Developing Methods for Assessing the Introduction of Smart Technologies into the Socio-Economic Sphere Within the Framework of Open Innovation

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ABSTRACT

The post-industrial society is transforming into a smart society, in which smart technologies control all the main processes. The study aims at proposing indicators for assessing the spread of smart technologies in various spheres of human life with due regard to the introduction of open innovations. The methodological basis of the study was an approach focused on the study of the processes of development of open innovations and the smartization of society with the involvement of special methods. Special methods include document analysis based on a literature review conducted by the authors, content analysis using multiple correspondence analysis and the cluster analysis method. This is the first study to use the Smart Progress Index like other social development indices, including the Social Progress Index, the Physical Quality Life Index and the Sustainable Economic Welfare Index. The Smart Progress Index will determine the state of society and the level of its development in technological, geopolitical, socio-economic, demographic and environmental terms. There are three indicators of the Smart Progress Index: 1) the scale of smart technologies; 2) the conditions and intensity of introducing smart technologies; 3) the results of smart technologies. Each aspect includes several components represented by seventeen indicators.

1. INTRODUCTION

Promoting open innovation contributes to the smartization of society [1]. According to the dialectical approach, the wave worldview implies mandatory changes. In this context, society went through pre-industrial, industrial and post-industrial periods of its development [2]. The post-industrial society, or the information society, is gradually transforming into a smart society. The relationship between open innovation and smartization is crucial to progress in general and contributes to the economic growth of countries. The development of open innovation and smartization are interrelated processes since smart technologies result from the activities of enterprises within the framework of specific projects and strategic partnerships [3]. In a smart society, the availability and openness of information resources and communication tools increase along with the development of open innovation. It radically changes all elements of the social paradigm: economics, social policy, education and labor relations. Smart technologies, which are open innovations (blockchain, artificial intelligence, big data, etc.), radically change all social spheres [4].

Until 1980, GDP indicators had been demonstrating the state of society. In the late 1980s, scientists proposed the Social Progress Index, the Physical Quality Life Index, the Index of Sustainable Economic Welfare, the Quality Indexes of Progress, the General Progress Indicator, etc. In 1994, the United Nations Commission on Sustainable Development offered a set of indicators that included 130 items [5]. Dissatisfaction with the traditional system of national accounts expanded the concept of inclusive wealth and required its complete quantitative assessment [6]. By analogy with physical capital, the concepts of "human capital" (people's health, the level of education) and "natural capital" emerged [7]. Given the rapid development of open innovation that affects the smartization of society, it is necessary to add the "smart progress" indicator to these concepts. Smart progress is of key importance as its assessment determines living standards and the quality of the socio-economic system [2]. Smart technologies available for industrial use are among the main conditions for human well-being [8, 9]. Without assessing smart assets, their conditions and constant changes due to the growing scale of innovation, it is difficult to determine conditions and prospects for the social progress of humankind. This study aims at proposing indicators for assessing the spread of smart technologies in various spheres of human life with due regard to the introduction of open innovations.

The introduction of open innovation is an important and evolving social process (in fact, the strategic direction for developing modern society), which is an actual object of statistics for many reasons. However, I our opinion, due to a number of circumstances, methods and tools for studying the spread of smart technologies are still being formed and reflected upon. This is the first study to use the Smart Progress Index like other social development indices.

2. LITERATURE OVERVIEW

Today entire industries are "smart". Tomorrow smart technologies will enter all the spheres of human activity, radically changing the direction of social progress and the information society will move to the next stage of its development, namely a smart society [10]. Despite their high initial cost, smart technologies have become a property and an obligatory attribute of the life of ordinary citizens who do not have high incomes [11].

A smart society is a goal that many countries are inevitably moving towards, but they do it at different rates and with different results. Thus, it is important to highlight the main indicators of smart progress at this stage of development. The selection of specific indicators that directly or indirectly reflect the quantitative and qualitative characteristics of smartization is due to the fact that the dynamics of these processes are significantly influenced by the development of open innovation [11, 12].

When choosing indicators, many scientists proposed various methods and approaches to determine the scope of open innovations and their impact on the smartization of society, therefore some hypotheses were tested using the sampling method and the SmartPLS2 software to model structural equations [13]. In most cases, researchers used a citation-based approach [14] to collect expert assessments of renowned authors in the research field [15]. However, this approach lacks peer review and content analysis [16].

Some experts mostly used the statistical method to reveal the dependence, spread and interaction of smart technologies, whose development is accompanied by major changes in all areas of society [17].

In relation to assessing the impact of smartization on the development of social, cultural, economic, trade, innovation, information and communication, and other processes, the advantages of the statistical method are conditioned by a wide coverage of smartization on a territorial basis [18]. Many studies prove the expediency of using the statistical method as a measure of the impact of smartization. In particular, this is evidenced by a statistical study conducted by Karmanov et al. [19] on the spread of smart technologies as exemplified by smartphones. In addition, the statistical method is being improved and effectively used to assess the spread of open innovations [20].

Some experts assessed the introduction of smart technologies in modern society using the following methods:
– One integral indicator;
– Groups of specific indicators (list or complementary);
– Systems of interrelated indicators.

It is tempting to focus on a single indicator to characterize smart technologies since the interpretation of the studied social process is greatly simplified [21]. Within this approach, we can try either to single out one of the most important indicators of the spread of smart technologies or develop a methodology for combining several significant indicators into one integral criterion, implying the equality or inequality of all its components [22].

The thing is that it is very difficult to choose and justify the only and best indicator that comprehensively reflects the spread and use of smart technologies. It is worth mentioning that such features of smart technologies as a total and multi-level nature hinder the use of only one indicator that clearly cannot cover the large-scale introduction of smart technologies into the life of modern society. There are prospects for using an integral or general indicator in relation to the spread of smart technologies.

For most scientists, the development of smart technologies using the statistical method is the most preferable. Some authors also highlighted its unique nature [20].

It is quite reasonable to form a group of private indicators since numerous forms of smart technology manifestation in various life spheres make this approach not only intelligible but also turn it into a logically consistent algorithm [23]. In addition to determining the structure of the selected indicators, other difficulties are associated with the interconnection of certain features. The list of statistical indicators implies their positioning, i.e. a strictly defined arrangement depending on their significance (as a rule, these lists are compiled from the most important to the least important indicator). If we keep in mind the complete equality of the indicators used (regardless of their position in the list), then we mean the regular complementarity of several parameters in order to create a complete picture of the research object [24]. In fact, private indicators should conduct a comprehensive assessment of smart technologies not only by their number and coverage of certain aspects but also by their inner connections, i.e. based on the so-called synergistic effect.

Traditionally, the system of indicators, in comparison with individual indicators or their groups, has a number of positive aspects. The system of indicators provides data of a higher level than the sum of individual indicators since it conveys not only information about the relationship of components but also the development of the system as a whole [25]. Many experts proposed methods to determine the introduction of smart technologies into society. However, a full-fledged methodology has not been developed yet. Therefore, it is necessary to develop a system of indicators that determine the Smart Progress Index of countries in which individual indicators are located not randomly or chaotically but in a strictly defined sequence. At the same time, private segments, sections or blocks of such indicators are designed in such a way as to complement each other.

In practice, we can recognize that one of the most common options for creating any system of indicators is their classification depending on the form of their presentation. In this context, scientists usually single out absolute (the number of smart goods), relative (the share of smart goods in a particular market), average (the number of smart goods per inhabitant), and other groups of indicators. This logic boils down to the fact that absolute characteristics form the basis for calculating other indicators. Starting from these features, we can proceed to using relative and average indicators to explore the structure, intensity, effectiveness and other aspects of the spread of smart technologies [26]. However, such a methodological approach is not universally recognized because it initially does not allow to focus on the key aspects of open innovation that play a major role in the smartization of society.

A literature overview allows concluding that analysts actively study the issues associated with the development and impact of open innovation on the smartization of society. However, there are no proven methods or tools to determine the extent of such smartization. These circumstances necessitate the creation of an applied research methodology to assess the impact of open innovation on socio-economic development.

Hypothesis: If a methodology is developed that allows to adequately assess the state and development of social phenomena and processes (somehow associated with the dissemination of open innovation), then it will be possible to assess the level of technological progress, which entails progress in many areas and in any country. Therefore, it is crucial to form an applied research methodology on the smartization of society, as well as an assessment of the impact of this process on socio-economic development with due regard to the introduction of open innovation.

While studying the corresponding scientific and methodological literature on the research topic, we identified different approaches to a wide range of issues related to the analysis of open innovations in the most diverse spheres of modern society. The content analysis and systematization of publications demonstrate that the SMART category is still being comprehended and insufficient attention is paid to methodological support for the dissemination of open innovations in society.

3. METHODOLOGY

This article presents the results of an exploratory quantitative and qualitative study based on a systematic review of sources. The chosen search protocol ensured the transparency and reproducibility of the study and covered such databases as Web of Science (WoS), Scopus and Scientific Electronic Library Online (SciELO). The first two databases were used to search for interdisciplinary surveys published in international journals with a high impact factor. The search query included two keywords – "open innovations" and "smart technologies" (without quotes). While studying the selected articles, we have revealed the existing approaches to the analysis of these concepts and concluded that many open innovations are smart technologies. Thanks to open access, they spread rapidly and are applied in various spheres. Filtering titles and keywords, we selected 48 publications, whose analysis revealed different approaches to the research topic under consideration. Since experts from different spheres are concerned with this topic, it testifies to its interdisciplinary nature.

After selecting the necessary articles, we analyzed the concepts of smartization and open innovation (Table 1).

After studying the selected articles, we have concluded that the development of open innovation and the smartization of society are interdependent processes since most articles consider the implementation of open innovation, which ensures the smart management of the state, economy and society as a whole.

We selected works in which the authors:

– Theoretically substantiated the significance and influence of open innovation on the development of modern society;

– Revealed the specific spread of open innovation as an object of statistical research;

– Proposed a system of indicators to assess the introduction of open innovations into various spheres of human life;

– Systematized methods for assessing the introduction of open innovations in certain areas of activity;

– Described prerequisites and conditions for the spread of smart technologies;

– Characterized the spread of open innovations and assessed the influence of various factors on the smartization of society;

– Forecasted the main indicators reflecting the spread of open innovations among the population and assessed possible scenarios for the impact of this process on the socio-economic situation.

The system of indicators focused on specific aspects of the process under consideration, including the scale, intensity, directions, conditions, results and consequences of introducing open innovations. The sequence of their consideration was associated with a gradual transition from the state to the factors and results of transforming the research object. Within the introduction of open innovations, this approach to smartization looked reasonable as it allowed to link the most important elements of smart technologies in modern society.

Table 1. The articles grouped by their topic

Topic	Only open innovations	Only smart technologies	Smart technologies and open innovations
The spread of knowledge	Amponsah and Adams [3]	Foresti et al. [27], Deebak and Al-Turjman [28]	Criado and Gil-Garcia [29], Iannone et al. [26]
The digitalization of society	Stolterman and Fors [5]	Záklasník and Putnová [30]	Brennen and Kreiss [31], Brennen and Kreiss [32]
Innovation activity		Sjödin et al. [33], Neves et al. [34], Singh et al. [35], Mohanta et al. [36]	Jones et al. [37], Gray and Rumpe [38], Bliznets et al. [39], Kane et al. [22], Lazaro et al. [40]
New business technologies	Chesbrough [41]	Gassmann et al. [42]	Parviainen et al. [43], Tihinen et al. [11], Markovitch and Willmott [44], Gasanova [20], Moradi et al. [13]
Social changes (smart cities)	Barrett et al. [17]	Zhang and He [4], Deng et al. [45], Jiang [2], Asadi Bagloee et al. [46]	Mutekwe [47], Xiao and Xie [6], Ullah et al. [7], Shamsuzzoha et al. [24], Nikki Han and Kim [12], Palumbo et al. [48], Majeed et al. [49], Ahad et al. [50]
Economic changes	Amponsah and Adams [3]	Low et al. [51], Karmanov et al. [19]	Reuschke et al. [10], Yuan et al. [52], Øiestad and Bugge [18]
Political changes			Sabbagh et al. [53], Nelson [54]

The study utilized content analysis and multiple correspondence analysis (MCA). This approach allowed to group results and graphically depict the indicators of smartization in different countries. The benefits of this approach are conditioned by a combination of expert approach and content analysis.

When choosing methods, special attention was paid to grouping and classification, methods for assessing structural changes, index, correlation-regression and cluster analysis, statistical forecasting techniques, as well as tables and graphs for presenting data.

4. RESULTS

4.1 General characteristics of open innovation influencing the smartization of society

Open innovations in the form of smart products actively enter into production, management and the social sphere, seriously transform traditional relations and form a different human environment, in which the way of life and living standards are at a fundamentally new level [39]. In addition, open innovations increase the efficiency of social reproduction, which contributes to the practical transition from the raw material economy to the innovative stage of development [41]. A literature review has proved that the concept of open innovation led to the production of smart technologies that began to be introduced into all spheres of life, while the development of smart technologies conditioned the formation of a smart society. The prospects for open innovations and smart technologies coincide (Table 2).

Open innovations in the form of smart technologies are developing rapidly. Previously, innovations comprised "smart" homes, with automated equipment and systems working without human control and serving the daily needs of families living in them. Now smart cities are being created that will solve social and communal problems of the population: traffic jams, queues, energy dependence and unsupervised urban structures [43].

There are many projects implemented with the help of smart technologies and introduced into all spheres of society [54]. The table below presents different areas where smart projects have been successfully realized (Table 3).

What makes countries adopt smart technologies so quickly? Firstly, the entire history of humankind in recent decades testifies to the growing development of natural resources and damage to the environment. However, an economy based on the introduction of open innovation is different since it relies on security, energy-saving, clean and biological technologies. This provides an opportunity not only to save the human environment but also more rationally and efficiently use all the resources available on the planet [52]. Secondly, people open up fundamentally new perspectives for themselves using innovations, for example, a smart car parks itself and informs the driver about the presence of obstacles; a smart TV allows to actively interact with the entire virtual environment via the Internet; a smart home not only regulates life support processes inside a house but also exchanges information with the owner, etc. [31].

4.2 Main features of the smartization process

Statistics recognizes the fact that the introduction of open innovations influences not only various spheres of human life but also addresses different groups of the population, easily overcoming closed state borders [44].

Another notable feature of smartization as the research object is the dynamic nature of this process. Even in the recent history of humankind, production and product lines were renewed every fifty years. Now it happens every year, sometimes several times a year. Due to these circumstances, it is necessary to reduce the time span from the development of open innovations to their implementation in the life of the general population [48]. At an ever-increasing pace, companies specializing in the field of open innovation present smart products designed to increase the demand for these technologies due to their higher quality and new opportunities. Such dynamism affects the timeliness of development and updating, as well as requires the clarification of methods for studying the introduction of smart technologies into the life of modern society.

Table 2. The comparison of open innovations and smart technologies

Features of open innovations	Features of smart technologies	Coinciding prospects	Sources
Created in association with external partners	Widespread use	Integrated into civil relations	Reuschke et al. [10], Sjödin et al. [33]
The use of external knowledge sources	Promotion	Enterprises and design engineering departments are both producers and users	Bliznets et al. [39]
The major role of a business model	New user models	Innovations increase the value of assets	Yuan et al. [52], Tihinen et al. [11]
The significance of knowledge	Knowledge accumulation	The possibility of building new infrastructures	Criado and Gil-Garcia [29], Foresti et al. [27]
The significance of mediation	The exchange of technologies	Mass implementation in different spheres	Low et al. [51], Mutekwe [47], Xiao and Xie [6]
High performance indicators	Operational perspectives	Job slashing	Jones et al. [37], Ullah et al. [7]
The rational use of resources	Effective use	The application of energy saving technologies	Iannone et al. [26]; Zhangand He [4]
The use of digital technologies	The application of digital technologies	Digitalization	Brennen and Kreiss [31], Gray and Rumpe [38], Parviainen et al. [43], Záklasník and Putnová [30]

Table 3. The scope of applying open innovations in the smartization of society

Scope of application	Examples
Financial services	– online trade finance, trading on the stock exchange, participation in auctions on the Internet
Credit commitments	– fulfillment of obligations under various forms of banking credit products at the time of the occurrence of events
Social services	– voting procedures, elections, insurance processes
Property relations	– holding digital assets and conducting operations with them, including cryptocurrencies and tokens (Bitcoin, ETH, XRP, etc.)
Economy	– energy saving technologies; ecological infrastructure; services find customers; citizens interact with business horizontally; remote offices; the management of goods delivery and storage
Education	– open educational resources; open online courses; educational platforms; electronic textbooks and libraries; open licenses; mobile learning; digital automated management systems for educational organizations; electronic portfolios and personal accounts
Employment	– the opportunity to cooperate with different employers simultaneously, to work in a convenient mode according to an individual schedule (including remotely) and receive the income necessary to maintain a high quality of life
Environment	– smart wells, waste bins, power supply control systems, polymers, packaging, fuel, etc.

When evaluating the spread of open innovations, it is necessary to emphasize the multi-level nature of the process under consideration. Statistics collects the necessary digital information at several levels. Among them, we can determine three levels (Figure 1):
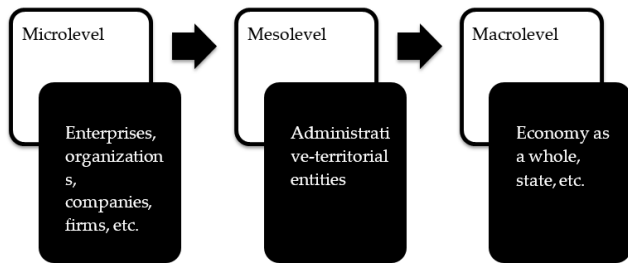
Figure 1. Levels of assessing the spread of smart technologies

The above-mentioned facts are not accidental. The spread of smart technologies lies in the fact that a wide range of smart technologies enters the lives of individuals, families, work teams, communities of citizens, sectors of production and economy, municipalities, cities, regions, countries and the world as a whole [50]. Smartization does not recognize the existing levels of management. It penetrates society from bottom to top and from top to bottom, making people forget about the approaches that have been forming and used for a long period of time [40]. This circumstance necessitates the search for new specific approaches to the characterization of smartization [42].

4.3 Indicators showing the spread of open innovations in society

In a broad sense, smartization implies the introduction of open innovations into various spheres of public life via the Internet. In practice, it manifests itself in the fact that open innovations created with the help of the latest achievements in science and technology form a completely new human environment in which a life based on knowledge becomes more thoughtful, meaningful and comfortable. Distinctive features of this process are as follows: comprehensive, dynamic, multi-level, irreversible and understudied. The methodological issues of studying the introduction of open innovations are associated with the lack of a generally accepted interpretation of this research object and the limitations and imperfections of the existing indicators and research methods.

As a result, we have developed a new system of indicators showing the spread of open innovations in society. The system of indicators tracing the introduction of smart technologies is presented in the table below.

The three-tier structure proposed in the table is reduced to the simplest but consistent chain, starting with volume-based and structural indicators showing the spread of open innovations in society. They create a general idea about external parameters of open innovations being introduced into different areas.

To clarify the reasons for the current situation, we need to consider the mechanism for introducing smart technologies. In this context, it is crucial to assess the conditions, factors and intensity of the process under study. Without a consistent and organic addition to the first component, the second one will not be supported by the relevant data. The final component is the actual achievements caused by the spread of open innovations, including the impact of this process on the most diverse areas of human life. The selected components were filled with the main indicators on the basis of literature analysis, in which scientists highlighted the importance of certain indicators. The above-mentioned indicators can be called the Smart Progress Index, which will allow determining the progress of society in particular countries and states.

Assessing the accelerating pace of global open innovations, we should dwell on the situation that has developed in some countries of the world since their specifics gives an idea of the actual differentiation of smartization [32]. To classify 178 states depending on conditions for the introduction of smart technologies, we decided to use a cluster analysis. The following indicators of 2020 were used as the initial data:

$x1$ – gross domestic product per capita, thousand dollars;
$x2$ – the share of Internet users in the total population, in %;
$x3$ – the share of people under the age of 15 in the total population.

Indicators for the multi-dimensional classification of countries to determine the degree of their smartization were selected by the following factors:

– The availability of comparable statistical information;
– The semantic content of indicators.

5. DISCUSSION

5.1 The specific application of the system of indicators showing the spread of smart technologies in society

The proposed system of indicators showing the spread of smart technologies in the form of open innovations allows to

determine the technological development of various countries and states. In particular, the use of open innovations indicates the progress of society and a high level of its development.

Table 4. Indicators showing the spread of open innovations (smart)

N	Indicators	Sources
1	The number of developed open innovations (smart)	Foresti et al. [27]
2	The cost of realized open innovations (smart)	Xiao and Xie [6]
3	The share of developed open innovations (smart) in the total volume of developed technologies	Brennen and Kreiss [31]
4	The share of produced open innovations (smart) in the total volume of produced technologies	Ullah et al. [7]
5	The structure of developed open innovations (smart) according to types, purposes, manufacturers, areas of application and territories	Shamsuzzoha et al. [24]
6	The volume of implemented open innovations (smart) per capita in value terms	Nikki Han and Kim [12]
7	The volume of produced open innovations (smart) per capita in value terms	Yuan et al. [52]

Table 5. Indicators assessing the scale of open innovations (smart)

N	Indicators	Sources
1	The volume of costs for the development of open innovations (smart) in value terms	Parviainen et al. [43], Ahad et al. [50], Kane et al. [22]
2	The share of costs for the development of open innovations (smart) in the total costs	Sjödin et al. [33], Sabbagh et al. [53]
3	The dynamics of prices for open innovations (smart) by types, purposes, manufacturers, areas of application and territories	Gray and Rumpe [38], Jiang [2]
4	Changes in the number of developed open innovations (smart)	Jones et al. [37], Deng et al. [45]
5	Changes in the volume of produced open innovations (smart) in value terms	Low et al. [51], Majeed et al. [49], Gassmann et al. [42]
6	Changes in the volume of implemented open innovations (smart) per capita in value terms	Bliznets et al. [39]
7	Changes in the volume of realized open innovations (smart) per capita in value terms	Iannone et al. [26], Palumbo et al. [48]

In the United States, the widespread industrial use of robotic systems and open innovations led to a change in the growth dynamics of GDP and labor productivity by 0.37% and 0.36%, respectively, from 2019 to 2021. When defining the Smart Progress Index, each indicator is calculated separately, for example, the spread of smart technologies in US enterprises in 2020 brought the following results: the introduction of smart manufacturing increased the speed of equipment by 190%, productivity grew by 180%, and the cost of production decreased by 65%. Manufacturing lead-time decreased by 50% and the number of jobs in the robotics industry increased by 35% [27].

After considering the relevant literature sources, we have concluded that several main factors should be considered for determining indicators describing the scale, directions and characteristics of the spread of open innovations (smart) (Table 4).

Considering the intensive spread of open innovations (smart), experts highlighted certain criteria presented in the table below and taken into account when developing indicators for the Smart Progress Index (Table 5).

Summing up the expert assessments presented in the selected studies, it was possible to identify the results of introducing open innovations (Table 6).

At the current stage of social development, the Smart Progress Index is comparable to GDP, whose results guide the world economies. In the near future, the Smart Progress Index might become the main indicator of the development of countries. The result of smart progress for the selected countries is presented below (Figure 2).

Table 6. Final indicators of the spread of open innovations (smart)

N	Indicators	Sources
1	The number of people using open innovations (smart) by groups of smart technologies	Mutekwe [47], Asadi Bagloee et al. [46], Nelson [54]
2	The share of people using smart goods in the total population	Criado and Gil-Garcia [29], Markovitch and Willmott [44]
3	The number of families using open innovations (smart)	Záklasník and Putnová [30]
4	The share of families with smart goods for collective use in the total number of families	Tihinen et al. [11]
5	The share of residential smart objects (apartments, cottages, etc.) in their total number	Zhang and He [4], Karmanov et al. [19]
6	Saving water, electricity and fuel through the use of open innovations (smart)	Reuschke et al. [10], Brennen and Kreiss [32], Schuster and Brem [1]
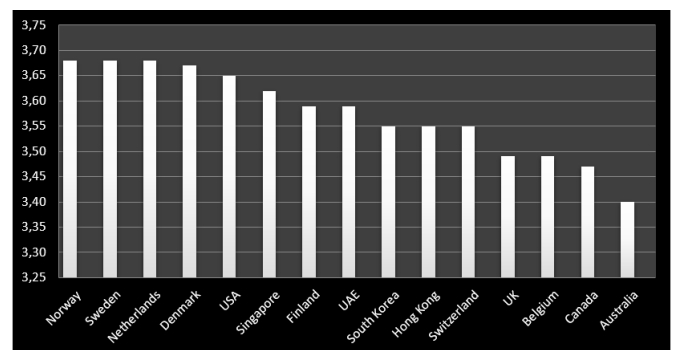
Figure 2. Country and the Smart Progress Index (vertical axis)

5.2 Possibilities of assessment tools to improve the effectiveness of smart progress in the context of open innovation

Gross domestic product per capita (*x1*) is a traditional indicator used for a wide range of international comparisons.

Within the framework of this study, it is worth mentioning that the smartization of society is an expensive process. Therefore, the quantitative component reflecting the average well-being of the population should be considered when considering conditions for the spread of smart technologies. The table below contains GDP indicators (Table 7).
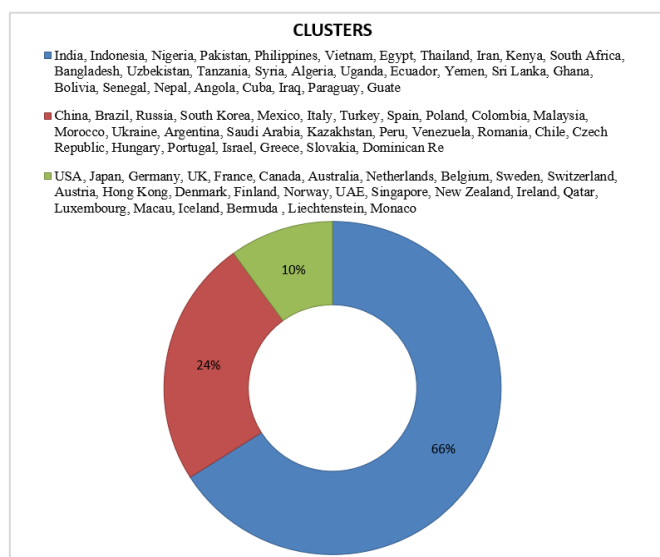
The share of Internet users is an objective parameter that reflects technical conditions for the introduction of smart technologies, goods and services into society. Therefore, people need Internet access and certain knowledge and skills to work on the Internet.

The United Nations and other international organizations use the share of people under the age of 15 in the total population (*x3*) to characterize the youth. Young people master technologies faster, which describes the demographic conditions of smartization [49].

Table 7. Annual percent change in real GDP

Time period	2019	2020	2021
Global output	2.8	-4.4	5.2
Developed economies	1.7	-5.8	3.9
USA	2.2	-4.3	3.1
Eurozone	1.3	-8.3	5.2
Japan	0.7	-5.3	2.3
UK	1.5	-9.8	5.9
Canada	1.7	-7.1	5.2
Other developed economies	1.7	-3.8	3.6
Emerging markets and developing countries	3.7	-3.3	6.0
Emerging markets and developing countries in Asia	5.5	-1.7	8.0
China	6.1	1.9	8.2
India	4.2	-10.3	8.8
Emerging markets and developing countries in Europe	2.1	-4.6	3.9
Russia	1.3	-4.1	2.8
Latin America and the Caribbean countries	0.0	-8.1	3.6
Middle East and Central Asia	1.4	-4.1	3.0
Sub-Saharan Africa	3.2	-3.0	3.1
Low-income developing countries	5.3	-1.2	4.9

Source: IMF. World Economic Outlook: IMF.org

CLUSTERS

■ India, Indonesia, Nigeria, Pakistan, Philippines, Vietnam, Egypt, Thailand, Iran, Kenya, South Africa, Bangladesh, Uzbekistan, Tanzania, Syria, Algeria, Uganda, Ecuador, Yemen, Sri Lanka, Ghana, Bolivia, Senegal, Nepal, Angola, Cuba, Iraq, Paraguay, Guate

■ China, Brazil, Russia, South Korea, Mexico, Italy, Turkey, Spain, Poland, Colombia, Malaysia, Morocco, Ukraine, Argentina, Saudi Arabia, Kazakhstan, Peru, Venezuela, Romania, Chile, Czech Republic, Hungary, Portugal, Israel, Greece, Slovakia, Dominican Re

■ USA, Japan, Germany, UK, France, Canada, Australia, Netherlands, Belgium, Sweden, Switzerland, Austria, Hong Kong, Denmark, Finland, Norway, UAE, Singapore, New Zealand, Ireland, Qatar, Luxembourg, Macau, Iceland, Bermuda , Liechtenstein, Monaco

Figure 3. The clusterization of countries in the world

As a result of clustering, using the z-transform (*z1–z3*) (various levels of data have been converted to a single Z-Score for comparison) and the K-means algorithm, we have determined three groups of states (Figure 3).

The first and smallest cluster (27 countries) includes developed economies, and its indicators are based on high material and technical indicators (gross domestic product per capita and the share of Internet users in the total population). In tactical aspects, these parameters create favorable conditions and predetermine the success of society's smartization. At the same time, the maximum number of senior people (the lowest share of people under the age of 15 in the total population) puts an additional demographic "barrier" to the spread of smart technologies, goods and services that are more popular among younger generations [30].

The second cluster (63 countries) holds an average position both in quantitative and in qualitative terms, i.e. it is defined as "moderate and intermediate". If compared to the first cluster, it is characterized by a lower level of social well-being but retains reliable prosperity. At the same time, almost half of the population actively uses the Internet and the share of people under the age of 15 in the total population testifies to a younger society within this cluster. Consequently, the second cluster has conditions for the active dissemination of open innovations, but they are less declared in material and technical aspects than in the group of leading countries.

The third cluster (88 countries) embraces developing economies that have worse material and technical conditions for the smartization of society. The low levels of well-being and Internet coverage do not give grounds for the introduction of smart technologies and goods or services produced on their basis. However, the highest share of young people is beneficial for the future, therefore this cluster should be called "lagging behind, but strategically promising".

6. CONCLUSION

Within the framework of this study, a systemic review of the relevant literature aimed at identifying various viewpoints on the interconnected development of open innovation and the smartization of society. Only 33 articles concerned with this relationship can serve as a basis for the further study of this topic. The analysis of sources has demonstrated that the connection between open innovation and society smartization is mostly explained through the dissemination of knowledge. As a result, the hypothesis has been proved.

Using the proposed indicators, one can evaluate the smartization of countries, which depends on the introduction of open innovations. The article proposes to use the Smart Progress Index for assessing state development. Three groups of interrelated statistical indicators allow assessing the scale and consequences of society smartization. The Smart Progress Index should be used in combination with such indicators as the GDP, General Progress Indicator, Social Progress Index, etc. The Smart Progress Index will determine the state of society and the level of its development in technological, geopolitical, socio-economic, demographic and environmental terms.

Further studies should specify and supplement the indicators of the Smart Progress Index, conduct a comparative analysis of two countries, highlight a single indicator of the Smart Progress Index and consider it in a comprehensive manner. Within the framework of the research, it is impossible to properly consider the indicators of the Smart Progress Index.

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