, Germany, Denmark, France) and cluster II (the Republic of Korea and Japan), as well as significant differences between these clusters and other clusters formed by individual countries (cluster III: Singapore; cluster IV: China; cluster V: Israel; cluster VI: Canada). The classification analysis was carried out on the basis of the identified clusters (classes) and the "decision tree" method, which resulted in the identification of combinations of indicators that most significantly differentiate the obtained clusters of countries. The indicators included in these combinations are the key ones for differentiating the innovation ecosystems of the world's leading countries, namely: "Expenditure on education"; "Tertiary enrolment"; "Gross expenditure on R&D", "Venture capi-

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tal recipients", "Gross expenditure on R&D financed by business", "Joint venture/strategic alliance", "Patent families", "Scientific and technical articles", "Software spending", "High-tech manufacturing". A comparison of the values of these indicators reflects the specificity of the analysed countries' innovation ecosystems and demonstrates their strengths and weaknesses. This contributes to a deeper understanding of national innovation ecosystems and is the basis for substantiating the priority areas for improving the efficiency of innovation ecosystems in order to improve the position of countries in global competition. The proposed approach can be used to develop innovation policy as well as in scientific research, particularly to explain the reasons for the gap between the world's innovation leaders and their followers.

AUTHOR CONTRIBUTIONS

Conceptualization: Maxim Polyakov, Igor Khanin, Vladimir Bilozubenko, Maxim Korneyev.
Data curation: Vladimir Bilozubenko, Maxim Korneyev.
Formal analysis: Maxim Polyakov, Vladimir Bilozubenko, Gennadij Shevchenko, Maxim Korneyev.
Investigation: Maxim Polyakov, Vladimir Bilozubenko, Gennadij Shevchenko, Maxim Korneyev.
Methodology: Maxim Polyakov, Igor Khanin, Gennadij Shevchenko.
Project administration: Maxim Polyakov, Igor Khanin.
Resources: Vladimir Bilozubenko, Maxim Korneyev.
Software: Gennadij Shevchenko.
Supervision: Maxim Polyakov, Igor Khanin.
Validation: Vladimir Bilozubenko, Gennadij Shevchenko, Maxim Korneyev.
Writing – original draft: Vladimir Bilozubenko, Gennadij Shevchenko, Maxim Korneyev.
Writing – review & editing: Maxim Polyakov, Igor Khanin.

REFERENCES

1. Aiyedogbon, J. O., Zhuravka, F., Korneyev, M., Banchuk-Petrosova, O., & Kravchenko, O. (2022). Impact of public debt profile on economic growth: Evidence from Nigeria. *Public and Municipal Finance, 11*(1), 10-19. https://doi.org/10.21511/pmf.11(1).2022.02
2. Aytekin, A., Ecer, F., Korucuk, S., & Karamaşa, Ç. (2022). Global innovation efficiency assessment of EU member and candidate countries via DEA-EATWIOS multi-criteria methodology. *Technology in Society, 68,* Article 101896. https://doi.org/10.1016/j.techsoc.2022.101896
3. Braja, M., & Gemzik-Salwach, A. (2020). Competitiveness of high-tech exports in the EU countries. *Journal of International Studies, 13*(1), 359-372. https://doi.org/10.14254/2071-8330.2020/13-1/23
4. Brás, G. R. (2023). Pillars of the Global Innovation Index by income level of economies: longitudinal data (2011–2022) for researchers' use. *Data in Brief, 46,* Article 108818. https://doi.org/10.1016/j.dib.2022.108818
5. Choi, J. (2023). The US-China rivalry and Europe's choice. *Asia and the Global Economy, 3*(1), Article 100057. https://doi.org/10.1016/j.aglobe.2023.100057
6. Gebrerufael, S. (2021). Dynamics of technology gap between OECD and African countries: A structural estimation. *Scientific African, 11,* Article e00674. https://doi.org/10.1016/j.sciaf.2020.e00674
7. Gontareva, I., Litvinov, O., Hrebennyk, N., Nebaba, N., Litvinova, V., & Chimshir, A. (2022). Improvement of the innovative ecosystem at universities. *Eastern-European Journal of Enterprise Technologies, 1*(13(115)), 59-68. https://doi.org/10.15587/1729-4061.2022.251799
8. Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation, 90-91*, Article 102098. https://doi.org/10.1016/j.technovation.2019.102098
9. Ituarte, J. V. (2020). Benchmarking Innovation: USA and China. *i-Manager's Journal on Management, 14*(3), 1-12. Retrieved from https://www.proquest.com/openview/4aac2865a07846674d2121715fcb3695/1?pq-origsite=gscholar&cbl=2030618
10. Jurickova, E., Pilik, M., & Kwarteng, M. A. (2019). Efficiency measurement of national innovation systems of the European Union countries: DEA model application. *Journal of International Studies, 12*(4), 286-299. https://doi.org/10.14254/2071-8330.2019/12-4/19
11. Kalenyuk, I., Tsymbal, L., Djakona A., & Panchenko E. (2018). Assessment of intellectual leadership under global competition. *Problems and Perspectives in Management, 16*(4), 212-223. https://doi.org/10.21511/ppm.16(4).2018.18
12. Kang, D., Jang, W., Kim, Y., & Jeon, J. (2019). Comparing national innovation system among the USA, Japan, and Finland to improve Korean deliberation organization for national science and technology policy.

Journal of Open Innovation: Technology, Market, and Complexity, 5(4), Article 82. https://doi.org/10.3390/joitmc5040082

13. Kowalski, A. M. (2021). Dynamics and factors of innovation gap between the European Union and China. *Journal of the Knowledge Economy, 12,* 1966-1981. https://doi.org/10.1007/s13132-020-00699-1
14. Kowalski, A.M., & Rybacki, J. (2021). Moderate innovator trap-does the convergence of innovation performance occur in the world economy? *Economies, 9*(1), Article 11. https://doi.org/10.3390/economies9010011
15. Kuzkin, Y., Cherkashyna, T., Nebaba, N., & Kuchmacz, B. (2019). Economic growth of the country and national intellectual capital (evidence from the post-socialist countries of the central and eastern Europe). *Problems and Perspectives in Management, 17*(1), 348-359. http://dx.doi.org/10.21511/ppm.17(1).2019.30
16. Maradana, R. P., Pradhan, R. P., Dash, S., Zaki, D. B., Gaurav, K., Jayakumar, M., & Sarangi, A. K. (2019). Innovation and economic growth in European Economic Area countries: The Granger causality approach. *IIMB Management Review, 31*(3), 268-282. https://doi.org/10.1016/j.iimb.2019.03.002
17. Marčeta, M., & Bojnec, Š. (2020). Drivers of global competitiveness in the European Union countries in 2014 and 2017. *Organizacija, 53*(1), 37-52. https://doi.org/10.2478/orga-2020-0003
18. Marcon, A., Ribeiro, J. L. D., Olteanu, Y., & Fichter, K. (2024). How the interplay between innovation ecosystems and market contingency factors impacts startup innovation. *Technology in Society, 76,* Article 102424. https://doi.org/10.1016/j.techsoc.2023.102424
19. Mohamed, M. M. A., Liu, P., & Nie, G. (2022). Causality between technological innovation and economic growth: Evidence from the economies of developing countries. *Sustainability, 14*(6), Article 3586. https://doi.org/10.3390/su14063586
20. Mokhtari Moughari, M., & Daim, T. U. (2023). Developing a model of technological innovation for export development in developing countries. *Technology in Society, 75,* Article 102338. https://doi.org/10.1016/j.techsoc.2023.102338
21. Nasir, M. H., & Zhang, S. (2024). Evaluating innovative factors of the global innovation index: A panel data approach. *Innovation and Green Development, 3*(1), Article 100096. https://doi.org/10.1016/j.igd.2023.100096
22. Okunevičiūtė Neverauskienė, L., Danilevičienė, I., & Tvaronavičienė, M. (2020). Assessment of the factors influencing competitiveness fostering the country's sustainability. *Economic Research-Ekonomska Istraživanja, 33*(1), 1909-1924. https://doi.org/10.1080/1331677X.2020.1763821
23. Paasi, J., Wiman, H., Apilo, T., & Valkokari, K. (2023). Modeling the dynamics of innovation ecosystems. *International Journal of Innovation Studies, 7*(2), 142-158. https://doi.org/10.1016/j.ijis.2022.12.002
24. Paredes-Frigolett, H., Pyka, A., & Leoneti, A. B. (2021). On the performance and strategy of innovation systems: A multicriteria group decision analysis approach. *Technology in Society, 67,* Article 101632. https://doi.org/10.1016/j.techsoc.2021.101632
25. Petrushenko, Y., Korneyev, M., Nebaba, N., Banchuk-Petrosova, O., & Bohorodytska, A. (2022). Assessment of the external debt impact on a country's economic development indicators: Evidence from Ukraine. *Investment Management and Financial Innovations, 19*(1), 360-369. https://doi.org/10.21511/imfi.19(1).2022.28
26. Polyakov, M., Bilozubenko, V., Korneyev, M., & Nebaba, N. (2020). Analysis of key university leadership factors based on their international rankings (QS World University Rankings and Times Higher Education). *Problems and Perspectives in Management, 18*(4), 142-152. https://doi.org/10.21511/ppm.18(4).2020.13
27. Reiter, A., Stonig, J., & Frankenberger, K. (2024). Managing multi-tiered innovation ecosystems. *Research Policy, 53*(1), Article 104905. https://doi.org/10.1016/j.respol.2023.104905
28. Shkolnyk, I., Pisula, T., Loboda, L., & Nebaba, N. (2019). Financial crisis of real sector enterprises: An integral assessment. *Investment Management and Financial Innovations, 16*(4), 366-381. https://doi.org/10.21511/imfi.16(4).2019.31
29. Sun, H. (2019). U.S.-China tech war. *China Quarterly of International Strategic Studies, 05*(02), 197-212. https://doi.org/10.1142/S237774001950012X
30. Vasylenko, Y. A., & Shevchenko, H. Y. (1979). Analytical method for test finding. *Avtomatyka, 2,* 3-8.
31. Wong, P. N. (2022). *Techno-geopolitics: US-China tech war and the practice of digital statecraft*. Routledge India.
32. World Intellectual Property Organization (WIPO). (2023). *Global Innovation Index 2023: Innovation in the face of uncertainty*. Geneva: WIPO. https://doi.org/10.34667/tind.48220
33. Xu, K., Mei, R., Sun, W., Zhang, H., & Liang, L. (2023). Estimation of sustainable innovation performance in European Union countries: Based on the perspective of energy and environmental constraints. *Energy Reports, 9,* 1919-1925. https://doi.org/10.1016/j.egyr.2023.01.010
34. Yu, T. H.-K., Huarng, K.-H., & Huang, D.-H. (2021). Causal complexity analysis of the Global Innovation Index. *Journal of Business Research, 137,* 39-45. https://doi.org/10.1016/j.jbusres.2021.08.013
35. Zabala-Iturriagagoitia, J. M., Aparicio, J., Ortiz, L., Carayannis, E. G., & Grigoroudis, E. (2021). The productivity of national innovation systems in Europe: Catching up or falling behind? *Technovation, 102,* Article 102215. https://doi.org/10.1016/j.technovation.2020.102215
36. Zhuravka, F., Botvinov, R., Parshyna, M., Makarenko, T., & Nebaba, N. (2021). Ukraine's integration into the world arms market. *Innovative Marketing, 17*(4), 146-158. http://dx.doi.org/10.21511/im.17(4).2021.13

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APPENDIX A

Table A1. Clusters of countries based on indicators characterizing innovation ecosystems

Source: Global Innovation Index 2023.

Countries (GII rank)	Indicators (the numbering corresponds to Table 1)																						
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}	x_{20}	x_{21}	x_{22}	x_{23}
Cluster I																							
Switzerland (1)	5.1	65.3	25.2	5,562.4	3.2	89.0	0.7	0.3	50.9	2.2	64.7	99.4	0.2	0.2	8.6	5.5	5.2	14.4	7.3	43.3	66.2	0.7	67.3
Sweden (2)	7.6	84.5	27.0	9,640.3	3.3	77.7	0.4	0.2	57.1	2.4	62.4	82.1	0.3	0.2	7.0	3.5	8.8	10.8	6.5	41.3	59.3	0.6	47.4
The United States (3)	5.0	87.6	20.1	4,500.5	3.5	100	0.4	0.3	51.5	2.7	67.9	99.9	0.2	0.2	3.3	1.6	18.5	11.4	2.4	14.1	100	1.0	42.4
The United Kingdom (4)	5.2	69.5	22.8	4,638.8	2.9	84.6	0.6	0.3	50.6	2.1	57.5	82.0	0.3	0.2	1.9	2.0	10.0	5.1	1.5	32.0	100	0.7	42.9
Finland (6)	6.4	95.0	27.9	7,870.6	3.0	73.2	0.3	0.2	47.4	2.1	56	81.5	0.4	0.2	6.1	1.0	7.4	12.3	5.4	42.5	43.0	0.6	38.1
The Netherlands (7)	5.2	92.0	18.8	6,069.3	2.3	82.0	0.4	0.1	53.6	1.5	56.9	87.9	0.2	0.1	4.4	6.1	12.0	7.9	3.3	31.7	70.2	0.7	47.4
Germany(8)	5.1	73.0	35.8	5,538.0	3.1	92.0	0.2	0.1	46.1	2.1	62.6	76.2	0.2	0.1	5.0	1.0	10.3	13.5	3.3	20.5	86.8	0.6	52.9
Denmark (9)	6.9	82.8	23.0	7,708.3	2.8	70.1	0.4	0.2	48.9	1.7	59.6	81.5	0.2	0.1	4.9	0.8	6.5	9.9	3.6	47.9	51.5	0.5	50.5
France (11)	5.4	69.3	25.9	5,025.4	2.2	80.4	0.3	0.2	47.7	1.5	56.8	58.6	0.2	0.1	2.9	1.4	9.4	7.2	2.1	18.6	77.9	0.7	48.8
Max for Cluster	7.6	95	35.8	9,640.3	3.5	100	0.7	0.3	57.1	2.7	67.9	99.9	0.4	0.2	8.6	6.1	18.5	14.4	7.3	47.9	100	1	67.3
Average for Cluster	5.8	79.9	25.2	6,283.7	2.9	83.2	0.4	0.2	50.4	2.0	60.5	83.2	0.2	0.2	4.9	2.5	9.8	10.3	3.9	32.4	72.8	0.7	48.6
Min for Cluster	5	65.3	18.8	4,500.5	2.2	70.1	0.2	0.1	46.1	1.5	56	58.6	0.2	0.1	1.9	0.8	5.2	5.1	1.5	14.1	43	0.5	38.1
Cluster II																							
The Republic of Korea (10)	4.7	102.5	30.2	9,097.1	4.9	88.8	0.1	0.0	39.6	3.9	76.1	72.8	0.0	0.0	12.5	1.6	17.2	74.0	8.0	24.5	46.5	0.2	56.2
Japan (13)	3.2	65.3	19.5	5,613.5	3.3	88.0	0.2	0.1	20.8	2.6	78.1	64.0	0.0	0.0	13.0	3.2	15.0	39.7	8.2	13.5	67.2	0.3	54.6
Average for Cluster	3.9	83.9	24.9	7,355.3	4.1	88.4	0.15	0.05	30.2	3.25	77.1	68.4	0	0	12.8	2.4	16.1	56.9	8.1	19	56.9	0.25	55.4
Cluster III																							
Singapore (5)	2.5	93.1	36.3	7,488.4	2.2	60.2	1.9	0.9	59.9	1.4	58.3	85.5	0.1	0.2	2.6	2.6	24.3	3.2	2.5	21.0	40.0	0.2	78.5
Cluster IV																							
China (12)	3.5	63.6	36.7	1,584.9	2.4	92.9	0.1	0.1	52.3	1.8	77.5	86.8	0.0	0.0	1.7	1.4	22.6	52.4	2.3	21.9	66.1	0.4	48.5
Cluster V																							
Israel (14)	6.1	61.1	26.9	5,450.1	5.6	64.4	0.9	0.7	51.9	5.1	40.0	100	2.9	0.3	4.9	0.9	10.2	3.6	4.0	29.5	46.7	0.2	38.0
Cluster VI																							
Canada (15)	4.8	79.5	25.7	4,860.5	1.6	64.9	0.5	0.4	43.7	0.9	44.1	85.8	0.2	0.3	2.0	2.6	10.3	2.3	1.2	30.3	80.0	0.7	34.7
For all countries																							
Max	7.6	102.5	36.7	9,640.3	5.6	100	1.9	0.9	59.9	5.1	78.1	100	2.9	0.3	13	6.1	24.3	74	8.2	47.9	100	1	78.5
Average	5.1	78.9	26.8	6,043.2	3.1	80.5	0.5	0.3	48.1	2.3	61.2	82.9	0.4	0.1	5.4	2.3	12.5	17.8	4.1	28.8	66.8	0.5	49.9
Min	2.5	61.1	18.8	1,584.9	1.6	60.2	0.1	0	20.8	0.9	40	58.6	0	0	1.7	0.8	5.2	2.3	1.2	13.5	40	0.2	34.7