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Innovative Clusters of Global Trade Leadership

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Abstract

The formation of a new global system and systemic global interdependence has generated new competitiveness factors for market participants, determining their appropriate strategic behavior to ensure a highly competitive position and leadership. Therefore, the purpose of the study is to identify the countries of intellectual leaders in the global market and the factors that influence the positions that countries achieve in terms of leadership. The following research methods were used: multifactor regression models, cluster analysis, and comparative analysis. Based on the authors' methodology for assessing countries' intellectual leadership, the clustering of countries in the global economy is determined. The evaluation algorithm was based on three levels: 1) resources, 2) the intermediate results of intellectual activity, and 3) the final results of overall progress.
Using a multifactor regression model and cluster analysis, four clusters of countries were identified according to key indicators of intellectual leadership. For each cluster, the specialization

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of the two countries in terms of merchandise exports was analyzed: cluster 1 – the United States and Germany; cluster 2 – Israel and Italy; cluster 3 – Brazil and Ukraine; cluster 4 – China and South Korea. Each country is assigned an index of economic complexity, and the change in position of each country within a cluster over ten years is noted.
An important goal is to understand the determinants of the leadership of countries in each geographic region.
The analysis is based on the cluster analysis carried out in previous publications. The clustering of countries was carried out based on the dynamics of macroeconomic indicators over the past 15 years.

Keywords: Index of economic complexity, intellectualization, clustering of countries, commodity exports

JEL: I23, I25

Introduction

The formation of a new global system based on knowledge and information has been accompanied by rapid change and significant stratification of the competitive environment. Systemic global interdependence has generated new competitive factors for the market participants, determining their appropriate strategic behavior to ensure a highly competitive position and leadership. It has become a key component of public economic policies and effective management and a subject of special interdisciplinary research. Reorientation to innovative development is a key feature of the current stage of development of the world economy, and it is the basis of the Fourth Industrial Revolution.

The goal of economic followers is to develop non-linear innovations, which are characteristic of the most developed economies of the world. Forming a global innovation space is a complex process that accompanies the current stage of development of the global economy. The fourth industrial revolution determines the further orientation and activation of technology in production, robotics, and network technologies, among others. Only innovation-oriented economies are highly competitive in these conditions, and the role of intellectual development factors is changing accordingly. Classically, factors of the intellectualization of the economy are education and science; however, education ceases to be the only driving force for the development of society (OECD 2011). Characteristics of the modern market include the offshoring of the labor market, a change in the structure of production, the development of opportunities through technology and network, and the active export of services. Expanding the scope of intellectual leadership as a way to ensure competitiveness in the knowledge economy in this aspect is seen as managing the changing business environment.

The modern understanding of leadership is based on its perception as a multifaceted, multilevel, factorial, and functionally determined phenomenon. When there are qualitative technological changes, in particular, super dynamic digital transformations, the networkization of economic systems, socialization and greening, global success, and the constant progress of business organizations, countries and regions are served, first of all, by intellectual leadership. In the 21st century, a new composition of its resource, scientific and technological, market, and civilizational imperatives is being formed, which is most fully reflected in the sustainability and inclusiveness of economic development, structural dynamics, and the global competitive disposition of countries. At the same time, the world is in a pre-paradigmatic state, which is determined by separate theories of intellectual leadership research and how it is implemented, in the absence of a comprehensive conceptual justification.

In the scientific literature, one of the most pressing issues is the theoretical and methodological understanding of the essence of innovation and its drivers, and the role of knowledge, education, and technology in ensuring the economic progress of society. In the 1950s, Solow substantiated the model of exogenous economic growth on the basis of the Cobb–Douglas production function and the Harrod-Domar Keynesian model of economic growth (Solow 1956). In the future, research will begin to consider in more detail the various aspects of the main factors (labor, capital, land) and scientific and technological progress.

The 21st century is marked by the emergence of radically new technologies and trends in informatization, digitalization, networking, and more. In the new context, the study of economic growth factors aims to identify more segments in dependencies that explain the impact of ICT (information and communication technology) on the dynamics and scale of economic development. Jorgenson and Vu (2005) described the impact of investment in information technology (IT) on the level of development of the world's largest economies, it is determined that the development of technology has led to rapid economic growth between 1989 and 2003. In a later study, Jorgenson and Vu (2010) analyzed the period 1989–2008. Oliner and Sichel (2000) demonstrated that productivity growth in the US since the 1990s has been associated with an investment in ICT. ICT capital comprised 1.1% of the 4.8% output growth rate from 1996–1999. Colecchia and Schreyer (2002) compared the impact of ICT capital on economic growth in nine OECD countries. Although they found significant differences in ICT investment, it grew rapidly in all countries.

Skorupinska and Torrent-Sellens (2017) showed that the rates of return on digital investment are relatively much higher than those on investment in other physical components. Meanwhile, Hong (2017) showed that in South Korea, private ICT R&D (Research and development) investment had a stronger relationship with economic growth compared to public ICT R&D investment. However, Kretschmer (2012) showed that as-

sessing the impact of ICT very much depends on the methodology. Nevertheless, over the last two decades, an increase in ICT by 10% translated into higher productivity growth, from 0.5 to 0.6%.

Yeganegi and Najafi (2022) analyzed the impact of innovations in certain industries on the level of economic development of the country, in general, and the specialization of countries. Vicente (2022) looked at the innovative development of countries and clusters. Meanwhile, Hanzhi and Wang (2022) researched individual economies, the determinants of their development and the prerequisites for specialization.

This article's purpose is to identify the key factors and prerequisites for the formation of leadership of particular countries through economic and mathematical modeling. Thus, an important *goal* seems to be to understand the determinants of the leadership of countries in each region of the world.

Method of analysis. The analysis is based on the cluster analysis that was carried out in previous publications. It was conducted based on the dynamics of macroeconomic indicators over the past 15 years.

Added value. Based on the analysis, the determinants of the leadership of the countries in the regions were determined, the prerequisites of the leadership of the countries in each of the regions were characterized, and the possibilities of further development of these countries in the regions and in the global economic space were determined.

Results

The economic development of countries, its determinants, factors of the greatest influence are an urgent issue of the study of economic science. Studies of scientists and authors in previous works testify to the significant impact, for example, of the intellectualization of economic activity on the overall development of the country (Kalenyuk et al. 2022). However, it requires a study to determine the features of development and its key determinants in different countries, which differ in the structure of the economy, features of economic activity, etc.

Determining the country's opportunities for development in the conditions of international division of labor, specialization, and the formation of global production and logistics networks remains an important issue. The determination of these prerequisites should be based on statistical data that allow the identification of the country's specialization factors. It was done on the basis of the clustering of countries by individual indicators. A total of forty countries and forty-four indicators have been selected over ten years, which makes it possible to assert the mathematical validity of clustering results. The author's methodology is based on the identification of key development factors at three levels: 1) resource level (accu-

mulated logistical, financial, human, and intellectual potential); 2) the level of intermediate results of intellectual activity (scientific-educational, technological, infrastructural, production, service, market); 3) the level of final results of the general progress (dynamics of general economic indicators, positions in world ratings and indices, etc.). It also makes it possible to conduct a complex estimation and comparison of the basic functional zones of the studied phenomenon and to follow the development experience of innovative systems of the intellectual leader states (Kalenyuk and Tsymbal 2021).

Intellectual leadership is quite complex in definition and structure, so assessing it requires a systematic approach, based on the characteristics of intellectual activity. Our approach is that intellectual leadership today should be determined by levels that characterize certain stages of intellectual activity and have their own characteristics. There are three levels of such stages: 1) resources, 2) intellectual performance, and 3) end results. For the sake of simplicity, this study will only consider country or national economy from all possible subjects (e.g., country, region, industry, institution, corporation, etc.).

The resource level is characterized by the availability of basic intellectual resources. Their presence and potential characterize the general ability of the country (or any other entity) to conduct intellectual activity. Although the availability of intellectual resources is an important condition for leadership, it does not mean actual leadership. More realistically, it may manifest itself at the next level, which characterizes the results obtained by the country. The level of results of intellectual activity involves evaluating specific results: patents, licenses, know-how, and publications, among others. The end results concern not only purely intellectual activity, but activity in general – the whole economy or society. The next step in the evaluation should be to identify key indicators at each of these levels. In our opinion, only such a systematic approach to assessing each of these levels using several indicators makes it possible to characterize the intellectual activity and assess the overall competitive position of different actors. Therefore, all indicators for assessing intellectual leadership consider either the potential of intellectual resources or the results of intellectual activity.

A multifactor regression model and cluster analysis were used to produce four clusters of countries with common characteristics and socio-economic development trends in key (static and dynamic) indicators of intellectual leadership (Table 1). This technique allowed us to analyze the impact of intellectualization indicators on GDP in each cluster.

Table 1. The results of clustering countries by indicator of intellectualization

Cluster 1	Cluster 2
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, Great Britain, USA	Czech Republic, Greece, Israel, Italy, New Zealand, Portugal, Slovenia, Spain
Cluster 3	**Cluster 4**
Brazil, Chile, Colombia, Estonia, Hungary, Latvia, Lithuania, Mexico, Poland, Russian Federation, Slovakia, Turkey, Ukraine	China, Hong Kong, India, South Korea, Singapore

Source: compiled by the author.

As a result of the analysis, it was determined that all clusters differ significantly in the set of countries in terms of the level of socio-economic development and the features of economic activity. The first cluster unites countries that have a high level of economic development and demonstrate consistently high dynamics. The second cluster includes countries with stable economies and a high level of socio-economic development, covering mainly the European region. The countries of the third cluster are more geographically diverse and show relatively low rates of development. The grouping of countries into cluster 4, which includes Asian countries that have certain features of general business conduct, are characterized by extremely dynamic rates of growth in a short period of time, seems interesting. The clustering made it possible to find common features of the development of the cluster countries, and it became the basis for identifying key development factors and prerequisites for achieving leadership positions globally, regionally, or sectorally.

The paper examines the export specialization of individual countries within each cluster, as well as the level of economic complexity of the products they export. The analysis used UN trade statistics (United Nations 2018), as well as information from the Center for International Development at Harvard University (The Atlas of Economic Complexity n.d.).

When specializing, countries belonging to the same cluster have significant common features in their export profile and have reached a similar level of economic complexity. To analyze the specialization of countries from each cluster, two countries were selected that best demonstrate the peculiarities of cluster development (The objective 2022). We will consider features of the countries of the first cluster on the example of the USA and Germany. The commodity exports of both countries are dominated by high-tech goods (machinery and transport equipment, chemical products, cars, electronic integrated circuits, and medicines, among others) (Table 2).

Table 2. Merchandise exports of USA and Germany, 2019

SITC*	Merchandise exports by SITC	USA		Germany	
		billion US$	%	billion US$	%
Total	All commodities	1,644.276	100.0	1,493.095	100.0
0 + 1	Food, animals + beverages, tobacco	111.957	6.8	78.108	5.2
2 + 4	Crude materials + anim. & veg. oils	77.353	4.7	24.998	1.7
3	Mineral fuels, lubricants	199.591	12.1	33.128	2.2
5	Chemicals	224.279	13.6	230.999	15.5
6	Goods classified chiefly by material	137.472	8.4	175.458	11.8
7	Machinery and transport equipment	534.875	32.5	715.426	47.9
8	Miscellaneous manufactured articles	165.843	10.1	171.380	11.5
9	Not classified elsewhere in the SITC	192.907	11.7	63.598	4.3

* SITC – Standard international trade classification.
Source: compiled by the United Nations (2020).

The United States is still the world leader in innovation, although today, most innovation goes to products made abroad. The loss of manufacturing jobs in the United States, especially to China's advantage, is not just a focus on producing cheap consumer goods using cheap labor. Over the past six years, the share of Chinese exports of products classified as high-tech goods has grown to more than 27%, while in the US, it is less than 18%.

A comparison of the development of countries' leadership in terms of the Economic Complexity Index (ECI), which considers the complexity and diversification of the country's exports, determined sufficient proximity of countries within one cluster. Thus, for the United States, this figure reached 1.55, and for Germany, it reached 2.09, one of the best results in the world. The positions of these countries in the ranking of economic complexity are quite close. In 2018, Germany ranked 4th out of 133 countries, and the United States was 11th (Table 3).

Table 3. Index of economic complexity, 2018

Country	Index of economic complexity	Ranking	
		2018 y. (from 133 countries)	Change over 10 years
1st cluster			
Germany	2.09	4	– 2
USA	1.55	11	+1

Country	Index of economic complexity	Ranking	
		2018 y. (from 133 countries)	Change over 10 years
2nd cluster			
Italy	1.44	14	+3
Israel	1.2	20	+3
3rd cluster			
Ukraine	0.37	44	0
Brazil	0.21	49	– 1
4th cluster			
South Korea	2.11	3	+8
China	1.34	18	+6

Source: The Atlas of Economic Complexity (n.d.).

Thus, countries in the same cluster have a fairly close position on indicators of economic proximity. If we consider the countries of the 2nd cluster, which include Italy and Israel, in 2018, they were in the second ten of the 133 countries in the ranking. Italy ranked 14th on the ECI with 1.44; its rating improved by three places over the previous ten years. The Israeli economy reached 20th place with an index of 1.2 The dynamics of change are the same as Italy's, as their rank also improved by three points.

Israel is characterized by a fairly high share of machinery and transport equipment (26.9% of total exports of goods in 2018). In Italy, it is dominated by merchandise exports (35.9%). According to the SITC, approximately the same share in Italian exports is occupied by products of the "Chemicals" group (13.2%), "Goods classified mainly by materials" (17.8%), and "Various manufactured products" (17.9%). The Top 10 Italian exports include medicines, cars, engine parts, and shoes (The Atlas of Economic Complexity n.d.). In Israeli exports, a significant place is taken by goods belonging to the "Chemicals" group (24.7%), "Goods classified mainly by materials" (29.1%), and "Various manufactured goods" (17.9%). The main commodity items of Israeli exports are processed and unprocessed diamonds, medicines, electronic integrated circuits, and medical equipment and instruments.

Table 4. Merchandise exports of Israel and Italy, 2019

SITC	Merchandise exports by SITC	Israel		Italy	
		billion US$	%	billion US$	%
Total	All commodities	58.489	100.0	532.684	100.0
0 + 1	Food, animals + beverages, tobacco	1.789	3.1	45.669	8.6

SITC	Merchandise exports by SITC	Israel		Italy	
		billion US$	%	billion US$	%
2 + 4	Crude materials + anim. & veg. oils	0.870	1.6	8.277	1.6
3	Mineral fuels, lubricants	1.201	2.1	15.368	2.9
5	Chemicals	15.599	26.7	75.635	14.2
6	Goods classified chiefly by material	14.724	25.2	90.231	16.9
7	Machinery and transport equipment	16.563	28.3	180.683	33.9
8	Miscellaneous manufactured articles	7.738	13.2	98.376	18.5
9	Not classified elsewhere in the SITC	0.004	0.0	18.446	3.5

Source: compiled by the United Nations (2020).

The third cluster of countries, which comprises mostly countries from Central and Eastern Europe, is considered on the example of Bulgaria and Ukraine. Both have rather low ratings of economic complexity and did not show significant progress in this area between 2008 and 2018. Thus, Ukraine, with an index of economic complexity of 0.33, ranks 47th, while after ten years, its positioning had worsened by 4 points. Bulgaria's economy is more complex than Ukraine's – its ECI was 0.52, putting it 42nd in the ranking, and it improved its position by three points.

In contrast to the countries of the previous clusters, the specialization of both countries is dominated by products with a low degree of processing. For Bulgaria, the leading exports are petroleum oils, other than crude. The SITC product group "Raw materials + oils of animal and vegetable origin" of Bulgarian exports is 7.7%, and "Food, animals + beverages, tobacco" is 12.8%. Ukraine's main export list in 2019 included sunflower seeds, semi-finished products of cast iron and non-alloy steel, corn, iron ore and concentrates, and flat-rolled hot-rolled iron. The SITC commodity groups "Food, Animals + Beverages, Tobacco" and "Raw Materials + Oils of Animal and Vegetable Origin" covered almost half of Ukrainian exports of goods (49.9%) in 2019. The group "Goods classified mainly by materials" comprised a significant volume of exports of both Ukraine and Bulgaria (28.7% and 19.9%, respectively) (Table 5). Chemical products occupy a smaller weight in the exports of the countries of this group compared to the previous group. In particular, war-related products account for 10.8% of the structure of Bulgarian merchandise exports, and only 3.7% of Ukrainian merchandise exports.

Table 5. Merchandise exports of Bulgaria and Ukraine, 2019

SITC	Merchandise exports by SITC	Bulgaria		Ukraine	
		billion US$	%	billion US$	%
Total	All commodities	33.415	100.0	47.335	100.0
0 + 1	Food, animals + beverages, tobacco	4.281	12.8	12.195	25.8
2 + 4	Crude materials + anim. & veg. oils	2.582	7.7	11.407	24.1
3	Mineral fuels, lubricants	3.181	9.5	0.861	1.8
5	Chemicals	3.611	10.8	1.729	3.7
6	Goods classified chiefly by material	6.646	19.9	13.603	28.7
7	Machinery and transport equipment	7.674	23.0	5.307	11.2
8	Miscellaneous manufactured articles	4.432	13.3	2.041	4.3
9	Not classified elsewhere in the SITC	1.008	3.0	0.192	0.4

Source: compiled by the United Nations (2020).

The peculiarities of the countries that were classified in the 4th cluster are their significant export specialization in machinery and transport equipment, as well as significant progress in increasing the economic complexity of national economies. We consider South Korea and China as examples of countries in the 4th cluster. South Korea ranks third in the world in terms of economic complexity (its ECI value is 2.11). Over the ten-year period, it rose eight places in the ranking, ahead of even Germany today. During the same period, China rose six places, with an ECI of 1.34 (18th place).

Machinery and transport equipment dominate by a large margin in both countries' exports. For China, the share of machinery in the country's exports is 48%. Meanwhile, in South Korea, it accounted for 57.5% in 2019 (Table 6). China's main export items were radio and television transmitters, television cameras, digital cameras and video recorders; computers; electronic integrated circuits; parts and accessories for office equipment, special equipment; semiconductor devices; phones. South Korea's exports were represented by the following commodity items: electronic integrated circuits; refined petroleum oils; cars; ships, boats; engine parts; parts and accessories for office equipment special equipment; liquid crystal devices, lasers; other optical instruments and instruments (United Nations 2020).

Thus, the study confirms common features in the specialization of countries within the cluster, as well as the achievement by countries of similar levels of economic complexity and diversification of export goods.

Table 6. Merchandise exports of China and South Korea, 2019

SITC	Merchandise exports by SITC	China		South Korea	
		billion US$	%	billion US$	%
Total	All commodities	2,494.230	100.0	542.172	100.0
0 + 1	Food, animals + beverages, tobacco	69.990	2.8	7.827	1.4
2 + 4	Crude materials + anim. & veg. oils	18.345	0.7	42.179	1.2
3	Mineral fuels, lubricants	46.628	1.9	73.997	7.8
5	Chemicals	167.699	6.7	73.997	13.6
6	Goods classified chiefly by material	408.746	16.4	68.640	12.7
7	Machinery and transport equipment	1,212.092	48.6	310.027	57.2
8	Miscellaneous manufactured articles	564.619	22.6	32.144	5.9
9	Not classified elsewhere in the SITC	6.112	0.2	0.934	0.2

Source: compiled by the United Nations (2020).

Recently, the number of scientific and technical workers has grown rapidly and, accordingly, the positions in the field of high technologies of those countries that previously belonged to the third world are strengthening. As already mentioned, in previous decades, developing countries managed to achieve certain results in economic development. The Asian market is already strategically important for many American exporters, especially producers of expensive consumer goods and means of production, as Japan and Europe experience a decline in high-tech developments.

During the 1990s and the 2000s, US exports to Singapore, Taiwan, and Hong Kong doubled. Today, these countries are a larger import market for the United States than any European country. In the high-tech market of Asia, the cost of R&D is increasing, but the situation today is not clear. For example, in China, the world's third-largest smartphone maker, Huawei Technologies, and the world's largest PC maker, the Lenovo Group, are already raising R&D spending significantly; the same is happening in Malaysia. The Hong Kong & Shanghai Banking Corporation predicts that by 2030, China will account for more than half of world trade in high-tech goods. Hong Kong and the United States will remain in second and third place, albeit with smaller market shares, and South Korea will overtake Singapore as the fourth largest exporter of high-tech goods. According to the latest report on the evaluation of high-tech innovation, which is a critical factor in China's innovation development and economic growth, they have made significant progress.

Conclusions

The clustering of countries indicates that countries united by the level of socio-economic development and economic growth rates have a certain specialization, which becomes both a prerequisite for and a consequence of accelerating economic development. In addition, the analysis indicates that countries in the same cluster have similar indicators of the complexity of economic activity and a similar structure of production of goods and export-import activity.

The countries of the first cluster are characterized by the highest indicators of socio-economic development, and they generally export mainly goods with a high degree of processing and level of added value. The countries of the second cluster, which includes some Central and Eastern European countries (including Slovenia and the Czech Republic), occupy an intermediate position between the first and third groups. In many parameters, they are close to the countries of the first cluster, but machines and equipment in their exports have a significantly lower weight than the countries of the first group. The countries of the second cluster specialized in producing low-technology products, especially food and raw materials. However, the countries of this cluster have potential based on products, machinery, and transport equipment, which can be a substratum for creating economic growth.

The countries of the third cluster, which unite the Central and Eastern European countries and the Baltic countries, mainly specialize in goods with a relatively small degree of processing and have low indicators of the complexity of the economy. The countries of the fourth cluster, which unites Asian countries, occupy a unique position. They have high indicators of economic complexity, specialize in high-tech exports, and are focused on goods with a high level of added value and ICT. The key feature of the countries of the fourth cluster is significant growth rates of economic indicators and specific development strategies. The criteria for the development of countries identified with the mathematical model, as well as the clustering based on the indicator of international specialization in the export profile, confirms the economic proximity and similarity of the economic structure of those countries.

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Innowacyjne klastry światowych liderów handlu

Powstanie nowego systemu globalnego i systemowej współzależności globalnej wygenerowało nowe czynniki konkurencyjności dla uczestników rynku, określające ich strategiczne zachowania służące zapewnieniu wysoce konkurencyjnej i wiodącej pozycji. Dlatego celem badania była identyfikacja krajów będących intelektualnymi liderami na rynku globalnym oraz czynników wpływających na pozycję głównych krajów. Zastosowano następujące metody badawcze: modele regresji wieloczynnikowej, analizę skupień oraz analizę porównawczą. Na podstawie autorskiej metodologii oceny przywództwa intelektualnego krajów dokonano grupowania krajów w gospodarce światowej. Algorytm oceny opierał się na trzech poziomach: 1) zasobach, 2) pośrednich wynikach aktywności intelektualnej oraz 3) ostatecznych wynikach ogólnego postępu.
Korzystając z modelu regresji wieloczynnikowej i analizy skupień, zidentyfikowano cztery klastry krajów wyodrębnione na podstawie kluczowych wskaźników przywództwa intelektualnego. Dla każdego klastra przeanalizowano specjalizację obu krajów w obszarze eksportu towarów: klaster 1 – Stany Zjednoczone i Niemcy; klaster 2 – Izrael i Włochy; klaster 3 – Brazylia i Ukraina; klaster 4 – Chiny i Korea Południowa. Każdemu krajowi przypisano wskaźnik złożoności gospodarczej i zarejestrowano zmianę pozycji każdego kraju w klastrze w ciągu dziesięciu lat.
Ważnym celem jest zrozumienie uwarunkowań przywództwa krajów w każdym regionie geograficznym.
Badania opierają się na analizie skupień przeprowadzonej we wcześniejszych publikacjach. Klasteryzacja krajów została przeprowadzona na podstawie dynamiki wskaźników makroekonomicznych w ciągu ostatnich 15 lat.

Słowa kluczowe: indeks złożoności gospodarczej, intelektualizacja, klasteryzacja krajów, eksport towarów