SMART

ISMA University of applied sciences

SMART ECONOMY: ESSENCE, EVOLUTION AND DEVELOPMENT FACTORS

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Smart economy: essence, evolution and development. I.Kalenyuk, L.Tsymbal, A.Djakona, I.Uninets.- ISMA University of applied sciences, Riga, 2024.

The monograph presents the joint work of scientists from Vadym Hetman Kyiv National University of Economics (KNEU, Ukraine) and the Higher School of Information Systems Management (ISMA, Latvia) in researching the phenomenon of smart economy in a global environment. The theoretical foundations of the smart economy, its essence in the global paradigm of economic development, features and forms of manifestation at different levels are substantiated. The global experience of developing smart cities has been analyzed and summarized, the factors of their success have been determined, and approaches to the assessment and ranking of cities have been systematized. The author proposed methodical approaches to the assessment of the development of the smart economy in the countries of the world and provided the results of such an assessment. The key characteristics of the relationship between the green and smart economies, the peculiarities of the implementation of the ecosystem approach in the model of global economic development are determined. Conceptualization of the problems of assessing the development of the smart economy, comparative analysis of the progress of the smart economy in different countries of the world was carried out. Recommended for researchers, educators, government officials, and students interested in smart development in a global economic environment.

CONTENT

INTRODUCTION

The modern world is undergoing rapid changes under the influence of unprecedented scientific and technological progress and related systemic transformations. The processes of intellectualisation, the spread of ICTs and digitalisation that have dominated in recent decades are changing society, the system of economic relations, and the principles and models of economic functioning. Knowledge and information are increasingly becoming the main resource and factor of development, and modern technologies create extraordinary opportunities for their dissemination and use on a global scale.

Strengthening of the intellectual and knowledge component of economic development in the context of the information revolution generates new approaches to solving global problems. On the fundamental basis of the concept of sustainable development, the latest scientific research is updating the conceptual search for ways to preserve the environment and social progress, and substantiating models of green and circular economies. In general, a new approach to the perception of economic phenomena and processes in the ecosystem paradigm is being formed, with the smart economy becoming the most progressive and dynamic enclave with currently insufficiently integrated functionalities (smart production/enterprise, smart marketing), localities (smart homes, smart cities, smart communities), and markets (smart demand and smart supply). It is the smart economy, as a breakthrough innovation in this area, that allows for a qualitatively new level of effective globally balanced development, which does not exclude the emergence of new challenges and threats.

Theoretical understanding of the essence of transformation processes that qualitatively modify modern society is in the centre of research interest, which is manifested in the evolution of theories of post-industrial, information, network society, reflected in the works of foreign and domestic economists L. Antoniuk, D. Bell, O. Belorus, V. Biloshapka, A. Boven, O. Lukianenko, R. Nelson, G. Nyameschuk, T. Orekhova, Y. Orlovska, E. Panchenko, A. Poruchnyk, S. Sidenko, Y. Stolyarchuk, V. Tarasevych, A. Filipenko, R. Florida, K. Freeman, O. Shvydanenko, etc. The problems

of ecosystem development and the development of smart economy and smart cities are studied: K. Ajarta, M. Angelidou, M. Belitsky, J. Brunekienė, Halperin, R. Giffinger, S. Giordano, M. Jeremiah, W. Joseph, A. Karagliu, D. Kellner, B. Cohen, V. Kumar, P. Lombardi, V. Mazurenko, A. McGray, R. Novotny, A. Oleshko, D. Audretsch, A. Pozniakova, J. Sinikienė, H. Farukh, L. Fedulova, D. Held, M. Heilin, N. Cherkas and many others.

Despite the academic popularity of smart economics, especially in the context of smart cities, there is still no conceptual vision of this phenomenon. The lack of systemic research and the obvious lag between theory and practice generate conceptual fragmentation and imperfection of the multi-level categorical apparatus in general. At the same time, it is smart economics that embodies the innovative imperative of effective development in the twenty-first century, becoming a moderator of the Industry 5.0 era. All these circumstances determine the relevance of studying the smart economy, the deployment of this trend in the global space and its qualitative characteristics.

The monograph presents the authors' many years of experience in this context. First of all, the authors conceptualise the phenomenon of the smart economy and offer an understanding of the essence of the smart economy in both broad and narrow terms. In the narrow sense, the authors define the smart economy as an economic system of a certain location based on the large-scale dissemination of the latest technologies in order to create comfortable and safe living conditions for citizens. In the broader sense, the authors substantiate the understanding of the smart economy as a way of organising society based not only on the spread of information and communication technologies and the development of artificial intelligence, but also on the understanding of the transformational processes of changing the architectonics of modern economic life of society towards the formation of a single global ecosystem, the important components of which are: a single digital space (digitalisation), a green (circular) economy (greening), and a human-centred environment (socialisation),

On the basis of a comparative analysis of the development of smart cities in different countries of the world, the methodology for assessing the development of

smart cities in the global environment is systematised and generalised; the cities - world leaders in terms of smart economy development are identified; the endogenous factors of smart city success are determined and the interdependence between the level of economic development of the smart economy and the presence of successful smart cities in individual countries is proved, since it is the example of such cities, where a significant part of the country's population lives, that becomes an important impetus for its successful development on the basis of technological and environmental imperatives.

The authors comprehensively describe the transformational impact of the latest information and communication technologies (big data, cloud computing, Internet of Things and industrial Internet of Things, cyber-physical systems, additive manufacturing, augmented reality, artificial intelligence, etc.) on the basic economic processes of modern society: the combination of the real and virtual worlds into a single global space with a reasonable vector of development. The newest features of the manifestation of the comprehensive process of ecologisation are identified, in particular: priority of sustainable development as a key goal of human society's progress; penetration of environmental protection ideas into all spheres of economic activity and society; emergence of a mandatory environmental component at all levels of economic management; consistent implementation of the goals of inclusive growth, climate protection, human centrism in the model of global economic development contributes to the formation of a reasonable, the intellectual nature of modern production and the economy in general; the green economy, as the embodiment of the global trend of environmentalisation, permeates the forms of manifestation of the smart economy at all levels, becoming an important strategic goal and imperative for its further progress.

The monograph proposes a methodological approach to assessing the development of the smart economy, which includes: systematisation of existing approaches to assessing the progress of countries around the world with their division into general ones that assess the innovative progress of countries (on a multi-criteria universal basis of various methodologies and criteria) and specialised ones (in the

innovative, digital, environmental, economic, social and psychological contexts); and a combination of global approaches to assessing the progress of countries with practices for assessing the success of smart cities. This made it possible to algorithmise the modelling of the Smart Economy Readiness Index, which allowed us to identify outcome and factor variables, build a system of structural equations, calculate the integrated score and group countries according to the integrated score.

CHAPTER 1
THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF SMART ECONOMY RESEARCH

1.1. Smart technologies in the global paradigm of economic development

Transformational processes in modern society determine the SMART vector of its development, which is a manifestation and consequence of comprehensive and large-scale intellectualisation. The process of intellectualisation has an objective nature and is manifested in the growing importance of intellectual factors of social production and, in general, development. The growing role of knowledge means that the intellectual component is increasing in both human resources and production means. An increasingly important part of the latter is information and communication technologies (ICTs), the spread of which is unprecedented and radically changes all processes and relations in modern society.

As the result of intellectual activity, ICTs are fundamentally transforming modern production and its technological structure, demand structure and management technologies. The requirements for human resources are changing, and they should not just possess large amounts of modern knowledge. Modern employees must be able to work with large amounts of knowledge, be proficient in modern technologies, be flexible, ready for continuous development and production of new knowledge.

It is the latest technologies that are becoming the basis and key driver of the modern economy. ICT does not just simplify the performance of certain production or logistics functions. These technologies allow for a new quality of management of processes and connections between different elements and entities. It is the acquisition of such a smart nature that means that smart technologies are emerging that can control

remotely, set the algorithm of action for various mechanisms, self-monitor, etc. The increasing penetration of smart technologies in our social and economic life marks its new quality, which is expressed in the emergence of the concept of smart economy. Clarifying the features of this concept and the main trends of its manifestation is an urgent problem of modern world economic science.

The theoretical and methodological understanding of the role of ICTs in modern transformation processes taking place in society is one of the most pressing issues in the scientific literature. Certain issues of the growing role of ICTs and digitalisation processes in the general context of global social development are studied by L. Antoniuk, N. Oulton, Vu Khuong, T. Kretschmer, O. Kuklin, H. Meijers, B. Santo, T. D. Stanley, J.-P. P. Hong, L. Tsymbal, et al.

As noted above, the emergence of the concept of smart economy in the new century is associated with the unprecedented spread of information and communication technologies that allow managing economic, social, and environmental processes. At the same time, the importance of environmental and social aspects of development is growing. That is why it becomes important to manage all social and economic processes in a comprehensive manner, in a single system, which is implemented in the approach to studying the economy as an ecosystem.

In the context of the ecosystem approach (understanding the smart economy as an ecosystem), systemicity, understanding of the complexity of interrelationships between actors, and the formation of a favourable environment are ensured. Ensuring the "smart" nature of the system, interconnections and all activities requires certain management tools. Such drivers are modern technologies, whose rapid development is fundamentally changing the technological basis and the entire system of economic relations in society. The tremendous acceleration of all transactions transforms all interactions, mechanisms and tools for implementing economic activities. Under the influence of increased attention to environmental and social issues, the latest technologies are already helping to manage all related processes in a smart way.

The spread of information and communication technologies (ICTs), often referred to as the digitalisation process, is characterised by new features that give rise to the

smart nature of technologies, processes and the economy as a whole. In today's global ecosystem, the latest technologies make it much easier and faster to perform certain important functions. However, it is also important to note that they create new opportunities for effective management of processes and connections between various elements and entities. Moreover, this is "smart" management, which requires a more precise definition of what exactly this "smartness" is, which actually gives the new type of economy its name.

J.Sinkiene and his colleagues pay considerable attention to the study of the emergence of the concept of "reasonableness". They agree with B. Hatt and S. Otto, who consider smartness to be a much broader phenomenon than just intelligence or awareness. "It is a social construct that includes cultural capital, social capital, innate intelligence, and creativity or ingenuity ... related to power"[1] J. Sinkiene et al. argue that the intelligence of a social system has the following properties: "intelligence, scholarship, digitality, innovation, knowledge management, resilience, networking and flexibility"[2].

In our opinion, the concept of "smartness" has several important aspects. The first aspect is related to the growing importance of important global and strategically important values in all spheres of social activity: preservation of the environment, ensuring a comfortable environment (economic, social, political, business environment, etc.).

Secondly, the modern world is expanding the perception and importance of a person - not just as a production resource. To ensure the development of a modern society, the necessary resource is not just a human resource as a carrier of labour abilities. The socio-economic development of any entities and systems at all levels is ensured by the increasingly active involvement of a person as a subject of social

[1] Hatt B., Otto S. A Demanding Reality: Print-Media Advertising and Selling Smartness in a Knowledge Economy. Educational Studies. 2011. Vol. 47. Is. 6. P. 507–526. URL: http://dx.doi.org/10.1080/00131946.2011.621075

[2] Sinkiene J., Grumadaite K., Liugailaite-Radzvickiene L. Diversity of theoretical approaches to the concept of smart city. *Business and Management 2014*: 8th International Scientific Conference, May 15–16, 2014. Vilnius, Lithuania Section: Smart Development.

relations (property, management), a bearer of social, cultural and moral values, and a bearer of sustainable development values.

And the third important aspect is the transformation of the management process itself, which consists in expanding the range of subjects and changing its mechanisms and tools accordingly. The management of various systems (national economy, region, locality, city) requires tools that ensure the “smart” nature of functioning, systematic nature of all interconnections, and focus on the values of sustainable development.

Systematic and comprehensive approach is ensured by involving as many stakeholders as possible, which allows taking into account their needs and interests. At the same time, ensuring effective management in the context of the complexity of the management entity itself becomes a difficult task. In such a situation, one cannot do without such a tool as modern technology. Thus, the rapid development of ICT is fundamentally changing not only the technological basis but also the entire system of economic relations in society. The tremendous acceleration of all transactions transforms all interactions, mechanisms and tools for implementing economic activities.

To the greatest extent, the principle of smartness can be implemented at the level of a single location - a city - where there are real opportunities to link all components into a single smart ecosystem. Such an ecosystem includes human-centric approaches to creating and implementing smart city solutions that create added value and turn into a collective good. It also necessarily involves ICT as a necessary tool for smart governance, but is far from being limited to technological solutions. Driven by the growing focus on environmental and social issues, the latest technologies are already helping to manage all related processes in a smart way.

In the scientific literature on smart cities, an opinion is expressed about the growth of smartivism and the role of the so-called smartivists as “an individual who steps forward actively supporting the creation of a better place on a free basis”. The distinction of smartivists is made by analogy with the “creative class” by R. Florida. A smartivist can act as an individual expert or support smart city initiatives (e.g. loose

consortia of projects, new legal entities such as non-profit organisations, associations) to address specific problems[3].

Such an expansion of the range of functions and areas of human qualities suggests that the role of a person is not only growing, but also its importance as a carrier of collective intelligence and a subject of management at various levels. According to R. Giffinger and his associates, collective intelligence is becoming the most effective success factor for smart cities. "Smart construction based on human capabilities as the sum of individual actors (bees) in a community (hive) allows for the creation and adoption of decisions that lead to the effective transformation of the community into a strong ecosystem of smart city solutions".

Thus, the ability of a city or community to use collective intelligence becomes an important point and driver of smart city success. "Collective intelligence provides a 360-degree perspective, covering all aspects of the community, as well as taking into account connections with neighbouring communities or the region"[4]. The success of the implementation of the smart city concept in each case depends on the ability to connect the entire sum of smart initiatives, projects and solutions that are developed and implemented by a large number of different private and public entities throughout the city and in different strategic areas of activity into one stream[5].

As noted above, information and communication technologies are a necessary tool for combining the entire mass of initiatives into a single effective management process. In today's world, they no longer just provide and accelerate communications, but are becoming smart, performing more and more intellectual and control functions.

The concept of the Internet of Things (IoT) is emerging as a system for managing things, devices, and animals via the Internet; Artificial Intelligence (AI) is the ability of an engineering system to acquire, process, and apply knowledge and skills. The Internet of Things (IoT) - networked devices and data acquisition from equipment - is

[3] Rise of the smartivist. URL: https://hub.beesmart.city/smartivists/
[4] Redefining the smart city concept: a new smart city definition. 2017. URL: https://hub.beesmart.city/en/strategy/towards-a-new-smart-city-definition
[5] Redefining the smart city concept: a new smart city definition. 2017. URL: https://hub.beesmart.city/en/strategy/towards-a-new-smart-city-definition

a fundamental part of Industry 5.0. Moreover, continuous advances in cellular technologies such as 5G and specialised IoT networks such as LTE-M and NB-IoT are opening up new possibilities for cellular communications, with more devices in one space, more efficient use of radio frequency spectrum, and applications to solve more complex problems. Along with the Internet of Things, the term Industrial Internet of Things is also used, which implies linking all stages and components of the production process into a single network where information is exchanged in real time.

The term Internet of Things (IoT) was first used by Kevin Ashton, one of the founders of the Auto-ID Centre at the University of Massachusetts. While working at Procter & Gamble, he suggested that the management use radio frequency tags to create a supply management system. Since then, physical object management systems have been increasingly entering our lives. The most commonly accepted definition of this concept is the following: "The Internet of Things is a network of physical objects that have built-in technologies that allow them to interact with the external environment, transmit information about their status and receive data from the outside"[6].

To create an object management system, the following elements are required: objects must have their own name ("label"), form a network with each other and receive information from the outside using various sensors, sensors, Bluetooth and Wi-Fi, and be controlled by a small embedded computer. The most famous example is Xiaomi's Smart Home, in which devices work only when needed: the kettle will boil when the owner wakes up; the air purifier will work when someone is nearby; the robot vacuum cleaner will clean when no one is home; the lights will turn on using motion sensors only when someone is in the room.

The main obstacles to the spread of the Internet of Things are the lack of a common "language" for creating a communication network between various devices and security issues. Objects do not have any antivirus or user identification systems, which makes them vulnerable to unfriendly intrusion. There is even the concept of a "botnet of things" - the creation of a network of virus-infected computers in which the

[6] Internet of Things, IoT. URL: https://www.it.ua/knowledge-base/technology-innovation/internet-veschej-internet-of-things-iot

virus monitors and transmits passwords and personal data to hackers, and in return executes criminal commands.

Artificial intelligence (AI) is the modelling of human intelligence processes by machines, primarily computer systems. AI enables a system to correctly interpret exogenous data and use it to achieve specific goals. Artificial intelligence (AI) can be used in almost all sectors of the economy, at different levels and stages of the production process: at the design stage to improve the efficiency of new product development, at the production stage to improve business processes and automation, at the sales stage to build a supply chain and effective marketing.

Artificial intelligence is the creation of systems that can perform intelligent functions: perceive and process information, make decisions and perform certain functions. The term artificial intelligence was first used by John McCarthy, the founder of Lisp programming and language. Today, artificial intelligence systems are already widely used in the space industry, industry (CNC equipment, production management systems and demand forecasting), education (educational products and technologies, university rankings), medicine (diagnostics, patient records and their physical condition), politics (analysis of voter data and preferences), trade (analysis of consumer behaviour), etc. The further spread of artificial intelligence systems also faces certain obstacles related to ethical considerations, technical limitations, and dependence on a large number of specialists and resources.

Along with the concept of ICT, other concepts are often used: digital technologies, NBICS - technologies (nano-, bio-, info-, cognitive-, sociotechnologies). Smart technologies are the broadest concept that includes all different types of technologies; they represent a way of expressing the maximum possible development of technologies, thanks to which we mark the maximum limits of human abilities, a kind of categorical level of technological evolution.

The smart economy is also characterised by the emergence of the concept of Big Data, which is large amounts of structured and unstructured information. The amount of information is so large that traditional management methods and approaches can no longer be applied to it. The term was first used by C. Lynch, editor of the journal Nature

in 2008, noting and exploring the explosive growth in the volume and variety of data. Following the McKinsey report “Big Data: The Next Frontier in Innovation, Competition and Productivity” in 2011, the topic has become widespread in both academic and practical research and policy.

Big Data or Big Data Analytics are data sets that are extremely large or complex, making it difficult to process them in a timely manner - even with software. A single IoT device can generate a huge amount of data for analysis. When you have tens of thousands of interconnected devices, the challenge is to find the most valuable ways to collect, store, analyse, and use that data. In Industry 4.0, dealing with big data is key to implementing predictive maintenance and understanding user behaviour. Manufacturers need to develop systems to effectively extract valuable information and manage the vast amount of aggregate data.

Horizontal and vertical system integration - smart technologies are fundamentally changing production processes and communications. In Industry 4.0, every company, process, employee, department and piece of equipment involved in production must communicate. From research and development to the supply chain, production, customer service, marketing and sales, transparency and coordination are required.

The integration of horizontal systems in Industry 4.0 involves the combination of various software and hardware used in production. All software and hardware must work together seamlessly and intelligently. This allows Smart Factories to dynamically respond to new production requirements and perform maintenance. For manufacturers with multiple plants, the integration of horizontal systems also involves coordinating production between them. When these systems are connected, the enterprise can use production resources more efficiently by automatically adjusting to delays, changes in the supply chain, and other variables that may affect each plant differently.

Vertical system integration in Industry 4.0 refers to the integration of different departments of a manufacturer, from production to IT to quality assurance and sales. Instead of accumulating data and making decisions based on limited data, each level of the business can access relevant information from the others. This helps to ensure

that decisions are always data-driven and made with an understanding of how it might affect other aspects of the business.

At the same time, it is the smart economy that embodies the innovative imperative of effective development in the 21st century, becoming the moderator of the Industry 5.0 era.

In addition, the spread of ICTs is associated with the emergence of new concepts and phenomena, which in turn demonstrate profound transformational changes in the modern economy. Cloud Computing - the emergence of cloud services has become an important milestone in the further advancement of ICT, as it has created conditions for the accumulation of large amounts of information and facilitated network access to it.

Cloud computing makes IT resources, such as data storage and computing power, available on demand. Cloud service providers use one of three cloud computing models:

Software as a Service (SaaS): A customer pays a supplier to use cloud-based software. Platform as a Service (PaaS): The customer pays the supplier for the IT resources and infrastructure needed to develop, operate and manage their own application. Infrastructure as a Service (IaaS): A customer pays a provider for the servers, storage, and data centres they need to support their own platform.

Cyber-physical systems (CPS) combine robotics, the Internet of Things, and machine learning. A CPS is essentially any mechanical process that is automatically controlled by software. Using sensors and other inputs from mechanical components, the software runs algorithms that determine how it should control machines, equipment, or infrastructure. CPS can respond to changes in the environment and operate in a variety of spaces and configurations, making it easy to adapt to a manufacturer’s changing needs.

Additive manufacturing allows manufacturers to quickly produce small batches of products based on individual customer specifications. By using 3D printing and digital modelling, factories can create one-off products at a cost-effective rate. Since these products are created layer by layer, the process uses materials more efficiently and the time to market is extremely short.

Augmented Reality or Augmented Reality or Virtual Reality (VR) is the projection of any digital information (images, video, text, graphics, etc.) on top of the screen of any device. As a result, the real world is supplemented with artificial elements and new information. It can be implemented through applications for conventional smartphones and tablets, augmented reality glasses, stationary screens, projection spaces, and other technologies. It is increasingly used in games, fitness, social media, education, art, and healthcare.

The use of AR/VR in business continues to expand in terms of maintenance, design, and training. For example, production equipment is out of order. An employee approaches the equipment wearing special glasses and sees both the equipment itself in real time and information on the screen that should help him solve the problem (information about a possible breakdown, instructions for fixing it, etc.).

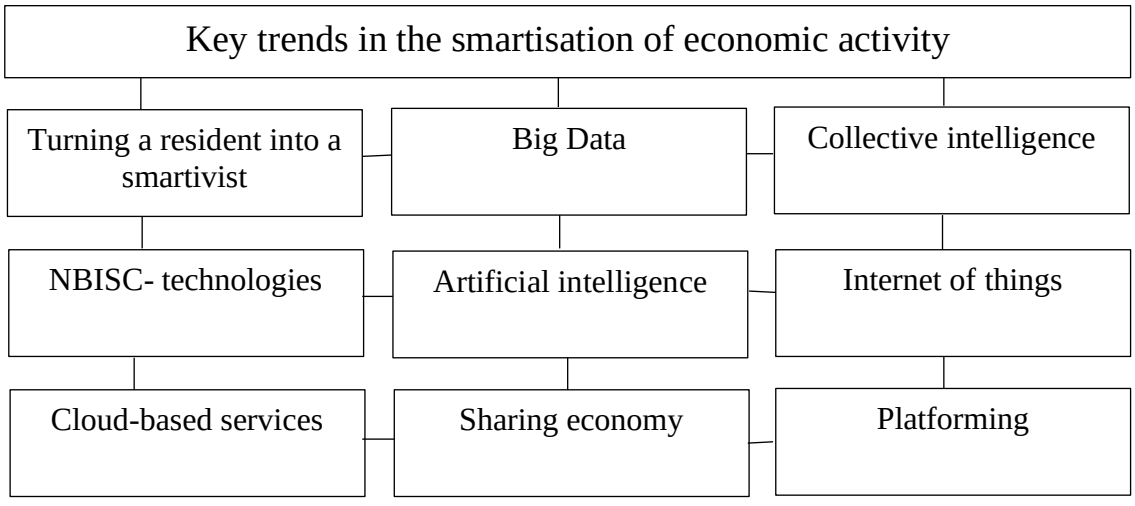
There are numerous examples of AR/VR applications in industry. In early 2014, Boeing implemented an augmented reality solution based on Google Glas glasses, which reduced production time by 25% and the number of errors by 50%. Lockheed Martin uses augmented reality technologies in the assembly process of the F-35 aircraft. The software allows engineers to work 30% faster and with 96% accuracy. Fiat Chrysler Automobiles (FCA) has applied the OPS Solutions projection AR system in its work. Now, at each stage of the assembly process, workers receive visual information about their next step. In 2015, AGCO (USA) equipped its assembly areas with large displays that showed the three-dimensional composition of products and a complete set of documentation necessary for fast and high-quality assembly of products (tractors and other agricultural machinery). In 2017, the company switched to using Google Glass, which helped speed up quality control by 20%. General Electric workers assembling wind turbines at a plant in Florida communicate with experts through augmented reality glasses, show the assembled equipment in their field of vision and receive answers to questions from experts who design turbines using the same glasses. The analysis shows a 34% increase in productivity compared to previous equipment assembly technologies.

The prospects of AR are confirmed by the creation of the Augmented Reality for Enterprise Alliance (AREA) in 2015. This alliance includes such large companies as Bosch and Boeing. The purpose of the alliance is to share best practices, lessons learned, and technological resources free of charge (for the US market) to help enterprises implement AR effectively.19 On 11 April 2017, it was announced that the members of the alliance had developed key industry guidelines. The documents were developed with the assistance of UI Labs, Lockheed Martin, Caterpillar, and Procter & Gamble[7].

A Preliminary Global Future Council on Augmented and Virtual Reality has been established within the framework of the NEF. The Global Future Council on Augmented and Virtual Reality will raise awareness of the prospects and dangers associated with the widespread adoption of these technologies, focusing on the rapid changes in the way they are being used around the world.

Platform Economy is also a new phenomenon associated with the latest trends. Platforms are online systems that offer comprehensive, standardised solutions for interaction between users. Sharing Economy - the emergence of this concept means the formation of an economic model based on the shared consumption of goods and services, barter and rent instead of ownership. Sharing is based on the fact that it is more convenient to pay for temporary access to a product than to own it.

Thus, we can identify the key trends in the smartification and development of both states and localities (Fig. 1.1).



[7] Augmented Reality AR. URL: https://www.it.ua/knowledge-base/technology-innovation/dopolnennaja-realnost-ar

Fig. 1.1. Key trends in the smartisation of economic activity

The UN Future Opportunities 2020 report identifies the rapid development of six areas as the main trend of future development: Exabyte Economy, Wellbeing Economy, Carbon Neutral Economy, Circular Economy, Biodegradation Economy, and Experience Economy. All these areas are a direct expression of the development of the smart economy. With regard to ICT, the following trends are predicted for the Exabyte Economy. After the pandemic, more and more people (+7% per year) will work online. The Internet of Things (IoT) will develop: By 2023, there will be about 3.5 billion connections, compared to 1 billion in 2018. By 2025, revenue from Big Data will exceed USD 90 billion, which is twice as much as in 2018.

5G technology will speed up the flow of data. Online learning, personalised healthcare, finance, and energy efficiency will gradually move to online learning. After the pandemic, digitalisation and automation will only increase. According to forecasts, the cognitive computing market will reach USD 49.3 billion by 2025. The estimated economic impact of the Internet of Things is estimated at $11.1 trillion per year in 2025. This is equivalent to 11% of global GDP, almost 40% of which can be generated in developing countries. 5G - up to $12.3 trillion in global economic output in ten years. Improving the health of people with chronic diseases through the connection of remote monitoring devices is estimated at USD 1.1 trillion per year by 2025[8].

The concept of a Smart-city, which is associated with building an energy-efficient, environmentally friendly and comfortable city, has long been in our minds and has become commonplace. This concept includes a whole range of important aspects of life: urban transport management, energy-efficient lighting management, construction of residential buildings and neighbourhoods in compliance with all environmental standards, and proximity to nature.

[8] Future possibilities. Report 2020. *Government of United States Emirates*. *UN*. 2020. URL: https://www.un.org/sites/un2.un.org/files/20200720_un75_uae_futurepossibilitiesreport.pdf

Understanding the importance of the spread of the latest technologies in the context of building a new quality of social life is at the heart of the global debate on the need to accelerate digital innovation ecosystems to ensure digital transformation. Research by the ITU (International Telecommunication Union) has shown that there is a growing digital innovation gap between countries. This innovation gap is at the heart of the digital divide, and many national policies and strategies - even in developed countries - often fail to bridge it. That is why the main objectives are to strengthen the capacity of countries to integrate ICT innovation into their national development programmes and to promote a culture of innovation. This mandate was further elaborated at the World Telecommunication Development Conference 2017 (WTDC-17) with the additional objective of developing "strategies that promote innovation initiatives, including through public, private and public-private partnerships". Relevant regional initiatives were included in each region[9].

Despite large investments in digital ecosystems, many countries are unable to adapt to rapidly changing digital conditions and technological revolutions. As a result, the slow digital transformation of communities affects social conditions and the achievement of national goals. The main ecosystem actors include: entrepreneurs, entrepreneurship support networks, corporations, financiers, and governments that integrate ICT/telecommunication innovations into their national development agenda. The main challenges in implementing digitalisation policies are: lack of appropriate policies, programmes, resources and know-how for innovators and digital change agents in their communities; lack of proper assessment of systemic issues of the ICT-oriented innovation ecosystem (entrepreneurial ecosystem, technology ecosystem and innovation ecosystem - the three engines of economic growth); lack of cooperation between stakeholders of the main growth factors to create ICT projects for innovation and entrepreneurship development[10].

[9] Future possibilities. Report 2020. *Government of United States Emirates*. *UN*. 2020. URL: https://www.un.org/sites/un2.un.org/files/20200720_un75_uae_futurepossibilitiesreport.pdf
[10] ITU-D Digital Innovation Ecosystems. *International Telecommunication Union.* URL: https://www.itu.int/en/ITU-D/Innovation/Pages/default.aspx

Thus, the modern understanding of progress in countries necessarily includes the spread of information and communication technologies, expanding access to communication networks and the latest means of communication. At the same time, it is important not just to cover the population with modern ICT in various forms (mobile communications, Internet access, mobile Internet, etc.), but to combine it with other aspects of social development - social and environmental.

Expanding access to ICTs should have a positive impact on the achievement of short- and long-term socio-economic development goals of countries. Increased inclusiveness should expand the potential benefits of ICTs for all, bridge the digital divide between developed and developing countries, and reach marginalised and vulnerable groups. This should be accompanied by efforts to ensure accessibility, local content, and the ability of individuals and communities to fully benefit from the potential benefits. Supporting the benefits of ICTs for sustainable development is also an important goal, as growth also brings challenges and risks that need to be managed. It is through innovation and partnerships that the evolving ICT ecosystem can effectively adapt to the changing technological and social environment.

Ensuring the progress of the modern world economy is possible only by creating favourable conditions for the functioning of innovative ecosystems based on the widespread use of the latest smart technologies. The smart economy is characterised by the widespread use of information and telecommunication technologies in production, management, and solving environmental and social problems at various levels. The production of new knowledge, intellectual assets as the main capital of the smart economy, and the training of highly skilled human resources are achieved through an effective education and science system. It is on these foundations that the vector of society’s development is laid, which is focused on improving the quality and safety of people’s lives and innovations.

In all spheres of society, the use of ICT technologies is becoming increasingly important, both to ensure and accelerate all transactions and to successfully manage various entities and processes. The emergence of the Internet of Things and the Industrial Internet of Things, artificial intelligence, big data, cloud computing, cyber-

physical systems, augmented reality and many other new technologies are fundamentally transforming the living conditions and the overall foundations of the economy. Economic activity takes on new forms and dynamics in a situation where smart technologies manage all production and logistics processes and control themselves. In addition, the latest technologies create opportunities and change the way people live. The spread of mobile communications and the Internet is changing and accelerating all communications. Together with other technologies, they make it possible to establish comfortable, safe and environmentally friendly living conditions for people within certain localities.

1.2. Prerequisites and imperatives for the formation of the smart economy

The modern world is undergoing rapid changes under the influence of an unprecedented increase in the role of knowledge and related transformations. The study of the factors and drivers that determine the development of countries in the new social context is an urgent problem of modern economic science. It has long been recognised that the successful development of countries depends not so much on the availability of certain material resources, but primarily on the technologies for their use and resources with a high level of intellectual component. Only those countries that make significant efforts to develop, accumulate intellectual resources and implement them in the economy are able to become world leaders. It is becoming clear that the socio-economic development of countries in modern conditions is ensured mainly by technological and innovative factors rather than by resources.

Under the influence of such crucial processes as intellectualisation, the spread of ICTs, digitalisation, society and its economic basis are changing, and fundamental changes are taking place in the system of economic relations, principles and mechanisms of economic functioning. Knowledge and information are increasingly

becoming the main resource and factor of development, and modern technologies create extraordinary opportunities for their dissemination and use on a global scale.

Since the end of the twentieth century, a new post-industrial paradigm has been emerging, for which there is still no single definition of society among scholars (post-industrial, information, technotronic, innovative society, knowledge society, etc.) All of these approaches recognise the crucial importance of knowledge and information in ensuring progress in these new conditions, which in turn have a systemic impact on all other factors (land, capital and human resources). Factors of production are becoming increasingly information-rich: capital resources, goods, technologies, and most importantly, human resources. Modern employees are an important resource not only as a labour force in the aggregate of their physical and intellectual abilities, but, first and foremost, as a carrier of information, its generator and user. Moreover, employees should not only possess large amounts of modern knowledge, they should be able to use it, work with it and thus produce qualitatively new knowledge.

In the scientific literature, one of the most pressing issues is the theoretical and methodological understanding of the essence of the transformation processes taking place in modern society. This was manifested by the emergence of theories of post-industrial society, technotronic society, information society, network society and knowledge society. In the works of foreign and domestic economists D. Bell[11], O. Bilorus[12], A. Bowen [13], I. Kalenyuk, O. Kuklin[14], D. Lukianenko [15], Ф. Makhloup [16], T. Orekhova[17], A. Chukhno[18], T. Kalchenko [19] et al. study the formation of a new type of economy in the general context of global social development at the conceptual level.

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[13] Bowen A. The Green Growth Narrative: Paradigm Shift or Just Spin? *Global Environmental Change.* 2011. Vol. 21(4). URL: https://www.researchgate.net/publication/251624314_The_Green_Growth_Narrative_Paradigm_Shift_or_Just_Spin
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[15] Lukyanenko D.G. Global management strategies. *International economic policy.* 2008. №8-9. P. 5-34.
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[19] Kalchenko, T. Sovremennie transformacionnije practicibglobalnoj economici.Kyiv,2018. 132 p. (in Ukrainian)

Along with such an important trend as the growing role of knowledge and information in social development, it is necessary to note such a relevant trend as increased attention to environmental issues. The general understanding of the importance of these problems has been manifested in the emergence of new conventions for the formation of an economy that would be safe for the environment. Since the end of the last century, the topic of environmental preservation has been relevant in scientific research, and the concepts of sustainable development, green growth, and green economy have emerged: in the works of N. Stern[20], M. Jänicke [21] at al.

The growing attention to social and environmental issues of human development has led to the formation of a new approach to the perception of economic phenomena and processes, namely, their study as elements of a single ecosystem. The issue of ecosystems is a topical issue of modern scientific research. The problems of innovative ecosystems are studied by L. Antoniuk[22], L. Fedulova [23]. Entrepreneurial ecosystems have become the subject of research by N. Cherkas, D. Audretsch, M. Belitsky [24] at al.

A new milestone in the early twenty-first century was the emergence of the concept of smart economy, which is associated with the spread of new smart technologies in the management of economic, social and environmental processes. The emergence of a new term - smart economy - is a sign of a number of processes and phenomena that are rapidly changing society and the principles of its organisation in the twenty-first century. The study of the formation of the smart economy is the basis for a significant number of works by the following scholars: A. Pozdnyakova[25], J.

[20] Stern N. Stern Review: The Economics of Climate Change. London: Grantham Research Institute on Climate Change and the Environment, 2006. 700 p. URL: http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf

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Bruneckienė[26], J. Sinkienė[27], L. Galperina[28], V. Mazurenko[29], P. Novotny[30], D. Held, A. McGray[31], M. Heylin[32], D. Kellner[33] at al. The problems of smart cities and the success of their functioning are the subject of research: R. Giffinger[34], M. Angelidou[35]; A. Caragliu[36], P. Lombardi, S. Giordano, H. Farouh, W. Yousef[37], V. Kumar[38], K. Adiyarta et. al [39], Eremia M., Toma L., Sanduleac M. [40].

Although this term is becoming very popular in various studies, there is still no conceptual vision of the essence and structure of the smart economy, its understanding in the system of other concepts of modern society. There is a lack of systematic, comprehensive research that would be devoted to the study of the essence and forms of manifestation of the smart economy at different levels. In general, the concept of smart economy has not yet received sufficient justification and definition.

The formation of the smart economy occurs both as a result of development processes and as its key trend, taking into account all the peculiarities of the formation of a new type of economy. In our opinion, the formation of the smart economy is based on the fundamental process of the current stage of global economic development - the

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[28] Galperina L.P., Girenko A.T., Mazurenko V.P. The concept of smart economy as the basis for sustainable development of Ukraine. *International Journal of Economics and Financial Issues.* 2016. № 6(88). P. 307-314. URL: https://www.econjournals.com/index.php/ijefi/article/view/3757

[29] Mazurenko V.P. Implementation of network paradigm as a guarantee a highly competitive country. 2014. Vol. 119. Kyiv: *Institute of International Relations of Taras Shevchenko National University of Kyiv*. P.60-73

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[39] Analysis of smart city indicators based on prisma : systematic review / Krisna Adiyarta et. al. *IOP Conference Series*: materials Science and Engineering. Vol. 725. 3rd Nommensen International Conference on Technology and Engineering. Nommensen HKBP University, Indonesia, 25–26 July, 2019

[40] Eremia M., Toma L., Sanduleac M. The Smart City Concept in the 21st Century: 10th International Interdisciplinarity in Engineering, INTER-ENG 2016. URL: https://www.sciencedirect.com/science/article/pii/S1877705817309402

process of intellectualisation, the enormous growth of the importance of the intellectual component of all socio-economic processes and resources. It is manifested in the fact that intellectual resources directly determine the parameters of economic growth, create the basis for innovative development and the formation of a post-industrial society. Intellectual resources create opportunities for breakthroughs in economic, scientific and technological development even for those countries that do not have pronounced natural resource factors for this. In view of these circumstances, the issue of intellectual resources, their role and mechanisms of intensive use as a factor of socio-economic development of society is relevant in modern domestic and foreign economic research.

In general, the smart economy is the result of the synergistic interaction of the following prerequisites: intellectualisation (increasing importance of intellectual activity and its results); innovation (growth and scaling of breakthrough innovations); globalisation (increasing global interdependence); digitalisation (spread of ICT, penetration of smart technologies in all spheres of life, in the management of production processes and personal consumption); ecologisation (penetration of environmental values and principles in all processes of management and life). In the context of globalisation, the smart economy has no borders, as its main driver - information and communication technologies - connects the whole world into a single interconnected network (Fig. 1.2).

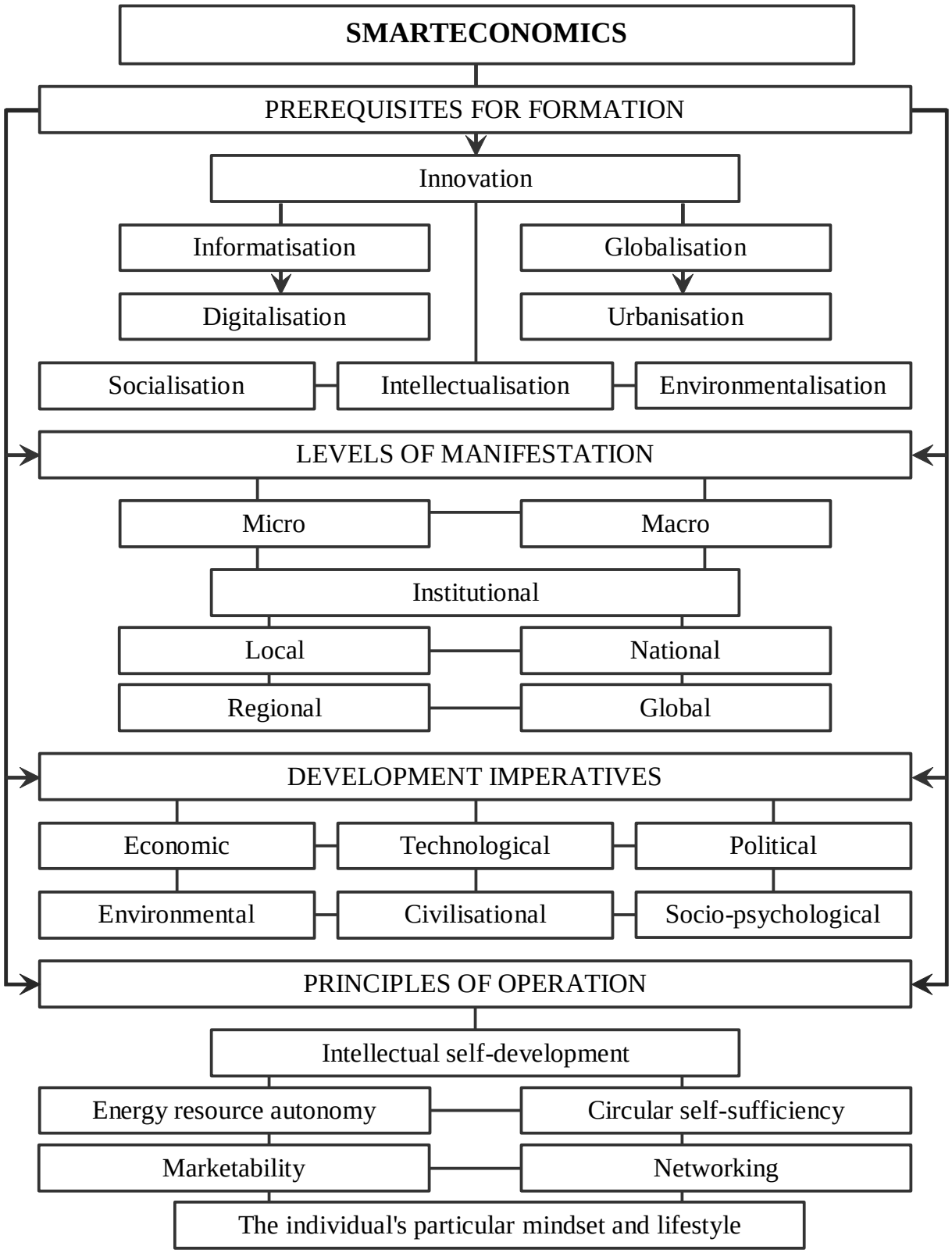

Fig. 1.2. Structural format of the essential characteristics of the smart economy

Intellectualisation is becoming a decisive factor in the formation of a new paradigm and the development of a post-industrial society focused on intellectual

development and non-material wealth (intellect, information, knowledge). Intellectualisation is manifested through an increase in the number of scientific and technical developments, the growth of innovation in production processes, stimulation of the creative component of activities, creative implementation of tasks, creation and development of intellectual needs, formation and development of the intellectual potential of both individuals and enterprises as a whole, constant growth of knowledge, creation of innovative products, etc. The intellectualisation of labour is a global trend, although it has specific forms of manifestation and different dynamics in individual economic systems. The manifestation of this trend in individual national economies is realised as a non-linear, but at the same time consistent and progressive process of accumulation of intellectual potential.

At the same time, intellectualisation means not only an increase in the quantity and quality of intellectual resources, the scope of intellectual functions in the work process and, accordingly, an increase in the educational level of employees. In our view, it is also manifested in the strengthening of cultural and ethical values in the economy. Economic activity is increasingly based on a combination of economic interests, ethical and cultural values.

In addition, intellectualisation processes have a pronounced multiplier effect, as the results of intellectual activity are already becoming independent factors that shape their own direction. These are, in fact, the latest technologies, information and communication technologies (ICT), which are the result of intellectual activity and are already forming their own special direction and gaining independent significance. The widespread digitalisation of the modern economy and society in general brings new phenomena and phenomena into our lives. Digitalisation not only leads to the emergence of new products and thus changes the commodity structure of production, but also affects the entire system of economic relations: it facilitates and accelerates all processes and communications, shortens transactions, facilitates and transforms the management of various entities at different levels.

That is why the emergence of the concept of “smart economy” (“SMART-economy”) is evidence not only of consistent and increasingly penetrating

intellectualisation, but also of the intensification of other processes related to the use of intellectual resources: strengthening human and nature-centred processes, and the formation of new institutions for managing the economy and society as a whole. Changes under the influence of the latest processes and technologies are becoming so rapid that the spread of the concept of "smart economy" requires understanding of new aspects related to it.

The etymology of the term "smart economy" comes from the English term "smart", which means intelligent, thus emphasising that smart economy is a smart economy. First of all, it is an economy whose main feature is the process of intellectualisation in its highest form. This means not only the development of intellectual activity and the intensive use of its results. In this economy, the values of smart governance, which means the embodiment of the values of sustainable, green development and human centredness in all economic and social processes, become key.

Intellectualisation is also driven by the process of digitalisation - the penetration of information and communication technologies and their intellectual functions into all spheres of life, the spread of Internet of Things (IoT), Artificial Intelligence (AI), Big Data, Cloud Computing, the formation of networks and networked forms of interconnections. The proliferation of digital technologies as a result of consistent intellectualisation is of particular importance - they are beginning to act as integral tools and mechanisms for communication, relationships and management in the modern environment.

Accelerated intellectualisation is manifested in the increased innovation of production processes and their creative component, the constant increase in knowledge and information, the creation of innovative products and the development of intellectual needs. Thus, the smart economy is being formed under the influence of the emergence of Industry 4.0, the spread of technology and its penetration into the economic system, the constant growth of human comfort and environmental quality, and the establishment of innovation networks[41]. The structure of the economy in the

[41] Galperina L.P., Girenko A.T., Mazurenko V.P. The concept of smart economy as the basis for sustainable development of Ukraine. *International Journal of Economics and Financial Issues.* 2016. № 6(88). P. 307-314. URL: https://www.econjournals.com/index.php/ijefi/article/view/3757

context of the emergence of a smart society is constantly transforming under the influence of the development of new technologies and their penetration into all spheres of human life.

Thus, smart means, firstly, the implementation of smart values in the management of modern development, secondly, the emergence of smart management tools and mechanisms, and thirdly, the formation of smart management institutions. Consistent and increasingly penetrating intellectualisation of the economy is beginning to be supported by and accompanied by growing attention to the problems of human development, the environment, and environmental protection. Thus, the transformation of the economic basis of modern society is accompanied by the intensification of human-centred and nature-centred processes, i.e., increased attention to social and environmental problems of social development.

As noted above, a prominent trend in modern global development is greening as an embodiment of the increasing attention of mankind to environmental issues. Greening is implemented in the system of ensuring the ecological and economic interests of all multi-level actors, ensuring the integrity of natural systems, environmental protection, etc. Moreover, this trend is manifested not only in the declaration of important principles and goals, but is becoming an integral part of all various types of social activities. When implementing any economic, social or business projects, consideration of the environmental context is increasingly becoming a mandatory norm.

It is also worth noting such an important trend of our time as socialisation - the growing importance of solving social problems of the population. Socialisation is aimed at ensuring the welfare of the population, compliance with universal civilisation values, the formation and implementation of social values, etc. The growing trends of ecologisation and socialisation are reflected in the concept of sustainable development, which is becoming a leading trend in global social progress. It is implemented in the UN policy through the Sustainable Development Goals (SDGs) or Global Goals, which were adopted in 2015 by UN member states.

The formation of a smart economy is also facilitated by globalisation processes, which lead to the possibility of systemic management and balance by coordinating the dependence of individual countries on the global level of development and key processes (political, economic, financial and social). The acceleration of globalisation processes means increased interdependence of all countries and greater openness of business entities, liberalisation of markets, creation of structures that are resistant to external influences or capable of rapid adaptation in response to challenges of the economic, social, cultural and information environment.

Institutionalisation becomes a necessary accompanying process because the implementation of new ideas requires strengthening of institutions - governance entities and new communications between them. Thus, Audretsch et al. emphasise the need to develop the institutionalisation of entrepreneurial ecosystems. Institutionalisation is ensured through the spread of new technologies and mechanisms of economic management, active participation of the state and other actors in regulating communications and various types of activities (research, innovation, entrepreneurship, etc.).

The spread of ICTs creates new opportunities for effective management, effective communication and feedback, and the expansion of opportunities for the inclusion of new actors in management processes. The concept of “e-government” is emerging as the embodiment of a new system of relations between the state and its institutions in various branches of government and citizens. Within the framework of e-government, ICTs and the Internet create new and broad opportunities for quick and direct access of citizens to the state authorities, for the provision of quality services by state institutions and, thus, for the protection of their interests.

Smart economy is also perceived as a concept of stimulating and spreading innovations in all spheres of public life, creativity combined with scientific research, advanced technologies and general trends of environmentalisation. With the help of information technology, the economic environment is increasingly becoming more intellectualised and taking on the form of a smart economy, which is also manifested through digitalisation and new forms of organising economic activity. Intelligent

database management is becoming a prerequisite for ensuring competitiveness at the enterprise and macroeconomic levels. The study of smart economy requires determining the main forms of its manifestation and functioning of economic entities in these conditions.

Thus, the general prerequisites for the formation of the smart economy can be defined as the processes of intellectualisation, digitalisation, informatisation, environmentalisation, socialisation, urbanisation, globalisation and innovation. In the context of globalisation, the smart economy has no borders, as its integral component, ICT, connects the whole world into a single interconnected network. It is being formed as a result of a whole range of different development imperatives, the main ones being:

-Economic: growth of the economy and general welfare; continuous improvement of the production base based on the latest production and management technologies; emergence of new forms of economic relations (network, platform); significant changes in the structure of demand at all levels, which is associated with the growing influence of the latest technologies and the increasing spiral of intellectual intensity of production;

-Technological: the emergence and widespread use of the latest technologies, primarily ICT; the emergence of fundamentally new opportunities for the production of materials and products at the nano level; acceleration of all transactions, acceleration of economic and management processes; creation of new opportunities for managing processes and systems;

-Social and psychological: aggravation of social problems of mankind and the need to solve them on the basis of personal development (providing decent employment, protecting the interests of various groups of the population (disabled, people with special needs, women and children));

-Environmental: deterioration of the environment, air, water and land surface ecology; growing understanding of the need for joint efforts of humanity to preserve the environment;

-Political: a growing understanding of the need for political will to address the complex problems of further human development (environmental, social, inequality

and poverty, economic and sustainable development, security and protection against terrorism, etc;)

-Civilisational: the formation of global interdependence of all people, countries, economies; globalisation processes that create opportunities for systemic governance and balance by coordinating the dependence of individual countries on the global level of development and key processes (political, economic, financial and social); expanding the openness of business entities, liberalising markets, and forming structures that are resistant to external influences and able to quickly adapt to environmental challenges (Figure 1.3).

All of the above-mentioned development imperatives contain key factors that, in fact, give grounds to characterise the economy as smart or smart-economy. This dynamic concept is developing very rapidly in the aggregate of all its components, which in turn causes the emergence of new processes and phenomena.

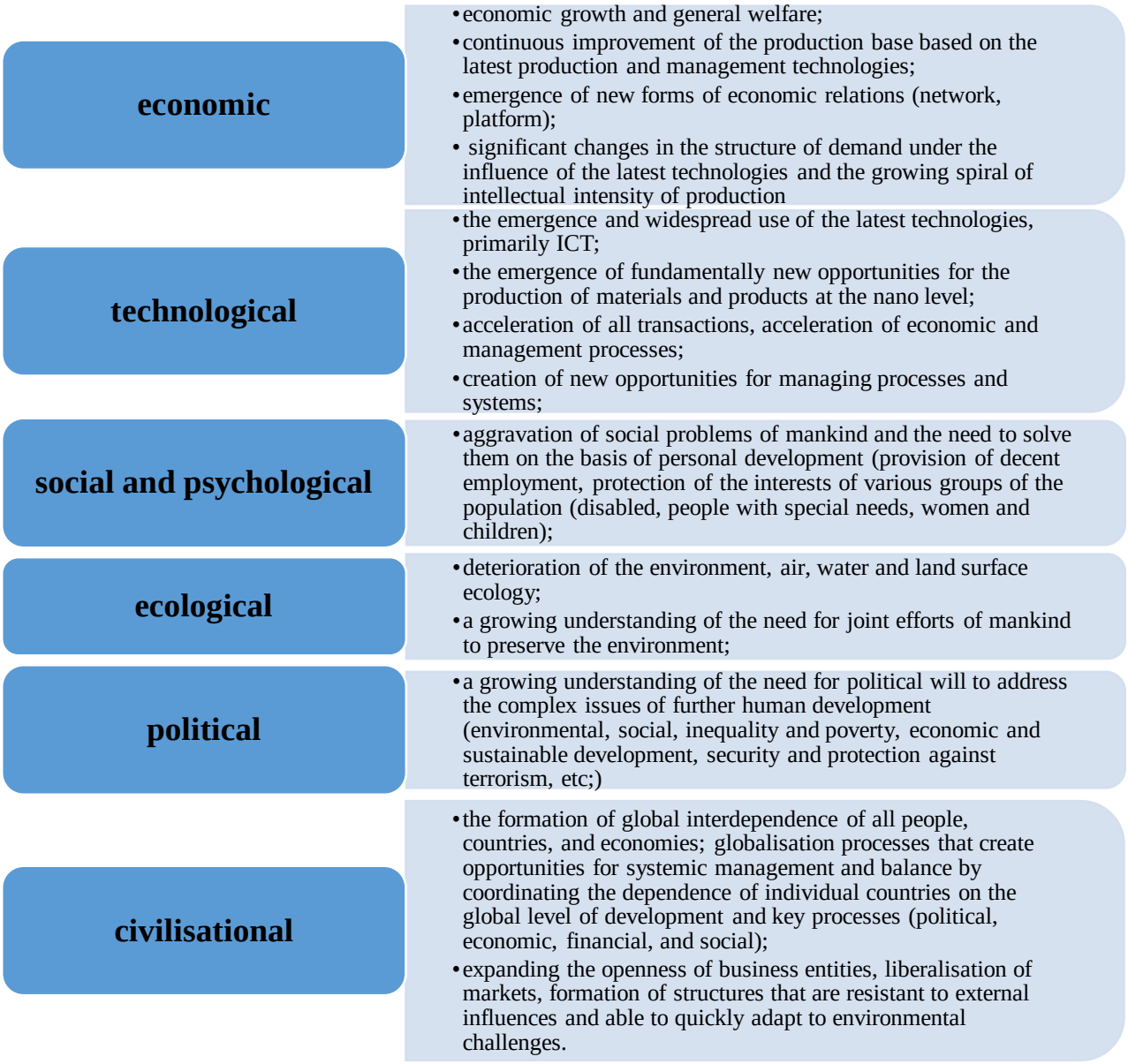

Fig. 1.3. Imperatives for the development of the smart economy

In general, the smart economy is the result of synergistic interaction and a concentrated expression of the following processes: digitalization (the penetration of ICT, the spread of smart technologies in all spheres of life, in the management of production and personal consumption processes, platformization and virtualization of economic processes); greening (penetration of ecological values and principles in all processes of management and life activities, priority of green economy and goals of sustainable development); socialization (distribution of social priorities and values, protection of different strata and population groups at all levels and in all areas of life); institutionalization (formation of institutions for managing life support and production

processes on the basis of the latest technologies, social and environmental priorities, goals of civil society formation) (Fig. 1.4).

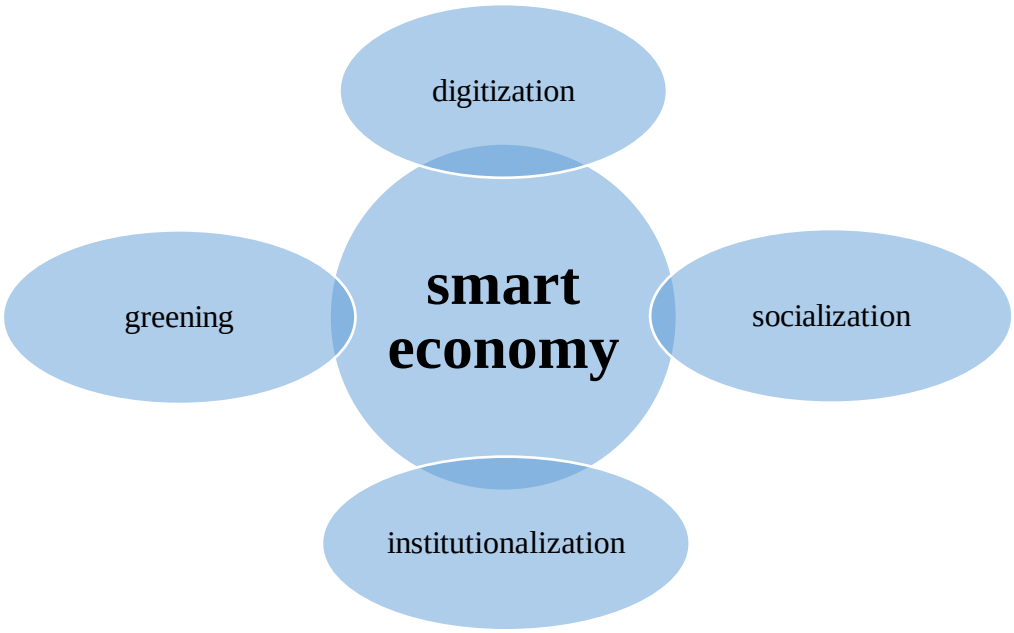

Fig. 1.4. Smart economy as a result of synergy

It is worth noting that only as a result of the interaction of all forms of manifestation of smartization of economic activity, the effect of increasing the level of implementation of smart decisions is generated, which in turn leads to an increase in the quality of the entire economic system. In accordance with this, smart economics finds its manifestation at different levels of economic activity and provides both its own manifestations for each level and accumulation for a higher level.

Accordingly, we define the key levels of smart economy manifestation as:

- Micro;
- Macro;
- Institutional;
- Local – at the level of cities, individual small localities;
- Regional – at the level of regions;
- National – at the level of countries;
- Global – at the international and global levels.

The successive deployment of the processes of formation of the smart economy is determined by a consolidated system of development imperatives (technological,

economic, political, socio-psychological, ecological, civilizational), which determine the general vector and parameters of its deployment. The formation of a smart economy takes place as an ecosystem in which, as a result of the interaction of all forms of manifestation of smartization of economic activity at balanced levels of manifestation (micro-, macro-, institutional, local, national, regional, global), the effect of increasing the level of implementation of smart solutions is generated, which in turn leads to to increase the quality of the entire economic system. At the same time, in the understanding of smart economy, in our opinion, two approaches can be distinguished.

Unfortunately, in the modern scientific environment, the perception of smart economy prevails only at the local level. Thus, the vast majority of scientists consider the concept of smart economy in a rather narrow sense, as part of a certain system, and most often such a system is considered a city - Smart-city. Actually, this term appeared for the first time in this sense. This is the definition of a system of a certain locality, all parts of which are connected by smart technologies, function and are managed based on the principles of economic feasibility, sustainability and social responsibility.

In general, attention to the new role of cities as entities in ensuring quality, safe and modern life of citizens has significantly intensified in recent years. This was evidenced by the appearance of concepts such as “digital city”, “cyber city”, “intelligent city”, “sustainable city”, “eco-city”, “knowledge-based city”, “cyberville”, etc. Each of them has the right to life, as it emphasizes the most important imperatives of the development of modern cities. In our opinion, Smart-city is the most appropriate term, as it includes the aspect of digitization, sustainability, and knowledge-based and smart technologies.

In general, we believe that there is every reason to consider smart economy in a broader sense, thereby distinguishing smart economy in a narrow and broad sense. In a narrow sense, smart economy is understood as a system of economic relations and relationships within a certain locality, which is provided by the most modern technologies based on the principles of sustainable development and social responsibility and serves the purpose of creating comfortable and safe living conditions for citizens.

In a broad sense, we can understand smart economy as a way of organizing economic relations and relationships, in which the spread of the most modern smart technologies is subordinated to the construction of the economy based on the implementation of the principles of sustainable development, social responsibility, digitalization and environmentalization.

Although the understanding of smart economy in the narrow sense is currently prevailing, in our opinion, a broader scientific approach to understanding smart economy is gradually being formed. At the level of a certain region, locality, there are technical possibilities to connect all these components in a single system: technologies, social and ecological aspects of life, infrastructure objects. These circumstances determine the significant popularity and spread of smart city ideas in both theoretical and purely applied contexts. At the same time, there is no doubt that under the influence of all these processes, both economic relations and the principles of economic life are transformed. This gives reason to talk about the formation of smart economy in a broad sense, as a system of economic relations.

According to some scientists, the main goals of smart economy include: ensuring high rates of economic growth, achieving high labor productivity, increasing the participation of intellectual workers and producing innovations in production, forming an innovative ecosystem, digitizing and innovating production, creating an effective business environment, forming a "green" economy, ensuring social stability, etc[42].

At the same time, one can agree with the opinion of some scientists who claim that there is a conflict in the very goals of smart economy, because social goals do not always correspond to economic goals, etc. Indeed, solving social and environmental problems quite often contradicts economic considerations, as it can incur additional costs, not contribute to cost savings, and reduce profits. The main goal of market management - achieving maximum profit at minimum costs - absolutely does not take into account the interests of people and the environment. Taking into account all these goals and problems in a single approach is quite a difficult task that requires non-

[42] Brinkley Ia. Knowledge economy: How Knowledge is Reshaping the Economic life in Nations. London: The Work Foundation, 2008.

standard solutions. And, in fact, that is probably why smart economy is a smart economy in which it is possible to reconcile multidirectional processes: both the achievement of economic efficiency of business entities, and the creation of a favorable environment, and comfortable conditions for the life and work of citizens.

Smart economy is built on the principles of intellectual self-development, energy resource autonomy, circular self-sufficiency, platformability and networking. Its development is characterized by flexibility, adaptability, interactivity, a significant reduction in transaction costs and the transition to virtual, immaterial forms of economic interaction, a special way of thinking of an individual and a way of life. This approach allows, on the one hand, to organize intelligent management of production and life support processes on the basis of the latest resource-saving and safe technologies, and, on the other hand, to form intelligent thinking of the individual, demand and consumption.

1.3. Forms and levels of manifestation of smart economics

The transformation of economic activity, the change in the role of individual subjects in the formation of a knowledge society is the subject of scientific attention of a significant number of scientists. Thus, the issue of global transformation of the economic system is considered in the works of D. Lukyanenko, I. Kalenyuk, A. Boven, I. Haydutskyi, N. Stern, Z. Brzezynskyi, and others. The subject disposition of the economy is considered in the works of A. Chuhno, L. Tsymbal, L. Antoniuk, T. Orekhova, and a significant number of others. Certain aspects of the development of smart economy are studied in the works of such scientists as: Bell D., Inozemtsev V., Castells M., Makhlup F. and others. However, the question of the formation of smart economy and the form of its manifestation for each of the key subjects of economic activity remains outside the attention of scientists.

The main approaches to understanding the essence of smart economy have already been defined above and the necessity of researching it on two levels has been proven: in the narrow and broad sense. In a broad sense, it is a system of economic relations based on the use of the most modern smart technologies, the implementation of the principles of sustainable development and social responsibility, and subordinated to the goals of creating comfortable and safe living conditions for the population. In a narrow sense, smart economy is considered within a certain locality.

At the same time, the scientific literature does not have a single position in defining the forms of manifestation and the main components of the smart economy ecosystem. The vast majority of scientists consider the concept of Smart Economy in a rather narrow sense, as part of a certain system - Smart-city. Actually, this term appeared for the first time in this sense. This is the definition of a system of a certain locality, all parts of which are connected by smart technologies, function and are managed on the basis of the principles of economic feasibility, sustainability and social responsibility.

Vinod Kumar considers the Smart-city system as follows: smart people (Smart People), smart economy (Smart Economy), smart mobility (Smart Mobility), smart environment (Smart Environment), smart living conditions (Smart Living), smart management (Smart Governance)[43].

The International Telecommunication Union (ITU) considers the ecosystem as a combination of the following components: business, finance, business support, the public sector, the academic community and the private sector[44].

Lithuanian scientists J. Bruneckiene and J. Sinkiene attribute the following to the main components of the Smart economy: innovation and knowledge economy; learning economy; digital economy; competitive economy; green economy; network

[43] Kumar M.V., Bharat Daliya. Smart Economy in Smart Cities. Smart Cities, Local Community and Socio-economic Development: The Case of Bologna. 2017. P. 12.
[44] ITU-D Digital Innovation Ecosystems. *International Telecommunication Union.* URL: https://www.itu.int/en/ITU-D/Innovation/Pages/default.aspx

economy; socially responsible economy[45]. The main ecosystem actors include: entrepreneurs, entrepreneurship support networks, corporations, financiers and governments that integrate ICT/telecommunications innovations into their national development agenda.

R. Novotny et al. consider the structure of Smart-city in a sufficiently applied way: general municipal and business services (general municipal and business services), intelligent, sustainable buildings and building management (smart building), education, health care and social protection (education, health and social care areas (smart education)), energy production and energy efficiency (smart energy, smart lighting)), gas, electricity and water smart supply (gas, electricity and water smart metering (smart grad)), smart water and waste management (smart utility), public safety, security and crime prevention, provision of services in real time and place (real-time locating services and geographic)[46].

A similar approach is declared by Romanian scientists M. Eremia, L. Toma, M. Sanduleac, who consider Smart-city as a combination of the following components: smart buildings, education, medical and social care, smart energy (smart energy), smart resource supply network (smart grid (smart metering of natural gas, water, electrical energy), smart utilities - smart water distribution and smart waste management), smart parking (smart parking), integrated supply systems, smart and integrated transport[47].

So, we can note two key principles for defining smart cities, the first of which is related to global development trends, the second - to functional features (Fig. 1.5).

[45] Galperina L.P., Girenko A.T., Mazurenko V.P. The concept of smart economy as the basis for sustainable development of Ukraine. *International Journal of Economics and Financial Issues.* 2016. № 6(88). P. 307-314. URL: https://www.econjournals.com/index.php/ijefi/article/view/3757

[46] Novotny R., Kuchta R., Kadlec J. Smart City Concept, Applications and Services. *Journal of Telecommunications System & Management.* 2014. Vol. 3. Is. 2. Doi:10.4172/2167-0919.1000117.

[47] Eremia M., Toma L., Sanduleac M. The Smart City Concept in the 21st Century: 10th International Interdisciplinarity in Engineering, INTER-ENG 2016. URL: https://www.sciencedirect.com/science/article/pii/S1877705817309402

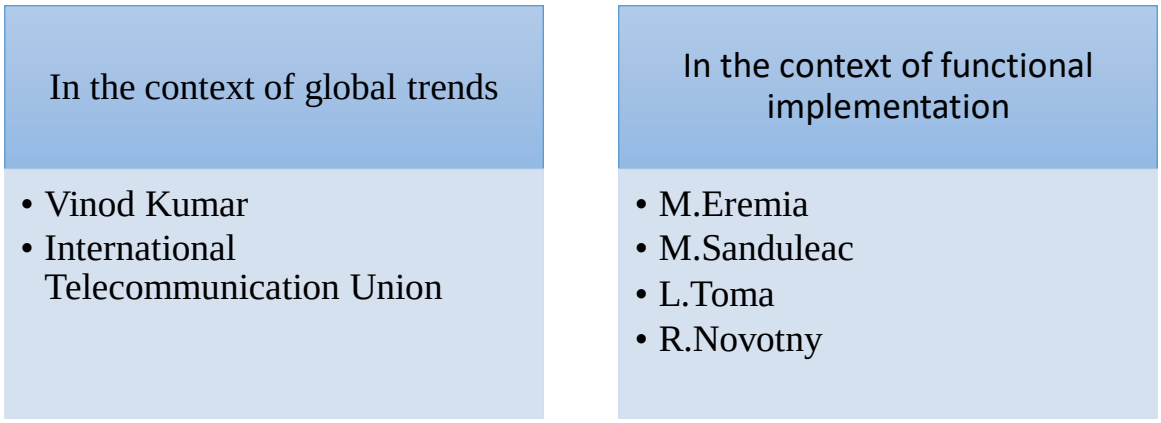

Fig. 1.5. Approaches to determining the elemental composition of smart cities

Thus, even at the level of a smart city, there is no unanimity in defining the main components of the smart economy. That is why we believe it is necessary to first define the structure of the smart economy in a broad sense, and then, on this basis, to structure the concept of the smart economy in a narrow sense, at the city level. As defined earlier, the smart economy is the result of the interconnected action of the following processes: digitalisation; ecologisation; socialisation; and institutionalisation. Moreover, the processes of ecologisation and socialisation determine the main goals, orientation, and direction of development of various actors. The processes of digitalisation determine the technologies and tools of communication and relationships between various actors. Institutionalisation means the emergence of new mechanisms for managing different actors and their relations.

The smart economy is implemented at all levels of economic relations - from the individual to the state as a participant and regulator of such activities. According to the fundamentals of economic theory, the main economic actors are households, businesses and the state. These are, of course, the most generalised subjects, since each of them can be divided into other types of subjects. With regard to the first actor, we can also distinguish between individuals, consumers, households, etc. Next to entrepreneurs, we can distinguish between small and medium-sized businesses, large businesses, financial entities (banks, non-bank institutions, financial intermediaries and other financial institutions), etc. The state is also a complex entity that operates at different levels; in addition, the public sector is part of it as a manifestation of the will

of citizens. In addition, given that the smart economy can be considered at different levels, localities, cities; regions; countries; and global cities can also act as subjects. Understanding the complexity and diversity of the main actors, in the context of the study of the formation of the smart economy, we will consider the following as the main ones: households, businesses and the state (Table 1.1).

Table 1.1

Forms of the smart economy

	Forms	Diigitalisation	Greening	Socialisation	Institutionalisation	Smart space
Smart economy	**Smart business**	- networking and interaction; - platform business; - financial innovations	- green business; - production organic products; - priority environmental imperatives	- socially responsible business	- Platform management	- spread of socially responsible business; - penetration of smart technologies in all areas of business, and governance; -responsibility for the environment; - priority of sustainable development goals in management at various levels; - formation of smart living conditions for individuals and communities
	Smart households	- purchase via online; - smart products and services; - smart transport; - smart utilities services; - digital banking	- transition to the consumption of organic products; - transition to energy saving technologies consumption	- development of of social networks; - participation in the life of local community; - socially responsible attitude to other people	- implementation of sustainable development goals in the management of communities	
	Smart government	- e-government, - development of science and education	- protection of local environmental projects; - availability of information on the state of the environment and projects to be implemented; - digital technologies for analytics and assessment of the environment environment	- priority social goals; - ensuring rights and support for of people with different needs and disabilities opportunities	- participation of the total population in processes of governance at different levels	

Source: developed by authors

The smart economy is formed by a set of various actors and their interaction, a system of relations and connections. Under the influence of modern innovations, these relations are moving to a new level - the level of networks and platforms, thus creating

a favourable environment. It is on these foundations that the vector of society's development is laid, which is focused on improving the quality and safety of people's lives and innovations.

Under the influence of globalisation, digitalisation, institutionalisation, environmentalisation, socialisation, urbanisation and many other processes, each entity undergoes changes and transformations in its activities, new types of activities, connections and relationships are formed. In the aggregate of all these transformational processes, the key ones that have a major impact on the formation of the smart economy should be highlighted.

The economy itself is also a complex phenomenon with many forms of manifestation. In order to thoroughly analyse the changes taking place in it under the "smart" sign, it is necessary to identify the main components that have common characteristics and signs. In our opinion, it is advisable to trace the changes in the main actors and their activities under the influence of key trends (digitalisation, socialisation, environmentalisation, institutionalisation). The cumulative effect of these trends and processes leads to the formation of a smart environment, which includes: smart business; smart living conditions; smart community; smart environment.

The above structure is the author's approach that forms a conceptual scheme for studying the essence and forms of manifestation of the smart economy. At the same time, this methodological approach does not exclude the possibility of other methods for identifying key areas important for the formation of the smart economy. For example, researchers at the University of Alicante (Spain) base their developments on the fact that the Europe 2020 strategy proposed by the European Union includes three priorities in the economic sphere that will enhance the use of IT to promote such economic priorities:

- - *smart growth:* developing an economy based on knowledge and innovation;
- - *sustainable growth:* promoting more efficient use of resources to ensure a more competitive economy;
- - *intensive growth:* creating an economy with high employment rates to promote social and territorial cohesion.

On this basis, they identify the following key areas of the smart economy that require smart ICT solutions:

- Entrepreneurship/productivity/competitiveness - parameters that are aimed at improving the quality of life in communities and society.
- Development of science and technologies that can produce solutions to existing problems, creation of innovative services and systems, network of laboratories or institutions.
- Tourist attractiveness and internationalisation, which involve the formation of a national brand that provides national and international prospects for the development of the tourism industry, with positive social and economic consequences.
- Education, primarily raising the level of education of the population, its development and nurturing creative and entrepreneurial abilities.
- Creation of a comfortable living environment, including smart construction, environmental standards, and general welfare parameters[48].

The smart economy is defined by Spanish researchers as the main basis for urban development in a smart community. This model is based on a number of concepts that promote development, sustainability and attractiveness for new investment, the main ones being: e-business, e-commerce, productivity, employment and innovation in it and the creation of new products and services, new models and opportunities for business and entrepreneurship[49].

Thus, the smart economy can be considered a general trend in economic development that covers all key areas of economic activity and opportunities for increasing welfare in society. Science and education are particularly important elements as the basis for the production and dissemination of knowledge and innovation. At the same time, the mechanisms for transforming the areas of innovation activity (science and education) into real intellectual solutions that will contribute to sustainable development are becoming key. In view of this, we believe that the key

[48] Smart Economy: Economía Inteligente. URL: https://web.ua.es/en/smart/smart-economy-economia-inteligente.html
[49] Smart Economy: Economía Inteligente. URL: https://web.ua.es/en/smart/smart-economy-economia-inteligente.html

elements of the mechanism for ensuring the smart economy are society itself, science (and the possibilities for its implementation), clusters and relevant intellectual solutions. In general, the chain of building relationships is formed within the framework of the interaction of various elements of the smart economy (Fig. 1.6).

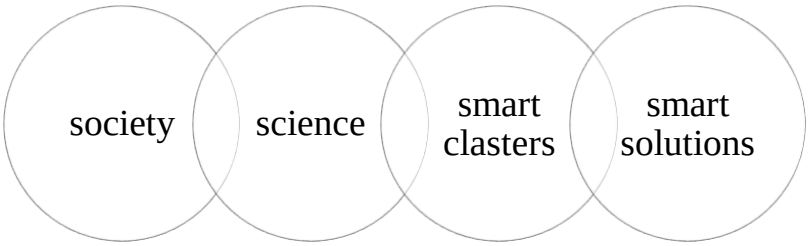

Fig. 1.6. Interaction in the smart economy system

Let us analyse in sequence the changes that are taking place under the influence of the processes of digitalisation, environmentalisation, and socialisation in relation to the main actors and their economic relations. Business: under the influence of digitalisation, there are fundamental changes in the economic activity itself, its content, methods and mechanisms of interaction between economic actors. The formation of networks is manifested in the emergence of global supply and value chains. Such networks and interactions link business entities of different forms, levels, countries and regions into a single global system interconnected and managed by modern technologies.

The trend of socialisation of business - socially responsible business - has emerged since the end of the nineteenth century under the influence of aggravation of social and labour relations. The last century saw its further spread both in business practice and in the understanding of this phenomenon in academic circles. Since the end of the twentieth century, with the intensification of globalisation, digitalisation, and the popularity of the concept of sustainable development, social responsibility has become a non-alternative development direction. The principles of social responsibility are becoming an integral part of companies' strategic management, and social responsibility reports are becoming a common practice in modern business.

An important milestone in the spread of this concept was the emergence in 2010 of the international standard on social responsibility ISO-26000 "Guidelines on Social

Responsibility"[50]. The standard defines social responsibility as "the responsibility of an enterprise for the impact of its decisions and activities on society and the environment through transparent and ethical behaviour that promotes sustainable development, health and well-being of society; takes into account the expectations of stakeholders; complies with existing legislation and is consistent with international standards of behaviour; is integrated into the activities of the entire enterprise and is implemented in the practice of relations".

The issues of corporate social responsibility remain highly relevant in the scientific literature. The theoretical origins of this concept are presented in the works of M. Alle, F. Burley, G. Bowen, M. Weber, P. Drucker, R. Cantillon, B. Karloff, E. Carnegie, F. Kotler, K. Marx, G. Minz, A. Saint-Simon, A. Smith, D. Ricardo, J. Schumpeter and other scholars. From the beginning of the XXI century to the present, the concept of corporate social responsibility has been further developed.

Social responsibility is the basis of scientific research of a wide range of scientists, including A.Kolot, O.Grishnova. The conceptual aspects of social responsibility, various aspects of social responsibility in labour relations, environmental responsibility of enterprises, as well as other fundamental issues in the field of social responsibility are studied by Professor O.Grishnova. A significant number of scientific studies in the field of social responsibility were conducted in the works of I.Bulieiev, Z.Galushka, V.Shapoval, G.Zadorozhnyi, O.Novikova, A.Plakhotnyi.

The spread of the concept of corporate social responsibility means increased attention to the social problems of consumers, employees and other stakeholders. It is increasingly common practice for modern business to conduct business activities without causing harm to humans, the environment and society, as well as to participate in solving important social and economic issues. Achieving the main goal of business activity - making a profit - is based on its alignment with the principles of social responsibility. Corporate social responsibility is becoming an integral feature of the

[50] International standart ISO/DIS 26000. URL: http://www.lsd.lt/typo_new/fileadmin/Failai/N172_ISO_DIS_26000__E_.pdf

management of all the world's leading and successful companies.

The spread of sustainable development ideas in politics and practice has contributed to the fact that in the modern sense, social responsibility necessarily includes not only social obligations, but also environmental ones. This is due to the rapid spread of the next major trend of our time - the so-called greening - and the increasing penetration of environmental goals and principles in all areas of economic activity. Environmental imperatives are becoming a priority for all projects, all types of activities, for any business, in management at various levels. The most popular trend in the development of modern business is the emergence of green business, which means the production of environmentally friendly, organic products. Supplying such products to the market already means having certain competitive advantages, as modern consumers clearly prefer such products.

It is also noteworthy that this trend is becoming increasingly widespread in the financial business. There are already examples of classification of all financial products depending on the level of social and environmental responsibility. ESG (Environmental, Social and Corporate Governance) criteria are in line with the UN Sustainable Development Goals and are becoming an integral part of both company reports and financial product specifications. For example, in Germany, consultations have resulted in a proposal to classify all financial products into four groups according to their level of social and environmental responsibility: non-ESG, ESG, Basic та ESG-Impact[51].

The next trend, institutionalisation, is becoming equally important and interesting. In business, the main management processes are related to market forces such as competition, supply and demand, the presence of monopolies, oligopolies, oligarchic entities and their relationship with small and medium-sized businesses. In today's environment, rapid and comprehensive digitalisation has led to the emergence of a new type of business relationship - platforms that simultaneously take on the functions of a management entity.

[51] ESG-investing on the rise: implications. URL: https://www.bankinghub.eu/banking/research-markets/the-rise-of-esg-investing

The so-called platform business is emerging, where platforms are being created that manage the processes of connecting and interacting with different parties (sellers and buyers). Amazon, Uber, AliExpress are examples of companies that have almost no capital resources of their own, but receive multibillion-dollar revenues from providing platforms and transaction capabilities for numerous agents around the world.

Platforms are made possible by a set of standardised rules and procedures that create an algorithm for transactions between suppliers and consumers of goods and services. For any business entity, the benefits of joining a platform are obvious: low entry costs, reduced risks, reduced costs for promotion and storage of goods, software, etc. For consumers, the real benefits are: reduced time spent searching for a product or service, increased choice, faster purchase process, etc. Thus, the platform creates an environment with almost perfect competition, a large number of agents, and a significant acceleration of all transactions. It is clear that the implementation of the platform becomes possible only with modern technical support, the use of ICT.

The penetration of the latest digital technologies is also changing the financial business sector. Platformisation is gradually reaching the financial sector, creating standardised procedures for customer service. Client assets can be managed by robots, and large platform companies are increasingly including financial transactions: payments, mobile or e-wallets, lending (not only to consumers but also to startups, as Amazon does), trust management services, etc.

In addition, we cannot ignore the emergence of virtual, digital money and, accordingly, the formation of a specific segment of the financial market - the cryptocurrency market. Digital currencies exist only in the virtual, networked space. They have no gold or other material backing. They are issued in a decentralised manner and can be issued by anyone with the right technical equipment. The cryptocurrency rate is not regulated by any government or supranational institutions; it is determined only by the balance of supply and demand. The first and main cryptocurrency at the moment is bitcoin (BTC) - from the English bit, bit - bit and coin - coin. In addition to bitcoin, the cryptocurrency market is being filled with new types of currencies: Ethereum, Litecoin, PCoin, Novacoin, Sifcoin, Namecoin, Ripple, Dash, etc.

All the above-mentioned key trends in modern development also cause dramatic changes in the activities of the next actor - households. Both individuals and households are experiencing significant changes in the structure of demand under the influence of digitalisation. Electronic goods, gadgets, communications and communication devices are making up an increasing share of consumer goods. Household appliances are not just being improved: new types of appliances with qualitatively new energy saving and safety features are being created, and smart products that can be controlled remotely are emerging.

The general trend towards greater environmental friendliness also significantly affects the structure of consumer demand, as modern consumers prefer organic, environmentally friendly products. A culture of frugal attitude to all consumed resources is gradually emerging, which in turn is driving the transition to energy-saving consumption technologies.

Digitalisation and the changes taking place in modern business are also changing the way individuals and households buy goods and services. Online shopping, including via large Internet platforms, is becoming the norm. In addition to well-known global leaders, we should mention those that have emerged in Ukraine: Rozetka, OLX, etc. The spread of web banking and mobile banking, which are now used by almost all consumers, greatly simplifies the process of purchasing goods and services. These technologies significantly accelerate the process of selling goods, which reduces the time consumers spend on searching, selecting and making purchases.

The local environment in which households live is changing. The management of public utilities and public transport is beginning to incorporate smart technologies that provide for the economical use of resources and are aimed at ensuring sustainable community life. ICTs provide data collection and transmission for all municipal management services, tracking the situation with traffic and citizen safety, online provision of administrative services, and feedback between the city administration and residents. Moreover, there is a constant expansion of the areas into which information technology is penetrating in order to create comfortable, high-quality living conditions

for citizens: healthcare, discussion of various urban improvement projects, cultural space, etc.

The trend of socialisation is positively impacting the lives of citizens and households, as it promotes sustainable development principles and socially responsible attitudes towards others. This has led to an increase in civic engagement and community activities, with support for local participation.

In recent years, there has been a significant trend towards the development of social networks. Active participation in these networks affects not only personal but also public and political life. Social networks are used to create virtual local communities where important projects are discussed, decisions are made, and pressing issues of life are raised. Such processes are developing not only at the community level but also at higher levels, such as industries, regions, and the country as a whole. Citizens have the opportunity to submit electronic petitions, participate in the discussion of draft laws, and defend their interests. Virtual socialisation contributes to the implementation of sustainable development goals in community governance and generally becomes an element of institutionalisation.

The formation of the smart economy has inevitably led to changes in the role of the state. Digitalisation has given rise to the concept of E-government, which facilitates all government transactions through the use of ICTs. Digitalisation has given rise to the concept of E-government, which facilitates all government transactions through the use of ICTs. E-government encompasses four areas of relations: government-citizens, government-employees, government-business, and government-government. The Government 2 Citizens (G2C) initiative aims to streamline the process of obtaining information, certificates, and documents for citizens. The goal is to reduce wait times and provide online services, resulting in cost savings for both the government and citizens.

Government to Business (Government 2 Business, G2B; relations between government agencies and businesses): automation of business activities (tax payments, e-procurement, reporting, etc.). Government to employees (G2E, government to officials or employees): managing the internal processes of government agencies. The

digitalisation of these processes also increases the efficiency of the civil service, and if properly organised, G2C and G2B can minimise this link. The Government 2 Government (G2G; automation of relations and workflow between agencies) system provides ICT-enabled management of the entire government apparatus, relations between different agencies, regional offices, internal processes.

In the concept of E-government, transparency of the government is an important issue, which is also aimed at increasing the efficiency of its functioning. In general, government services become more accessible to citizens, which speeds up the resolution of issues and increases the public's assessment of the government's performance. The government should develop policies that promote resilience for the benefit of the population, and promote citizen-centred services.

In this regard, the main parameters of government functioning within the smart economy are:

1. Transparency, which is ensured by the ability of citizens to access information and processes carried out by the government, access to all projects and decisions.
2. E-governance, which includes electronic voting, the use of common platforms, and the promotion of IT technologies, as the services of such system integrators are part of e-government. In addition, e-governance can be implemented through facilitating the relationship between citizens and the government by facilitating access to information (including through updating databases, statistics, etc.), procedures, payment of fees and taxes, single window (including electronic), electronic signature, etc.
3. Open Data, which provides access to key data and indicators of government functioning and decision-making that will have a significant economic impact [52].

It should be noted that socialisation and environmentalisation processes are becoming important and integral aspects of e-governance. In community management,

[52] Smart Government. URL: Https://web.ua.es/en/smart/smart-government.html

important tasks include protection of local environmental projects; access to information on the state of the environment, on projects to be implemented; analytical materials on environmental assessment. Social goals are also becoming a priority; ensuring the rights and support of people with different needs and disabilities. As a result of the synergistic effect of all the above processes, the participation of the entire population in governance processes at various levels is increasing, which generally means the consistent institutionalisation of the smart economy - smart economy.

The increasing complexity of modern country development highlights the interdependence of all processes. The growing importance of knowledge in contemporary social development is marked by an unprecedented focus on social and environmental issues. It is crucial to not only promote development but also to identify factors and drivers that balance country development with the natural environment. In the current social context, the focus is not only on innovation or ensuring innovative development, but primarily on ensuring the development of ecosystems. This approach highlights the perception of the economy as an ecosystem in which various spheres of activity and the actions of all actors are balanced.

The cumulative effect of modern global transformation processes is fundamentally changing the architectonics of modern economic life in society towards the formation of a single global ecosystem. Important components of this ecosystem include a green economy (greening), a single digital space (digitalisation), a human-centred environment (socialisation), and a developed civil society (institutionalisation).

In general, the term “ecosystem” is a category of ecology that was coined by the English ecologist Arthur Tansley in 1935. The next important step was taken by Raymond Lindeman in 1942 in his article on the biology of Lake Minnesota. This article investigated the patterns of energy transformation between different parts of ecosystems and thus laid the foundations for studying the energy balance of ecosystems. He defined the ecosystem itself as “a system consisting of physical, chemical and biological processes operating in a unit of space-time of any size” and considered the ecosystem concept to be of “fundamental importance in the

interpretation of dynamic ecology data"[53]. From an ecological perspective, an ecosystem is a community of organisms that have adapted to coexist in a specific habitat, forming a cohesive unit with it.

The term "ecosystem" was first used in economic research in 1996 by J. F. Moore, who formulated the idea of a business ecosystem, which he defined as "an economic community supported by the creation of interacting organisations and individuals - the organisms of the business world"[54]. Since then, the study of the economy as an ecosystem has gained popularity in scientific circles, with the phenomenon of entrepreneurial ecosystems becoming a pressing issue. According to Z. Aks, a renowned researcher of entrepreneurial ecosystems, "an ecosystem is a biotic community that includes its physical environment and all possible interactions among living and non-living components, in its most abstract sense"[55].

Attempts to view the economy as an ecosystem are gaining popularity. They can be carried out, first, in a broad research context, when economic phenomena and processes are part of the interaction of biological, physical, ecological and other processes. Thus, H.Whitmore defines the global ecosystem as a set of the following 11 components Slowly renewable basic resources (clean air and ocean water); natural renewable resources, consisting of various combinations of fresh water, soils, plants and animals; processed/transformed renewable resources for sale (harvested, frozen, canned, smoked, refined, pasteurised, transported and various other forms of natural renewable resources) Human populations; non-renewable non-mined resources (fossil fuels and minerals); extracted/transported commodity resources; capital goods; consumer goods; public infrastructure (roads, bridges, airports, seaports, power plants); treated and stored waste; untreated waste (pollution)[56] (Fig. 1.7).

[53] Lindeman R.L. The trophic–dynamic aspect of ecology. *Ecology*. 1942. № 23. P. 399–418.
[54] Moore J. F. The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems. NY: Harper Business, 1997. P. 6-7.
[55] Acs Z.J., Stam E., Audretsch D.B., O'Connor A. The lineages of the entrepreneurial ecosystem approach. *Small Business Economics*. 2017. №49 (1). URL: http://www.kluweronline.com/issn/0921-898X/. Doi: 10.1007/s11187-017-9864-8.
[56] Harland Wm. Whitmore. The Global Ecosystem. 2007. DOI: 10.1057/9780230607309_2.

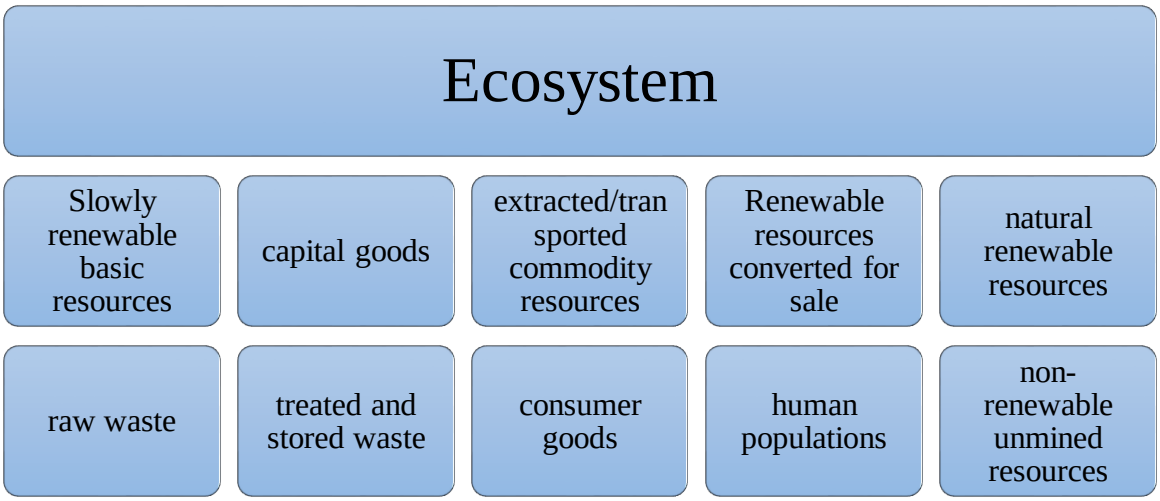

Fig. 1.7. The ecosystem according to H.Whitmore [57]

Second, the ecosystem becomes a specific economic concept that describes economic phenomena or processes. R. Adner's definition is typical in this regard: "an 'ecosystem' is a structure for coordinating a multilateral set of partners that must interact in order for a focal value proposition to be realised"[58].

At the same time, the spread of this category in economic science has different aspects. The most common perception is that of an entrepreneurial ecosystem. Ben Spiegel, a well-known researcher of the phenomenon of entrepreneurial ecosystems, considers them to be "a type of cultural, social, economic and political environment in a region that supports highly developed entrepreneurship". He argues that successful and unsuccessful entrepreneurship in an ecosystem generates important entrepreneurial resources such as investment capital, skilled workers and entrepreneurial knowledge. This, in turn, supports the future creation of a high-growth venture[59]. In his 2020 study, Spiegel defines entrepreneurial ecosystems as "a set of interdependent actors and factors coordinated in a way that facilitates productive entrepreneurship in a given area"[60].

[57] Harland Wm. Whitmore. The Global Ecosystem. 2007. DOI: 10.1057/9780230607309_2.
[58] Adner R. Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management. 2017.* Vol. 43. No. 1. P. 39–58. DOI: 10.1177/0149206316678451.
[59] Ben Spigel, Richard Harrison. Toward a process theory of entrepreneurial ecosystems. *Stratigic Entreprenerial Journal*. 2017. URL: https://doi.org/10.1002/sej.1268
[60] Ben Spigel. Entrepreneurial ecosystems: Theory, Practice and Future. *EE Publishing.* 2020. 200 p. DOI: https://doi.org/10.4337/9781788975933.

According to Spiegel, the structure of an entrepreneurial ecosystem has four key components: 1) interdependent actors and factors; 2) coordinated in a way that: 3) enable productive entrepreneurship; and 4) within a defined area. This definition emphasises that all actors and factors in a given area must be interdependent. That is, an ecosystem is not just the sum of actors, but also necessarily includes the synergistic effect of their interaction. In addition, their activities must be coordinated in such a way as to ensure productive entrepreneurship that creates value not only for the entrepreneur but also for the wider society by introducing new technological innovations, increasing efficiency or reducing barriers in markets. Another important characteristic of entrepreneurial ecosystems is that they are located in a particular territory. Thus, entrepreneurial ecosystems are a geographical phenomenon rather than a sector or industry-specific phenomenon.

Z. Aks et al. (2014) define entrepreneurial ecosystems as "the dynamic, institutionalised interplay between individuals' entrepreneurial attitudes, abilities and aspirations that guides the allocation of resources through the creation and operation of new businesses"[61]. D. Oudretsch and M. Belitsky understand the entrepreneurial ecosystem as a dynamic community of interdependent actors (entrepreneurs, suppliers, buyers, government, etc.) and the institutional, informational and socio-economic context of the entire system[62].

At the same time, the concept of "digital ecosystem" is emerging under the influence of the digitalisation process. A digital ecosystem is defined as "a self-regulating, large-scale and sustainable system consisting of heterogeneous digital entities and their interconnections, focusing on the interaction between entities to increase the system's utility, gain benefits and facilitate information exchange, internal and cooperative system innovation[63]. A digital ecosystem is a "digital environment" in which "digital species" or "digital components" reside, which can be software

[61] Acs Zoltan, Autio E. and Szerb L. National Systems of Entrepreneurship: Measurement issues and policy implications. *Research Policy.* 2014. Vol. 43. Is. 3. P. 476-494.
[62] David Bruce Audretsch, Maksim Belitski, Nataliia Cherkas. Entrepreneurial ecosystems in cities: The role of institutions. PLOS ONE. 2021. URL: https://doi.org/10.1371/journal.pone.0247609.
[63] Li W., Badr Y. & Biennier F. Digital ecosystems: Challenges and prospects: Proceedings of the International Conference on Management of Emergent Digital EcoSystems - MEDES '12. 2012. doi:10.1145/2457276.2457297.

components, applications, services, knowledge, business processes and models, training modules, contractual frameworks, laws, etc.[64].

Despite some disagreements, all discussions of this concept recognise two fundamental pillars of the digital ecosystem: digital technologies and people. The ecosystem is shaped by the fact that digital technologies, such as a mobile search engine, are considered inanimate components, while people who use these technologies, including anyone who uses Google, are animate. According to F. Soussan and Z. Ax, the interaction between living and inanimate elements is dynamic and constantly changing. This interaction shapes the behaviour of the ecosystem as a whole[65].

D. Tilson clearly defines the dual meaning of digitalisation as a technical process on the one hand, and "the socio-technological process of applying digital technologies in a broader social and institutional context that makes digital technologies infrastructural"[66]. Smith defined an ecosystem as the interactions that provide entrepreneurs with access to resources that can be used to achieve desired outcomes [67]. S. Kraus explains digital ecosystems through the concept of bridge and connection. Bridges provide connections between actors in a network, ideally striving for as many connections as possible in order to gain access to new knowledge. Links refer to the behaviour of actors in the network[68].

As a result of the development of research in both areas, a new concept has emerged: "digital entrepreneurial ecosystems". Digital entrepreneurial ecosystems consist of entrepreneurs who create digital companies and innovative products and services for numerous users and agents in the global economy[69]. For entrepreneurs, the

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[64] Ratih Purbasari, Zaenal Muttaqin, Silvya Sari. Digital Entrepreneurship in Pandemic Covid 19 Era: The Digital Entrepreneurial Ecosystem Framework. *Review of Integrative Business and Economics Research*. Vol. 10. Is. 1. P. 114-135.

[65] Sussan F. & Acs Z. J. (2017). The digital entrepreneurial ecosystem. Small *Business Economics*. 2017. Vol. 49(1). P. 55–73. Doi:10.1007/s11187-017-9867-5.

[66] David Tilson, Kalle Lyytinen, Carsten Sorensen. Research Commentary Digital Infrastructures: The Missing IS Research Agenda. *Information Systems Research. 2010.* Vol. 21, No. 4. P. 748–759.

[67] Smith C., Smith J.B. & Shaw E. Embracing digital networks: entrepreneurs' social capital online, *Journal of Business Venturing*. 2017. Vol. 32. No. 1. P. 18-34

[68] Digital entrepreneurship / S. Kraus et. al. *International Journal of Entrepreneurial Behavior & Research.* 2018. DOI:10.1108/ijebr-06-2018-0425.

[69] Sussan F. & Acs Z. J. (2017). The digital entrepreneurial ecosystem. Small *Business Economics*. 2017. Vol. 49(1). P. 55–73. Doi:10.1007/s11187-017-9867-5.

digital ecosystem is not only a business model, but first and foremost a digital innovation platform that provides an environment for innovators to test ideas and implement digital solutions based on common agreements[70].

In his research, A. Song identified 3 components of the digital entrepreneurial ecosystem, namely:

a) Digital user citizenship, or DUC for short, is an element of the digital entrepreneurial ecosystem that expresses the explicit legitimacy and implicit social norms that allow Internet users or consumers to participate in the digital society while supporting entrepreneurial activities by both producers and consumers.

b) Digital technology entrepreneurship, or DTE for short, is an element of the digital entrepreneurial ecosystem that includes industry players, application developers, apps, and all other agencies that produce platform-related goods and services. Digital technology entrepreneurship creates entrepreneurial innovation and increases the efficiency of the platform. The larger the user base, the larger the market segment and niche. A good platform sponsor provides resources that facilitate the entrepreneurial innovation process and offers a fair profit-sharing plan.

c) A digital multilateral platform, or DMP for short, is an element of the digital business ecosystem that includes intermediary transactions in goods and services, as well as knowledge-sharing facilities that enable and facilitate experimentation and value creation. Digital multilateral platforms are demand-side intermediaries whose core competence is to reduce or eliminate transaction costs through timeliness, accuracy and appropriate quality[71].

According to A. Cavallo, digital entrepreneurial ecosystems can be local, global, and even larger. Their size depends on the adaptation, absorption, and diffusion of

[70] Digital entrepreneurship / S. Kraus et. al. *International Journal of Entrepreneurial Behavior & Research.* 2018. DOI:10.1108/ijebr-06-2018-0425.
[71] Song A. K. The Digital Entrepreneurial Ecosystem—a critique and reconfiguration. Small Business Economics. 2019. DOI:10.1007/s11187-019-00232-y.

digital technologies [72]. The result of a digital entrepreneurial ecosystem is a sustainable ecosystem [73].

The result of a digital entrepreneurial ecosystem is a sustainable ecosystem. For example, Davidson et al. believe that digital entrepreneurship consists of three interrelated types of entrepreneurship: the business itself, knowledge entrepreneurship and institutional entrepreneurship[74]. Whereas, according to Lee et al. "digital entrepreneurship is one stream of entrepreneurship"[75].

In addition to the above-mentioned concepts of ecosystems, the scientific literature includes the following: innovation ecosystems [76], platform ecosystems[77], organisational ecosystems [78], etc. The position of understanding the economy as a national innovation ecosystem is quite common in the scientific literature. This approach allows us to understand that this system is not fixed, it evolves and develops in accordance with new needs and circumstances. It is receptive to changes brought about by new initiatives and policies. The ecosystem approach recognises that a set of complex interrelationships is formed between the various actors in the innovation economy (individual entrepreneurs, corporate actors such as big business and universities) and emphasises the importance of incentives for different actors to create an innovation-friendly environment[79].

Considering the evolution of concepts, it is reasonable to view the smart economy as an ecosystem. Based on the evolution of concepts, we believe that there is every reason to consider the smart economy as an ecosystem. Based on Adner's definition of

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[72] Cavallo A., Ghezzi A. & Balocco R. Entrepreneurial ecosystem research: Present debates and future directions. International Entrepreneurship *and Management Journal.* 2018.
[73] Sussan F. & Acs Z. J. (2017). The digital entrepreneurial ecosystem. Small *Business Economics*. 2017. Vol. 49(1). P. 55–73. Doi:10.1007/s11187-017-9867-5.
[74] Davidson E. & Vaast E. *Digital entrepreneurship and its sociomaterial enactment*: Proceedings of the 43rd Hawaii International Conference on System Sciences. 2010. P. 1-10.
[75] Wenjie Li, Wenyu Du and Jiamin Yin. Digital entrepreneurship ecosystem as a new form of organizing: the case of Zhongguancun. *Frontiers of Business Research in China.* 2017. DOI: 10.1186/s11782-017-0004-8.
[76] Fedulova, L., Marchenko, O. Innovacijni ecosystemi: sutnist ta metodologichni zasadi formuvannja. *Economichna teoria ta pravo*. 2015. № 2 (21).PC. 21-33. (in Ukrainian)
[77] Annabelle Gawer, Michael A. Cusumano. Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management* 2014. Vol. 31(3). DOI: 10.1111/jpim.12105.
[78] Acs Zoltan, Autio E. and Szerb L. National Systems of Entrepreneurship: Measurement issues and policy implications. *Research Policy.* 2014. Vol. 43. Is. 3. P. 476-494.
[79] [79] Fedulova, L., Marchenko, O. Innovacijni ecosystemi: sutnist ta metodologichni zasadi formuvannja. *Economichna teoria ta pravo*. 2015. № 2 (21).PC. 21-33. (in Ukrainian).

an ecosystem as “a structure for coordinating a multilateral set of partners that must interact in order for a focal value proposition to be realised”[80], the smart economy is fundamentally a system for mutually aligning the interests and actions of various actors Such coordination is based on the principles of smart management, consideration of important values of sustainable development and the use of the latest ICTs.

Summarising the above, the following important features of ecosystems can be noted: first, systemic nature (i.e., a complete form of unification of various objects); second, close interconnections between actors and the formation of a new type of interaction in general - networking; and third, the formation of an environment favourable to both the actors themselves and the global space of human activity.

To ensure the system’s intelligence and manage interconnections and activities, specific management tools are necessary. These tools and drivers are modern technologies that are rapidly changing the technological basis and the entire system of economic relations in society. The acceleration of transactions is transforming interactions, mechanisms, and tools for implementing economic activities. A networked economy is emerging, characterised by flexibility, adaptability, interactivity, reduced transaction costs, and a shift towards virtual and intangible forms.

The proliferation of networks, in turn, contributes to the emergence of new forms of business - the creation of platforms, which are online systems that connect two-sided markets - buyers and sellers - on the basis of standardised integrated solutions. Examples of platform businesses include the activities of well-known corporations such as Amazon, Uber, Alibaba, etc., which have created opportunities for a huge increase in the number of buyers and supply, and facilitated the entire transaction.

Driven by increased attention to environmental and social issues, the latest technologies are already helping to manage all related processes in a smart way. In a growing open global economy, achieving a competitive economy requires new approaches to creating an environment conducive to digital innovation and

[80] Ron Adner, Rahul Kapoor. Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in New Technology Generations. *Strategic Management Journal. 2010. №* 31(3). P.306 – 333. DOI: 10.1002/smj.821.

entrepreneurship. At the global level, there is a need to accelerate the formation of digital innovation ecosystems to ensure digital transformation.

Thus, ensuring the progress of the modern world economy in the current conditions is possible only through the implementation of an exosystem approach. This means that the world economy should be perceived as a global ecosystem in which all parts are interconnected, the main guiding principles of which are the goals of sustainable development (in which social, environmental and economic aspects are balanced), the main drivers are ICT and the widespread use of the latest smart technologies in all spheres of life (in production, management, solving environmental and social problems at various levels, personal consumption, etc.).

Thus, the conceptualisation of the global economy as an ecosystem implies an understanding of the unity of the processes of development of living and non-living nature, the interconnectedness of economic, environmental, social and technological development. All of this is also accompanied by increased attention to social and environmental issues. The most important conclusion is that the smart economy is becoming an important part of the global ecosystem. In today's complex context, it is very important to realise that the global economy is not just an economy in a global space, not just a globalised world economy. In fact, a single global ecosystem is being formed, in which the complex impact of such processes as globalisation, digitalisation, socialisation, greening, urbanisation, etc. radically transforms the environment, enhances its interconnectedness and systemic nature, and aims its development at human and nature-centred values and goals. The formation of the smart economy is becoming a concentrated expression and manifestation of this new configuration of global economic development.

CHAPTER 2
CONCEPTS AND INTERNATIONAL PRACTICE OF SMART CITY

2.1. Essential features and principles of organizing smart cities

Along with such defining processes and trends in the formation of the smart economy as digitization; environmentalization; socialization, in our opinion, is also represented by institutionalization and urbanization. Highlighting as a separate trend of institutionalization is due to the fact that one of the most common problems on the way to the formation of an intellectualized economy are institutional obstacles that arise in the process of transformation and modification of the economic system, the transition from a resource economy to a highly developed and high-tech one. That is why, in modern world practice, the processes of searching for new management mechanisms and tools, which would be more flexible and effective, are being intensified.

It is also impossible to ignore the clearly expressed processes of urbanization in modern world economic development. The growth of the urban population, the number of individual cities, the number of large and super-large cities actualizes the issue of managing the processes of their functioning and life support. Moreover, it is not just management, but such management, which is aimed at ensuring comfortable and safe living conditions for the population.

As mentioned above, the expanded system of the main subjects of the smart economy includes: individuals; localities, cities; regions; countries; global cities. It is important to note that the concept of smart economy was initially widely spread precisely at the city level - in the form of smart city. In our opinion, this is explained by the fact that overcoming the above-mentioned institutional obstacles and solving

numerous issues of citizens' lifestyles becomes possible, first of all, at the level of individual localities - cities. It is the institutionalization of the influence of all stakeholders on decisions within cities that is becoming an important and distinctive modern trend.

Cities as a subject of the economy, and even more so of the global economy, are gaining enormous importance in the context of the acceleration of the urbanization process. The share of the urban population has been growing steadily, and since the second half of the 20th century, at a rapid pace. In general, the share of the urban population in the world has increased from 29.6% in 1950 to 56.2% in 2020, and according to forecasts, it will be 68.4% in 2050 - that is, it will more than double in a century.

These average figures vary significantly by region. The urban population grew most rapidly during 1950 - 2020 in Africa (growth rate - 3.04), Asia (2.92), Latin America and the Caribbean (1.97). In Europe and North America, the growth rates are not so significant, but the share of the urban population is very high - in 2020, 74.9% and 82.6%, respectively (Table 2.1):

Table 2.1

Urban population in the world and regions, % (1950-2050) [81]

	1950	1980	2000	2015	2020	2050
Africa	14,3	26,8	35,0	41,2	43,5	58,9
Asia	17,5	27,1	37,5	48,0	51,1	66,2
Europe	51,7	67,6	71,1	73,9	74,9	83,7
Latin America and the Caribbean	41,3	64,6	75,5	79,9	81,2	87,8
North America	63,9	73,9	79,1	81,6	82,6	89,0
Oceania	62,5	70,9	68,3	68,1	68,2	72,1
World	29,6	39,3	46,7	53,9	56,2	68,4

Moreover, it is not just the number of the urban population that is growing. There are trends both in the growth of the number of cities with millionaires, and in the total number of residents of individual cities. According to the UN website "World Population Review" at the beginning of 2020, the population of the largest cities in the

[81] World Urbanization Prospects. 2018. URL: https://population.un.org/wup/Download/

world was: Tokyo - 37.4 million people, Delhi - 29.4 million people, Shanghai - 26.3 million people, Sao Paolo - 21.9 million people, Mexico City – 21.7 million people (Table 2.2):

Table 2.2

Top 10 cities in the world by the number of inhabitants [82]

№	City	Number of inhabitants	Country	Change, %
1	Tokyo	37,435,191	Japan	-0,11
2	Delhi	29,399,141	India	3,03
3	Shanghai	26,317,104	China	2,82
4	Sao Paulo	21,846,507	Brazil	0,90
5	Mexico City	21,671,908	Mexico	0,51
6	Kairo	20,484,965	Egypt	3,56
7	Dhaka	20,283,552	China	2,03
8	Mumbai	20,185,064	India	2,13
9	Beijing	20,035,455	China	1,12
10	Osaka	19,222,665	Japan	-0,30

Most of all large cities are located in the largest countries of the world - China and India. Among European countries, the largest cities are Istanbul (14.5 million inhabitants), Moscow (more than 12 million), and Paris (more than 11 million).[83].

Along with the increase in the number of large cities and the number of their population, attention to the new role of cities as entities to ensure a high-quality, safe and modern life of citizens has been significantly intensified in recent years. Evidence of this was the appearance of such concepts as “future city”, “smart city”, “sustainable city”, “smart sustainable city”, “connected city”, “resilient city”, “intelligent city”, “digital city”, “digital community”, “cyber city”, “knowledge-based city”, “cyberville”, etc. Each of them has the right to life, as it emphasizes the most important imperatives of the development of modern cities. Each of these concepts reflects important features of a new phenomenon: whether it is the growing role of digital technologies, whether it is the growing intellectualization of urban life, or its environmentalization. Recently, the term “smart city” has become more and more

[82] World City Populations. 2021. URL: https://worldpopulationreview.com/world-cities
[83] World City Populations. 2021. URL: https://worldpopulationreview.com/world-cities

widely used as the embodiment of all the mentioned trends. Nevertheless, despite certain attention of scientific circles to this issue, there is no single approach to understanding its essence and structure. In our opinion, Smart-city is the most appropriate term, as it includes the aspect of digitization, sustainability, and knowledge-based and smart technologies.

Different countries implement various approaches to the development of smart economy in general and smart cities as one of the key elements. Smart cities become the basis of competitive economic development, forming the basis for attracting investors to the most innovative sectors of the economy. Do global development trends indicate the need to smarten up development and review it as a national one? and local development strategies. According to analysts' forecasts, the global smart city market will grow to $820 billion by 2026. (Fig. 2.1).

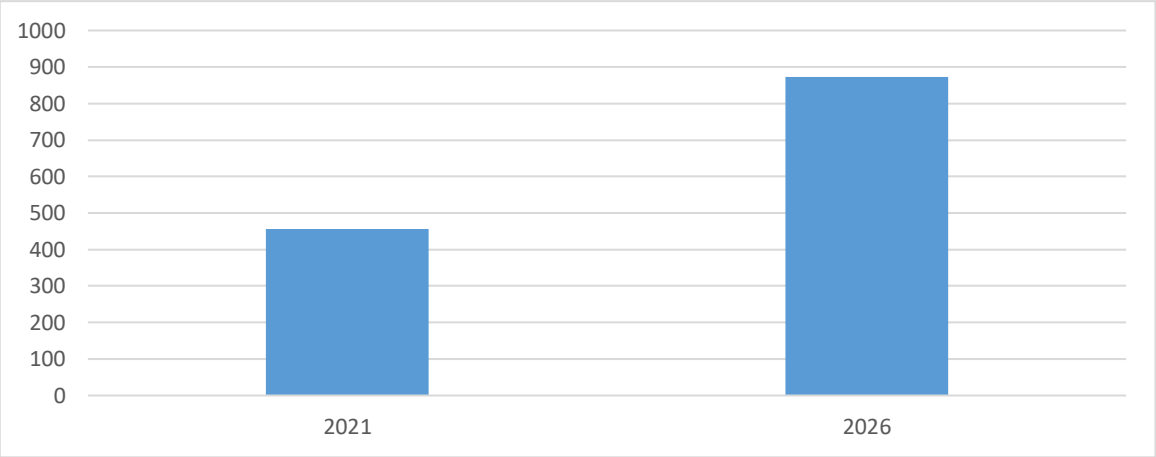

Fig. 2.1. Forecast of the development of the global market of smart cities, 2021-2026 [84]

The average annual growth rate is calculated at the level of 13.8% for the specified forecast period of time. Such rates are supported within the framework of the development of the concept of public security within the framework of smartization and urbanization. Research determines that the Smart Transportation segment will develop most actively, as one of the most innovative and within the framework of the

[84] Global Smart Cities Market. URL: https://www.researchandmarkets.com/reports/5146372/global-smart-cities-market-by-focus-area-smart?utm_source=GNOM&utm_medium=PressRelease&utm_code=pns38g&utm_campaign=1447896+-+Smart+Cities+Market+Report+2020+-+Global+Forecast+to+2025%3a+Market+Size+is+Expected+to+Grow+from+%24410.8+Billion+in+2020+to+%24820.7+Billion&utm_exec=chdo54prd

implementation of the decarbonization policy. This segment involves the development of a complex optimization solution for the use of transport (combining road, rail, air, water and other transport), infrastructure and the entire service complex to meet the needs of citizens and implement the concept of safety.

However, one of the largest segments of the development of smart cities is energy. Smart Utilities in Energy is one of the most promising for the formation of network capabilities and the use of artificial intelligence from the moment of energy production to the moment of its distribution and consumption by the final consumer. Smart grids can minimize the negative consequences of power outages and shift networks to other sources of supply.

In the Smart Citizen Services development segment, the highest growth rates are predicted for Smart Healthcare. Provides network integration and remote monitoring of patients, remote medical assistance, monitoring and reporting of the workflow of doctors and medical institutions of cities, workflow automation, mobile health, transfer of referrals and prescriptions, integration of the pharmacy system and various types of medical institutions[85].

The concept of smart cities has become widespread with the development of ICT since the end of the last century. Moreover, the practical level of implementation of smart cities is rapidly developing and provides a lot of food for thought.

The research group of European smart cities at the Center for Regional Science of the Vienna University of Technology under the leadership of Professor Dr. R. Giffinger deals with the issue of smart cities. They identify the smart city with the beehive, calling it “the smart city of bees” and popularize it on the corresponding website. In their opinion, a smart city is “using the capabilities of the city / community to create and make decisions in order to overcome challenges and increase opportunities that will help transform the “place we call home” into a promising and

[85] Global Smart Cities Market. URL: https://www.researchandmarkets.com/reports/5146372/global-smart-cities-market-by-focus-area-smart?utm_source=GNOM&utm_medium=PressRelease&utm_code=pns38g&utm_campaign=1447896+-+Smart+Cities+Market+Report+2020+-+Global+Forecast+to+2025%3a+Market+Size+is+Expected+to+Grow+from+%24410.8+Billion+in+2020+to+%24820.7+Billion&utm_exec=chdo54prd

more livable one for all stakeholders. The ecosystem of implemented solutions is what determines whether a city / community is smart." A smart city is a human-centered approach to the development and implementation of an ecosystem of smart city solutions that create added value and translate into collective good. This scientific group identifies six key areas of a smart city: Smart Governance, Smart Economy, Smart Environment, Smart Living, Smart Mobility and Smart People.

Vinod Kumar also considers the Smart-city system as part of: Smart People, Smart Economy, Smart Mobility, Smart Environment, Smart Living, Smart Governance[86].

Krisna Adiyarta and others. distinguish eight components of a smart city: Smart Governance, Smart Environment, Smart Mobility, Smart People, Smart Economy, Smart Living, Smart Infrastructure/Technology and smart energy[87].

R. Novotny et al. consider the structure of the Smart-city in a rather applied way: "general municipal and business services", "smart, sustainable buildings and building management (smart building)", "fields of education, health care and social assistance (smart education)", " energy production and energy efficiency (smart energy, smart lighting)", "smart gas, electricity and water metering (smart grad)", "smart water and waste management (smart utility)", "public safety, security and crime prevention", "real-time location and geographic services"[88].

A similar approach is declared by Romanian scientists M.Eremia, L.Toma, M.Sanduleac, who consider Smart-city as a combination of the following components: "smart buildings", "education, medical and social assistance", "smart energy", "smart network (smart metering of natural gas, water, electricity)", "smart utility management (smart water distribution and smart waste management)", "smart parking", "integrated supply systems", "smart and integrated transport"[89].

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[86] Kumar M.V., Bharat Daliya. Smart Economy in Smart Cities. Smart Cities, Local Community and Socio-economic Development: The Case of Bologna. 2017. P. 12.

[87] Analysis of smart city indicators based on prisma : systematic review / Krisna Adiyarta et. al. *IOP Conference Series*: materials Science and Engineering. Vol. 725. 3rd Nommensen International Conference on Technology and Engineering. Nommensen HKBP University, Indonesia, 25–26 July, 2019.

[88] Novotny R., Kuchta R., Kadlec J. Smart City Concept, Applications and Services. *Journal of Telecommunications System & Management.* 2014. Vol. 3. Is. 2. Doi:10.4172/2167-0919.1000117.

[89] Eremia M., Toma L., Sanduleac M. The Smart City Concept in the 21st Century: 10th International Interdisciplinarity in Engineering, INTER-ENG 2016. URL: https://www.sciencedirect.com/science/article/pii/S1877705817309402

Although each of the approaches has its differences, they all have in common the allocation of such blocks as: management, economy, infrastructure, social sphere. Different authors can take a more in-depth look at infrastructure, separately highlighting not only transport, but also energy supply, water supply, waste management, etc. The authors can also emphasize various aspects of the social sphere: the education system, culture, "smart people", living conditions, etc. But management is an integral component of smart cities and, although this is not highlighted separately in the structure, information and communication technologies, which are a key tool for its implementation.

Smart cities are a modern and dynamic phenomenon that is rapidly developing and improving, forming new forms of communications and implementation of various aspects. In general, there is no standard, each city develops based on its capabilities, mental and cultural traditions. At the global level, the leading cities stand out, which were able to best implement the main aspects of smart life in their community. It is also characteristic that the management of a smart city does not remain unchanged.

Boyd Cohen, who has been investigating the problem of smart cities since 2011, distinguishes three stages, three different generations or evolutionary phases of the development of smart cities: Smart cities 1.0, based on a technology-centric vision; Smart cities 2.0, which are characterized by a government-centric vision; and Smart Cities 3.0, in which a citizen- and people-centric approach prevails.

Smart Cities 1.0: A technology-centric vision of smart cities, characterized by technology providers encouraging their solutions to cities that were not really equipped to properly understand the implications of technology solutions or how they might affect citizens' quality of life. Smart Cities 1.0 is also the underlying philosophy behind most smart city projects proposed around the world, from PlanIT in Portugal to Songdo in South Korea. These visions of the city of the future were driven by private sector technology companies such as Living PlanIT and Cisco.

Smart cities 2.0: a government-centric vision using technological solutions as means to improve the quality of life. In this generation, the municipality - led by forward-thinking mayors and city administrators - is taking the lead in defining the

future of their city and the role of implementing smart technologies and other innovations. At this stage, city administrators increasingly focus on technological solutions that contribute to improving the quality of life. A good example is Barcelona, which has over 20 smart city program locations and literally over 100 active smart city projects.

Smart cities 3.0: a citizen- and human-centric vision of smart cities, citizen- or person-centered and based on co-creation. In this model, smart cities apply citizen co-creation strategies to help manage smarter cities to improve quality of life and prosperity for generations to come. Vancouver led one of the most ambitious joint strategy initiatives, involving 30,000 citizens in co-authoring the Vancouver Green City 2020 Action Plan, while Vienna engaged citizens as investors in local solar farms as a contribution to the city's 2050 renewable energy goals [90].

Cohen argues that some cities are moving from one phase to another, while others are stuck in one and experimenting with smart cities. Overall, in his opinion, the combination of Smart Cities 2.0 and Smart Cities 3.0 is the best choice for the future.

Thus, the main trend in the development of the smart city management system is the involvement of all parties, all subjects in the management process. It is even called the "quadruple helix" - the involvement and cooperation of all stakeholders: between the government, the private sector, academia and civil society (primarily citizens). It is the targeting of all stakeholders to achieve important city development goals that is a key success factor in all indicators of a smart city[91].

A smart city is not only the involvement of all stakeholders in management, it is also the orientation of all activities (and goals, and mechanisms, and tools) on people. The overall goal is to create and implement an ecosystem of smart city solutions that produces added value and turns into a collective good. In such an ecosystem, smart actions are taken by all stakeholders: smart people formulate smart goals, business connects to their smart implementation, the municipality smartly manages all

[90] The 3 Generations Of Smart Cities. 2015. URL: https://www.fastcompany.com/3047795/the-3-generations-of-smart-cities
[91] Redefining the smart city concept: a new smart city definition. 2017. URL: https://hub.beesmart.city/en/strategy/towards-a-new-smart-city-definition

components of city life that function on the basis of smart ecologically and socially oriented development.

Further analysis requires clarification of the concept of “reasonable”. In our opinion, two important aspects should be noted in this context. First, it is the penetration of all activities and the process of city management with important social and ecological values. And secondly, it is the strengthening of the intellectual nature of both the management process and all decisions made.

Such a situation even gave rise to the opinion that now, by analogy with the “rise of the creative class” of Richard Florida, the rise of smartivists is taking place. A Smartivist can be defined as “a person who steps forward to actively support the process of creating a better place on a voluntary basis.” A smartivist can be an individual expert or creator of a smart city initiative (for example, free consortia of projects, new legal entities such as non-profit organizations, associations) to solve specific problems[92].

According to the founders of the bee smart city concept, the most effective factor for the success of a smart city is the collective intelligence as the embodiment of the collective intelligence of all subjects connected by smart management based on modern smart technologies. This is what allows us to identify a smart city with a beehive in which each bee fulfills its intelligent role. It allows you to create and make decisions that lead to the effective transformation of the community to a strong ecosystem of Smart-city solutions.

Proponents of the bee approach believe that the differences between different smart cities lie in the ability of a city or community to use collective intelligence. This aspect characterizes the ability to connect different subjects in a city or community. Collective intelligence provides a 360-degree perspective, covering all aspects of a community, as well as taking into account connections to neighboring communities or the region. The journey to becoming a smarter city or community is largely not driven by a top-down master plan or technology partnership with one big player. Rather, it is

[92] Redefining the smart city concept: a new smart city definition. 2017. URL: https://hub.beesmart.city/en/strategy/towards-a-new-smart-city-definition

the sum of smart initiatives, projects and solutions that are developed and implemented by a large number of different private and public actors throughout the city and in different strategic areas of activity.

In the smart city of the third wave, which is focused on citizens, not only technological "sensors" are used, but, first of all, people as "smartivists" and living "sensors" of the environment. Therefore, "encouraging the growth of smartivists who can shape this third wave and take urban challenges into their own hands is key to driving innovation now. This will ensure that human ideas and experiences can influence not only the current smart city strategy, but also the "smart" movement into the future.[93].

Active citizens become part of city management, while remaining only members of such a cohesive society. The formation of such an ecosystem is facilitated by the development of technologies where anyone can join the management system, such as Waze and Citymapper, in which each participant can make changes and convey some information to all users. The joint use of the resource becomes the basis for the formation of a conscious society.

However, not only technologies contribute to building a smart society. This is how the "Incredible Edible" project was formed in Britain, within the framework of which mini-farms are formed, in particular in yards, on roadsides and other places, where you can grow vegetables, useful crops and greens, which can then be used for food. It is worth noting that this initiative is spreading not only in Great Britain, but also in the cities of other countries. In reality, this means that Smart-economica is formed in this case in a "bottom-up" way, as projects are developed that cannot be implemented by governments or local authorities[94].

On a larger scale are the Better Reykjavik projects, or citizen hackathons, such as the Barcelona CCCB Data Quality Datathon, in which the public is involved in shaping the ecosystem of urban areas, planning, land management through forums, platforms

[93] Redefining the smart city concept: a new smart city definition. 2017. URL: https://hub.beesmart.city/en/strategy/towards-a-new-smart-city-definition
[94] If you eat, you're in. URL: https://www.incredibleedible.org.uk/

and initiatives. This format gives the population the opportunity to directly participate in the improvement of the functioning of the place of residence, its convenience and environmental friendliness, to find new ways and methods of management, implementation of ideas. In general, the initiation of some changes by people living in a certain territory will contribute to the formation of a reasonable, sustainable development vector of their area, which becomes more economically justified and effective, will really contribute to the formation of a cohesive society, reduce distrust in authorities, state institutions, etc.

It is worth noting that the classic system of city management involves the formation of a bureaucratic hierarchical system that manages a set of elements as separate units (Fig. 2.2).

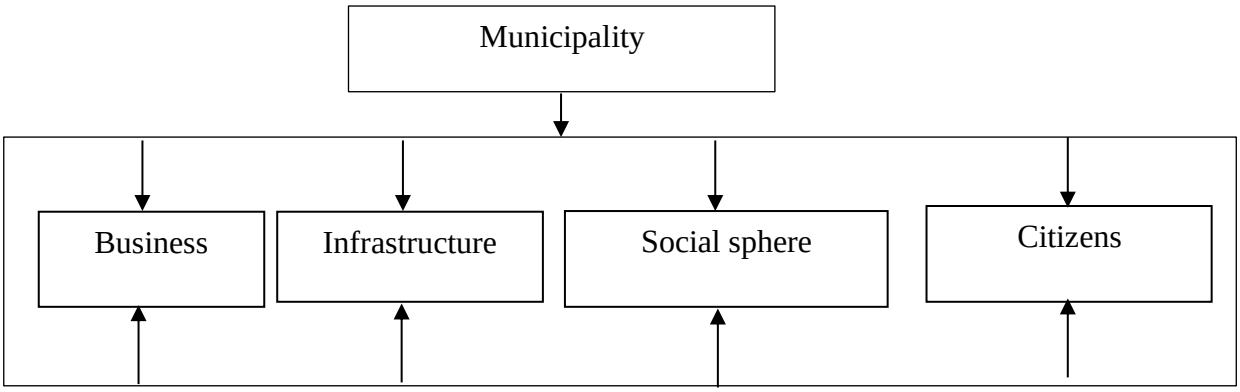

Fig. 2.2. Classic city management system

Involvement of a significant number of residents contributes to the formation of a powerful public-private partnership, strengthening the inclusiveness of society, its cohesion. In fact, the “embedding” of the community in the management of the city is formed through the active participation of citizens, entrepreneurs, initiators of social changes, so-called smartivists. The formation of a smart ecosystem also leads to the so-called chain effect, when the involvement of one citizen or entrepreneur contributes to the dissemination of information and, in fact, the further involvement of other citizens and the formation of collective intelligence, synergistic effects. In fact, the smart city stops using classic management systems, a special system of interaction is formed, which consists in uniting all active participants to manage the city (Fig. 2.3).

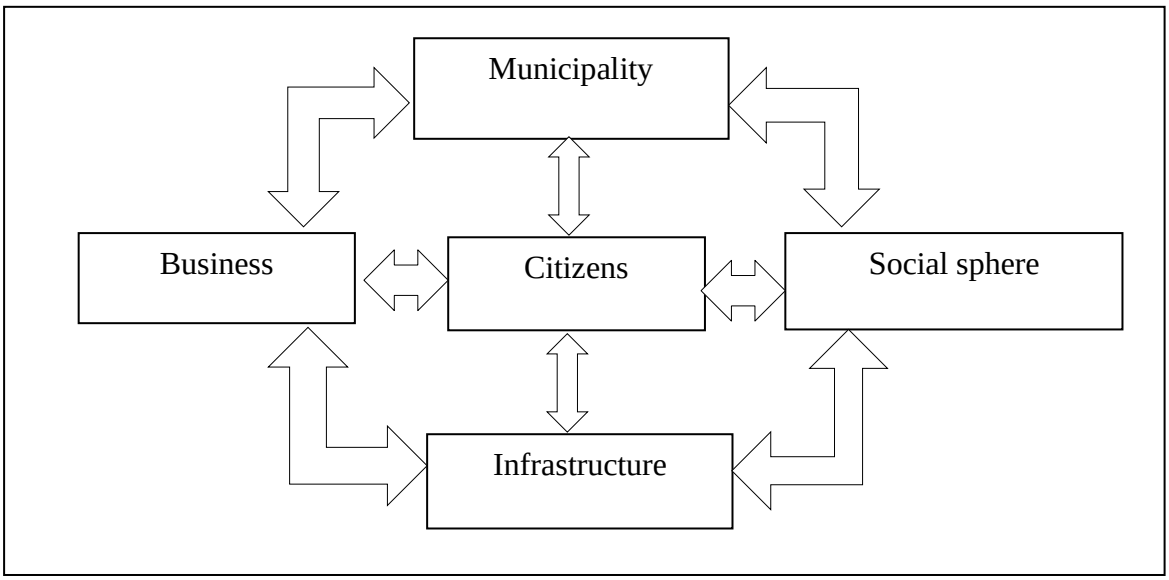

Fig. 2.3. Smart city management system

In a smart city, all stakeholders participate in management. Moreover, the initiative of various subjects is not simply welcomed: private businesses, citizens, public organizations, educational and cultural institutions, infrastructure units, etc. In general, effective mechanisms are created for their participation in the city management process. These are opportunities to discuss various projects, and opportunities to take the initiative and implement one's own projects, and control over the implementation and management of projects. In addition, information and communication technologies make it possible to develop software tools that actually replace individual government services. Thus, the collective intelligence (which is the personification of the synergistic interaction of all stakeholders) together with the active penetration of modern technologies forms and becomes the basis of the new quality of the city.

Collective management involves the interaction of all participants of a local entity in order to increase the comfort of living and the quality of life. One of the most successful examples can be called the Smart-city development strategy of Amsterdam (Netherlands), where the combination of interests of all active participants creates a

specific ecosystem within which business structures, research institutions and laboratories, authorities, and city residents unite to reduce the level of carbon emissions gas In total, the program includes more than 30 projects, which include both business projects and innovative ideas, among which separate areas of implementation are defined, for example: smart life, smart society, economy, databases, mobility, infrastructure, etc. All initiatives in these areas should be tested and approved in small regions and then spread to other areas of the city, in particular, this applies to educational activities regarding the wise use of energy, water and other resources. Among the initiatives for the introduction of smart management are "Climate Street" and "West Orange", which are aimed at the use of smart meters and the spread of energy-saving technologies[95].

In general, it is worth understanding that the concept of "smart city" involves the use of innovative technologies and their integration into already existing ecosystems, including management. The key goal is to simplify life for all residents and guests of the city. For example, the Ministry of Transport and Communications of Finland, together with the Innovation Funding Agency Tekes, launched a special program within the concept of Mobility as a Service (MaaS)[96]. As part of this, a separate application is designed to solve all transport problems, looking for opportunities and options to get to the right place on different types of transport, with the possibility of paying for services through the application. This application integrates taxis, shared car rides, city bikes, city buses, rail vehicles. It is planned to expand such initiatives to the possibility of buying special tickets that will allow you to pay for all types of transport at once, or be used as a season ticket or a special account. The Finnish Federation of Taxi Owners and the VR railway company are already implementing such solutions in their operations[97]. Actually, the program itself began its

[95] Amsterdam Smart City. *Amsterdam Smart City official website.* 2014. URL: http://amsterdamsmartcity.com/about-asc.
[96] Finland's Mobility as a Service Legislation. 2022. URL: https://www.nordicpolicycentre.org.au/mobility_as_a_service_legislation_in_finland
[97] Arias-Molinares and García-Palomares. The Ws of MaaS: understanding mobility as a service from a literature review. *International Association of traffic and Safety Sciences Research*. 2020. URL: https://www.sciencedirect.com/science/article/pii/S0386111220300455

implementation in 2015, but today a significant regulatory and legal framework for the implementation of this service has already been developed [98].

The work of such transport integrators can be scaled to the international level, the possibilities of implementation and integration into the system of international transport, such as air and sea transportation, the possibility of joining transport engaged in the transportation of mail or goods, the possibility of using car sharing are expanding. This, in turn, leads to a combination of opportunities for managing the city, time, transport and reducing the level of environmental pollution, implementing Smart & Clean solutions, which contributes to the development of the bioeconomy and environmentally friendly technologies within the framework of digitalization. The key directions of such a project are intelligent low-carbon transportation and increasing the level of mobility, increasing the level of environmentalization, intellectualization and the level of energy security in cities, increasing the level of efficiency of water use and the use of resources in general.

It is important to note another feature of the realization of a smart city. Encouraging "reasonableness" from citizens, business, academic and public sectors also allows to solve the issue of financing to some extent. A fairly common problem for social, environmental and other projects is the lack of financial resources, which cannot always be provided by state funding. Crowdfunding allows you to connect local business and the public community to finance projects important for the development of the city.

The smart city of the third wave "uses not only technological "sensors", but also people as "smartivists" and living "sensors" of the environment. So encouraging the growth of smart minds who can anticipate this third wave and take urban challenges into their own hands is key to driving innovation now. This will ensure that human ideas and experiences can influence not only the current smart city strategy, but also the movement into the future[99].

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[98] Future Mobility Finland. The Act on Transport Services – Mobility is a Service. 2022. URL: https://futuremobilityfinland.fi/cases/the-act-on-transport-services-mobility-is-a-service/

[99] Redefining the smart city concept: a new smart city definition. 2017. URL: https://hub.beesmart.city/en/strategy/towards-a-new-smart-city-definition

The modern and dynamic phenomenon of smart cities is rapidly developing and taking on new forms. Moreover, this evolution also in turn confirms the inevitability of the constant process of intellectualization, the growing importance of the human factor as the bearer of intelligence. World practice provides rich experience in the implementation of smart cities. Moreover, each city is unique, as it develops and creates its own history based on its capabilities, mental and cultural traditions. Nevertheless, the general trend is the strengthening of the role of people, important humanitarian and ecological values in the management and implementation of the smart city project. This is manifested in the increasing involvement of citizens in the processes of city management, the forms of this participation are becoming more and more diverse. Such a situation allows us to talk about the formation of the collective intelligence of the city as an effective force for managing its development on the basis of environmental sustainability and sustainability.

The allocation of cities to a separate entity of the smart economy is an important trend of modern global development. At the same time, the trend of highlighting the most active players - leading cities or global cities that have entered the global arena relatively recently - becomes evident. Urbanization and the formation of the global financial space in general lead to a change in the role of large cities in globalization processes. Large cities occupying a favorable geographical position (especially on trade routes) increased their activity in the market, which led to their designation as separate subjects of economic relations and acquired the features of a financial center.

In the concept of smart economy, the most active players in modern scientific literature are the leading cities that entered the global arena relatively recently. Urbanization and the formation of the global financial space in general lead to a change in the role of large cities in globalization processes. Large cities occupying a favorable geographical position (especially on trade routes) increased their activity on the market, which led to their designation as separate subjects of economic relations and acquired the features of a financial center (Table 2.3).

There is no unambiguous interpretation of the financial center, but such new entities are actively researched, for example, by the Z/Yen agency, which publishes its

reports together with the City of London Corporation and the China Development Institute, and within the framework of their work, financial centers are designated as "international centers with full services that have modern settlement and payment systems support large national economies. The sources of funds are diverse, and the legal and regulatory framework is sufficient to preserve the integrity of the principal-agent relationship."[100].

Table 2.3

Financial Center Performance Indicators (GFCI)

Evaluation indicators	Характеристика
Business environment	Level of corruption and rule of law, data protection, taxation, macroeconomic environment, institutional and regulatory environment, political stability
Human capital	Security, safety and human rights, labor market flexibility, education and development, quality of life
Taxation	It is important for new businesses that tax rules should be harmonized at the international level
Reputation	Reputation as a good and safe place to live is extremely important, level of innovation, cultural diversity, attractiveness, competitive position relative to other centers
Infrastructure	Air transport, ICT infrastructure costs are increasing, building infrastructure, sustainable development
Development of the financial sector	Financial infrastructure, insurance companies, debt level, availability of capital, economic return, market liquidity, etc.

Source:[101]

London is one of the most active financial centers, followed by New York. However, the economic efficiency of functioning of global cities is not the only measure of their competitiveness in the global economy. Thus, financial indicators, indicators of human capital development, quality of living in cities, etc. are considered as separate factors. (see table 2.3).

It is worth noting that not only indicators of its presence are used to assess the human capital index of a global city, but also opportunities for recreation, attendance at cultural events, the health care system, real estate suitable for living, infrastructure

[100] The Competitive Position of London as a Global Financial Centre. URL: http://www.zyen.com/PDF/LCGFC.pdf
[101] The Global Financial Centres Index 28 September 2020. https://www.longfinance.net/media/documents/GFCI_28_Full_Report_2020.09.25_v1.1.pdf

support, transportation, in general, quality of life parameters are determined with a weight of 4.30 points within the range of 3.89-5.37[102].

According to the 2020 assessment, New York occupies a leading position in almost all criteria (Table 2.4).

Table 2.4

Distribution of TOP-15 leading cities by rating categories 2020 (GFCI) *[103]*

Rank	Business environment	Financial center development	Infrastructure	Human capital	Reputation
1	New York	New York	New York	New York	New York
2	London	London	London	London	London
3	Hong Kong	Hong Kong	Tokyo	Shanghai	Singapore
4	Geneva	Luxembourg	Singapore	Singapore	Hong Kong
5	Chicago	Singapore	Hong Kong	Hong Kong	Tokyo
6	Singapore	Paris	San Francisco	Frankfurt	Shanghai
7	Amsterdam	Shanghai	Stockholm	Zurich	Geneva
8	Beijing	Chicago	Beijing	Beijing	Beijing
9	Shanghai	Tokyo	Shanghai	San Francisco	Zurich
10	Zurich	Beijing	Amsterdam	Paris	Toronto
11	Frankfurt	Los Angeles	Madrid	Tokyo	Chicago
12	Copenhagen	Geneva	Boston	Shenzhen	San Francisco
13	Tokyo	San Francisco	Vancouver	Los Angeles	Stockholm
14	San Francisco	Shenzhen	Brussels	Amsterdam	Sydney
15	Montreal	Dubai	Paris	Copenhagen	Oslo

In general, several key criteria are used to evaluate the functioning of financial centers, among them: “connections” (characterizes the level of connections of the financial center with other cities and regions of the world, is issued on the basis of assessments of specialists from other centers, if the center receives more than 63% of the assessment , then it is considered “global”, more than 42% - international); “diversity” (defined through a range of factors affecting the number and uniformity of areas of competitiveness, this component is measured through two elements: richness and uniformity, the higher the score, the higher the diversity and richness of the

[102] Global Financial Centres Index 20. URL: http://www.longfinance.net/global-financial-centres-index-20/1037-gfci-20.html
[103] The Global Financial Centres Index 28 September 2020. https://www.longfinance.net/media/documents/GFCI_28_Full_Report_2020.09.25_v1.1.pdf

business environment); “specialization” (depth and quality of areas such as investment management, banking, insurance, government and regulatory sectors, etc.). In accordance with this, the disposition of global cities is formed (Table 2.5).

Table 2.5

Disposition of global cities according to profiles, 2020[104]

Width and depth	Relatively wide	Relatively deep	Зароджується
Global leaders	**Global diversified**	**Global specialized**	**Глобальні претенденти**
London	Frankfurt	Guangzhou	-
New York	Amsterdam	Abu Dhabi	Guangzhou
Shanghai	Paris	Chengdu	Dalian
Beijing	Moscow	Qingdao	
Hong Kong	Brussels		
Singapore	Los Angeles		
Shenzhen	Dublin		
San Francisco	Seoul		
Dubai	Zurich		
Geneva	Chicago		
Tokyo			

As we can see, the list of global cities is dominated by classic financial centers, but in recent years, cities from highly dynamic Asian countries have joined the cohort of cities from highly developed countries. The rapid development of the regions led to the need to analyze the potential of regional leaders (Table 2.6).

Table 2.6

Disposition of regional (international) leading cities according to profiles, 2020 [105]

International leaders	International diversified	International specialized	International applicants
Boston	Sydney	Luxembourg	Tianjin
Washington	Istanbul	Mumbai	Wuhan
Milan	Mexico	Mauritius	Nur-Sultan
Rome	Madrid	Riga	Doha
Athens	Toronto	Taipei	
Montreal	Munich	British Virgin Islands	
Edinburgh	Vienna	Vilnius	
Bucharest		Almaty	

[104] Global Financial Centres Index 20. URL: http://www.longfinance.net/global-financial-centres-index-20/1037-gfci-20.html

[105] Global Financial Centres Index 20. URL: http://www.longfinance.net/global-financial-centres-index-20/1037-gfci-20.html

Busan		Buenos Aires	
Hamburg		Bermudas	
Tel Aviv		Panama	
Stuttgart		Nanjing	
		Cyprus	

The study indicates that a city's reputation becomes a basis for attracting additional capital, both financial and human, with London, Hong Kong and Singapore showing the most stable positions and the highest competitiveness positions, but regional (international) centers show steady trends to improve their positions, gaining high scores from both residents and non-residents[106].

Thus, the study of smart economy involves the analysis of the functioning of subjects of economic activity, taking into account development trends and forms of its manifestation.

As part of the assessment of the smart economy for various subjects, we can note the presence of key indicators, including: material income; material derivation; employment opportunities; education and training; functioning of the health care system; dwelling; access to childcare; the right to leave; decent social security; safe environment; environmentally friendly environment; lack of discrimination; access to the justice system[107].

However, there is still a lot of room for research into the essence, forms of manifestation, and indicators for assessing the development of the smart economy in general and at the level of various subjects. An important task is to determine the main indicators of the assessment of smart economy based on the peculiarities of the functioning of each individual subject of economic activity.

In general, such a specific subject of economic activity was first introduced into the theory of globalism in the works of Saskia Sassen, where we find the term "global city" precisely in the meaning of the subject of the economy[108]. In her works, the

[106] Global Financial Centres Index 20. URL: http://www.longfinance.net/global-financial-centres-index-20/1037-gfci-20.html
[107] Regional indicators of socioeconomic well-being. URL: http://ec.europa.eu/social/BlobServlet?docId=17480&langId=en
[108] The global city: New York, London, Tokyo (Princeton: Princeton University Press, 2001). Updated 2d ed., original 1991.

scientist substantiates the key differences between a metropolis and a global city, which differ in population size, the formation of agglomerations, economic indicators of activity, social opportunities, cost of living, implementation opportunities, etc.

However, the intellectual component in assessing their potential is also considered important for global cities. Various approaches take into account such indicators as, for example, the number and quality of higher education institutions (the number of universities that are among the best universities in the world, the number and quality characteristics of the functioning of world-class research centers, etc.): Global Cities Outlook - innovations; The Global Power City Index (GPCI) - developed by the Institute for Urban Strategies of the Mori Memorial Foundation (Tokyo, Japan) - includes 70 indicators in 6 dimensions: economy, accessibility, environment, convenience for life, cultural interaction, research and development (R&D), Smart City Index, City in Motion Index (SIMI) - technologies, Human Capital Index (GNI, Global Cities Index).

For example, the City in Motion Index takes into account the following indicators of human capital: the share of the population with secondary and higher education, the number of public and private schools in the city, the number of business schools in the city (which are included in the TOP-100 according to the Financial Times version; education expenditures relative to income per capita; annual expenditure on leisure and recreation relative to income per capita; expenditure on leisure and recreation as a percentage of GDP; number of foreign students; number of museums and art galleries per city; number of universities included in the QS Top 500 Universities; number of theaters per city.

The study of the essential forms of manifestation of smart economics allows us to note that the trends in the development of economic science and practice indicate a transition to a new paradigm of economic development, which is based on the harmonious combination of elements of the concept of sustainable development and technological development. The development of technologies becomes a prerequisite for the formation of a digital environment, which in turn is a platform for the functioning of subjects of economic activity and increases their level of

competitiveness. Institutionalization in global cities becomes a necessary element of coordinating the rules of operation and often goes beyond locality management, solving the issue of the development of an individual city in a global environment. In general, this complicates management, which, on the one hand, should be under national control, and on the other hand, take into account the specifics of the development of an individual agglomeration, taking into account its place on the world map. Greening and socialization find their manifestation in the formation of the elements of the environment of the global city and the quality and comfort of its functioning specifically for the community. Global cities are becoming drivers of the formation of the concept of smart economy and its practical implementation.

2.2. The phenomenon of smart cities in the world economy

Over the last decade, many ratings have appeared that try to evaluate smart cities. In general, many of them use a comprehensive approach, taking into account various aspects of the life of the city. Some ratings are implemented on the basis of objective information and statistical data, some - on the basis of surveys of the population or interested parties. Given that the annual preparation and publication of the rating is a rather troublesome and time-consuming matter, not all of them can withstand a long history. A certain barrier is the difficulty in obtaining objective information, and therefore some stop publishing after a couple of years. In addition, the COVID-19 pandemic has become a difficult test for the world, which has seriously affected both the living conditions of people and the ability to collect objective information.

For quite a long time, the problem of assessing living conditions in cities has been relevant in international analytics. Among the most famous indices of living conditions in cities are the following: “Quality of Life Survey” (Monocle magazine); The best cities to live (World’s Best Cities To Live (Global Finance)); “Global Liveability Ranking” (Economist Intelligence Unit); “Mercer Quality of Living Survey”;

Liveability Survey (Deutsche Bank); Numbeo's global database of consumer prices, crime rates, quality of health care and other indicators by city (also based on surveys).

Since 2006, lifestyle magazine Monocle has published an annual list of livable cities [109]. The main criteria in this survey are: safety/crime, international connectivity, climate/sun, quality of architecture, public transport, tolerance, environmental issues and access to nature, urban design, business conditions, proactive politics and health care.

Global Finance is a monthly English-language financial magazine that publishes a list of the World's Best Cities To Live. This list is based on a score based on eight unique factors: economic strength; research and development; cultural interaction; suitability for life; environment; accessibility; GDP per capita (nominal in US dollars); and the number of deaths from COVID-19 per million in the country.

The Economist Intelligence Unit (EIU) publishes its annual Global Liveability Ranking, which ranks 140 cities on the quality of urban life based on assessments of their sustainability, healthcare, culture, environment, education and infrastructure[110].

The American consulting company Mercer annually publishes its study of the quality of life "Quality Of Living Rankings Mercer". Its main goal is to help multinational companies in solving issues related to the possibilities and prospects of opening offices or enterprises, paying employees in different cities. The list compares 230 cities based on 39 indicators and the following criteria: political and social environment, affordability of consumer goods, housing, utilities and transportation, medicine and health care, natural environment, school and education, and recreation. New York is given a base score of 100, and other cities are rated against it[111].

In all of the above-mentioned approaches, a fairly wide range of indicators characterizing living conditions in cities is considered. At the same time, the next stage

[109] Copenhagen named Monocle magazine's best city in its 2021 Quality of Life Survey. *PRNewswire*: website. URL: https://www.prnewswire.com/in/news-releases/copenhagen-named-monocle-magazine-s-best-city-in-its-2021-quality-of-life-survey-886938304.html

[110] The Global Liveability Index 2021 / A report by the economist intelligence unit. URL: https://www.eiu.com/n/campaigns/global-liveability-index-2021/

[111] Mercer releases 2019 quality of living rankings / Global Benefits Vision. URL: https://www.global-benefits-vision.com/mercer-releases-2019-quality-of-living-rankings/

is the study of the emphasis on smart characteristics. It has already been repeatedly noted above that the practice of creating smart cities is becoming more and more widespread in the world. After 2010, more and more countries are working on the creation of smart cities, highlighting those cities in which there are the best opportunities for the implementation of the Smart-city concept. In these cities, infrastructure is being developed in the context of the basic principles of Smart-city functioning. Of course, the activity of such processes actualizes the issue of assessing their success. That is why different approaches to assessing the success of smart cities are developing in global practice.

Smart-city Index:

The International Institute for Management Development (IMD) is an independent academic institution with Swiss roots and global reach, founded 75 years ago by business leaders for business leaders. In 2017, IMD and Singapore University of Technology and Design (SUTD)[112] decided to join forces to create a smart city index that would balance measured economic, technological and humanitarian (quality of life, environment, inclusiveness) aspects of city functioning[113].

The original goal was to develop an internationally recognized global smart city index. The first edition was published in 2019, and at the moment there is already a third edition. The methodology of the Smart city Index (SCI) provides for the selection of two main pillars: Structure and Technology. Each is assessed in five key areas: health and safety, mobility, activity, capability and management.

Within the framework of the index, the issues of greening are studied quite closely, it is determined that in large cities, where the standard of living is higher in general, concern for the quality of the environment is much greater. Affordable housing is also a problem, the availability of which is assessed within the framework of the

[112] Smart City 2021: світові тренди розвитку розумних міст. Де Україна? 2021. URL: https://biz.nv.ua/ukr/experts/rishennya-dlya-zdorov-ya-ta-zruchnosti-smart-city-yak-rozvivayutsya-kijiv-ta-ukrajinski-mista-50182226.html

[113] Smart City Observatory / *International Institute for Management Development*. URL: https://www.imd.org/smart-city-observatory/home/

index, priority is also given to air quality, access to medical services, which was especially relevant during the pandemic[114].

In general, the level of satisfaction with life and the level of development of the city is assessed as a result of a survey of respondents, in which key questions are asked about health and safety, mobility, activity, employment and education opportunities, and city management. The presence of technologies designed to solve problems in various aspects of city life, or specific urban life challenges, is assessed. Also, the city population can choose several priority areas for their city from the proposed list, which have the biggest problems, need improvement, or have increased the level of citizens' trust in the city administration, including evaluating their activities in conditions of acute challenges (for example, pandemics, accidents or catastrophes). . It is worth noting that in the latest reports, which were formed during the pandemic, the issue of urban design and urban planning arose, which were not adapted to new challenges, requiring improvement and the introduction of innovative approaches to the distribution of protective equipment, the use of the medical field and its functioning, the formation of a convenient vaccination systems, etc. As a result of global challenges, it turned out that cities are quite flexible in solving global problems, in particular, their effectiveness in solving the problems and challenges of the global pandemic was higher than that of national measures. As part of the index, it was investigated that high-quality digital infrastructure and technological culture, the digital system of the city contributes to the rapid dissemination of information, and in general, there was a significant acceleration of the implementation of plans for ecological and digital transformations in smart cities.

These studies revealed features that only appeared during the pandemic, in particular, the ability to respond quickly and to be able to control the effective functioning of the city. The first places in the ranking were taken by cities that effectively and efficiently coped with the problems of COVID, among them Singapore took 1st place, Taipei (China) took 4th place, however, in the 2022 ranking, high

[114] 2021 Global Smart City Index. 2022. URL: https://www.quantumesco.it/en/2021-global-smart-city-index/

positions were taken by cities with relatively small or medium sizes, for example, 3 place was taken by Oslo (Norway), 5th place – Lausanne (Switzerland), 8th place – Geneva (Switzerland), 10th place – Bilbao (Spain)[115].

According to the report, cities that developed a sufficiently strong health care system even before the pandemic coped quite well with the challenges of isolation and vaccination, which allowed them to focus on solving other problems, in particular, affordable housing, the education system, increasing the level of digital competence.

According to the Smart-city Index evaluation methodology, each region has its own leader, which is the most competitive center for investment and talent realization, for example, New York (12th place) leads North America, Abu Dhabi (28th place) leads the Middle East, and Moscow (54th place) leads Eastern Europe. As for Latin America and Africa, the cities of these regions are mostly in the lower quartiles of the rating, the most successful examples in the region are Buenos Aires (98th place) or Cairo (104th place)[116].

In addition, the SCI is closely related to the Human Development Index, which is the main approach to measuring the sustainable development of the countries of the world. All cities rated by the SCI are divided into four quartiles (similar to the results of the Human Development Index) and within this group, each city is assigned a rating scale based on its score relative to other cities. In total, more than 100 cities are evaluated (in 2019 – 102 cities, in 2020 – 109, in 2021 – 118).

City-in-Motion-Index:

The index was developed by the IESE Business School of the Spanish University of Navarra. The index is calculated based on 10 key dimensions: governance, urban planning, public administration, technology, environment, international recognition, social cohesion, mobility and transport, human capital and economy.

According to the methodology, the main development goal of every city is to improve human capital, and the ecosystem of the city should develop in such a way as to attract and retain talent, form plans to improve the level of education and develop

[115] 2021 Global Smart City Index. 2022. URL: https://www.quantumesco.it/en/2021-global-smart-city-index/
[116] 2021 Global Smart City Index. 2022. URL: https://www.quantumesco.it/en/2021-global-smart-city-index/

innovations in the field of education. The number and share of the population with an average and higher education level (PHS) is subject to assessment; number of graduate business schools (MBARs); the flow of foreign students in each city or country (IFS); number of universities (WUR); the number of museums per 100,000 inhabitants (NM); number of art galleries per 100,000 inhabitants (NAG); and leisure and recreation (CER) expenditures. As a measure of access to culture, the number of museums, the number of art galleries and spending on recreation and leisure are considered. These indicators demonstrate the city's commitment to culture and human capital. Creative and dynamic cities around the world tend to have museums and art galleries that are open to the public and offer visits to art collections and events dedicated to art preservation. The presence of cultural and entertainment institutions in the city implies an increase in the population's spending on these types of activities.

Social unity (cohesion) is considered as concern for the social environment and requires analysis of indicators of immigration, community development, care for the elderly, efficiency of the health care system, city safety, etc. Social cohesion in an urban context refers to the degree of coexistence between groups of people with different incomes, cultures, ages and occupations living in a city. The presence of different groups in the same space, mixing and interaction between groups are key to a sustainable urban system. The key indicators in this category are the death rate per 100,000 population (DR); crime index (PI); Health Index (HCI); unemployment rate (EBU); the Gini index (GIN); and property price as a percentage of income (PPIR). This selection of indicators attempts to include all the sociological sub-dimensions that social cohesion contains. The health and future expectations of society are represented, in this case, by the ratio of deaths per 100,000 inhabitants, with the crime rate having a negative value and the health index having a positive value for this measure.

The "Economy" category includes all aspects that contribute to the economic development of territories, in particular, local economic development plans, plans for the transition and integration of the city's regions, strategic plans for the development of industry, the creation of clusters, innovative and entrepreneurial initiatives, etc.

The indicators used to reflect the economic dimension of the city's activity are: gross domestic product (GDP) in millions of dollars at constant 2013 prices; productivity measured in dollars per labor force (LPR); time required to open a business in days (TSB); ease in the regulatory plan of starting a business (EABR); number of the main office (headquarters) of listed companies (NHQ); and the early-stage entrepreneurship (TEA) rate, defined as the percentage of the population aged 18 to 64 who is a start-up entrepreneur or owner/operator of a new business (up to 42 months).

While CIMI attempts to measure the future sustainability of the world's largest cities and the standard of living of their residents using multiple dimensions, real GDP is one indicator of a city's economic power and the income of its residents, which in turn is an important indicator of the quality of life in cities . GDP is generally considered a key indicator for evaluating the effectiveness of the functioning of a significant number of economic systems, including cities. However, as part of the CIMI assessment, GDP is only one of the indicators, which is not decisive, if the city has low indicators in other economic indicators, then it is not possible to take high positions in the rating, yes, the position of a city with a high level of GDP, but with problems in the transport infrastructure, financing, production system, high level of pollution, etc., will be adjusted. The production system, which is an important element of the functioning of the city, determines local and international competitiveness, can affect the level of wages, business profits, etc. This, accordingly, can determine the quality of life in the city, opportunities for implementation, standard of living, etc.

Representative indicators measure certain aspects of a city's business environment, such as the number of public company headquarters (NHQ), the potential and entrepreneurial opportunities for city residents (TEA), the time required to start a business (TSB) and the ease of starting a business in a regulatory environment (EDB). These indicators measure a city's ability to sustainably develop over time and its potential ability to improve the quality of life of its residents. TSB and EDB indicators are included in the economic dimension with a negative value, as lower values indicate greater ease of starting a business, while NHQ and ASD have a positive relationship,

as high values of these indicators reflect cities that are ready for enterprise creation and development.

In the framework of the report, public administration is understood as closely related to the state of public finances in a city or country. In this sense, public accounts have a decisive influence on the standard of living of citizens and on the sustainability of the city, since they determine the level of present and future taxes that must be paid by people and the production system; expected increase in the general price level; potential public investment in basic social infrastructure and incentives for private investment. In fact, we are talking about the processes of decentralization of the management of funds and the possibilities of the city's development. In addition, it is worth considering that state authorities can compete with local authorities for investments, their level and quality, influencing the financial system through taxation, financial policy, etc. As part of this, the report takes into account tax-to-commercial ratio (TAX), central bank reserve level (TR), per capita reserve level (TRPC), type of government (TG), reported local government scandals Media (SC), number of embassies (NE) and number of Twitter users listed in prominent Twitter directories (NDTU). The indicator related to the taxation system (TAX), which is included with a negative effect on the value of the synthetic indicator of this dimension, covers aspects of the state of public finances. TAX measures the amount of taxes and statutory contributions paid by businesses after taking into account allowable deductions and exemptions as a proportion of business profits. This excludes taxes withheld (such as personal income tax) or those collected and remitted to tax authorities (such as value added taxes, sales taxes or goods and services taxes). The level of reserves is of great importance, which serves as a measure of the strength of state finances in the short and medium term, their ability to cope with changing economic cycles, as well as the strength and stability of the economic structure in relation to the state. The Type of Government (TG) indicator distinguishes states whose governments promote the development of sustainable cities because they have more transparent, efficient, tight and broad governance.

Local government scandals reported by the media are related to corruption, violence, crime, drugs, etc. A city with more scandalous situations is a city that is less ready to implement strategic plans for innovation and development, the level of security in this city is significantly lower, which means that its attractiveness for living also decreases. The number of embassies (NE) is an indicator of the international importance of a city by world standards and is based on the allocation of embassies to the city by foreign countries.

The number of active Twitter users with public data listed in the Twellow (NDTU) directory is those who have identified themselves as opinion leaders (eg, activists, prominent government critics, business leaders, writers, journalists, etc.). In some authoritarian countries, airing views and opinions as an opinion leader is risky, so there will be fewer critical leaders in Twitter directories. This indicator must have a positive value in order to have a positive effect on the final rating.

City management involves measuring the level of efficiency of the City Administration, developing new management models, opportunities for private initiatives, etc. The “Governance” category takes into account the ability of the population to participate in governance, the ability to attract business leaders and local influencers, as well as e-government plans and opportunities.

This indicator is evaluated through the Strength of Legal Rights Index (SLR), the Corruption Perception Index (CPI), the number of city innovation management functions (IDM) and the quality of local government web services (LGW).

The Strength of Legal Rights Index (SLR) measures the extent to which collateral and bankruptcy laws have developed to protect the rights of borrowers and lenders and thereby facilitate lending. Values range from 0 (low) to 12 (high), with higher scores indicating that laws are better designed to increase access to credit. The higher the value, the better the living conditions for citizens and companies in the city, and accordingly, the perception of the rule of law has a positive effect on the business environment and forms investment incentives. The index of perception of corruption determines the inefficiency of state intervention from the point of view of social economy. A high level of corruption becomes an obstacle to increasing the

attractiveness of the city and its competitiveness. The level of digitization of the city government is also important for both the city's residents and its guests. The higher the index, the greater the positive impact on city development, as higher values are associated with higher quality web services.

Mobility and transport are designed to determine the level of quality of movement in the city, facilitating access to public services. Therefore, traffic index (TI), inefficiency index (INIDX), number of road accidents per 100,000 inhabitants (RIA), number of metro stations per 100,000 (NS) and number of air routes (entrances and exits) that have city (NF).

Within the framework of the "Environment" category, opportunities for improving environmental sustainability, the presence of pollution control plans, support for "green" construction and the development of the system of alternative energy sources, efficient use of resources, and the presence of policies that help counteract the consequences of global climate change are explored. The indicators selected for this measure are CO2 emissions (CO2), CO2 rate (CO2i), methane emissions (MET), percentage improvement in water supply, total population with access to it (H2O); PM2.5 and PM10, as well as Pollution Index (PI) and Environmental Development Index (EPI).

Urban planning as a category of research involves the formation of local and general plans for the landscaping of the territory, the formation of spaces for public use, the acceptance of obligations to increase the level of intellectualization of the development of territories, the development of public services.

Based on the available information, indicators of this dimension are included as indicators of the quality of health infrastructure (ISF), the number of people in a household (OCC), the bicycle circulation system (BL) of the city, the number of bicycle shops per 100,000 inhabitants (NBS) and the number of architects per 100 thousand inhabitants (NA).

"International recognition" involves the formation of the city's own brand and its exit to the global level through the formation of strategic plans for the development of international tourism, the attraction of foreign investments, the presence of a

representative office abroad, etc. This sub-index includes the following indicators: international tourist arrivals (ITA); the number of passengers by airline (AEP), the number of hotels in the city (NH), the ranking of the most photographed people in the world according to SightsMap (SM) and the number of meetings and conferences taking place in the city (MIT) according to the International Association Meetings congresses and conferences. The latter is an important indicator of the city's international reach, given that these events usually take place in cities with international hotels, specially equipped rooms for such purposes, a high frequency of international flights and appropriate security measures.

And the category of "technological development" involves the development of ICT and its share in the development of the city itself or its parts, where technologies become the basis of the smart city system. Indicators selected to measure the performance of cities in terms of technological coverage and urban growth: Number of broadband Internet users per 100 inhabitants (FIS) - country-level data on the number of urban broadband users (BIU), number of IP addresses assigned to a city (NIAR), the number of companies offering Wi-Fi hotspots (NBW), the number of Facebook users per 1000 inhabitants, (NF) the number of mobile phones per capita (NMPC), the quality of municipal websites (QMW) and the Innovation Index (ICI), published by the Innovative Cities Program [117].

In general, the assessment is based on 101 indicators. This index already covers a larger number of cities (2015 – 148, 2016 – 181, 2017 – 180, 2018 – 165, 2019 – 174, 2020 – 174). City Prosperity Index (CPI), UN-Habitat - City Prosperity Index (CPI), UN - 6 dimensions and indicators: 1) State institutions. Laws and urban planning; 2) Productivity; 3) Infrastructure; 4) Environmental sustainability; 5) Justice and social inclusion; 6) Quality of life (Table 2.7). The last edition of 2016 included 333 cities from different countries of the world.

[117] IESE Cities in Motion Index. 2015. URL: https://media.iese.edu/research/pdfs/ST-0366-E.pdf

Table 2.7

City Prosperity Index indicators and evaluation indicators [118]

Constituents	Subindexes	Indicators
Productivity index	1. Subindex of economic strength (ES)	1.1 Urban product per capita 1.2 Ratio of elderly people 1.3 Average household income
	2. Economic agglomeration (EA)	2.1 Economic density 2.2 Economic specialization
	3. Employment subindex (E)	3.1 Unemployment rate 3.2 Ratio of employment to population 3.3 Informal employment
Infrastructure Index (ID)	1. Subindex of housing infrastructure (HI)	1.1 Improved shelter 1.2 Access to quality water 1.3 Access to improved sanitary conditions 1.4 Access to electricity 1.5 Sufficient living space 1.6 Population density
	2. Social infrastructure (SI)	2.1 Density of the doctor 2.2 Number of public libraries
	3. ICT subindex	3.1 Access to the Internet 3.2 Home Computer Access 3.3 Average broadband speed
	4. Subindex of urban mobility (UM)	4.1 Use of public transport 4.2 Average daily travel time 4.3 Length of mass transport network 4.4 Fatalities on the roads 4.5 Autonomy of transport
	5. Subindex of urban form (UF)	5.1 Density of intersections 5.2 Density of streets 5.3 Land set aside for streets
Quality of life (QOL) index	1. Health sub-index (H)	1.1 Life expectancy at birth 1.2 Mortality rate of children under five years of age 1.3 Vaccination coverage 1.4 Maternal mortality
	2. Education subindex (E)	2.1 Literacy level 2.2 Average duration of training 2.3 Preschool education 2.4 Net higher education enrollment ratio
	3. Safety and security sub-index (SS)	3.1 Kill rate 3.2 Level of theft
	4. Public space (PS)	4.1 Access to open public places 4.2 Green area per capita
Equity and Social Inclusion Index (ESI)	1. Subindex of economic capital (EE)	1.1 Gini coefficient 1.2 Poverty level
	2. Subindex of social engagement (SI)	2.1 Households 2.2 Youth unemployment
	3. Sub-index of gender inclusion (GI)	3.1 Equitable admission to high school 3.2 Women in local self-government bodies 3.3 Women in the local workforce
	4. Subindex of urban diversity (UD)	4.1 Structure of land use
Environmental Sustainability Index (ES)	1. Air quality sub-index (AQ)	1.1 Number of monitoring stations 1.2 PM2.5 Concentration 1.3 CO2 emissions
	2. Subindex of waste management (WM)	2.1 Collection of solid household waste 2.2 Wastewater treatment 2.3 Share of solid household waste processing
	3. Subindex of sustainable energy (WE)	3.1 Share of renewable energy
Management and Legislation Index (UGL)	1. Subindex of participation (P)	1.1 Voter turnout 1.2 Access to public information 1.3 Public participation
	2. Municipal Financial and Institutional Capacity (MFIC)	2.1 Collection of own income 2.2 Days to start business 2.3 Subnational debt 2.4 Effectiveness of local costs
	3. Urbanization Management (GU)	3.1 Efficiency of land use

In general, as we can see, there is a rather wide range of indicators, due to which

[118] Measurement of city prosperity. Methodology and Metadata. 2016. URL: https://unhabitat.org/sites/default/files/2019/02/CPI-METADATA.2016.pdf

the level of development of smart cities is assessed.

Sustainable Cities Index, ARCADIS - 3 dimensions and 48 indicators:

People sub-index (personal well-being (health, education, crime); work experience (income inequality, working hours, retention rate); urban life (transportation accessibility, digital services and other amenities)).

Planet sub-index (immediate needs of citizens (water supply, sanitation and air pollution); long-term impact (energy consumption, recycling rates, greenhouse gas emissions); investment in low-carbon infrastructure (renewable energy sources, cycling infrastructure and incentives for electric vehicles); city sustainability (exposure natural disasters and risk monitoring)).

Profit sub-index (efficiency of transport infrastructure (railway, air and traffic congestion); economic indicators (GDP per capita, employment rate, ease of doing business, tourism, position in global economic networks); Business infrastructure (mobile and broadband connection, employment rate and research of university technologies)).

The index was calculated for 100 cities in 2016 and 2018, in addition, the study was also conducted in 2022[119].

Global Power City Index (GPCI) - developed by the Institute for Urban Strategies The Mori Memorial Foundation (Institute for Urban Strategies The Mori Memorial Foundation), located in Tokyo, Japan. GPCI includes 70 indicators in 6 dimensions: Economy, Accessibility, Environment, Convenience for Living, Cultural Interaction, R&D. The index is calculated for 48 cities annually from 2008 to 2021. In general, this index evaluates the ability of these cities to attract intellectual capital, people, enterprises, investments from all over the world[120].

The "Economy" indicator includes indicators of market size (Nominal GDP, GDP per capita), market attractiveness (GDP dynamics, economic freedom), human capital (number of unemployed, employed in business support sectors), economic viability

[119] Sustainable cities index 2022. URL: https://www.arcadis.com/en/knowledge-hub/perspectives/global/sustainable-cities-index
[120] What is the GPCI? URL: https://mori-m-foundation.or.jp/english/ius2/gpci2/index.shtml

(stock market capitalization, presence of the largest 500 companies in the world), business environment (salary level, availability of qualified human resources, variety of workplace options), ease of doing business (level of corporate taxation, political, economic and business risks).

The research and development (R&D) sub-index defines indicators of scientific resources (number of scientists, presence of world-class universities), scientific ecosystem (expenditure on research, number of international students, academic presentation), innovations (number of patents, number of awarded in the field of science and technology, number of startups).

The indicator "Cultural interaction" defines quite complex indicators, for example, the possibilities of trend formation (number of international conferences, number of cultural events, export of cultural content, Art market ecosystem), tourism resources (attractions for tourists, proximity to world heritage sites, options for nightlife), cultural institutions (number of theaters, museums, stadiums), amenities for visitors (number of hotel rooms, number of luxury rooms, shopping opportunities), international interaction (number of foreign residents and foreign visitors).

Convenience for life is calculated through the working environment (number of unemployed, total number of working hours, flexibility of work style), cost of living (rental cost, price level), safety and security (number of murders, economic risks of natural disasters), well-being (social freedoms, mental health, life expectancy), ease of life (number of doctors, network availability, number of retail outlets, restaurants).

The environment is evaluated through sustainability (maintenance of the climate agreement, level of use of renewable resources, level of waste recycling), air quality and comfort (CO2 emissions per person, air quality, temperature that is comfortable for living), urban ecosystem (water quality, urban greening, satisfaction with city cleanliness).

Accessibility as a separate indicator is evaluated through international networks (availability of international flights, international cargo flows), availability of air infrastructure (number of air passengers, number of arrivals and departures from airports), intercity railway connections (availability of stations and their density, use of

public transport, time in roads to airports), comfort of transport (travel time, traffic jams, ease of movement by taxi or bicycle)[121].

In addition to the above-mentioned indices, there are also many attempts by private consulting companies, magazines and other institutions that also try to define a certain hierarchy in the leadership of cities according to their progress on the path of smart sustainable development. Such attempts include: Disruptive Technologies. The top 20 sustainable smart cities in the world[122], Networked Society City Index (company Ericsson), Global Cities Index[123] та Belt and Road Cities' Connectivity Index[124].

Smart City Strategy Index. 90 percent of all analyzed cities do not have integrated strategies, which confirms the need to work on their implementation. In total, two editions of this index were published: 2017 and 2019.

In addition to all the above-mentioned indices, some indices that do not have a long research period, but are nevertheless quite interesting from the point of view of analytics, cannot be overlooked.

Digital Cities Index - The Digital Cities Index (DCI) was developed by the Economist Impact research group with the support of (NES) Nippon Electric Company. This group has 75 years of research experience in 205 countries, resulting in analytics on benchmarks, economic and social impact analysis, official documents, forecasting and scenario modeling. One of Economist Impact's products is the Digital Cities Index, which is calculated based on four key pillars: digital connectivity, services, culture and sustainability. DCI assesses the scale and impact of digitalization in 30 global cities. The first iteration of the DCI provides a global ranking of 30 cities based on 17 indicators and 48 sub-indicators. The most efficient cities in 2022 are Copenhagen, Amsterdam, Beijing, London and Seoul, with the last two cities taking fourth place (Table 2.8).

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[121] Global Power City Index 2021. URL: https://mori-m-foundation.or.jp/pdf/GPCI2021_summary.pdf

[122] Hamza Megi. These Are The Top 20 Sustainable Smart Cities In The World. 2021. URL: https://www.disruptive-technologies.com/blog/the-top-20-sustainable-smart-cities-in-the-world

[123] Prime Global Ciries Index. URL: https://www.knightfrank.com/research/report-library/prime-global-cities-index-q1-2022-9021.aspx

[124] The Belt and Road Cities' Connectivity Index. URL: https://www.weforum.org/reports/belt-and-road-cities-connectivity-index-report/?DAG=3&gclid=Cj0KCQjw1bqZBhDXARIsANTjCPJEHsfpow7nqyk9DGNLG2INpVbjR4Ojrv0PNAh8oWCeQLuBa7MXRyMaAn4oEALw_wcB

Table 2.8

Digital Cities Index by the Economist Impact, 2022 [125]

№	City	DCI	№	City	DCI	№	City	DCI
1	Copenhagen	81.5	11	Toronto	70.1	21	Rome	61.2
2	Amsterdam	74.6	11	Zurich	70.1	22	Oakland	60.1
3	Beijing	73.7	13	Barcelona	69.7	23	Kuala Lumpur	58.2
4	London	73.6	14	Frankfurt	69.1	24	San Paolo	50.7
4	Seoul	73.6	15	Dallas	68.7	25	Bangkok	49.1
6	New York	73.3	16	Berlin	68.2	26	Buenos Aires	45.1
7	Sydney	72.6	17	Hong Kong	68.0	27	Jakarta	43.5
8	Singapore	71.4	18	Dubai	63.8	28	Mexico	42.6
9	Washington	71.2	19	Madrid	63.2	29	New Delhi	40.3
10	Paris	70.2	20	Tokyo	63.0	30	Manila	39.1

DCI's calculation combines quantitative and qualitative analysis, includes a survey of 3,000 residents of all cities, and the results provide evidence of how cities perform in terms of both quantitative indicators (such as Internet speed) and qualitative factors (such as the presence of strategies, policies and plans for such technologies like 5G and AI).

The following index has the same name (Digital City Index), which is calculated by Bloom Consulting, a global company specializing in determining national and city branding [126]. Since 2003, Bloom Consulting has developed nation branding and city branding strategies for various local and national governments around the world, working with prime ministers, presidents, mayors, tourism board chairs and investment agency directors. Every two years, Bloom Consulting publishes the brand ranking for trade and tourism, which analyzes in detail the performance of brands in almost 200 countries and territories around the world. The Place Analytics division of the company has developed an intelligent tool for analyzing and measuring the nation's digital identity - a new concept of nation and city branding[127].

[125] Digital City Index 2022. URL: https://impact.economist.com/projects/digital-cities/
[126] The State of Broadband 2020: Tackling digital inequalities A decade for action. URL: https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.21-2020-PDF-E.pdf
[127] We are a global firm that specializes in nation branding, city branding & placemaking / Bloom Consulting. URL: https://www.bloom-consulting.com/en/nation-branding

The index is used to measure the total number of searches by citizens worldwide for a specific country or city. The greater the number of requests, the greater the attractiveness of the country or city brand. Countries are ranked according to the perception of their national brand Country Brand Ranking in two aspects: tourism and trade (investment). The rating was published in 2018 and 2022. The following indexes are measured: Digital Country Index and Digital City Index. The last edition of the Digital City Index was published in 2018 and includes results for 2017. There are 136 cities in this rating, among which the TOP-30 are the following (Table 2.9):

Table 2.9

Digital Cities Index by the Bloom Consulting, 2017 [128]

№	City	№	City	№	City
1	London	11	Munich	21	Brussels
2	Barcelona	12	Zurich	22	Moscow
3	Paris	13	Lisbon	23	Istanbul
4	Berlin	14	Budapest	24	Stockholm
5	Amsterdam	15	Valencia	25	Geneva
6	Rome	16	Edinburgh	26	Nice
7	Dublin	17	Milan	27	St. Petersburg
8	Madrid	18	Copenhagen	28	Venice
9	Vienna	19	Manchester	29	Florence
10	Prague	20	Hamburg	30	Frankfurt

In general, we can note that all the analyzed indices for assessing the level of development of smart cities include a wide range of indicators that are used to assess the quality of living in the city. There are a significant number of indicators that determine these aspects, but the key aspects are the quality of human resources, safety, comfort of living, environmental friendliness, welfare indicators.

2.3. Success factors and global competitive leadership of smart cities

[128] The Digital City Index. URL: https://www.digitalcityindex.com/city-index-results

An important and interesting issue from the scientific and practical point of view is the identification of the decisive factors for the success of countries and cities on the path of advancement to the smart economy. In order to identify the impact of intellectual factors on the leadership positions of smart cities, first of all, we will define those components related to intellectual resources or the results of intellectual activity. Table 2.10 presents the main smart city assessment indices and information on those components that relate to intellectual factors:

Table 2.10

The main indices of the development of smart cities, 2020

№	Index	Number of indicators	Number of indicators characterizing intellectual factors	Number of Smart city
1	City in Motion Index	101	Human capital – 10; Technologies – 17 (26.7%)	174
2	Smart City Index	39	Mobility – 7; Opportunity – 9 (41%)	109
3	Global Cities Index	29	Human capital (30%)	156
4	Global Cities Outlook	13	Innovations (25%)	156
5	Global Power City Index (GPCI)	70	R&D – 8 (11%)	48

Source: systematized by the authors

The data in Table 2.10 make it possible to clearly see that the weight share of intellectual factors (which are related either to the quality of human capital or to technologies) ranges from 11 to 41 percent. These are actually intellectual indicators. Whereas, as noted above, intellectual factors are quite diverse and already embodied in other resources.

An important point is to determine the impact of individual factors on the final result - the city rating. For this purpose, a correlation analysis was conducted between the CIMI index rank values for 2020 and individual factors. In order to determine the degree of influence of various factors on the effective final CIMI indicator, a correlation matrix was calculated (Table 2.11).

Table 2.11

Correlation matrix of productive and factor indicators of the CIMI 2020 index

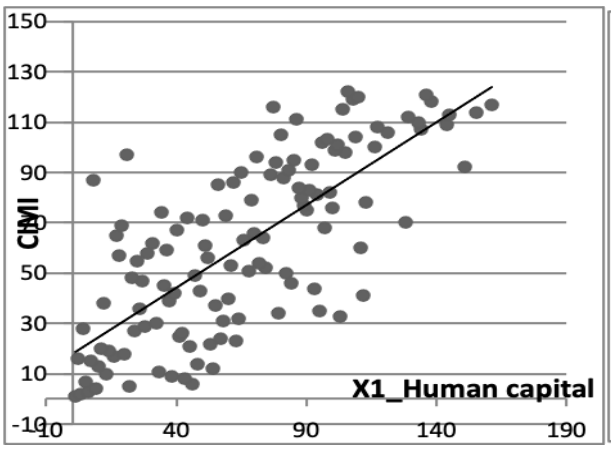
	CIMI	***X1_Human capital***	***X2_Technologies***	***X3_Governance***	***X4_Urban planning***	***X5_Economy***	***X6_Social Cohesion***	***X7_Environment***

CIMI	1							
X1_Human capital	**0,744**	1						
X2_Technologies	**0,704**	*0,512*	1					
X3_Governance	**0,712**	*0,540*	*0,510*	1				
X4_Urban planning	*0,577*	*0,515*	0,340	0,376	1			
X5_Economy	**0,714**	0,477	**0,709**	0,435	0,414	1		
X6_Social Cohesion	0,339	0,003	0,252	0,284	-0,008	0,134	1	
X7_Environment	0,326	0,023	-0,015	0,239	-0,006	-0,111	0,340	1

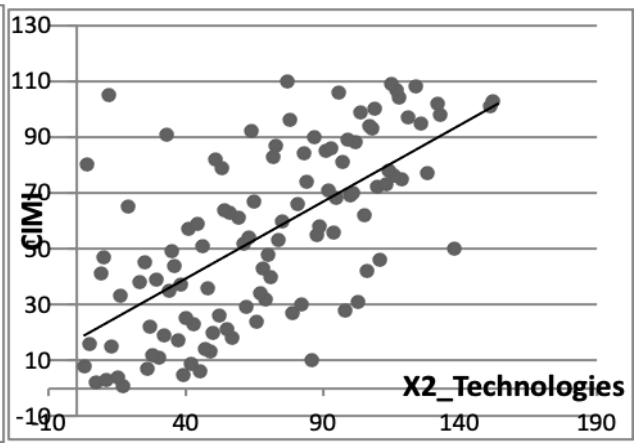
Source: calculated by the authors

According to the results of the table. 2.11 it can be seen that the effective CIMI indicator has a high correlation coefficient, i.e. the strongest linear relationship with such factors as: Human capital (0.744), Economy (0.714), Governance (0.712) and Technologies (0.704). All correlation coefficients are statistically significant according to the Student's test. In addition, a close linear relationship was found between factors such as Economy and Technologies (0.709). The economic meaning of such a value of the correlation coefficient is logical, because the economic component of a smart city cannot improve without the development of modern technologies and vice versa. This is confirmed by the scatter diagrams shown in Figure 2.4.

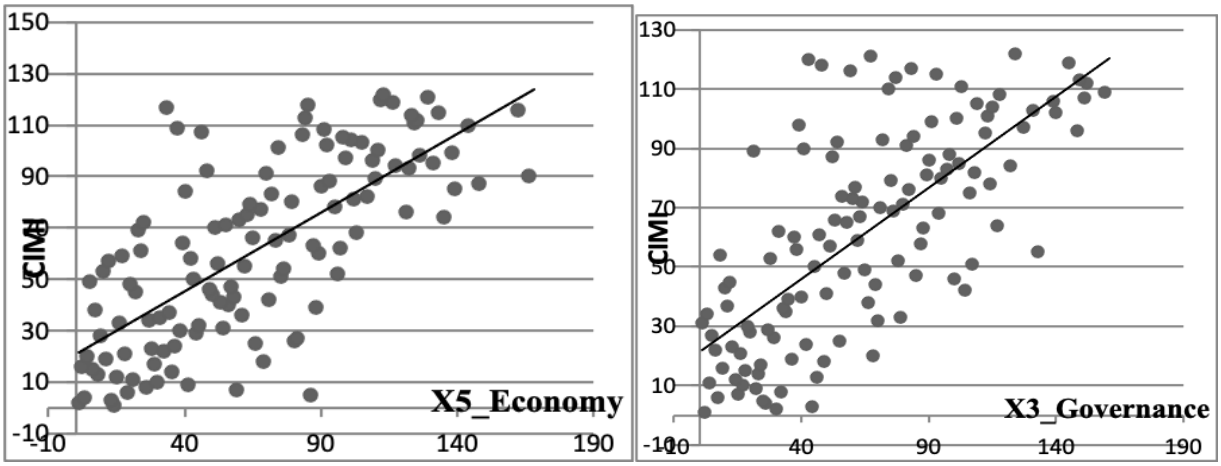
Determining rankings and leading cities is the goal of all indexes. Given that each of them has its own characteristics and focuses on different aspects of the functioning of cities, it is also interesting to analyze the ratings of cities according to various indices. In this context, it is advisable to determine the TOP 20 smart cities according to various ratings and analyze the results obtained.



a)



d)



b) c)

Fig. 2.4. Scatterplots between the 2020 CIMI index performance and its most closely related factors: Human Capital (a), Economics (b), Governance (c) and Technology (d)

Source: built by the authos

Of the entire set of modern indices, the five main indices (above) are the most common and have a certain time series. Also, for the analysis, we will take one year - 2020, for which there are data on all indices. Table 2.12 presents the obtained results.

We can observe that the list of leaders is very similar in all ratings. Among those cities that are in the TOP-20 in all five indexes are: London, Sydney and Singapore. There are four indexes: New York, Paris, Tokyo, Copenhagen, Berlin, Amsterdam, Melbourne. In three: Hong Kong, Los Angeles, San Francisco, Toronto, Zurich, Stockholm, Washington, Seoul. In two: Oslo, Chicago, Vienna, Geneva, Munich, Beijing, Shanghai, Madrid, Dubai. Of course, if you look at the entire list of the index, then most likely smart cities will have a place in almost all of them. But in this case, we are talking about the leaders - the twenty best cities.

Table 2.12

TOP-20 smart cities by main indices, 2020

№	City in Motion Index	Smart City Index	Global Cities Index	Global Cities Outlook	Global Power City Index (GPCI)
1	London	Singapore	New York	London	London
2	New York	Helsinki	London	Toronto	New York
3	Paris	Zurich	Paris	Singapore	Tokyo
4	Tokyo	Oakland	Tokyo	Tokyo	Paris

5	Reykjavik	Oslo	Beijing	Paris	Singapore
6	Copenhagen	Copenhagen	Hong Kong	Munich	Amsterdam
7	Berlin	Geneva	Los Angeles	Abu Dhabi	Berlin
8	Amsterdam	Taipei	Chicago	Stockholm	Seoul
9	Singapore	Amsterdam	Singapore	Amsterdam	Hong Kong
10	Hong Kong	New York	Washington	Dublin	Shanghai
11	Zurich	Munich	Sydney	San Francisco	Sydney
12	Oslo	Washington	Shanghai	Sydney	Los Angeles
13	Chicago	Dusseldorf	San Francisco	Montreal	Madrid
14	Stockholm	brisbane	Brussels	Berlin	Melbourne
15	Washington	London	Berlin	Boston	Beijing
16	Los Angeles	Stockholm	Madrid	Geneva	Vienna
17	Sydney	Manchester	Seoul	Luxembourg	Dubai
18	Vienna	Sydney	Melbourne	Dubai	Toronto
19	Seoul	Vancouver	Toronto	Melbourne	Copenhagen
20	San Francisco	Melbourne	Moscow	Copenhagen	Zurich

Source: systematized by the authors

The development of smart cities in the modern world takes place within the framework of the formation of a general concept of intellectualization of economic activity. The development of technologies, the formation of a new type of society are prerequisites for the development of smart cities and the formation of a new type of ecosystems. An actual issue is the possibility of developing smart cities in countries with different levels of socio-economic development. When determining the level of development of the country, we will take as a basis the data of the Organization for Economic Cooperation and Development, as well as its key partners, as countries with the highest level of development in the world and can serve as a basis for determining the level of dependence between the level of development of the country and the presence and number of smart cities.

The studied sample included countries that differ markedly in terms of socio-economic and geopolitical situation. In the scientific literature, there is a method for assessing the level of intellectualization of countries, which takes into account differences in development and according to which, all countries selected for the study are divided into 4 groups[129]. Initially, a group of rapidly developing Asian countries (China, Hong Kong, Singapore, India, the Republic of Korea) was formed. According

[129] Kalenyuk I., Tsymbal L. The impact of intellectual factors in economic development of a country: a cluster analysis. *Financial-credit activity: problems of theory and practice*. 2020. T. 3. № 34. P. 330-342. URL: https://fkd.net.ua/index.php/fkd/article/view/3065/3046

to the methodology, the rest of the countries are divided into three groups by the size of GDP per person. During the distribution of countries, the methodology relied on the results of the hierarchical agglomerative cluster analysis procedure.

According to the results of clustering, 3 groups of countries were distinguished, characterized by high (cluster 1), medium (cluster 2) and low (cluster 3) values of GDP per person. The 4th cluster includes previously selected Asian countries. The composition of each cluster is given in table. 2.13.

Table. 2.13

List of countries included in each cluster

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

Source: structured based on [130]

In general, each cluster is characterized by certain development parameters in both the static and dynamic planes. For better visualization, it is worth determining the average indicators for each cluster and showing them in dynamics. The dynamics of average values of GDP per person for each cluster is presented in Fig. 2.5.

[130] Kalenyuk I., Tsymbal L. The impact of intellectual factors in economic development of a country: a cluster analysis. *Financial-credit activity: problems of theory and practice*. 2020. T. 3. № 34. P. 330-342. URL: https://fkd.net.ua/index.php/fkd/article/view/3065/3046

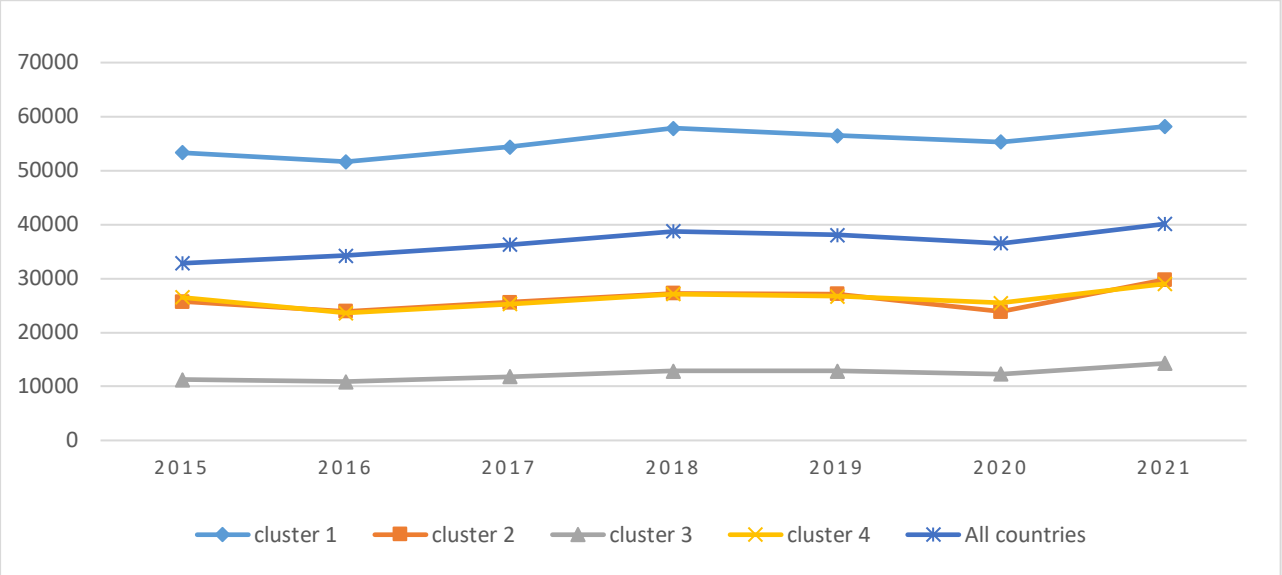


Fig. 2.5. Average values of GDP per person by cluster, USD USA in 2015-2021

Source: created by the authors based on [131]

It should be taken into account that the level of development of the countries acts as a strong basis for the formation of the smart city system. The obtained data give reason to conclude that the countries of the first cluster, which are represented by the most developed countries in the world, are characterized by the largest number of smart cities (Table 2.14):

Table 2.14

Number of smart cities by clusters

	cluster 1	cluster 2	cluster 3	cluster 4
2015	53	20	19	10
2016	57	20	17	9
2017	57	21	18	9
2018	60	25	13	6
2019	69	23	15	18
2020	68	25	16	18
2021	50	11	14	17

Source: created by the authors based on [132]

[131] World bank open data. 2022. URL: https://data.worldbank.org/indicator
[132] Smart sity index. 2022. URL: https://wwwcontent.imd.org/smart-city-observatory/home/

We can also see that the largest number of countries belong to the first cluster. However, there is no correlation between the number of countries and the number of smart cities in the cluster. However, it can be noted that the growth rate of smart cities in Asian countries is much higher than in other clusters. If for highly developed countries the level of growth has a negative value and shows a decrease in the number of smart cities (this situation is characteristic of the first three clusters), then in the fourth cluster the growth is 70% in 2021 compared to 2015 (Fig. 2.6).

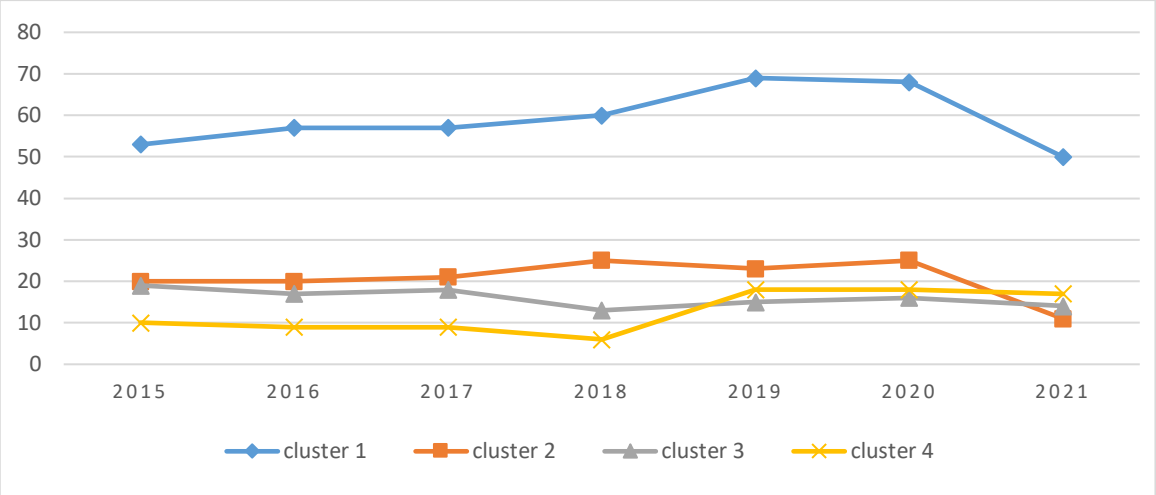


Fig. 2.6. Dynamics of the number of smart cities by clusters, 2015-2021.

Source: created by the author based on [133]

If the analysis is carried out by country, then within the framework of the clusters, the largest number of smart cities is in the countries of the first cluster (countries with the highest level of socio-economic development, world leaders), but the countries of cluster 4 (countries with the highest growth rates of welfare, Asian countries) show the greatest growth . The countries with the largest number of smart cities in 2021 combine representatives of these two clusters (Fig. 2.7).

[133] Smart sity index. 2022. URL: https://wwwcontent.imd.org/smart-city-observatory/home/

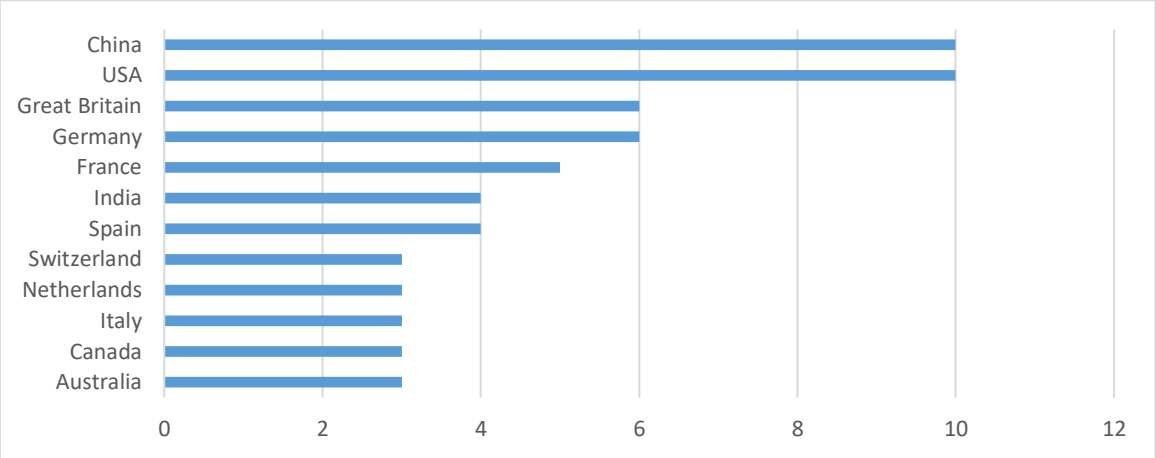


Fig. 2.7. TOP countries by number of smart cities, 2021

Source: created by the authors based on [134]

It is worth noting that China is one of the few countries that significantly increased the number of smart cities during the analyzed period. This was the result of China's purposeful digitalization and intellectualization policy. Thus, the construction of a "digital" China is one of the priorities of state policy, which contributes to the construction of a technological society, the formation of an industrial ecology, a digital economy, a digital society, deepening international cooperation, in the digital sphere, the use of digitization and technology to fight pandemics, poverty and provide digital services to the population, the formation of stable development[135]. It was also a consequence of the global coronavirus pandemic in 2020, when the world economy fell into recession and the governance system needed drastic changes [136].

Digitization provides opportunities for management in new conditions, in the conditions of the need for remote management and control. As a result of the development of the digital and information ecosystem, there was an increase in the competitiveness of the economy in 2020[137]. Digitalization and China's digital economy are becoming an important source of innovation in economic activity, so in 2020 the

[134] Smart sity index. 2022. URL: https://wwwcontent.imd.org/smart-city-observatory/home/
[135] Shanghai's new digital infrastructure is energizing and paying dividends. URL: http://www.gov.cn/xinwen/2021-08/20/content_5632427.htm
[136] Coronavirus: How the pandemic has changed the world economy. URL: https://www.bbc.com/news/business-51706225
[137] New infrastructure creates a new engine for the digital economy. URL: http://www.gov.cn/xinwen/2021-08/21/content_5632578.htm

value of the main sectors of the digital economy was 7.8% of China's GDP [138], and revenues from software production in 2020 increased to 8.16 trillion. yuan in relation to 4.9 trillion. in 2016.

Accordingly, during the same period, the income from the production and sale of computers, communications equipment, semiconductors, electronic equipment, etc., increased significantly, from 10 trillion yuan in 2016 to 11 trillion in 2019. The big data industry has grown from 0.34 trillion yuan (2016) to more than 1 trillion yuan (2020). Key process management and R&D design digitization in key manufacturing industries overall increased from 45.7% and 61.8% in 2016 to 52.1% and 73%, respectively, in 2020. In addition, e-commerce transactions increased from 21.8 trillion yuan to 37.2 trillion yuan from 2015 to 2020, respectively. Also, during the specified period, the scale of information consumption increased from 3.4 trillion yuan to 5.8 trillion yuan, respectively[139].

In China, the fields of software development, distributed operating systems, cloud services and database formation, microcircuit design, memory technologies (flash memory 3D-NAND and DRAM), artificial intelligence technologies, display production (in 2020 China's strength in the production of TFT-LCD displays ranks first in the world), optical communications, high-quality optoelectronic chips, 25G laser chips, detector chips, auxiliary electrical chips, quantum information, etc. All these technologies have received significant development and wide distribution, making a breakthrough in China's economic and technological development and forming the prerequisites for the development of technologies for providing smart cities and their operation. Quantum information technologies and the production of supercomputers are also used to form the smartmist digital ecosystem, where China shows quite good results in the world ranking and occupies 45% of the world market[140]. In addition, the formation of a smart ecosystem is facilitated by the unified operating

[138] China's digital economy sees continued growth. URL: http://english.www.gov.cn/archive/statistics/202103/25/content_WS605be874c6d 0719374afb663.html
[139] Shanghai's new digital infrastructure is energizing and paying dividends. URL: http://www.gov.cn/xinwen/2021-08/20/content_5632427.htm
[140] China continues to claim most supercomputers on Top500 list. URL: http://www.xinhuanet.com/english/2019-06/17/c_138150718.htm

system (UOS) and mobile smart terminal operating system “Hongmeng OS”, intelligent voice recognition, cloud computing, etc.[141].

Significant volumes of digital public services are aimed at the formation of a digital government, which becomes the basis for the modernization of the national management system. In this area, China also advanced quite significantly from 65th place in 2018 to 45th place in 2020 according to the e-Government Development Index[142]. This was the result of the formation of a national integrated public service platform, which was connected to 31 provinces, 46 departments of the State Council and 400 million users.

It can be noted that the level of technological development, digitalization and, in general, the level of socio-economic development can affect the level and quality of the formation of smart cities. The number of smart cities to some extent depends on the level of socio-economic development of the country, but the analysis shows that recently Asian countries have become quite active in the smartization of urban development, which prioritize the technologicalization of the economy as a whole and the formation of smart cities as a certain enclave of technology accumulation and the formation of a certain plan of technological clusters, an example of which can be the Chinese policy for the development of a digital country.

[141] Huawei releases the innovative operating system HarmonyOS 2. What is the future of the Hongmeng ecosystem in the era of Internet of Everything? URL: https://www.breakinglatest.news/business/huawei-releases-the-innovative- 89 operating-system-harmonyos-2-what-is-the-future-of-the-hongmeng-ecosystemin-the-era-of-internet-of-everything-_equipment/

[142] UN E-Government Survey 2020. URL: https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-GovernmentSurvey-2020

CHAPTER 3
METHODOLOGY FOR THE FORMATION OF A GLOBAL SMART ECONOMY ECOSYSTEM

3.1. The nature of the interrelation between green and smart economies

The modern era of social development is characterised by an unprecedented increase in the role of knowledge and attention to social and environmental issues. Greening, as an increase in humanity's attention to environmental issues, is an important trend in modern global development.

Greening is implemented in the system of ensuring ecological and economic interests, ensuring the integrity of natural systems, environmental protection, etc. Moreover, this trend is manifested not only in the declaration of important principles and goals, but is becoming an integral part of all various types of social activities. When implementing any economic, social, or business projects, consideration of the environmental context is increasingly becoming a mandatory norm.

In the international community, environmentalisation is known as "greening", and there are different approaches to its understanding. The term was first used in 1970 in Charles Reich's book The Greening of America. In fact, he meant this concept much more broadly than attention to the environment. Nevertheless, at the beginning of the 21st century, the term was picked up and began to be widely used both in scientific literature and in the media.

The Earth Summit, held in Rio de Janeiro, Brazil, in 1992, was a crucial turning point in the growing attention to environmental issues. As a result, the governments of 178 countries adopted the Declaration on Environment and Development and the Statement of Principles on Sustainable Development. The same year, the Commission

on Sustainable Development was established. Since then, there have been many important global events that have consistently promoted the ideas of sustainable development and environmental protection in politics and economics at various levels. Following 20 years of the conference, a new conference, Rio+20, was held in Rio de Janeiro in 2002, bringing together leaders of countries, thousands of representatives of the private sector, NGOs and other groups. Together, the summit developed a strategy for how to reduce insecurity, promote social justice and ensure environmental protection in a sustainable manner. Countries have outlined the following ways to address these challenges: - Transition to a greener economy, with a focus on poverty reduction.

- Protecting the oceans from overfishing, the destruction of marine ecosystems and the negative impact of climate change.

- Rational urban development and creation of more favourable living conditions in cities.

- Increased use of renewable energy sources, which will significantly reduce carbon emissions and indoor and outdoor pollution, while promoting economic growth.

- More effective forest management offers a range of benefits - halving deforestation by 2030 will avoid the estimated $3.7 trillion in climate change costs from greenhouse gas emissions, even before considering the value of jobs and income, biodiversity, clean water and medicines provided by forests.

- Improving the way water is conserved and managed to promote development and protect against desertification [143].

In 2008, the United Nations Environment Programme (UNEP) launched the Green Economy Initiative (GEI), a programme of global research and country-level assistance designed to encourage policymakers to support green investments. At the UN General Assembly in 2015, UNEP published “Charting the Path to an Inclusive Green Economy”. The document emphasises concepts such as sharing, circularity, cooperation, solidarity, resilience, opportunity and interdependence.

[143] United Nations Conference on Sustainable Development (UNCSD) – Rio+20. URL: https://web.archive.org/web/20120718211632/http://www.un.org/en/ecosoc/about/uncsd-rio.shtml

Over the past decade, the concept of a green economy has become a strategic priority for many governments and intergovernmental organisations. In total, 65 countries have embarked on the path of an inclusive green economy and related strategies. By transforming their economies into a driving force for sustainability, these countries are poised to address the major challenges of the 21st century - from urbanisation and resource scarcity to climate change and economic instability.

The UNEP defines a green economy as one that improves human well-being and social equity while significantly reducing environmental risks and environmental distress. It has been determined that the green economy includes three main concepts: low-carbon, resource-efficient and socially inclusive development. In a green economy, employment and income growth is driven by public and private investment in infrastructure and assets that reduce carbon emissions and pollution, increase energy and resource efficiency, and prevent biodiversity loss[144].

As a result of the hard work to implement a green economy, the concept of an inclusive green economy has emerged. An inclusive green economy is an economy that improves human well-being and creates social justice while reducing environmental risks and resource scarcity. An inclusive green economy is an alternative to the current dominant economic model, which exacerbates inequality, promotes waste, causes resource scarcity and poses widespread threats to the environment and human health. This is an opportunity to advance both sustainability and social justice as a function of a stable and prosperous financial system within a finite and fragile planet. It is a pathway to achieving the 2030 Agenda for Sustainable Development, eradicating poverty while maintaining the environmental thresholds that underpin human health, well-being and development[145].

In its simplest terms, such an economy is low-carbon, efficient and clean in production, but also includes consumption and outcomes based on sharing, circularity, cooperation, solidarity, resilience, opportunity and interdependence. It focuses on

[144] UN Environment Programme. *Green Economy*: вебсайт. URL: https://www.unenvironment.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency/green-economy
[145] UN Environment's Green Economy Initiative (GEI) / *The United Nations Environment Programme (UNEP)*. URL: https://www.unep.org/explore-topics/green-economy/why-does-green-economy-matter/what-inclusive-green-economy

expanding opportunities and choices for national economies through targeted and appropriate fiscal and social protection policies, and supported by strong institutions specifically aimed at protecting social and environmental floors.

In his book The Economics of Climate Change, renowned economist Nicholas Stern notes "that if we do not act, the total costs and risks of climate change will be equivalent to a loss of at least 5% of global GDP now and forever. If a wider range of risks and impacts are taken into account, the damage estimate could rise to 20% of GDP or more[146].

Thus, we can trace the process of the world community's growing attention to environmental issues, which is confirmed by the growing number of events, publications, and action programmes at various levels. The emergence of the concepts of "green economy" and "inclusive green economy" in important international documents also indicates the strategic guidelines for global development. This process - the so-called "greening" - has received various definitions in the scientific and media literature.

The greening of a person or organisation means that this person or organisation is becoming increasingly aware of environmental issues; the process of accepting or becoming aware of environmental considerations; becoming more mature and less naive, especially in understanding social and political forces; any apple that has a ripe greenish-yellow skin".

In our opinion, we can talk about "greening" in a broad and narrow sense. In a broad sense, it is a process of increasingly active environmental protection; a process of beginning to pay attention to the protection of the natural environment (as defined by the Cambridge Dictionary). In a narrower sense, "greening" refers to specific actions or processes to preserve the environment, or even just "greening". The same Cambridge dictionary also defines this process as "making grass, trees and all plants greener"[147].

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[146] Stern N. Stern Review: The Economics of Climate Change. London: Grantham Research Institute on Climate Change and the Environment, 2006. 700 p. URL: http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf

[147] The Cambridge Dictionary. URL: https://dictionary.cambridge.org

In the European Commission's materials, "greening" is defined as a policy of supporting farmers to increase the production of environmentally friendly products. Farmers receive direct green payments for conserving natural resources and providing public goods to the public at non-market prices. These direct environmental payments are made if farmers comply with three mandatory rules for the benefit of the environment: diversifying crops (greater crop diversity makes soils and ecosystems more resilient); maintaining permanent pastures (pastures support carbon sequestration and protect biodiversity (environment)); setting aside 5% of arable land for areas beneficial to biodiversity (ecological priority areas (EFAs), such as trees, hedges or land left fallow), which improves biodiversity and habitat[148].

Regarding the first point, the requirement for crop diversification, farms with an arable land area of more than 10 hectares must grow at least two crops, while farms with an area of more than 30 hectares must grow at least three crops. The main crop cannot occupy more than 75% of the land. There are exceptions to the rules, depending on the specific situation. For example, farmers with a large share of pastures, which in itself is environmentally beneficial. As for the support for pastures, the ratio of permanent pastures to agricultural land is set by EU countries at the national or regional level (with a 5% flexibility margin). In addition, EU countries define areas of environmentally sensitive permanent grassland. Farmers cannot plough or convert permanent grassland in these areas. The last point requires that farmers with more than 15 hectares of arable land must set aside at least 5% of their land for ecologically oriented areas in order to conserve and improve biodiversity[149].

The green economy is seen as a way to achieve sustainable development. It requires a shift away from a resource-intensive growth model, a transformation of consumption and production towards a more sustainable model, and an increase in value added and reinvestment in resource-rich developing countries. To achieve a

[148] Rational land use (greening) / *Agriculture and rural development*.URL: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/greening_en
[149] Rational land use (greening) / *Agriculture and rural development*.URL: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/greening_en

green economy, policymakers should strategically reorient consumption, investment and other economic activities towards a green economy:

1) Reducing carbon emissions, increasing energy and resource efficiency, preventing the loss of biodiversity and ecosystems, including efficient, low-impact development of technologies, buildings, transport infrastructure; investment in renewable energy; application of the life cycle approach; promotion of environmental goods and services; sustainable sourcing of materials; maintenance and restoration of natural capital consisting of land, soil, forests, fresh water, oceans, marine resources, wild fauna, flora and other components of biodiversity;

2) improving access to energy, food, clean water, biological resources, sanitation, public health and health care systems, new jobs, labour protection and social security systems, ICT, training and education, including education for sustainable development and promotion of sustainable consumption [150].

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focused on "making natural values visible". Its main goal is to incorporate the values of biodiversity and ecosystem services into decision-making at all levels. It aims to achieve this by following a structured approach to valuation that helps decision-makers recognise the wide range of benefits provided by ecosystems and biodiversity, demonstrate their values in economic terms, and incorporate these values into decision-making[151].

In the context of the general trend of greening, a term for a new understanding of growth has also emerged - green growth. Green growth is also defined as a policy that ensures "environmentally sustainable economic progress to promote low-carbon socially inclusive development"[152]. The study of the essence and factors of green growth is devoted to the works of scientists [153].

[150] Working towards a Balanced and Inclusive Green Economy / *A United Nations System-wide Perspective*. URL: https://issuu.com/christinadianparmionova/docs/working_towards_a_green_economy
[151] The Economics of Ecosystems and Biodiversity (TEEB). URL: http://teebweb.org/
[152] Greengrowth. URL: http://www.greengrowth.org/index.asp.3OECP(2011a) (
[153] Jänicke M. Green growth: From a growing eco-industry to economic sustainability. *Energy Policy*. 2012. P. 13-21. URL: https://www.sciencedirect.com/science/article/abs/pii/S0301421512003503

At the start of the new century, national and international efforts are intensifying to promote green growth as a new approach to increasing sustainable wealth. In 2009, the OECD, which promotes an integrated approach to addressing interconnected global challenges, launched its work on green growth as a way to address some of the world's most serious problems. In June 2009, the Ministerial Declaration on Green Growth was signed by all OECD countries, confirming that it is possible to achieve both greening and growth at the same time. The Towards Green Growth (GGS) strategy (OECD, 2011a) was endorsed by OECD ministers in May 2011. It suggests that green growth can unlock new sources of wealth by encouraging greater efficiency and productivity of natural resources, innovation and new markets for green technologies, goods and services[154].

Thus, greening is considered a tool for achieving sustainable development and poverty eradication. It is clear that the green economy concept is at the heart of the global community's efforts to integrate environmental and social considerations into economic decision-making. The UNEP calls its green economy activities one of its "key contributions to the Rio+20 process and the overall goal of fighting poverty and ensuring a sustainable 21st century" (UNEP (2011b)).

The growing attention of the international community to solving the problems of greening and environmentally oriented economic development is manifested in numerous initiatives, programmes and real actions, as evidenced by the above examples. In our opinion, the further development of the green economy concept is its inclusion in a broader perception within the framework of understanding the realities and essence of the smart economy. The latter embodies a type of economy in which increased intellectualisation is accompanied by digitalisation (spread of digital and other new technologies), a combination of economic and environmental interests, ethical and cultural values, and the inclusion of all these important goals in management at various levels.

[154] Green Growth and Developing Countries / OECD. Consultation Draft. URL: https://www.oecd.org/development/environment-development/50559116.pdf

This is confirmed by the spread of comprehensive indices and indicators in international analytics that measure the degree of development of the green economy in the overall context of the smart economy. In today's world, not only environmental aspects of the economy are becoming important, but also the parameters of comfortable living and well-being characteristics.

It should be noted that most approaches to assessing the development of the green economy also include indicators related to other aspects of life. Moreover, it is most likely in combination with such parameters as social issues, social inclusiveness, etc. that the degree of green economy development can be assessed. For example, the Green Economy Progress Index measures gender equality, education, life expectancy, well-being, etc. Another index, the Green Growth Index, measures the performance of governments in achieving sustainable development goals, including four key aspects: efficient use of resources, protection of natural resources, opportunities for environmental initiatives, and social inclusion. The Green Growth Index is determined for each region separately, including five geographical regions - Africa, the Americas, Asia, Europe and Oceania[155].

Thus, different methods of assessing the development of the green economy have their own characteristics: key aspects, target focus, and a set of indicators. All of this once again confirms the growing importance of various aspects of greening for the modern development of the global economy.

Greening is becoming a major trend in modern political activity, first at the global level and then at the level of national governments. The international practice of government support for the environmental orientation of all country activities is becoming increasingly diverse and large-scale. The introduction of economic incentives influences the greening of investments and the production of goods and services in general. This, in turn, shapes a new nature of demand - consumption of goods and services with an environmental component. Consumers are becoming more

[155] Green Growth Index. URL: http://greengrowthindex.gggi.org/#cover

interested not only in the general and technical characteristics of products or services, but also in their impact on human health and the environment.

The chain reaction goes on to form an environmentally conscious public opinion and mentality. This has a wide range of manifestations in economic, public, social and other activities. And most importantly, environmental guidelines must penetrate people's psychology, and environmental awareness must be formed among all segments of the population and business entities. Environmentally oriented consumer behaviour must also be formed, when important values include conservation and economical use of resources in both production and consumption, transition to renewable energy sources, proper waste disposal, etc. An important aspect of the overall process of greening is that all its manifestations are made real by the capabilities of the latest technologies, including information and communication technologies, nanotechnologies, biotechnologies, etc.

Based on the analysis of key indices for assessing the greening of economic activity, we can note that the European Union is the centre of the leading countries. The basis for the greening of economic activity is Articles 11 and 191-193 of the Treaty on the Functioning of the European Union, which declares the mandatory integration of environmental protection policy into the activities of national governments and the EU as a whole, which is the basis for the formation of sustainable development policy. Article 191 declares the basic rules for conducting economic activity with due regard for basic environmental standards. In particular, it defines the principles of pollution prevention, elimination of the consequences of environmental disasters and accidents, the polluter pays principle, defines air and water quality parameters, waste management and disposal policy, etc. In general, Article 192(2) defines the key priorities of environmental policy, including the taxation system, land use, resource use, energy market structure, water use, urban planning[156].

In general, we can say that the European Union has rules for concluding environmental agreements, their formats and standards on an international scale, in

[156] Consolidated version of the Treaty on the Functioning of the European Union. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A12012E%2FTXT

particular, such provisions are set out in the Lisbon Treaty. In addition, developed countries have a wide range of approaches to environmental protection that cover all aspects of environmentally conscious consumption. General programmes that cover a significant part of environmental issues include:

- - 7 the European Union's environmental action programme;
- - strategies for the transition to a competitive low-carbon economy (until 2050).

The first programme is aimed at protecting and preserving the natural resources of the European Union, reorienting economic activity to new environmental standards, increasing resource efficiency, environmental friendliness, reducing carbon use, protecting the population from environmental disasters and threats related to the environment, safety of the place of residence, clean air, access to water, its quality, etc..

In accordance with the strategies for the transition to a low-carbon economy, the goals of reducing emissions by 20% and increasing investment in environmental and energy-efficient technologies and production (planned growth of 1.5% of GDP per year, which is more than EUR 270 billion of investment) have been set. It is believed that such investments will pay off by reducing energy costs and healthcare costs (in particular, energy costs are expected to be reduced by EUR 175-320 billion per year, while savings on healthcare costs are projected to be up to EUR 88 billion)[157].

In addition to general policies and programmes, the European Union has separate programmes that focus on specific aspects of greening economic activity. These include programmes aimed at

- sustainable consumption and production;
- ensuring air quality;
- regulation of the use of various chemicals in the chemical industry;
- regulation of waste management;
- circular economy;
- land use, forestry;
- level of funding for environmental projects;

[157] Roadmap for moving to a competitive low-carbon economy in 2050. URL: https://ec.europa.eu/clima/sites/clima/files/strategies/2050/docs/roadmap_fact_sheet_en.pdf

- sustainable financing.

For example, separate Corporate Social Responsibility (CSR) strategies have been developed. These Strategies are defined within the framework of Directive 2014/95/EU, which regulates the activities of companies employing more than 500 people and requires them to publish reports on non-financial performance, such as the company's policies and measures to protect the environment, respect for human rights, social responsibility and awareness, and anti-bribery and anti-corruption measures[158]. In addition, the EU regulations define key aspects, recommendations and standards for disclosure of information on environmental activities and social responsibility measures[159].

In terms of sustainable consumption and production policy, we also include the Environmental Management and Audit Scheme (EMAS), which regulates environmental labelling and standards, in particular, EU Regulation 2017/150520 regulates the information contained in the EMAS annexes in relation to the ISO14001 standard. This standard regulates quality management systems at enterprises and includes environmental standards and working conditions[160].

In general, the eco-labelling system includes not only standardisation of production quality. The General Regulation on Environmental Labelling was adopted in 1992, and according to this document, household goods, paper and textile products, household chemicals, tourist accommodation, and fuels and lubricants are all regulated and labelled[161].

In addition, European Union Directives regulate the energy efficiency of various appliances and buildings in general[162], as well as energy labelling (in particular,

[158] Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups Text with EEA relevance. URL: https://eurlex.europa.eu/legalcontent/EN/TXT/?qid=1568651553866&uri=CELEX:32014L0095

[159] Communication from the Commission — Guidelines on non-financial reporting. URL: https://eurlex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A52017XC0705%2801%29

[160] The EU Eco-Management and Audit Scheme. URL: https://ec.europa.eu/environment/emas/index_en.htm

[161] Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel. URL:https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32010R0066

[162] Environment, consumers and health protection. URL: https://eurlex.europa.eu/legalcontent/BG/TXT/PDF/?uri=CELEX:32010R0066&from=en

Regulation 2017/1369)[163]. A separate part of the regulatory documents concerns environmental design and energy efficiency design of large household appliances (boilers, televisions, etc.). енергетичне маркування (зокрема, Регламент 2017/1369)[164].

In addition, environmental regulation also defines public procurement regimes, the so-called "green public procurement", according to which governments and public authorities are obliged to purchase only products with a higher level of environmental friendliness and low pollution. For example, the Public Procurement Directives (2014) define and regulate public procurement in accordance with the Single European Act[165]. A total of 21 lists of criteria for public green procurement have been defined within the European Union, including for the transport sector, construction, insulation materials, gardening, office equipment, cleaning products, etc. In general, such programmes are mainly defined within the framework of national action plans, in particular innovation plans or environmental innovations.

Regulation of environmental activities in developed countries also defines standards for the use of chemicals, regulation of their production, etc. (REACH)[166]. In general, these Directives define the specifics of the operation of enterprises that manufacture or use chemicals, these rules apply to both exported and imported products, even if export and import activities are carried out outside the European Union.

Chemical pollution also includes the issue of packaging and labelling of chemicals and hazardous substances, which is generally regulated under EC No. 1272/2008[167]. However, it is worth noting that the EU Regulation is globally

[163] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/. URL: https://eur-lex.europa.eu/eli/reg/2017/1369/oj
[164] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products. 2009. URL: https://eur-lex.europa.eu/legalcontent/EN/ALL/?uri=celex:32009L0125
[165] Directive 2014/23/EU of the European Parliament and of the Council of 26 February 2014 on the award of concession contracts. URL: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32014L0023
[166] Understanding REACH. 2020: website. URL: https://echa.europa.eu/regulations/reach/understanding-reach
[167] Globally Harmonized System of Classification and Labelling of Chemicals. URL: https://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html

harmonised with the global Globally Harmonised System of Classification and Labelling of Chemicals.

The next block of regulatory documents governing environmental standards, regulations and labelling relates to the use of resources, their efficiency, waste management, zero waste production, etc. It is worth noting that within the framework of the Europe 2020 strategy, 7 key initiatives have been separately identified, including the Resource Efficient Europe initiative[168], and the Road to Energy Efficiency in Europe initiative[169], which set medium- and long-term development goals and implementation of resource efficiency goals, reduction of the amount of resources used while maintaining overall production volumes, transition to and formation of a "closed-loop" or zero-waste economy, where all resources can be recycled. Within this area, the Action Plan for the Transition of the Economy to a Closed Loop has been developed[170], which identifies priority sectors that can implement this programme most easily and quickly, or currently have the highest level of environmental pollution. In particular, these sectors include the processing of plastics, food waste, biomass, biological products, raw materials, installation and dismantling of buildings, etc. In total, fifty-four key measures have been identified that include and cover the entire production cycle, as well as the rules for dealing with production waste in the secondary raw materials and recycling market.

The concept of "closed-loop production" creates its own ecosystem of waste management (both production and households), for example, in highly developed countries it is prohibited to export hazardous waste and store it on the territory of the country (for example, this rule is regulated by the European Union or the OECD). At the same time, this rule also prohibits the export of such substances to less developed

[168] EUROPE 2020. A strategy for smart, sustainable and inclusive growth. URL: https://eurlex.europa.eu/legalcontent/EN/TXT/?qid=1568194157849&uri=CELEX:52010DC2020

[169] Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions / Roadmap to a Resource Efficient Europe. URL: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A52011DC0571

[170] Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions / Closing the loop - An EU action plan for the Circular Economy. URL: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A52015DC0614

countries, and they are subject to disposal[171]. In this regard, an amendment to the 2014 Regulation was adopted, which recommended strengthening the inspection of illegal waste transport. Separate directives regulate the disposal of specific wastes that require careful handling and specific disposal conditions, for example, Directive 86/278/EEC is aimed at protecting soils from slag, etc.[172], Directive 96/59/EC regulates the control of the disposal of polychlorinated biphenyls and polychlorinated terphenyls, with the key objective of phasing out the use of these substances [173], Directive 2011/65/EU aims to restrict the use of certain substances in the manufacture of electronics and electronic or electrical products [174].

Another set of Directives relates to land use and natural capital, and includes:

- Our life insurance, our natural capital: an EU biodiversity strategy to 2020[175].
- An Action Plan for nature, people and the economy (2017 p.)[176].
- A new EU Forest Strategy: for forests and the forest-based sector [177].

The main goal of the Biodiversity Strategy is to introduce legislation aimed at protecting nature, preserving biodiversity, increasing the use of green infrastructure, managing natural resources, sustainable fishing and agriculture, preserving forests, etc.

The Nature Action Plan defines key measures for biodiversity strategies, including mapping and ecosystem assessment, including through the accounting of environmental services, and similar criteria are set out in the Biodiversity Strategy.

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[171] Regulation (EC) No 1013/2006 of the European Parliament and of the Council of 14 June 2006 on shipments. URL: https://eur-lex.europa.eu/legalcontent/EN/ALL/?uri=CELEX%3A32006R1013

[172] Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture. URL: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31986L0278

[173] Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls. URL: https://eurlex.europa.eu/legal-content/GA/TXT/?uri=CELEX:31996L0059

[174] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. 2011. URL: https://eurlex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A32011L0065&qid=1605463666049

[175] Communication from the commission to the european parliament, the council, the economic and social committee and the committee of the regions / Our life insurance, our natural capital: an EU biodiversity strategy to 2020. URL: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A52011DC0244

[176] Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions / An Action Plan for nature, people and the economy. URL: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=COM%3A2017%3A198%3AFIN

[177] Communication from the commission / A new EU Forest Strategy: for forests and the forest-based sector. URL: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A52013DC0659

The European Union's strategy on forest cover or forest resources is focused on preserving forest cover, reducing deforestation, the document sets out criteria for reducing deforestation and its scale within the European Union, such criteria are set by 2030, in particular, for example, reducing deforestation by 50% compared to 2008.

The next block of Directives and documents relates to the financial aspect of environmental activities, in particular the financing of eco-projects or eco-activities, including the LIFE Programme and the documents of the High Level Expert Group on Sustainable Finance (HLEG).

In particular, the LIFE Programme, for example, for the period 2014-2020, used a budget of EUR 3.4 billion[178]. This programme is intended to focus only on financial support for the environment. In addition, financial support for environmental projects is also provided under the Horizon 2020 Development Programme, for example, the EU Framework Initiative allocates 35% of the budget for the period 2021-2027 to research related to climate, environment, etc. Thus, climate research receives more than €11 billion in funding under this programme[179].

For the period 2014-2021, the programme allocated €77 billion, including €135 million for research on plastics and their processing, €132 million for the development of new generation battery technologies, storage devices, etc., and €206 million for the development of green energy technologies and their implementation[180].

The Sustainable Finance Programme, developed by the Expert Group on Sustainable Finance (HLEG), sets out general recommendations for a sustainable financial system that supports the functioning of the environmental sector[181]. All the recommendations identified by the Expert Group underpin the Sustainable Finance Action Plan developed and adopted in 2018.

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[178] LIFE programme. *European Commission*. URL: https://ec.europa.eu/easme/en/life

[179] EU Environment and Climate Change Policies. Policy Department for Economic. *Scientific and Quality of Life Policies*. 2019. URL: https://www.europarl.europa.eu/RegData/etudes/STUD/2019/638428/IPOLSTU(2019)638428_EN.pdf#page=17&zoom=100,0,852

[180] EU Environment and Climate Change Policies. Policy Department for Economic. *Scientific and Quality of Life Policies*. 2019. URL: https://www.europarl.europa.eu/RegData/etudes/STUD/2019/638428/IPOLSTU(2019)638428_EN.pdf#page=17&zoom=100,0,852

[181] High-Level Expert Group on sustainable finance. Financial Stability. *Financial Services and Capital Markets Union*. 2016. URL: https://ec.europa.eu/info/publications/sustainable-finance-high-level-expert-group_en

It is worth noting that a significant number of policies of developed countries relate not only to general aspects of greening, but also to specific activities (e.g., protection of forest cover, river basins, etc.), such as Directive 92/43/EU on the Conservation of Natural Habitats and Species of Natural Fauna and Flora[182].

As an example of the implementation of the greening policy, we can cite the Swedish state policy, which focuses on green growth and defines efficient energy supply characterised by low greenhouse gas emissions (by 2050) among its plans. The key instruments are information, regulatory and market instruments aimed at ensuring the implementation of a balanced policy of economic growth, smart economy, and diverse development. At the same time, Sweden also defines the possibilities of public participation in the management of environmental projects, for example, Directive 2003/4/EC and Directive 1367/2006 define the possibilities of public access to environmental project management and environmental information, in addition, the Aarhus Convention on Access to Information defines the possibilities of public participation in environmental justice, which corresponds to the concept of Smart City 3.0.

In addition, a reasonable approach to management involves the formation of a conscious approach to the management of environmental projects at the stage of education, for example, the Swedish curricula include classes on the environment and its preservation at all levels of education, a specific environmental code (Miljöbalken) has been formed, which, in essence, has become the basis for promoting the goals of environmental development in various sectors of economic activity[183]. Sweden actively uses Directive 2009/125/EC on environmental design, which defines key requirements for energy use in construction, and Directive 2012/27/EU, which regulates the methodology for measuring the energy efficiency of the country's facilities[184]. n

[182] Sweden's forest crimes. Euractiv. 2020. URL: https://www.euractiv.com/section/biomass/opinion/swedens-forest-crimes/

[183] The Swedish Environmental Code. 2000. URL:https://www.government.se/contentassets/be5e4d4ebdb4499f8d6365720ae68724/the-swedish-environmental-code-ds-200061

[184] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. URL: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=celex%3A32012L0027

accordance with certain directives, specific taxes on carbon emissions, energy use, fuel, vehicles, etc. are established to stimulate environmental improvements (for example, in the cities of Stockholm and Gothenburg, vehicles are taxed based on their CO2 emissions, technical characteristics and compliance with car standards)[185]. In addition, Sweden has fairly high taxes on carbon dioxide emissions and provides special subsidies for the use of alternative energy sources, provided that greenhouse gas emissions are reduced and energy efficiency is increased. It is worth noting that a similar attitude to environmental projects is typical for all Nordic countries (Norway, Finland, Denmark, Sweden and Iceland), where the Nordic Eco label operates as a voluntary environmental labelling, according to the level of environmental impact of products and goods, taking into account all stages of the product's life cycle and use[186].

However, it is worth noting that such labelling applies not only to polluting emissions, but also to the consumption of various products. For example, WWF regulations define the specifics of labelling fish as a food product, and accordingly, products are labelled green, yellow or red. Red labelling indicates endangered fish species, yellow - those that are under threat, and green - the most common fish species. Thus, consumers are provided with information about the products they consume and, accordingly, the opportunity to make choices based on environmental approaches[187]. However, in Sweden, this programme is implemented only at the level of green and yellow labelling, as after working with retailers, it was decided to refuse to sell fish with red labelling.

Northwest European countries also follow a similar policy, for example, Germany has put the concept of sustainable development at the heart of its national development strategy[188]. Germany's national strategy is based on an equitable distribution of resources between generations, social cohesion, responsibility (including internationally) and quality of life. In general, a comprehensive approach to

[185] Vehicle Tax Calculation and Payment in Sweden. Carfax. URL: https://www.carfax.eu/article/vehicle-tax-sweden
[186] The official ecolabel of the Nordic countries. URL: http://www.nordicecolabel.org/the-nordic-swan-ecolabel/
[187] Seafood species from wild-capture fisheries / *WWF*. URL: https://wwf.panda.org/get_involved/live_green/out_shopping/seafood_guides/methodol ogy/
[188] Perspectives for Germany – Our Strategy for Sustainable Development / *The Federal Government*. URL: https://www.bundesregierung.de/breg-en/issues/sustainabi lity/the-strategy-214722

the formation of economic activity is based on the principles of sound management and includes economic performance, environmental protection and social responsibility. In Germany, special institutions have been created for this purpose, including the Council for Sustainable Development and the Parliamentary Advisory Council. Accordingly, environmental tax reform has been implemented, which gradually increases taxes on fossil fuels and energy resources[189].

In general, we can note that the developed countries of the world are formulating a targeted sustainable development policy focused on the synergistic participation of all economic actors and their active cooperation, which would generally make it possible to comply with the key principles of environmentalisation and socialisation. As we can see, developed countries are guided by a significant number of documents that regulate and standardise the activities of companies, households, individuals and the state as a whole.

Greening is becoming a key trend in modern global development. Since the end of the twentieth century, the principles and values of environmental protection have not only been declared, but have increasingly penetrated the management and activities of various entities. Environmental values are becoming decisive in political, economic, public and social activities. They are increasingly taken into account when making investments, conducting production activities, shaping consumer demand, and general environmentally oriented awareness and consumer behaviour. An important tool for promoting greening is the latest technologies that create the necessary opportunities and tools for this.

3.2. Implementation of the ecosystem approach in the global economic development model

[189] Kohlhaas M. Gesamtwirtschaftliche Effekte der ökologischen Steuerreform. *DIW Berlin.* 2005. URL: https://www.ecologic.eu/sites/files/download/projekte/1850- 1899/1879/1879_2_gesamtw.pdf

The green economy, as part of the implementation of the smart economy, currently requires state support and the development of balanced approaches to the greening of economic activity at various levels. The formation of such a policy involves taking into account the specifics of governance at different levels: at the state, local and individual enterprise levels. Such decisions may involve implementation in the political sphere, forming a certain investment climate that can promote the interest of each economic actor in complying with environmental standards or principles of economic activity in the most environmentally friendly world. Each country chooses measures, mechanisms and instruments in accordance with its own characteristics and needs, taking into account the realities of the functioning of both localities and enterprises. A vertical structure of greening economic activity is being formed as part of the key tasks of establishing a smart society. Developed countries implement quite successful practices of greening economic activity at various levels of government, including at the level of public policy, and identify the specifics of implementing the experience of greening the functioning of localities and enterprises. Adaptation of plans for the development of the environmental component of economic activity to the specifics of each economic entity requires the priority development of general implementation plans, as specific measures should be implemented within the framework of key trends and issues of global development.

The study of the peculiarities of environmental protection, the concept of sustainable development, green growth, green economy is carried out in the works of foreign and domestic economists A. Boven, I. Gaidutsky, D. Pierce, N. Stern, M. Janicke, etc. In particular, the issues of forming a new type of economy in the general context of global social development are studied, but the issues of forming a vertical structure of greening economic activity at different levels of government are not addressed.

The formation of environmental awareness, a holistic ecosystem approach that can be implemented at all stages of economic and business activity is becoming a priority in the context of the formation of a smart society and smart economy. Each

country pursues its own interests based on its needs and capabilities, developing mechanisms and tools that can ensure the country's development in the context of sustainable development.

A balanced policy is formed at different levels of governance, which is caused by the need for a systematic approach and, accordingly, the possibility of implementing a holistic concept of environmental development as one of the key elements of a smart society.

The Austrian environmental policy strategy is implemented at the level of ministries, departments and municipalities. In general, there is a Conference of Regional Ministers for the Environment, the Austrian Committee for Sustainable Development and the National Committee on Climate Change[190]. In Austria, sustainability policy is implemented through two key strategies that aim to integrate environmental protection and sustainable economic development policy. These key strategies include the National Sustainable Development Strategy adopted in 2002 and the Austrian Sustainable Development Strategy adopted in 2010. The first of these strategies focuses on integrating the principles of sustainable development into national policy, with 20 key goals covering various aspects of quality of life, competitiveness, environmental protection, and international responsibility. The 2010 Sustainable Development Strategy aims to create a general framework for policy-making at various levels of government and economic activity (both national and subnational - from the federal government, communities, regions to municipalities or provinces). However, some articles and provisions are duplicated in these two strategies and somewhat impede the effectiveness of sustainable development and the implementation of certain goals[191].

These strategies also define further legislative frameworks related to specific elements of economic development, such as the Green Energy Law, the Climate Protection Law, and the Energy Efficiency Law, among others. In this format, the key

[190] Climate change legislation in Austria. Grantham Research Institute. 2015. URL: https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/AUSTRIA.pdf
[191] OECD Environmental Performance Reviews: Austria. 2013. URL: http://www.oecd.org/environment/oecd-environmental-performance-reviews-austria2013-9789264202924-en.htm

goals are to increase energy efficiency by 1.5% and increase investment in electricity generation from green (renewable) sources. Fiscal policy is a popular tool for implementing sustainable development policy; the application of environmental taxes brought Austria EUR 9.6 billion, which is 57% of all tax revenues for energy, 34% of transport taxes, 8% of resource taxes, and 1% of pollution taxes. The structure of revenues from environmental taxes is shown in Table 3.1. It is worth noting that the energy tax accounts for the majority of environmental taxation, followed by the transport tax (Table 3.1).

Table 3.1.

Structure of the Austrian environmental tax, 2010-2018 [192]

Environmental taxes	2010	2011	2012	2013	2014	2015	2016	2017	2018
million euros									
Energy tax	4585	5008	5031	5093	5024	5216	5284	6640	5485
Transport tax	2265	2437	2562	2559	2875	2908	3018	3219	3295
Pollution tax	51	53	53	53	54	56	58	62	79
Resource use tax	603	615	635	653	664	682	691	708	724

In general, the amount of revenues from environmental taxes has been gradually increasing in all these categories over the period under review (Figure 3.1).

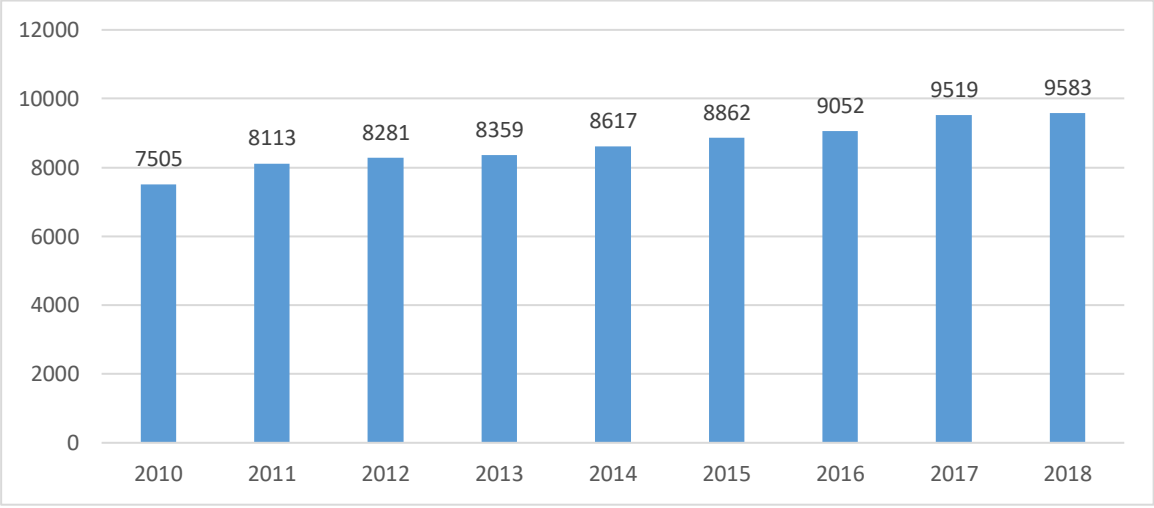

Fig. 3.1. Dynamics of revenues from eco-taxes in Austria, millions of euros, 2010-2018 pp. *i*[193]

[192] OECD Environmental Performance Reviews: Austria. 2013. URL: http://www.oecd.org/environment/oecd-environmental-performance-reviews-austria2013-9789264202924-en.htm
[193] OECD Environmental Performance Reviews: Austria. 2013. URL: http://www.oecd.org/environment/oecd-environmental-performance-reviews-austria2013-9789264202924-en.htm

The share of the pollution tax, although rather small, has been gradually increasing over the period of time. Overall, however, the level of environmental tax revenue is not indicative of an overall environmental policy or environmental awareness in Austria. The indicators can indicate both a high level of use of high-polluting products and a high level of use of low-polluting products and environmental taxation.

The key goal of Austria's strategic development is energy independence by 2050, which requires a combination of financial instruments and development models that involve smart cities and the government's overall programme[194]. At the city level, developed countries are addressing a significant number of problems that can delay or impede the implementation of long-term projects to create new innovative ecosystems, the development of which is possible through highly educated talent, high-tech industries, network development, etc.

In general, one of the key elements of the development of a smart society is the development of sustainable innovations, for example, Austria has launched the Climate and Energy Fund on Smart Cities initiative, which will promote sustainable energy, reduce greenhouse gas emissions and develop a climate strategy as part of the federal government's activities. In total, about €150 million is allocated annually for such projects, which should promote "pilot projects" to combine technical and social innovations. In general, this is being formed within the framework of the Climate and Energy Fund, whose strategic goals are to create a specific system of smart, networked and integrated solutions in cities for the sustainable development of the energy system; to create technical and social systems through the combination of energy networks, recycling systems, communications, mobility, etc.

In Austria, such projects are being implemented in Vienna (about 2 million inhabitants) and Graz (about 300 thousand inhabitants), focusing on smart city

[194] Smart cities as sustainable innovation actors. URL: https://www.zsi.at/object/news/3239/attach/0_CASI_Policy_brief_No1_Smart_Cities_As_Sustainable_Innovation_Actors_Insights_from_and_for_Austria.pdf

initiatives, in particular in terms of reducing polluting emissions, greening the energy system, increasing technological innovation, etc.

In general, the key conceptual characteristics of building a smart economy at different levels of governance are “policies and initiatives”, “sustainability”, “public participation” and “monitoring” (Table 3.2).

Table 3.2.

Characteristics of smart initiatives in different Austrian cities

City	Policies and initiatives	Sustainability	Public participation	Observations
Graz	Establishes a framework for cities to develop smart cities with the participation of their residents	Zero emissions policy in the energy sector, reducing emissions and the environmental footprint of each city resident	Involvement of city residents in the management of the city and city districts by increasing their capabilities through training programmes, briefings, etc.	Reducing emissions and introducing technological innovations
Vienna	Reducing emissions from construction and energy consumption, raising environmental awareness of the city’s residents, developing their environmental and social responsibility, and positioning Vienna as a leading environmental city in the European Union	Reducing energy costs and energy consumption, increasing the share of renewable and environmentally friendly energy sources, changing the transport system in accordance with the most stringent environmental standards, reducing the number of cars on the city’s roads, primarily through the development of a multimodal transport system	Growth in the number of environmentally conscious citizens, increased activity of the local population in the processes of managing and supporting environmental awareness, smart consumption, etc.	Focus on zero waste and zero emissions, taking into account technological innovations for the development of a smart city

Source: compiled from [195]

Thus, we can note that Austria is actively developing the concept of smart economy and smart cities, implementing greening projects at various levels of government. Denmark, which can generally claim global leadership in the process of

[195] Smart cities as sustainable innovation actors. URL: https://www.zsi.at/object/news/3239/attach/0_CASI_Policy_brief_No1_Smart_Cities_As_Sustainable_Innovation_Actors_Insights_from_and_for_Austria.pdf

economic transformation and greening, is also close to Austria in terms of its key development concept. In fact, Denmark's key achievements in this area are confirmed by the Green Development Index (Table 3.3).

Table 3.3

Green Development Index, 2019 [196]

Country	Green growth indicators				Green growth index		
	Efficient and sustainable use of resources	**Protection of natural capital**	**Opportunities for the green economy**	**Social inclusive development**	Points	Level	Rank in the ranking
Denmark	75,50	72,52	63,84	92,07	75,32	High	1
Sweden	75,79	77,26	57,96	93,70	75,09	High	2
Austria	71,57	79,56	52,27	72,32	72,32	High	3
Finland	67,36	72,25	58,86	71,69	71,69	High	4
Czech Republic	63,04	78,40	61,85	71,29	71,29	High	5
Italy	58,31	83,15	57,63	70,22	70,22	High	6
Germany	55,02	81,52	60,55	70,04	70,04	High	7
Estonia	62,02	69,31	59,12	68,50	68,50	High	8
Latvia	72,05	74,43	49,40	68,24	68,24	High	9
Slovakia	61,57	83,35	49,51	67,60	67,60	High	10

In general, at the level of public administration, Denmark is joining global trends in the transition to ecological heating, the formation of ecological energy hubs focused on the use of alternative energy sources, and the growth of investments in green technologies, etc. The key agreements in this regard are the Energy Agreement (2018), the Danish Climate Act (2020), and the Danish Climate Agreement for Energy and Industry (2020). The key characteristics of Danish state policy are defined in the Energy Agreement, in particular:

- ecological heating
- cheap green electricity;
- the impact of CO2;
- efficient use of energy;

[196] Drivimo agrobisnes schodnja. 2023. URL: https://www.kernel.ua/ua/

- energy and climate research.

Ecological heating involves increasing trends of consumers disconnecting from collective heating systems and increasing the use of heat pumps or biomass energy.

The reduction in the cost of green energy includes a reduction in the tax on:

- electric heating (from DKK 307 per kWh to DKK 155 per kWh);
- electricity (from DKK 914 per kWh to DKK 774 per kWh);
- electricity for certain freelance professions (from DKK 914 per kWh to DKK 104 per kWh).

Reducing the CO2 footprint is determined by allocating DKK 500 million for greening the transport network by 2024 and reducing carbon emissions from passenger cars by 40% by 2030.

Improving the efficiency of energy use is also one of the basic tasks of shaping Denmark's smart development, as about 100-150 thousand boilers that heat Danish homes run on dirty energy sources (in particular, fuel oil), and to reduce their number, funding of about DKK 20 million is envisaged in the period up to 2024, which primarily involves replacing them with heat pumps.

The greening of the economy programme also envisages an increase in funding for scientific and applied research on energy, environment, climate change, etc. from DKK 580 million in 2020 to DKK 1 billion in 2024.

Denmark is actively involved in the development of a green economy, including through the creation of energy islands, including the construction of two such energy islands with a total capacity of 5 GW. Wind power plants with a capacity of 1 GW are being gradually installed, which is more than 3 times the capacity of Danish power plants.

The next step in the development of the energy industry in terms of ecology is to expand opportunities for investing in green technologies (Power-to-X), which involves

the construction of power plants with a total capacity of more than 100 MW, which is more than 5 times the capacity of the largest plants in the world [197][198].

This concept envisages the possibility of storing surplus renewable electricity and converting it into other energy carriers, which can be used later to minimise the effects of energy fluctuations, both in consumption and production. Such storage is possible by converting renewable energy into hydrogen through electrolysis, and this hydrogen can either be used or stored in sealed tanks. Hydrogen (H2) does not emit CO2, which makes it possible to store it and then use it in the gas grid, but it can be methanated and used. Hydrogen can also be converted for use in fuel cells for cars and ships according to the Power-to-Liquids concept. Thus, such "green" hydrogen can be used in conventional oil refineries as a result of hydrogenation[199].

In general, the use of hydrogen can lead to the gradual decarbonisation of natural gas, which increases its attractiveness for developed countries, which is especially relevant in the context of the emerging smart economy concept. For example, gas with up to 20% hydrogen can be freely used and transported in gas networks without the risk of damage or failure. However, in the history of Germany, the United States and the United Kingdom, there have been examples of using gas with a hydrogen content of 50% through gas pipelines. In general, this method can be used both for decarbonising the energy sector and for moving or transporting hydrogen itself, which eliminates the need to build separate transport networks for pure hydrogen. The United Kingdom and the Netherlands are considering the possibility of switching to hydrogen heating systems in the regions for municipal needs. Denmark is testing a small closed natural gas network with a pressure of 3 to 65 bar, where the hydrogen content is up to

[197] Danish Climate Agreement for Energy and Industry. 2020. URL: https://stateofgreen.com/en/uploads/2020/09/faktaark-klimaaftale-English-august-14.pdf
[198] Environment, consumers and health protection. URL: https://eurlex.europa.eu/legalcontent/BG/TXT/PDF/?uri=CELEX:32010R0066&from=en
[199] Power-to-X: The concept of storing, converting and reviving power in different forms. URL: https://www.avkvalves.com/en/gain-knowledge/innovation-and-sustainability/the-concept-of-power-to-x

15%, conducted by Energinet[200]. The Netherlands has decided to invest 1 billion kroons in this project [201][202].

As a result of such a targeted policy, Denmark has 5 Danish companies in the list of the world's most sustainable companies, with 3 of them in the top 10. In general, companies are increasing the share of revenues from renewable energy by 10% in general, from 58% to 68%, and company productivity has increased by 50%.

In general, the implementation of the smart cities concept in Denmark is taking place within the framework of the association and formation of a network of smart cities (Table 3.4).

Table 3.4.

Features of smart initiatives in different Danish cities [203]

City	Policies and initiatives	Sustainability	Public participation
Municipalities of Copenhagen and Aarhus: Open access to data.	Web portals managed by the city administration	The vast majority of data on the portals is information on transport, transport infrastructure and resource management. The intention of the municipal administrations is that the data will be used by external actors to address environmental and climate challenges in cities. The project shows potential sustainable solutions that can be achieved by making the information available to the public/external stakeholders/experts/entrepreneurs	By sharing information/data generated by municipalities, the platforms create opportunities for citizens to engage in urban planning projects
Smart Cities Network	The experience of networked Smart Cities is formed on a single portal [204]		

It should be noted that the formation of a smart city system is part of the system of managing the development of the smart economy at all levels, where management

[200] Power-to-X: The concept of storing, converting and reviving power in different forms**.** URL: https://www.avkvalves.com/en/gain-knowledge/innovation-and-sustainability/the-concept-of-power-to-x
[201] Danish Climate Agreement for Energy and Industry. 2020. URL: https://stateofgreen.com/en/uploads/2020/09/faktaark-klimaaftale-English-august-14.pdf
[202] Environment, consumers and health protection. URL: https://eurlex.europa.eu/legalcontent/BG/TXT/PDF/?uri=CELEX:32010R0066&from=en
[203] Sinkiene J., Grumadaite K., Liugailaite-Radzvickiene L. Diversity of theoretical approaches to the concept of smart city. *Business and Management 2014*: 8th International Scientific Conference*,* May 15–16, 2014. Vilnius, Lithuania Section: Smart Development. URL: http://www.bm.vgtu.lt
[204] Smart sity index. 2022. URL: https://wwwcontent.imd.org/smart-city-observatory/home/

takes place from the national to the corporate level. Thus, green economic growth becomes effective only in the case of a systematic approach, when each element performs its functions. One of the key elements is the formation of an environmental approach within the framework of companies' operations and the introduction of innovation in the environmental aspect. Many companies from these countries are among the top companies in terms of sustainability (Table 3.5).

Table 3.5.

Ranking of the most sustainable companies in the world, 2019-2022 (TOP-20)[205]

Rank	Company	Country	Sector of economic activity
1	Orsted A/S	Denmark	Energy sector
2	Chr. Hansen Holding A/S	Denmark	Bioprocessing sector
3	Neste Oyj	Finland	Oil refining
4	Cisco Systems Inc	UNITED STATES	Communications and technology
5	Autodesk Inc	USA	Software supply (CAD)
6	Novozymes A/S	Denmark	Biotechnology
7	ING Groep NV	Netherlands	Financial sector
8	Enel SpA	Italy	Energy sector
9	Banco do Brasil SA	Brazil	Banking activities
10	Algonquin Power & Utilities Corp	Canada	Renewable energy
11	Osram Licht AG	Germany	Electrical devices
12	Sekisui Chemical Co Ltd	Japan	Plastics manufacturer
13	Storebrand ASA	Norway	Financial services
14	Umicore SA	Belgium	Development of computer technologies
15	Hewlett Packard Enterprise Co	USA	IT sector
16	American Water	USA	Utilities (water supply)
17	Iberdrola SA	Spain	Electricity supply
18	Outotec Oyj	Finland	Computer technology development
19	CEMIG	Brazil	Energy sector
20	Accenture PLC	Ireland	Consulting and outsourcing services

A significant number of companies in this ranking are from the analysed countries, six of the top ten companies in the world belong to the European Union, while the leader is the Danish company Ørsted, which implements quite innovative

[205] An index of the Global 100 most sustainable corporations in the world. *Corporate Knights*. URL: https://www.corporateknights.com/reports/2020-global-100/.

solutions, including offshore wind farms, hydrogen energy, etc. Offshore wind farms involve the use of powerful wind to generate energy reserves in regions with high population density, which is made possible by increasing capacity from 20 GW to 450 GW by 2050[206] and up to 40 GW by 2030[207].

The next element of the company's activities is hydrogen energy, which converts excess water into hydrogen by electrolysis, in fact, it can replace other energy sources, which in general leads to a 91% reduction in the use of fossil fuels in 2019 compared to 2006, and total coal consumption was only 9%, which was also achieved through the closure or restructuring of coal-fired power plants (a 26% reduction, 67 plants were closed, and such plants were converted to work on the basis of sustainable biomass, wood or pellets). In general, the company also uses fossil energy sources where they cannot be replaced (about 25%) or in cases of backup fuel.

Companies also encourage eco-efficient approaches for their employees and in their operations. Within the company, emissions from employee air travel are offset by purchasing carbon credits and planting greenery. In addition, all purchased furniture is made from certified wood, old furniture is recycled and reused, and all personal computers have high energy efficiency ratings (at least Energy Star 6.1) and are transported in fully recycled packaging. Danish companies join The Climate Group's EV100 global initiative to accelerate the transition to electric vehicles for companies[208].

The second place in the ranking of the most sustainable companies is also occupied by the Danish company Chr. Hansen Holding A/S, which is working on the development of a new type of bacteria that will help preserve the freshness of food, which can be an alternative product to preservatives[209].

The third place is taken by Neste Oyj, a Finnish company that produces renewable diesel fuel made from waste and residues and offers new environmental solutions in

[206] Green energy for the planet and its people. URL: https://orsted.com/sustainability/esg-ratings-and-reporting/sustainability-report/we-can-make-green-energy-a-force-for-positive-change (дата
[207] Offshore wind. Leading the global green energy transition. URL: https://orsted.com/en/our-business/offshore-wind
[208] Carbon neutral to stop global warming at 1.5°C. *Ørsted Sustainability report*. 2019. URL: https://orsted.com/-/media/annual2019/Sustainability_report_2019_online_readable-version.pdf
[209] Sustainability Report 2018/19. *Chr. Hansen*: website. URL: https://cdn.chr_hansen.com/_/media/files/chrhansen/home/sustainability/reporting-and-disclosure/2018- 19/chr-hansen-sustainability-report-2018-19.pdf

the polymers and chemical industry. The company has set key corporate climate goals, including reducing greenhouse gas emissions and the carbon footprint of its own production. The company plans to reduce its greenhouse gas emissions by at least 20 million tonnes of carbon dioxide annually by 2030. In addition, the company advocates the formation of a specific ecosystem within the supply chain, and all new contracts are signed with suppliers who work exclusively on renewable raw materials[210].

Another company in the top performers is Novozymes, a biotechnology company that analyses the environmental impact of its operations, from the extraction of raw materials to the final disposal or recycling of products. In total, renewable energy will account for about 30% of the company's total energy consumption in 2019-2021, and the company is also developing special IT solutions for, for example, dairies[211].

ING Groep NV, a financial company, closes the top 5 countries on the list of the most environmentally sustainable companies, with an inclusive approach to creating an ecosystem to achieve the climate goals of the Paris Agreement[212], such as the Kijk vooruit forecasting tool (Netherlands) to understand the nature and eco-compliance of financial flows, EmpowerCamp (Austria, Romania) for clients and understanding of financial profiles[213].

In general, environmentally sustainable companies use fairly similar business practices (Table 4.6). Comparative analysis shows that there is no single approach to the formation of the ecosystem, in particular, that all companies do not have either an environmental code or a part of the charter that would set out the company's environmental approach. However, all companies adhere to both environmental management standards and EU environmental standards, which define the main actions and tasks of both management and employees in terms of environmental awareness and responsibility.

Table 3.6.

[210] Sustainability reports NESTE. 2019. URL: https://www.neste.com/sustainability/performance
[211] The Novozymes report 2019. URL: https://report2019.novozymes.com/#Industries
[212] We align financial markets with climate goals. The 2° Investing Initiative. URL: https://2degrees-investing.org/about-us/
[213] Sustainable development goals. ING. 2019. URL: https://www.ing.com/Sustaina bility.htm

Summary of social and corporate practices of the world's key sustainable companies[214]

CSR practices	Orsted A/S	Chr. Hansen Holding A/S	Neste Oyj	Novozymes A/S	ING Groep NV
Development and availability of an environmental code or part of the company's charter	+	-	+/-	-	-
Increased taxation for the use of fossil energy resources	+	+	+	+	+
Formation of a package of eco-goods or eco-services	+	+	+	+	+/-
Implementation of EU eco-standards	+	+	+	+	+
Availability of criteria for personal responsibility or reduction of the negative impact of company employees	+	+	+/-	+/-	+/-
ISO 14000	+	+	+	+	+/-
Environmental labelling	-	+	+	+	-
Strategy for reducing carbon dioxide emissions	+	+/-	+/-	-	-

The formation of an ecosystem at all levels of government is a very important task for every country. After all, both state authorities, local governments and companies play a significant role in greening the economy. In order to achieve a full transition to such an ecosystem, it is necessary to develop a balanced state policy aimed at forming an integrated system that combines the elements of the work of each of the participants or economic entities. In order to achieve an effective transition to a green economy, corporate practices are being developed that should be consistent with broader social and environmental issues. The development of such a strategy involves identifying the capabilities of the company and the national economy to go green.

3.3. The digital landscape of the smart economy

[214] Sustainable development goals. ING. 2019. URL: https://www.ing.com/Sustaina bility.htm

The unprecedented spread of information and communication technologies (ICTs) is fundamentally changing not only the technological basis but also the entire system of economic relations in society. The tremendous acceleration of all transactions transforms all interactions, mechanisms and tools for implementing economic activities. The increased focus on environmental and social issues has already required new technologies to manage all related processes in a smart way. The dependence of the socio-economic development of countries on technological and innovative factors rather than on resources makes digitalisation processes particularly relevant for each country.

In view of this, it is extremely important to study the processes of ICT diffusion, the emergence of the smart economy, and the architecture of the modern world and the country's position in it. For each country, an important goal is to ensure and improve its competitive position in the global economic environment. The perception of all ICT-related innovations in all spheres of economic and personal life of the population is becoming a requirement of the times for each country.

In the context of the widespread use of ICTs, their penetration into all spheres of society, and the growing globalisation trends, the study of the processes of country development in the new social context is an urgent issue of economic science and practice. It is an axiom that the success of countries' development depends on technologies and the latest means of using resources. Being an effective participant in the global environment is possible only if the most advanced technologies are used and turned into an indispensable element of everyday life. In fact, this is becoming an important and indispensable stage in the formation of the smart economy.

Analytical studies of digitalisation processes have intensified significantly since the beginning of the new century. Analysing the extent of the spread of information and communication technologies in the economy is one of the most pressing issues in modern international economic research. Measuring the role of ICTs in social development was the subject of discussion at the World Summits on the Information

Society held in Geneva (World Summit on the Information Society - WSIS 2003) and Tunis (WSIS 2005). The Geneva Plan of Action aimed to create a system of international assessment using comparable statistical indicators and analytical results.

The first World Summit resulted in the launch of the Partnership for Measuring ICT for Development initiative, which aims to improve the collection and quality of ICT data and indicators, especially in developing countries. Members of the Partnership (International Telecommunication Union (ITU), OECD, UNCTAD, UNESCO and others) are constantly working together to develop an agreed set of statistical indicators («core list»).

ITU Member States have signed up to a common vision of "an information society in which telecommunications/ICTs will enable a stronger interconnected world and accelerate social, economic and environmentally sustainable growth and development for all". Thus, the Connect 2020 goals were adopted in the context of broader socio-economic development goals, in particular, the 8 MDGs related to poverty reduction and meeting basic needs, which were agreed by the UN in 2000. In September 2015, the United Nations agreed on 17 SDGs (the Sustainable Development Goals (SDGs)), which replaced the Millennium Development Goals (the MDGs) as the international policy framework for socio-economic development and poverty reduction.

Of the 17 goals that cover an even broader range of issues, four are relevant to ICT: Goal 4 on quality of education (Goal 4b), Goal 5 on gender equality (Goal 5b), Goal 9 on industry, innovation and infrastructure (Goal 9c), and Goal 17 on partnerships for the goals (Goal 17.8). There are at least 38 other goals that rely on universal and affordable access to ICT and broadband to achieve development, including science and technology goals, internet access, infrastructure, innovation, information, efficiency, early warning, disaster risk management, knowledge and data sharing.

In response, the Broadband Commission was renamed the Broadband Commission for Digital Development to demonstrate and document the power of ICT and broadband for sustainable development.

Since then, it has become important for the international community not only to measure the processes of ICT diffusion, but also the social aspects - their impact on sustainable development, inclusion and innovation. The Broadband Commission on Sustainable Development has set key goals for 2025:

Goal 1: All countries should have a funded national broadband plan or strategy or include broadband in their definition of universal access and services (UAS).

Goal 2: By 2025, entry-level broadband services should be made available to countries with less than 2 per cent of monthly gross national income per capita.

Goal 3: By 2025, broadband Internet user coverage should reach:

1) 75 per cent globally;

2) 65 per cent in developing countries;

3) 35 per cent in the least developed countries.

Goal 4: 60 per cent of youth and adults should have achieved at least a minimum level of proficiency in sustainable digital skills;

Goal 5: 40 per cent of the world's population to use digital financial services;

Goal 6: ICT inequality in micro, small and medium-sized enterprises should be reduced by 50 per cent by sector;

Goal 7: gender equality should be achieved across all goals [215].

From 2007 to 2017, the International Telecommunication Union (ITU) annually published Measuring the information society, which analysed in detail the state of ICT development in most countries of the world and calculated the ICT development index. The ICT Development Index (IDI) is an index calculated by combining the values of 11 key indicators into a single score. It was used to monitor and compare the development of information and communication technologies (ICT) between countries and over time. The IDI was published from 2009 to 2017.

In March 2017, at an extraordinary meeting of the Expert Group on Household ICT Indicators (EGH) and the Expert Group on Telecommunications/ICT Indicators (EGTI), it was decided to expand the set of indicators to 14. However, after the change

[215] Measuring the information society 2010. International Telecommunication Union 2010. URL: http://www.itu.int/ITU-D/

in the number of indicators from 11 to 14, countries faced problems in collecting and submitting quality data. For example, to calculate the 2018 IDI, 58 per cent of the data points need to be assessed. In addition, there were problems with the consistency and quality of the data used, as well as with the methodology used to derive some of the newly adopted indicators. These shortcomings made it impossible to calculate a methodologically sound index that would reflect the true state of ICT development. Since 2018, attempts to either publish the IDI in accordance with the Plenipotentiary Conference Resolution (PP)131 (Dubai, 2018) or to develop an entirely new index have failed, as consensus could not be reached between the Expert Group on Telecommunications (EGTI) and the Expert Group on Household ICT Indicators (EGH)[216].

It is precisely because of the lack of a single agreed approach that the ICT Development Index is not currently calculated. However, the ITU collects and publishes a wide range of data on both previously defined and new indicators. The core list consisted of 41 ICT indicators related to infrastructure, access to and use of ICT at the household and enterprise levels, the ICT sector (production), and trade in ICT goods. Over time, the list has been revised and expanded to include more than 60 indicators as of June 2019. ICT is a very dynamic phenomenon that is taking on new forms of manifestation and requires new indicators for measurement. Phenomena such as the Internet of Things and Artificial Intelligence are emerging, broadband Internet is spreading, and ICT is becoming a reality in educational, medical, and financial services, participation in governance, etc. Of particular importance are not only the processes of dissemination and access to ICTs, but also the acquisition of skills required to use modern technologies. All these circumstances necessitate the expansion of the system of indicators for measuring the information society.

Broadband Internet access can be a tool for inclusive and sustainable development, facilitating access to education (e.g. through massive open online courses), access to health services (e.g. remote diagnostics, remote surgery) and

[216] The ICT Development Index / International Telecommunication Union. URL: https://www.itu.int/en/ITU-D/Statistics/Pages/IDI/default.aspx

financial inclusion (e.g. mobile banking), and facilitating environmental monitoring (e.g. meteorological measurements, humanitarian aid after a natural disaster). Skills in ICT (and other areas) underpin the effective use of ICT and are critical to harnessing the full potential of ICT for socio-economic development. Economic growth and development will lag behind potential levels if economies are unable to harness new technologies (ITU, 2009a)[217].

The core list of ICT diffusion indicators consists of 61 indicators in the following areas:

- ICT infrastructure and access (10 indicators);
- access and use of ICT by households and individuals (19 indicators);
- access and use of ICT by enterprises (12 indicators);
- ICT sector and trade in ICT goods (4 indicators);
- ICT in education (9 indicators);
- ICT in public administration (7 indicators).

Therefore, in recent years, a series of more specialised studies have been published:Measuring digital development Facts and figures (2021), Measuring Digital Development: ICT Price Trends 2021, Gender ICT Statistics, ITU's ICT SDG indicators, Connectivity in the Least Developed Countries та ін.

According to the ITU, at the end of 2009, there were 4.6 billion mobile users worldwide (or 67 per 100 inhabitants)[218], , while in 2019 they exceeded the world's population - 108 users per 100 people, and in 2021 - 110 per 100 people. In developed countries, mobile phone coverage was 135 per cent in 2021, while in developing countries it was slightly lower - 105 per 100 inhabitants - and growing at a very rapid pace: in 2005, only 23 per cent of the population of this group of countries used mobile phones. In the world's least developed countries, there are 76 mobile users per 100 inhabitants[219].

[217] Manual for Measuring ICT Access and Use by Households and Individuals, 2020 Edition / International Telecommunication Union. URL: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/manual.aspx
[218] Measuring digital development. Facts and figures 2019. *ITU Publications.* URL: https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2019.pdf
[219] Measuring digital development. Facts and figures 2021. URL: https://www.itu.int/en/ITU-D/Statistics/Documents/facts/FactsFigures2021.pdf

The expansion of fixed mobile broadband networks has had a significant impact on the global economy over the period 2010-2017. Studies have found that a 1 per cent increase in fixed broadband coverage results in an average increase in gross domestic product (GDP) of 0.08 per cent. This impact is attributed to economies of scale, whereby the economic impact of fixed broadband is higher in more developed countries than in less developed ones (ITU, 2018a)[220] (Table 4.7).

Internet access is spreading, with a sharp increase since the start of the pandemic. In 2009, only 24 per cent of the world's population (1.7 billion people) used the Internet, including 64 per cent in developed countries and 18 per cent in developing countries. By 2019, this number had grown to 4.1 billion people, or 54 per cent of the world's population, and in 2021 it was already 4.9 billion, or 63 per cent of the population, including 90 per cent in developed countries and 47 per cent in developing countries, and 27 per cent in the least developed countries. Also, on average, 65.7% of households in the world have access to the Internet at home, with 87.8% in developed countries, 57.8% in developing countries, and 22% of households in least developed countries [221].

Table 3.7.

ICT access indicators by country, 2009 - 2020[222]

Country	ICT access indicators									
	Fixed telephone lines per 100 inhabitants		Mobile phone users per 100 inhabitants		Internet users (%)		Share of households with computers		% of households with Internet access	
	2009	2020	2009	2020	2009	2020	2009	2020	2009	2020
Sweden	57,8	16,0	118,3	128	91,0	94,54	87,1	-	84,4	96.1
Luxembourg	54,2	43,0	147,1	142	87,31	98,82	82,8	94.0	80,1	93.6
Korea	44,3	47,0	94,7	138	81,6	96,51	80,9	71.6	94,3	91.8
Denmark	45,6	16,0	125,7	123	86,84	96,55	85,5	77.7	81,9	92.5
Netherlands	44,3	29,0	124,8	125	89,63	91,33	87,7	91.1*	86,1	93.8*
Iceland	61,6	31,0	108,6	123	93,0	99,0**	91,9	97.0	87,7	96.0
Switzerland	64,1	34,0	118,0	126	81,3	93,15**	80,6	93.0	78,0	91.6
Japan	38,0	49,0	86,7	152	78,0	92,73**	85,9	74.6	79,8	96.9

[220] Measuring the information society 2016. International Telecommunication Union 2016. URL: http://www.itu.int/ITU-D/

[221] Measuring digital development Facts and Figures 2021 / *International Telecommunication Union.* URL: https://www.itu.int/itu-d/reports/statistics/facts-figures-2021/

[222] Measuring the information society 2016. International Telecommunication Union 2016. URL: http://www.itu.int/ITU-D/

Norway	39,8	6,0	110,2	107	92,08	97,0	85,8	95.0	84,0	96.1
United Kingdom	54,2	47,0	126,3	116	83,56	94,82	78,0	87.5	71,1	95.2
Finland	31,1	4,0	128,8	129	82,49	92,17	75,8	88.9	72,4	91.1
USA	49,6	31,0	86,8	134	71,09	89,43**	72,5	83.1	62,5	86.6
Russia	31,8	19,0	141,1	164	29,0	84,99	40,0	72.1	30,0	80.0
Ukraine	**28,7**	**8,0**	**121,1**	**129**	**17,9**	**70,12****	**21,2**	**66.2**	**10,3**	**65.8**
China	25,5	13,0	47,9	118	28,9	70,64	31,8	-	18,3	-
Hong Kong	58.7	52,0	165.9	292	69.04	92,41	74.6	75.3	70.9	93.9

* 2013
**- 2019

Internet access is spreading, with a sharp increase since the start of the pandemic. In 2009, only 24 per cent of the world's population (1.7 billion people) used the Internet, including 64 per cent in developed countries and 18 per cent in developing countries. By 2019, this number had grown to 4.1 billion people, or 54 per cent of the world's population, and in 2021 it was already 4.9 billion, or 63 per cent of the population, including 90 per cent in developed countries and 47 per cent in developing countries, and 27 per cent in the least developed countries. Also, on average, 65.7% of households in the world have access to the Internet at home, with 87.8% in developed countries, 57.8% in developing countries, and 22% of households in least developed countries[223].

Table 3.8 presents data on the population's access to ICT in selected countries. It is noteworthy that the provision of fixed telephone lines has a steady downward trend in all countries; among the leading countries, only Hong Kong exceeds 50 (52 per 100 people), while in Ukraine it is 8.0, Finland 4.0, and China 13.0. In terms of mobile phone users, Ukraine (129 people per 100 people own a mobile phone) is at the level of advanced countries, where from 116 (UK) to 152 (Japan) and 292 (Hong Kong) people use mobile phones. Ukraine is lagging behind in terms of households' ownership of computers (66.2 vs. 72 to 98.5 in the leading countries) and Internet access (65.8 vs. 85.3 to 99.7).

Between 2008 and 2019, Ukraine has significantly improved its position in terms of ICT use. For example, the number of Internet users in Ukraine increased

[223] Measuring digital development Facts and Figures 2021 / *International Telecommunication Union.* URL: https://www.itu.int/itu-d/reports/statistics/facts-figures-2021/

significantly from 10.6 to 70.12 per 100 people, but this is much lower than the level of advanced countries: in Japan, it is 92.73, Iceland - 99.0, Norway - 97.0, Finland - 92.17, and the United Kingdom - 94.82 (see Table 3.7). In general, it can be concluded that in terms of access to and use of ICTs, Ukraine is approaching the world's leading countries, but lags far behind in terms of better services provided by the capabilities of modern information and communication technologies[224].

The spread of ICTs among the population and households is the first level, the basis for analysing a country's involvement in digitalisation processes. Next, it is important to analyse the resources and opportunities for implementing ICT in the economic environment. The resources identified as necessary include the level of ICT penetration in global trade flows. The dynamic development of the knowledge-intensive products sector is clearly observed in the structure of production, the structure of R&D expenditures, the structure of world trade.

As for the latter, the share of knowledge-intensive and technology-intensive products is the most significant in commodity trade and provides value added worth USD 24 trillion, which is almost a third of global GDP. Among them, commercial knowledge-intensive services, such as business, financial and information services, have the largest share (15% of GDP). Knowledge-intensive sectors such as education and healthcare are second (9% of GDP).

Since 2018, the calculation of intellectually intensive sectors of the economy has also included medium- and high-tech manufacturing industries, which include motor vehicles and parts, electrical machinery, machinery and equipment, chemicals, except pharmaceuticals, railway and other transport equipment, which account for 4% of GDP. High-tech manufacturing industries such as aircraft and spacecraft; communications; computers; pharmaceuticals; semiconductors; and instruments for testing, measuring and controlling have a 2% share, but embody the latest technologies. It is worth noting that in recent years, China has been actively increasing its participation in global ICT exports (Figure 3.2).

[224] Statistics. Developing countries less equipped to use ICTs to minimise disruption caused by coronavirus / International Telecommunication Union. URL: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/covid19.aspx

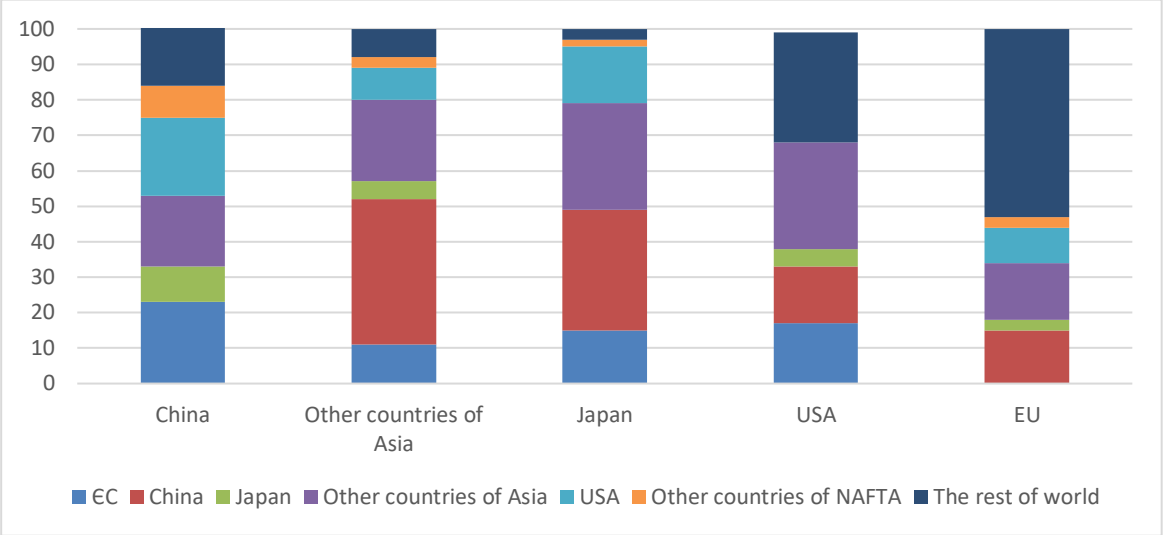

Fig. 3.2. Global exports of ICT products, by selected countries, 2016, % [225]

Chinese ICT exports dominate high-tech exports, and overall China is the world's largest exporter of ICT products. China is the centre that produces most of the world's ICT products. China's trade patterns with its main partners show its integration with other Asian manufacturers that supply components and parts. Imports from eight Asian countries - Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, Thailand and Vietnam - account for three-quarters of China's ICT imports.

However, conventional trade statistics do not measure the contribution of countries that produce ICT and other goods in global value chains. Value-added trade data, which assesses the contribution of countries to goods produced in global value chains, shows that the US, EU, South Korea and Taiwan are important sources of China's ICT imports in the form of inputs. More than half of China's ICT exports are destined for the three major developed economies: EU (23%), USA (22%) and Japan (10%). The share of China's exports to eight Asian economies is 20%, which is much smaller than its share of imports.

ICTs are rapidly becoming part of consumption, which is evident in such indicators as the number of standard, wireless and high-speed access channels per person, Internet access, the number of Internet users, etc. In general, the analysis allows

[225] Modulnye reaktory I novye tehnologii Ukraina rasskazala SSHA kak obnovit energosistemu. URL: https://biz.liga.net/ua/all/tek/novosti/modulnye-reaktory-i-novye-tehnologii-ukraina-rasskazala-ssha-kak-obnovit-energosistemu

us to conclude that information and communication technologies are part of the country's intellectual resources, as they are a product with high intellectual content. In turn, they are becoming a necessary factor in the economic development of countries on an innovative basis. At the same time, not only the production and export of ICT goods and ICT services, but also their use is characterised by unevenness both within a country and when comparing countries.

At the global level, the need to accelerate digital innovation ecosystems to ensure digital transformation is being raised. ITU research has shown that there is a growing digital innovation gap between countries. This innovation gap is at the heart of the digital divide, and many national policies and strategies - even in developed countries - often fail to bridge it. That is why the main objectives are to strengthen the capacity of countries to integrate ICT innovation into their national development programmes and to promote a culture of innovation. This mandate was further elaborated at the World Telecommunication Development Conference 2017 (WTDC-17) with the additional objective of developing "strategies that promote innovation initiatives, including through public, private and public-private partnerships". Relevant regional initiatives were included in each region[226].

Despite large investments in digital ecosystems, many countries are unable to adapt to rapidly changing digital conditions and technological revolutions. As a result, the slow digital transformation of communities affects social conditions and the achievement of national goals. Significant inequality among countries remains a problem, and bridging the digital divide is becoming an urgent issue in modern global economic development[227].

Another important approach to measuring ICT development is the Networked Readiness Index, a comprehensive indicator that characterises the level of development of information and communication technologies (ICT) and the networked economy in countries around the world. The Index was developed in 2002 and previously released

[226] ITU ICT-EYE / *ICT Data portal.* URL: https://www.itu.int/net4/ITU-D/icteye/#/topics/1001
[227] The State of Broadband 2020: Tackling digital inequalities A decade for action September 2020 / International Telecommunication Union and United Nations Educational, Scientific and Cultural Organization. 2020. URL: https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.21-2020-PDF-E.pdf

by the World Economic Forum and INSEAD as part of a special annual series of reports on the development of the global information society. In 2019, the Index was extensively revised and transferred to the Portulans Institute, a non-profit organisation that conducts this research in partnership with the World Alliance for Information Technology and Services (World Information Technology and Services Alliance).

Today, the Index is considered one of the most important indicators of the innovation and technological potential of countries around the world and their development opportunities in the field of high technology and the digital economy. The research is also used as an analysis tool to build comparative rankings that reflect how technology and people should be integrated into effective governance structures to have the right impact on our economy, society and environment. The NRI 2021 is the third edition of this updated methodological model, and it focuses on the impact of digital technologies on making the post-COVID world more equitable. The index measures the level of ICT development across 62 benchmarks, grouped into four main groups: Technology; People; Governance; and Impact.

The authors of the project assume that there is a close link between ICT development and economic well-being, as ICTs play a leading role in fostering innovation, increasing productivity and competitiveness, diversifying the economy and stimulating business activity, thereby contributing to a higher standard of living. This relationship was first highlighted at the World Economic Forum in 2001 and described in the first Global Information Technology Report. The Index is intended to be used by public and private sector leaders to analyse their policies and monitor their progress in the development of the information society (Table 3.8*)*.

Table 3.8.

Network Readiness Index of countries, 2021[228]

№	Countries	Technology	People	Governance	Impact	Index
1	Netherlands	81.74	75.18	90.23	81.10	82.06
2	Sweden	80.38	76.48	88.10	81.31	81.57
3	Denmark	76.76	79.53	90.13	78.52	81.24
4	USA	87.81	75.65	87.26	73.64	81.09

[228] Countries. Benchmarking the Future of the Network Economy. URL: https://networkreadinessindex.org/countries/

5	Finland	75.13	76.51	89.71	80.54	80.47
6	Switzerland	82.96	72.81	84.84	80.19	80.20
7	Singapore	75.80	74.75	84.74	84.77	80.01
8	Germany	80.03	75.12	84.22	76.41	78.95
9	Norway	71.88	75.27	90.88	75.94	78.49
10	United Kingdom	76.78	69.44	83.64	76.52	76.60
53	Ukraine	49.20	54.29	58.93	60.40	55.70

The calculation part of the Index is based on statistical data from international institutions, as well as the results of an annual comprehensive survey of managers' opinions conducted jointly with a network of partner organisations in the countries surveyed. In the final report, the indicators are combined into a single Network Readiness Index. When determining the place in the global ranking, all countries are ranked on the basis of this Index, where the first place in the ranking table corresponds to the highest value of this indicator, and the last place to the lowest. The final report contains detailed country profiles and a large selection of statistical tables with all the indicators used to calculate the Index.

Ensuring sustainable economic development of countries in the modern world economy is possible only on the basis of creating favourable conditions for the functioning of innovative ecosystems based on the widespread use of ICT. The smart economy is characterised by the widespread use of information and telecommunication technologies in production, management, and solving environmental and social problems at various levels. The production of new knowledge, intellectual assets as the main capital of the smart economy, and the training of highly skilled human resources are achieved through an effective education and science system. It is on these foundations that the vector of society's development is laid, which is focused on improving the quality and safety of people's lives and innovations.

The main actors in digital ecosystems include: entrepreneurs, entrepreneurship support networks, corporations, financiers and governments that integrate ICT/telecommunication innovations into their national development agenda. The main challenges in implementing digitalisation policies are: lack of appropriate policies, programmes, resources and know-how for innovators and digital change agents in their

communities; lack of proper assessment of systemic issues of the ICT-oriented innovation ecosystem (entrepreneurial ecosystem, technology ecosystem and innovation ecosystem - the three engines of economic growth); lack of cooperation between stakeholders of the main growth factors to create ICT projects for innovation and entrepreneurship development[229].

That is why an equally important aspect of the formation of the smart economy is the institutional one - the formation of governance institutions, which in turn cannot occur without the active participation of ICT. The level of e-government development is measured by the United Nations Department of Economic and Social Affairs (UNDESA) using the EGDI (EGovernment Development Index). Methodological framework for data collection and assessment The e-Government Development Survey is based on a comprehensive view of e-government, which includes three important aspects that enable people to benefit from online services and information: the adequacy of telecommunications infrastructure, the ability of human resources (human resources) to promote and use ICT, and the availability of online services and content[230].

Progress in e-government development is monitored through the E-Government Development Index (EGDI), which is calculated every two years, shows the level of e-government development at the national level and is a composite index based on the weighted average of three standard indices:

- - The Telecommunications Infrastructure Index (TI), based on data from the International Telecommunication Union (ITU),
- - Human Capital Index (HCI), based on data from the United Nations Educational, Scientific and Cultural Organisation (UNESCO),
- - Online Services Index (OSI), based on data from an independent sociological survey conducted by the UN Department of Economic and Social Affairs (UN DESA) (it assesses the level of national online presence of all 193 UN member

[229] ITU ICT-EYE / *ICT Data portal.* URL: https://www.itu.int/net4/ITU-D/icteye/#/topics/1001
[230] UN E-Government Survey 2020. URL: https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-GovernmentSurvey-2020

states). The survey assesses a range of online service features, including the approach to scale, open government data, e-participation, omni-channel service delivery, mobile services, usage and digital barriers, and new forms of participation through the use of ICT. This data is being collected by a team of researchers under the supervision of UNDESA in the form of a primary study[231].

Digitalisation indices are designed to assess the peculiarities of the development of digital technologies and the possibilities of their use for economic development. The digital economy is an important element in the formation of a new type of economy within the framework of the Fourth Industrial Revolution and requires an assessment of its capabilities through various indices and rankings. One such index that has been developed recently is DiGiX (the Digitisation Index), developed by Banco Bilbao Vizcaya Argentaria (BBVA)[232]. The DiGiX assesses the factors that enable a country to use ICT in economic activities, which is aimed at increasing competitiveness and welfare of the population. The index evaluates 100 countries and is structured around six key indicators: infrastructure, users' adoption, enterprises' adoption, costs, regulation, content[233]. Each sub-index has a number of indicators of its own, with a total of 21 indicators.

Each indicator is assigned a weighting factor in the resulting Index, and the score is calculated accordingly. The DiGiX uses a two-stage methodology for assessing the level of digitalisation of the economy, which involves identifying the most correlated indicators at the first stage and aligning them according to the weighting coefficients at the second stage (PCA, Principal Component Analysis)[234]. While the first stage involves determining the weight of influence and the level of interdependence and

[231] UN E-Government Survey 2020. URL: https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-GovernmentSurvey-2020
[232] Li W., Badr Y. & Biennier F. Digital ecosystems: Challenges and prospects: Proceedings of the International Conference on Management of Emergent Digital EcoSystems - MEDES '12. 2012. doi:10.1145/2457276.2457297.
[233] Noelia Cámara and David Tuesta. WORKING PAPER DiGiX: The Digitization Index. 2017. URL: https://www.bbvaresearch.com/wp-content/uploads/2017/02/WP_17-03_DiGiX_methodology.pdf
[234] Nagar L. and Sudip Ranjan Basu. Weighting socioeconomic indicators of human development: a latent variable approach. *Handbook of applied econometrics and statistical inference. New York : Dekker, 2002, P. 609-641*. URL: https://www.econbiz.de/Record/weighting-socioeconomic-indicators-of-human-development-a-latent-variable-approach-nagar-anirudh/10001702004

dispersion between the groups of indicators themselves, the second stage involves determining the weighting of the indicators themselves in the index structure.

It is worth noting that the DiGiX assessment uses available indicators that are more typical for developing countries and take into account mainly physical accessibility and the level of use of information and communication technologies in economic activity. However, the structure of the Index itself is being revised, and the 2020 Index has already expanded the list of indicators used to assess the level of digitalisation of countries (Table 3.9)

Table 3.9

Adjusted DiGiX structure, 2018 [235]

Infrastructure	**Users' adoption**	**Enterprises' adoption**
- Coverage by 3G or higher mobile networks - International Internet bandwidth (bps per user and Mbps) - Secure Internet servers	- Active mobile users - Subscription to fixed (wired) broadband access - Digital skills of the population - Individual internet users	- Components of the innovation ecosystem - Growth of innovative companies
Affordability	**Regulation**	**Government Adoption**
- Tariffs for fixed broadband access	- Software piracy rate, % of installed software - Adaptability of the legal framework to business models - Burden of state regulation - Effectiveness of the legal framework in disputed areas - Judicial independence - Efficiency of the judicial system in resolving disputes - Regulation of conflicts of interest	- Index of public (government) online services

As we can see, this index already takes into account not only quantitative indicators of the level of digital technologies use, but also certain qualitative parameters. The list of the top 20 countries according to this index is shown in the table (Table 3.10).

[235] Noelia Cámara. DiGiX 2018: A Multidimensional Index of Digitization. URL: https://www.bbvaresearch.com/wp-content/uploads/2019/04/Digix_v7-1.pdf

The Digital Economy and Society Index (DESI), calculated by the European Commission, is also quite interesting. This is a composite index that summarises relevant indicators in five main areas: connectivity, human capital, internet use, digital integration and digital public services. Unfortunately, this index only tracks the evolution of EU member states in the field of digital competitiveness[236].

Table 3.10

DiGiX 2018-2020 RANKING[237 238]

Rank 2020	Countries 2020	Weight Of The Indicator 2020	Rank 2018	Countries 2018	Weight Of The Indicator 2018
1	Denmark	1,00	1	Luxembourg	1,00
2	Hong Kong	0,97	2	United States	0,95
3	Singapore	0,94	3	Netherlands	0,94
4	United States	0,92	4	Singapore	0,94
5	Netherlands	0,91	5	Hong Kong	0,90
6	Luxembourg	0,90	6	Denmark	0,90
7	Finland	0,88	7	Germany	0,88
8	Switzerland	0,87	8	Switzerland	0,88
9	United Arab Emirates	0,84	9	Finland	0,88
10	Sweden	0,83	10	Sweden	0,88
11	Estonia	0,82	11	Iceland	0,87
12	New Zealand	0,81	12	United Kingdom	0,86
13	Iceland	0,81	13	New Zealand	0,82
14	Germany	0,81	14	Australia	0,81
15	Japan	0,80	15	Ireland	0,80
16	United Kingdom	0,80	16	Israel	0,80
17	Canada	0,78	17	Japan	0,80
18	Norway	0,77	18	Canada	0,80
19	Australia	0,77	19	United Arab Emirates	0,79
20	Israel	0,77	20	Norway	0,78

Thus, the unprecedented spread of information and communication technologies is an important trend in modern development and an integral part of the formation of the smart economy. Tracking and analysing current trends in the development of the smart economy should be carried out on a comprehensive basis, taking into account

[236] Digital Economy and Society Index. URL: https://eufordigital.eu/uk/library/digital-economy-and-society-index-desi-2020/

[237] Prikladi 5 naselenih punktiv v Ukraini, jaki realizovuut Smart City. URL: https://sites.google.com/site/666smartcity/prikladi-5-naselenih-punktiv-v-ukraieni-aki-realizovuut-smart-city

[238] Rational land use (greening) / Agriculture and rural development.. URL: https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/income-support/greening_en

various aspects of society. It is important not only to study the pace of ICT diffusion, but also the trends in the deployment of other important processes using ICT: governance, environmental monitoring, education, healthcare, etc.

This analysis confirms the importance of continuous monitoring of the processes of spreading modern technologies in the economy, identifying the most acute problems and determining the key areas of ICT use in the context of building a smart economy. This problem leaves a lot of room for further analysis at different levels: the use of smart technologies at the city level, involvement of the population in modern technologies and networks, creation of conditions for socially responsible business, and formation of a smart living environment.

CHAPTER 4
ANALYTICAL FORMATS OF GLOBAL SMART ECONOMY

4.1 Conceptualization of the problems of assessing the development of the smart economy

At the current stage of development, the economy is at the turn of the global paradigm of its functioning. There is not only an acceleration of the process of intellectualization of society, but also its convergence with the processes of sustainable development, gradual and steady greening of economic activity. The existence of a wide variety of concepts of society's development and their further diversification raises the issue of defining the boundaries of smart economy and its correlation with other development concepts. This, in turn, requires the identification of key indicators for assessing the smart economy and their analysis. The formation of the phenomenon of the smart economy and its key forms of manifestation in economic activity requires its own study. The emergence of the smart economy, as noted earlier, is the result of the complex action and influence of the processes of intellectualization and greening of all types of economic activity, which, under the influence of the unprecedented spread of ICTs.

In scientific research, the issue of assessing the degree of development of the smart economy is relevant and open. In which countries or cities is it developing and in which not? How can the level of development of the smart economy be assessed, and what indicators can be used? Probably, this is possible only with the help of a system of indicators that would reflect various aspects and take into account all possible variations in its implementation. Defining the smart economy as the latest trend in the global economy, we note the absence or fragmentation of its assessment at

the national level. It should be noted that the topic of smart economy has been one of the most relevant in economic science and practice in the last decade. At the same time, most of the research is devoted to the problems of smart cities - their essence, structure, evolution and assessment methods. Moreover, the latter (assessment methods) already have significant developments: global analysts already have many tools for assessing smart cities in their basket.

As for the assessment of the smart economy at the country level, i.e. the national level, it should be noted that such approaches are rather poorly analyzed. The whole set of existing approaches to assessing the development of countries can be divided into two parts: general ones that assess the overall progress of countries (based on different methods and criteria) and specialized ones that usually assess the progress of countries in a particular context (environmental, economic, social, innovative, etc.). Let's consider the main, most well-known and widespread approaches to assessing the progress of countries in the context of how they can be applied to measuring the development of the smart economy.

It is worth noting that countries themselves, as subjects of economic relations, are also participants in the development of the smart economy. Moreover, the assessment of the development of the smart economy at the national level should be based on the same parameters and indicators. For states as separate subjects of the smart economy, the following indicators remain important: quality of life and optimal resource management, business opportunities, technological development, infrastructure development and its quality, formation of a network of information and communication technologies, availability and quality of insurance business, level and structure of debt obligations, cultural diversity, economic return and efficiency, liquidity and quality of markets, human capital and its quality, health care and education, security (which includes both individual safety and environmental safety, which generally affects the quality of life of society), etc.

The formation of smart economics at the country level is an important issue of economic science and practice, which leads to a constant search for new approaches to measuring and evaluating progress in the modern world. As noted above, international

analysts have developed many approaches to assessing certain aspects of country development. All currently developed general systems for assessing the progress of countries are comprehensive and take into account indicators on various aspects. It should be noted that it has long been clear that economic indicators alone (such as GDP growth, income, or employment) are not enough to measure progress in a country. Since the end of the last century, there have been various attempts to find other approaches that would more broadly assess the development of countries. That is why many attempts have already been made at the global level to assess development in countries that would take into account various aspects of life, not only economic ones.

Table 4.1 summarizes the most well-known approaches to such an assessment at the global level. This list clearly confirms that the progress of countries in the modern sense includes a wide range of different aspects of life (Table 4.1).

Table 4.1

Global approaches to measuring the progress of countries

№	Indexes	Aspects	Indicators
1	Human development index	economic	GDP per capita
		social	Secondary education level
		ecological	Life expectancy
2	World Prosperity Index by Legatum Institute	state, economic, responsible and environmentally friendly	economy; entrepreneurship; governance; education; healthcare; security; personal freedoms; social capital; environment
3	The Global Happiness and Well-Being Policy Briefs	Economic; social; political; environmental	healthcare, education, employee well-being, happy cities, policy mechanisms and practical tools of the central government
4	The Happy Planet Index (The Happy Planet Index)	economic, social, environmental	well-being, life expectancy, inequality and the environment
5	Index OECD Better Life	Economic, Social, Civil, Environmental; Security	Living conditions; Income; Work; Society; Education; Environment; Civil rights; Health; Satisfaction; Safety; Work/leisure
6	A report about happiness (The World Happiness Report)	Economic; Social; Civil	GDP per capita; social support; life expectancy; freedom of citizens to make important decisions on their own; generosity and attitudes towards corruption
7	SDG Index (Index SDG)	Economic, social, environmental, political	THE 17 SDGS ARE: 1) ending poverty, 2) ending hunger, 3) good health, 4)

			quality education, 5) gender equality, 6) clean water and sanitation, 7) renewable energy, 8) decent work and economic growth, 9) innovation and infrastructure, 10) Reducing inequality, 11) Sustainable cities and communities, 12) Responsible consumption, 13) Combating climate change, 14) Conservation of marine ecosystems, 15) Conservation of terrestrial ecosystems, 16) Peace and justice, 17) Partnership for sustainable development

Source: developed by the authors

Identification of the main approaches to assessing various aspects of the development of countries in the world implies that the next stage of the analytical study is to identify the results of progress assessment using different methodological approaches. The most famous and widespread is the Human Development Report, which has been published annually by the UN since 1990 and is based on the Human Development Index. The Human Development Index is calculated on the basis of three sub-indices that take into account the economic, social and environmental aspects of the population's life in the country. The economic aspect of a country's development is measured by GDP per capita; the social aspect is measured by the average level of education of the population; and the environmental aspect is measured by life expectancy. In addition, each report additionally measures other issues: democratic freedoms, gender issues, etc. Today, the Human Development Report is considered to be one of the most successful approaches to comprehensively assessing the progress of countries. At the same time, it is increasingly clear that these three components alone cannot fully assess development.

It is worth noting that the leading countries in many approaches are almost all repeated. In particular, the Scandinavian countries and developed European countries are the leaders in the global economic environment in terms of human development (Table 4.2).

Thus, the list of leading countries in the Human Development Index includes the most developed countries in Europe, North America and Asia. As noted earlier, this

index includes generalised indicators of economic, social and environmental development.

Table 4.2

TOP-20 countries in terms of human development

Rating	Країна	1990	1995	2000	2005	2010	2015	2020
1	Norway	0.849	0.883	0.917	0.931	0.940	0.944	0.957
2	Australia	0.865	0.882	0.898	0.912	0.927	0.935	0.944
3	Switzerland	0.831	0.846	0.888	0.904	0.924	0.930	0.955
4	Denmark	0.799	0.830	0.862	0.902	0.908	0.923	0.940
5	Netherlands	0.829	0.861	0.877	0.891	0.909	0.922	0.944
6	Germany	0.801	0.830	0.855	0.887	0.906	0.916	0.947
6	Ireland	0.770	0.803	0.861	0.895	0.908	0.916	0.955
8	USA	0.859	0.876	0.883	0.897	0.909	0.915	0.926
9	Canada	0.849	0.861	0.867	0.892	0.903	0.913	0.929
9	New Zealand	0.820	0.855	0.874	0.895	0.905	0.913	0.931
11	Singapore	0.718	0.773	0.819	0.841	0.897	0.912	0.938
12	Hong Kong	0.781	0.808	0.825	0.871	0.898	0.910	0.949
13	Liechtenstein	-	-	-	0.888	0.902	0.908	0.919
14	Sweden	0.815	0.856	0.897	0.892	0.901	0.907	0.945
14	United Kingdom	0.773	0.837	0.865	0.890	0.906	0.907	0.932
16	Iceland	0.802	0.826	0.859	0.889	0.892	0.899	0.949
17	South Korea	0.731	0.781	0.821	0.858	0.886	0.898	-
18	Israel	0.785	0.817	0.850	0.870	0.883	0.894	0.919
19	Luxembourg	0.779	0.805	0.851	0.880	0.886	0.892	-
20	Japan	0.814	0.838	0.857	0.874	0.884	0.891	0.919

Source: compiled based on[239]

The formation of the smart economy is influenced by a significant number of factors, and the smart economy itself is implemented in several planes, which is ultimately realised through the formation of a general system of comfortable living in a country or location. The list of indices for measuring overall progress also includes the Wellbeing or Better Life Index, which takes into account a significant number of aspects of comfortable living, including housing, income, work, society, education, environment, civil rights, health, satisfaction, security, work-life balance. [240] In general, for each of the analysed aspects, a score is calculated and, accordingly, the level of satisfaction of the population with this aspect in a particular country is determined. [241]

[239] Human Development Index. URL https://hdr.undp.org/data-center/human-development-index#/indicies/HDI
[240] Better life Index. URL: https://stats.oecd.org/Index.aspx?DataSetCode=BLI
[241] Better life Index. URL: https://stats.oecd.org/Index.aspx?DataSetCode=BLI

The OECD Better Life Index also attempts to go beyond purely economic indicators in assessing the well-being of the population. This index allows comparing well-being in countries in 11 areas that the OECD has identified as important in the areas of material living conditions and quality of life[242]:

- housing conditions (number of rooms per person, housing with basic utilities, housing costs);
- income (adjusted net family income after taxes; *net family wealth*);
- work (employment rate; long-term unemployment rate; average wage; job security);
- society (social support network);
- education (time to education; level of education; skills of students);
- environment (air pollution; water quality);
- civil rights (voter participation; involvement of stakeholders in rule-making);
- health (life expectancy; self-assessment of health);
- satisfaction (life satisfaction);
- safety (feeling safe walking down the street alone; homicide rate);
- work/rest (employees working overtime; time for rest and personal care).

The well-being index is calculated for OECD countries and individual partner countries. According to the analysis, a list of countries characterised by a high level of social progress (or its individual aspects) is determined, including the most developed countries in the world (Table 4.3).

Table 4.3

Well-being index, 2019

[242] How's life? / OECD. URL: https://www.oecdbetterlifeindex.org/#/11111111111

	Accommodation	Income	Job	Community	Education	Ecology	Civil rights	Health	Satisfaction	Security	Work-life balance
Canada	7,8	5,4	8,0	7,6	7,9	8,3	6,8	9,6	9,1	9,1	7,3
Denmark	6,2	3,0	8,3	8,8	7,9	8,3	7,0	7,9	9,7	9,3	9,0
Switzerland	6,5	6,9	9,3	7,8	7,4	7,3	3,4	9,0	9,6	9,5	8,4
Sweden	6,9	4,6	8,1	6,7	7,7	9,1	6,8	8,5	8,9	8,5	8,4
Finland	6,2	3,7	7,5	8,6	8,9	8,9	5,2	7,9	10,0	9,3	8,0
Netherlands	7,3	3,3	8,3	6,5	7,4	7,2	7,8	8,4	9,3	9,2	9,5
New Zealand	6,2	4,3	8,0	8,9	6,9	8,5	7,3	9,5	8,9	7,6	5,9
Luxembourg	6,7	9,1	8,4	7,4	5,0	6,4	6,9	8,0	7,5	8,6	8,0
United Kingdom	5,5	6,0	8,0	8,1	6,8	6,7	7,2	7,7	7,2	8,9	6,4
Germany	6,8	4,7	8,2	6,2	7,6	7,0	5,3	7,4	7,8	8,3	8,4
Ireland	7,3	3,1	7,2	8,6	7,4	7,6	3,1	9,1	7,7	8,6	7,9
Austria	6,2	5,0	8,1	6,9	6,6	6,6	4,8	7,9	8,3	9,1	6,8
France	6,6	4,4	6,8	6,2	6,1	5,9	5,8	7,7	6,1	8,2	8,7
South Korea	7,6	3,1	7,4	0,0	7,6	2,4	7,8	4,7	4,0	7,7	4,1
Israel	5,0	3,2	7,3	4,*	5,6	2,7	6,5	9,3	8,5	7,8	4,6

Source: compiled by the authors on the base of[243]

Canada, Denmark, Switzerland, Sweden, Finland, the Netherlands, New Zealand, and Luxembourg are the highest performers in all of these aspects. These countries score well above the OECD average. For example, Denmark scores significantly higher in terms of work-life balance, social connections, and environmental quality, but lags behind in terms of income per capita after all taxes (while the OECD average is more than $33,000 per year, in Denmark it is only $29,000)[244]. In general, developed countries are characterised by high employment rates, high levels of education, a strong sense of belonging to civil society and a high level of participation in society by each of its members.

Another approach to assessing the development of countries is The Legatum Prosperity Index, a composite indicator that measures the achievements of countries in terms of their well-being and prosperity. It has been published since 2006 by the British think tank The Legatum Institute (a division of the international investment group

[243] Better life Index. URL: https://stats.oecd.org/Index.aspx?DataSetCode=BLI
[244] Status timchasovogo zahistu v Evropi otrimali 3,2 mln bijencib z Ukraini.Interfax-*Ukraina*. URL: https://interfax.com.ua/news/general/838562.html

Legatum). The purpose of the research is to study social well-being and its development on a global scale. The index is based on a large number of different indicators (about 300), grouped into 4 domains: Inclusive Society; Openness; Economy; Responsible People.

An inclusive society is revealed in the following areas: security (War & Civil Conflict, Terrorism, Politically Related Terror & Violence, Violent Crime, Property Crime), personal freedom (Agency, Freedom of Assembly & Association, Freedom of Speech & Access to Information, Absence of Legal Discrimination, Social Tolerance), public administration (Executive Constraints, Political Accountability, Rule of Law, Government Integrity, Government Effectiveness, Regulatory Quality), social capital (Personal & Family Relationships, Social Networks, Interpersonal Trust, Institutional Trust, Civic & Social Participation).

Openness in such areas as the investment environment (Property Rights, Investor Protection, Contract Enforcement, Financing Ecosystem, Restrictions on International Investment), умови для бізнесу (Domestic Market Contestability, Environment for Business Creation, Burden of Regulation, Price Distortions, Labour Market Flexibility).

Economy - infrastructure and market access (Market Distortions, ImportTariff Barriers, Open Market Scale, Border Administration, Transport, Water, Energy, Communications), economic quality (Labour Force Engagement, Dynamism, Productivity & Competitivenes, Macroeconomic Stability, Fiscal Sustainabilit.

Responsible people - living conditions (Material Resources Nutrition Basic Services Shelter Connectedness Protection from Harm), education (Pre-Primary Education Primary Education Empowered Peop le Secondary Education Tertiary Education Adult Skills), healthcare (Behavioural Risk Factors Preventative Interventions Care Systems Mental Health Physical Health Longevity), ecology (Emissions Exposure to Air Pollution Forest, Land and Soil Oceans Freshwater Preservation Efforts).

Each country’s ranking is determined by calculating the weighted average of these indicators, each of which is defined as the basis for prosperity. The indicators are

based on statistical analysis, sociological research and expert opinions of the survey participants. The statistical data used in the ranking are obtained from the United Nations, the World Bank, the Organisation for Economic Cooperation and Development, and the World Trade Organisation, Gallup, Economist Intelligence Unit, IDC, Pyramid Research і інших інститутів[245].

The vast majority of countries in the top 10 according to the Legatum Institute's World Prosperity Index belong to the Nordic countries, which have achieved a high level of development in all the above aspects: economic, social, environmental, and institutional (Table 4.4).

Table 4.4

Country Prosperity Index, 2021[246]

Rating	Country	Index
1	Denmark	83,86
2	Norway	83,50
3	Sweden	83,11
4	Finland	82,96
5	Switzerland	82,89
6	Netherlands	82,18
7	Luxembourg	81,10
8	New Zealand	80,93
9	Germany	80,57
10	Iceland	80,12

It is important to note that prosperity is seen as a complex phenomenon that includes four main aspects: governance, economic, responsible and environmental. The governance dimension means that governments make decisions in a way that inspires trust and fairly respects the freedom of their citizens: prosperous countries are those where governments govern with the consent of the people and where citizens take responsibility. Economic - economic decisions are made responsibly to ensure an enabling environment for productive employment, sustainable economic growth and personal development. The aspect of social responsibility, the unity of the principles of personal responsibility and freedom, means that citizens are free to manage their

[245] Rankings. *The legatum prosperity index*. URL: https://nonews.co/directory/lists/countries/legatum-prosperity-index
[246] Rankings. *The legatum prosperity index*: website. URL: https://www.prosperity.com/rankings

lives, taking responsibility for their families and communities. The environmental aspect means that people take care of their own physical health and mental well-being, and medical care is available to all. They do not make decisions that endanger the health of others. “True prosperity means that everyone, no matter how dark the days, has the opportunity and responsibility to fulfil their unique potential and play their part in strengthening their communities and nations. Prosperous countries are built on trust and respect.”[247].

Report The Global Happiness and Well-Being Policy Briefs developed by the Global Happiness and Wellbeing Council (the Global Happiness Council (GHC)) and expert working groups on better governance for happiness. These reports are intended for policy makers and those interested in shaping well-being policy. Global Happiness and Wellbeing Council (GCHW) - is a global network of leading academics and practitioners in fields spanning psychology, economics, education, health, urban planning, civil society, business and government. The GHC identifies the best evidence-based happiness and well-being policies to encourage their adoption and promotion at local, national and international levels. The Council’s work complements the annual World Happiness Report and related theoretical research, measurement and promotion of happiness and well-being. According to Jeffrey Sachs, Director of the Global Happiness and Wellbeing Council, “The main economic strategy since Adam Smith’s Wealth of Nations Adam Smith has been to increase national wealth in order to increase national happiness. In a sense, the pursuit of economic growth has worked. Today, the world is very rich, at least on average. Yet, despite this remarkable wealth, there remains considerable unhappiness. Of course, some of this unhappiness is the result of enormous inequality in the distribution of global income”[248].

The 2019 report focuses on developing and presenting a set of practical policy lessons in the context of several thematic areas: health, education, employment, cities, personal happiness, frailty and policy development, as well as a synthesis section.

[247] The Legatum Centre for Global Prosperity. URL: https://www.prosperity.com/
[248] Global Happiness and Wellbeing Policy Report 2019. URL: https://s3.amazonaws.com/ghwbpr-2019/UAE/GH19_Ch1.pdf

Using rigorous evidence and international case studies, the report not only presents best practices for effective methods of promoting happiness and well-being through public policy, but also shows how governments can implement them for the sake of happiness and well-being. The report contains the following sections on health, education, employee well-being, happy cities, policy mechanisms and practical tools for central government[249].

The key idea of the report is that happiness is a complex phenomenon and is shaped by a holistic approach to development, which includes: economic development, overcoming extreme poverty, promoting social inclusion, social justice, and environmental protection. The best way to achieve this is through the Sustainable Development Goals (SDGs), as defined by the Agenda 2030 strategic plan. Agenda 2030 specifically commits to creating "a world with equitable and universal access to quality education at all levels, health and social protection, and physical, mental and social well-being"[250].

The adoption of the Agenda 2030 and the Sustainable Development Goals (SDGs) in 2015 set a universal agenda for all countries. There are 17 important goals - the Sustainable Development Goals - that should ensure that countries move towards sustainable development. The SDGs truly serve as a framework and roadmap for global happiness and well-being. The SDGs contribute to happiness, and vice versa - happiness also contributes to the achievement of the SDGs[251]. The achievement of these goals is assessed using reliable indicators, and the results of such an assessment become important information for applying practical tools and solving problems. Since then, the UN has been publishing the annual Sustainable Development Report, which includes the SDG Index (Index SDG) and other dashboards, which in general serves as a broad statistical framework for measuring countries' progress towards sustainable development.

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[249] Happiness and wellbeing indicesurl / *Global Wellness Institute*. URL: https://globalwellnessinstitute.org/industry-research/happiness-wellbeing-index/

[250] Global Happiness and Wellbeing Policy Report 2019. URL: https://s3.amazonaws.com/ghwbpr-2019/UAE/GH19_Ch1.pdf

[251] Global Happiness and Wellbeing Policy Report 2019. URL: https://s3.amazonaws.com/ghwbpr-2019/UAE/GH19_Ch1.pdf

In the context of our study, it should be noted that the SDG Index is also essentially a comprehensive measure of progress, as it takes into account very different aspects of life: 1) ending poverty, 2) ending hunger, 3) good health, 4) quality education, 5) gender equality, 6) clean water and sanitation, 7) renewable energy, 8) decent work and economic growth, 9) innovation and infrastructure, 10) Reducing inequality, 11) Sustainable cities and communities, 12) Responsible consumption, 13) Combating climate change, 14) Conservation of marine ecosystems, 15) Conservation of terrestrial ecosystems, 16) Peace and justice, 17) Partnership for sustainable development. Obviously, these goals cover various aspects of progress, such as economic, social, environmental, and political. It is also important to note that Goal 11 includes sustainable development of cities and communities, which is directly related to the development of the smart economy at the local level. Table 5.5 shows the results of the SDG Index for 2021.

Happy Planet Index (The Happy Planet Index) measures sustainable well-being for all. It shows what countries are doing to achieve a long, happy and sustainable life. The index has three components: well-being, life expectancy and the environment. These components are assessed both on the basis of statistical data and population surveys. Well-being: how satisfied the people of each country are with their overall experience of life, on a scale from zero to ten; assessed on the basis of data collected as part of the Gallup World Poll. Life expectancy: The average number of years a person will live in each country based on data collected by the United Nations. Ecological footprint: The average environmental impact of each resident of a country, based on data prepared by the Global Footprint Network. The Footprint is expressed in a standardised unit: global hectares (ha) per person[252].

Table 4.5

Top 20 countries by SDG Index, 2021[253]

Rank	Country	SDG Index
1	Finland	85.9
2	Sweden	85.6

[252] Who is behind the Happy Planet Index? *Happy Planet Index*: вебсайт. URL: http://happyplanetindex.org/about
[253] Ukrlandfarming zabezpechuje dobrobut ludej. 2023. URL: https://www.ulf.com.ua/ua/

3	Denmark	94.9
4	Germany	82.5
5	Belgium	82.2
6	Austria	82.1
7	Norway	82.0
8	France	81.7
9	Slovenia	81.6
10	Estonia	81.6
11	Netherlands	81.6
12	Czech Republic	81.4
13	Ireland	81.0
14	Croatia	80.4
15	Poland	80.2
16	Switzerland	80.1
17	United Kingdom	80.0
18	Japan	79.8
19	Slovakia	79.6
20	Spain	79.5

To calculate the Happy Planet Index, thresholds for each of the three components were determined (Table 4.6).

Table 4.6

Thresholds for the components of the Happy Planet Index[254]

	Life expectancy	Well-being	Ecological footprint
Worst values	less than 65 years old	Less than 5/10	less than 2 (3.12 gha and more in 2019)
Average values	65 -75	5 – 6/10	Between biocapacity per capita and its 2-fold value (1.56 - 3.12 gha in 2019)
Best values	75 and over	6/10 and more	Below the biocapacity per capita (1.56 gha in 2019)

The results of the Happy Planet Index are quite unexpected, as the top countries are those with good environmental performance, not just high economic income. Table 4.7 shows the top 10 countries and some of the world's leading countries in 2021.

[254] Who is behind the Happy Planet Index? *Happy Planet Index*: вебсайт. URL: http://happyplanetindex.org/about

Interestingly, it is precisely because of the negative values of the environmental burden that developed countries are far from the top in the Happy Planet Index (Table 4.7).

Table 4.7

Top 10 countries and individual countries according to the Happy Planet Index (2021)[255]

Rank	Country	Life expectancy	Well-being	Environmental footprint	HPIndex
1	Costa Rica	80.4	7.00/10	2.65 gha/p	62.1
2	Vanuatu	70.5	6.96/10	1.62 gha/p	60.4
3	Colombia	77.3	6.35/10	1.90 gha/p	60.2
4	Switzerland	83.8	7.69/10	4.14 gha/p	60.1
5	Ecuador	77	5.81/10	1.51 gha/p	58.8
6	Panama	78.5	6.09/10	2.1 gha/p	57.9
7	Jamaica	74.5	6.31/10	1.84 gha/p	57.9
8	Guatemala	74.3	6.26/10	1.77 gha/p	57.9
9	Honduras	75.3	5.93/10	1.58 gha/p	57.7
10	Uruguay	77.9	6.6/10	2.62 gha/p	57.5
14	United Kingdom	81.3	7.16/10	3.95 gha/p	56.0
33	Finland	81.9	7.78/10	5.76 gha/p	53.1
57	Japan	84.6	5.91/10	4.71 gha/p	47.1
88	Australia	83.4	7.23/10	7.53 gha/p	43.1
103	Ukraine	72.1	4.7/10	2.64 gha/p	40.9
122	USA	78.9	6.94/10	8.21 gha/p	37.4
143	Luxembourg	82.3	7.4/10	12.59 gha/p	31.7

The World Happiness Report (The World Happiness Report) has been published by the United Nations since 2012 in the context of finding solutions for sustainable development. In 2011, the UN General Assembly adopted a resolution calling on countries to measure the happiness of their people and use it in public policy. Six factors are used to measure happiness: GDP per capita; social support; life expectancy; freedom of citizens to make important decisions on their own; generosity; and attitudes towards corruption.

The approach to assessing regional progress in socio-economic well-being used in the EU can also be considered an example of progress assessment. Although the activities of different smart economy actors may be assessed differently, the main

[255] Happy Planet Index rank. URL: https://happyplanetindex.org/compare/

aspects are within the framework of basic groups of needs and economic activities, including:

- material income;
- material derivation;
- employment opportunities;
- education and training;
- functioning of the healthcare system;
- housing
- access to childcare;
- the right to travel;
- decent social security;
- safe environment;
- environment of high quality
- non-discrimination;
- access to the justice system[256].

In this approach, we also observe the following main areas: economic, environmental, social and legal aspects. These aspects of activity are generally in the context of the concept of sustainable development, when the main parameters and indicators are divided into groups within the following: ecology, development of society on the key principles of democracy, and the economic component. In most of the above approaches to assessing the progress of countries, the assessment is made in relation to these key parameters of functioning. The differences lie in the aspects and indicators that are used as the basis for the assessment, the weight of different indicators, and the source base used. The above approaches to assessing the progress of countries and other entities are the most well-known and widespread in modern international practice. In addition, they are universal in nature, as they attempt to assess progress in general.

[256] Regional indicators of socioeconomic well-being. URL: http://ec.europa.eu/social/BlobServlet?docId=17480&langId=en

Approaches to assessing progress from different perspectives will be discussed in more detail below. Identifying trends in the development of the smart economy requires clarifying the key indicators for its assessment at different levels. The study confirms that there is no single index for assessing the smart economy, while certain aspects of its manifestation are assessed in separate assessment indices (Global Cities, Environmental Development, Green Economy, etc.). It is worth noting that further study of the smart economy requires identifying the main aspects and forms of its manifestation.

It is also important to note that almost all assessment systems do not include such an aspect as digitalisation, i.e. measuring the processes of ICTs diffusion in various spheres of life. This area is extremely relevant and has undoubtedly received attention in modern international analytics, which will be discussed in more detail below. At this point, it should be noted that the measurement of the processes of formation of the smart economy cannot be complete without taking into account this important aspect, since its very essence is the widespread use of ICTs to address the issues of managing the economic, social, environmental and legal development of human communities at various levels.

4.2. Global comparative analysis of economic smart progress

It has already been mentioned above that an important component of the smart economy is the spread of ICTs, which is a manifestation of the general process of intellectualisation. As for the intellectual component, we can note its presence in most rankings, but in a rather limited form. The Human Development Index includes the general level of education of the population, while others include the expected duration of education, the average level of education of the population or the workforce, skills, etc. The intellectual component is more thoroughly present in approaches to measuring

innovation development. These are, first of all, the Global Innovation Index and the Bloomberg Innovation Index.

Global innovation index (Global Innovation Index - GII) - is a global study and ranking of countries by the level of innovation development. It is calculated according to the methodology of the International Business School INSEAD, France. The research has been conducted since 2007 as part of a joint project of INSEAD and Cornell University. (Cornell University) and the World Intellectual Property Organisation (World Intellectual Property Organization, WIPO) and currently represents the most comprehensive set of indicators of innovation development around the world.

The GII consists of 82 different variables that describe in detail the innovative development of countries at different levels of economic development. The authors of the study believe that the level of economic development is related to both the availability of innovation potential and the conditions for its implementation. Therefore, the index is calculated as a weighted sum of the scores of two groups of indicators, grouped into seven blocks:

Available resources and conditions for innovation (Innovation Input): institutions; human capital and research; infrastructure; domestic market development; business development.

The achieved practical results of innovation (Innovation Output): development of technologies and the knowledge economy; results of creative activity.

The final Index visualises the ratio of costs and effects, which allows for an objective assessment of the effectiveness of efforts to develop innovations in a country.

Another well-known index is the Bloomberg Innovation Index, which ranks countries by their ability to innovate and identifies the top 50 countries in the world. This index is determined based on the weighting of 6 parameters that have a range of values from 0 to 100 for each country:

1. Research and development: R&D expenditure as a percentage of GDP;

2. Production: value added per capita;

3. High-Tech Companies: The number of state-owned high-tech companies located in the country, such as: aerospace and defense, biotechnology, hardware, software, semiconductors, Internet software and services, and renewable energy companies, such as share of the total number of high-tech public companies in the world;

4. Higher education: the number of secondary education graduates enrolled in higher education institutions, as a percentage of the cohort; the percentage of the workforce with higher education; annual natural and engineering graduates as a percentage of the labor force and as a percentage of the total number of higher education graduates;

5. Scientific personnel: specialists, including graduate students, engaged in research and development per 1 million population;

6. Patents: resident patent applications for utilities per 1 million population and $1 million spent on research and development; utility patents issued as a percentage of the world total.

It is also important to analyze the results of assessing the progress of countries taking into account the innovative component. The formation of an innovative environment is reflected in individual aspects of activity and affects the formation of the general structure of the economy. We can see that according to the global innovation index, among the top ten world leaders are not only advanced European countries and the USA, but also such Asian countries as South Korea and Singapore (Table 4.8).

It is worth noting that the TOP-10 countries demonstrate the stability of their own development, and the list of driver countries has practically not changed over the last decade. Although the results of the Bloomberg Global Innovation Index are slightly different from the previous index (Table 4.9).

Table 4.8

Global Innovation Index, WIPO, 2021[257]

Place in the rating	Country	Region	Indicator

[257] Who is behind the Happy Planet Index? *Happy Planet Index.*URL: http://happyplanetindex.org/about

1	Switzerland	Europe	65,5
2	Sweden	Europe	63,1
3	USA	North America	61,3
4	Great Britain	Europe	59,8
5	South Korea	Asia	59,3
6	Netherlands	Europe	58,6
7	Finland	Europe	58,4
8	Singapore	Europe	57,8
9	Denmark	Asia	57,3
10	Germany	Europe	57,3
49	Ukraine	Europe	35,6

Of the more than 200 countries and sovereigns assessed, 69 had data for all six indicators. Postsecondary education and patent activity consisted of several factors that were equally weighted. Weights were adjusted for countries with some but not all factors in these two indicators. The rating shows only those countries that are in the top 50. The latest available data were used.

Table 4.9

Global Innovation Index, Bloomberg, 2020 [258]

Rank 2020	Rank 2019	Country	Index
1	2	Germany	88,21
2	1	South Korea	88,16
3	6	Singapore	87,01
4	4	Switzerland	85,67
5	7	Sweden	85,50
6	5	Israel	85,03
7	3	Finland	84,00
8	11	Denmark	83,22
9	8	USA	83,17
10	10	France	82,75

In general, it is worth noting that the list of countries present in all TOP ratings practically does not change, which indicates a high level of attention of these countries

[258] Germany Breaks Korea's Six-Year Streak as Most Innovative Nation. URL: https://www.bloomberg.com/news/articles/2020-01-18/germany-breaks-korea-s-six-year-streak-as-most-innovative-nation

to all aspects of their own development, the formation of a balanced and thorough state policy of comprehensive development. So, in terms of the level of social progress, development of human potential, innovations, ecological development, almost the same countries are leading.

As noted, innovativeness is manifested not only in the general development of the country, but also in individual aspects. Thus, for our analysis, the results of the index of eco-innovations, that is, innovations of an ecological nature, are important (Table 4.10).

Table 4.10

Eco-innovation index, 2010-2018[259]

Country	2010		2015		2018	
	Point assessment	Place in the rating	Point assessment	Place in the rating	Point assessment	Place in the rating
Denmark	149	1	131	3	115	6
Sweden	143	2	121	5	132	3
Finland	139	3	131	2	121	4
Germany	134	4	132	1	137	2
Austria	127	5	105	9	119	5
Netherlands	117	6	100	11	92	12
Great Britain	116	7	113	6	110	9
Luxembourg	112	8	125	4	138	1
Belgium	109	9	90	13	83	13
France	109	10	113	7	112	7
Spain	105	11	109	8	105	10
Italy	105	12	104	10	112	8
Ireland	100	13	94	12	94	11

It is worth noting that the countries have a fairly high level of innovation in eco-storage and are constantly improving their positions, which is especially noticeable when calculating individual sub-indices of eco-innovation (Table 4.11).

Table 4.11

[259] Eco-innovation index. Eurostat. URL: https://ec.europa.eu/eurostat/databrowser/view/t2020_rt200/default/table?lang=en

The results of the leading countries of the eco-innovation rating in terms of sub-indices, 2018[260]

Country	Investments in eco-innovation	Eco-innovative activity	Results of eco-innovation activities	Efficiency of use of resources	Socio-economic results of eco-innovation activity
Luxembourg	93	136	224	186	66
Germany	175	154	124	125	101
Sweden	130	179	147	127	81
Finland	135	162	146	47	112
Austria	95	144	130	131	99
Denmark	154	63	150	145	72

At the same time, analyzing individual aspects of innovativeness, we note that an integral indicator is calculated for each country, and individual parameters can differ significantly even within the same country. So, for example, Finland shows high indicators for eco-innovation activity, but has extremely low indicators for the "Resource Efficiency" index. Luxembourg lags behind in the parameters of "Socio-economic results of eco-innovation activity". The degree of influence and contribution of each sub-index to the overall index of the country can be displayed graphically (Fig. 4.1).

We observe a significant leadership of Austria and Luxembourg in terms of investment in innovation activity, but we note the high level of efficiency of such activity in Luxembourg. Germany has the highest level of investment in eco-innovation, while, unfortunately, the efficiency of such activity is one of the lowest among the selected countries. It should be noted that efficiency often has a delayed effect and may not be reflected in the current year's indicators. Denmark has the second highest level of investment in eco-innovation and has one of the highest numbers of scientific personnel among the selected countries. It is worth noting that the selected parameters for the evaluation of ecological innovation activity also include the number of registrations of companies and products according to ISO 14001 standards, which

[260] Eco-innovation index. Eurostat. URL: https://ec.europa.eu/eurostat/databrowser/view/t2020_rt200/default/table?lang=en

takes into account indicators of environmental friendliness of production, the number of eco-products that are exported, the number of employees in the eco-industry, the level of turnover in the eco-industry etc.[261]

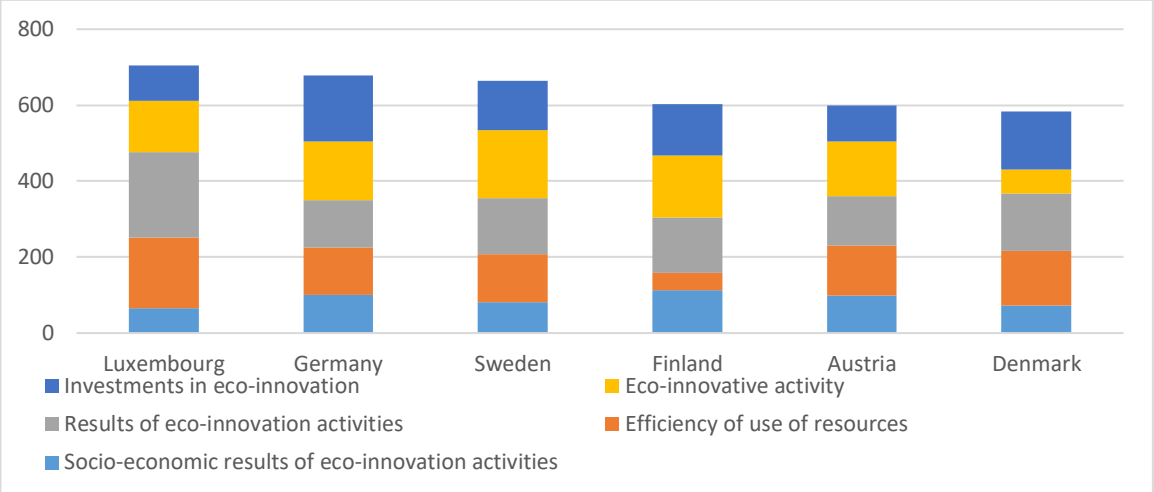

Fig. 4.1. The results of the countries of the leaders of the eco-innovation rating in terms of sub-indices, 2018[262]

In the context of the growing role of knowledge in social progress, one cannot fail to note the attempts to measure the progress of countries on the way to the knowledge economy. The Knowledge Index (KI) was developed as an interactive tool for comparing a country's position in relation to others in the global knowledge economy. It was created by the World Bank Institute using a knowledge assessment methodology to measure a country's ability to generate, absorb and disseminate knowledge. The KI calculation methodology involved finding the average value of the normalized performance indicators of the country or region for key variables in three dimensions of the knowledge economy – education and human resources, the innovation system, and information and communication technologies (ICTs). The World Bank stopped calculating the knowledge index after 2012.

[261] Spaini C. EU Eco-Innovation Index. 2018. URL: https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/eio_brief_eu_eco-innovation_index_2018.pdf
[262] Eco-innovation index. Eurostat. URL: https://ec.europa.eu/eurostat/databrowser/view/t2020_rt200/default/table?lang=en (

"The EBRD's Knowledge Economy Index includes indicators such as institutional and legal frameworks (as a basis for patents, etc.), number of technical graduates, research expenditure, number of patents, a specific measure of collaboration, and amount of venture capital (38 indicators in total). The Knowledge Economy Index (KEI) represents the overall level of development of a country or region in the direction of the knowledge economy. It is calculated on the basis of the average of the normalised performance of a country or region across all 4 dimensions: economic incentives and institutional regime, education and human resources, innovation system and ICTs.

Based on the two above-mentioned indices, a new ranking, the Global Knowledge Index (GKI), was developed in 2017 as a joint initiative of the United Nations Development Programme (UNDP) and the Mohammed bin Rashid Al Maktoum Knowledge Foundation (MBRF). The Global Knowledge Index (GKI) already includes 7 dimensions: pre-university education; technical and vocational training; higher education; research, development and innovation; ICTs; economy; and the overall enabling environment. Each of these dimensions includes sub-dimensions and a significant number of indicators (153 in total).

For example, the heading "Pre-university education" includes two subheadings: knowledge capital and educational environment. Knowledge capital has the following dimensions: numbers, completion and outcomes:

- enrolment: schooling up to the end of secondary education (net primary enrolment rate; net lower secondary enrolment rate; net upper secondary enrolment rate);

- completion: number of years of compulsory primary and secondary education guaranteed by the legal framework; secondary education completion rate; gross enrolment rate in the last grade of lower secondary education;

- results: "assessment of 15-year-old students in mathematics, science and reading", "years of schooling adjusted for learning".

The educational environment includes: costs, resources, early learning, equity and inclusion. Expenditure includes four variables: public expenditure on primary

education (% of GDP); public expenditure on secondary education (% of GDP); public funding per primary student (% of GDP per capita); public funding per secondary student (% of GDP per capita).

Resources: pupil-teacher ratio in primary education (based on number of students); pupil-teacher ratio in secondary education (based on number of students); schools with access to computers in primary education (%); schools with access to computers in secondary education (%).

Early learning: gross enrolment rate in pre-primary education; proportion of children aged 24-59 months who are on track for good development in terms of health, learning and psychosocial well-being; proportion of children under five who experience a positive and stimulating learning environment at home; teacher training ratio in pre-primary education (headcount basis).

Thus, we can see that even just one heading - "Pre-university education" - is represented by a significant set of indicators in 2 main subheadings and 7 more detailed subheadings, and a total of 23 indicators. Accordingly, each of the main headings is also detailed by a significant number of indicators (153), which allows us to form a fairly comprehensive generalised view of the country's progress towards the knowledge economy. Table 4.12 shows the TOP-10 ranking of the Global Knowledge Index in 2021, and again, we see the world's leading countries.

As we can see, the indices take into account almost all parameters of the smart economy, but it is worth noting that there is no general integral index that would take into account all aspects of the smart economy, which makes it necessary to develop one. All of the above indices and assessment methods take into account only certain aspects or focus on certain areas of activity, leaving out other forms of work and building the smart economy.

Table 4.12

Ranking of countries by the Global Knowledge Index (GKI) 2021 [263]

Rank	Country	Index
1	Switzerland	71.5

[263] Global Knowledge Index / Infographics. 2021. URL: https://knoema.com/infographics/aomssce/global-knowledge-index?origin=ru.knoema.com

2	Sweden	70.0
3	USA	70.0
4	Finland	69.9
5	Netherlands	69.5
6	Singapore	69.3
7	Denmark	69.0
8	United Kingdom	69.0
9	Norway	68.7
10	Iceland	67.5

In addition to the above approaches to assessing the progress of countries, there are many other methods that assess various aspects of progress: social, environmental (green economy), technological (ICTs penetration), governance (e-governance), economic, etc. It should be noted that even the economic direction can have many different aspects and measurement indicators, as well as at different levels and for different actors. The proliferation of environmental, social and governance (environmental, social and governance criteria) criteria for assessing not just economic activity, but even such highly specialised areas as finance, financial markets, and banking. The structure of the modern economy also includes such an active component as business, which must be taken into account in the further development of methodological approaches to assessing the development of components and elements of the smart economy.

Before considering specialised indices, it should be noted that some of them are also quite comprehensive and reflect various aspects of the country's life. The indices that measure the social progress of countries in a fairly broad format include the Social Progress Index (Social Progress Index)[264], which measures the achievements of countries in terms of social well-being and social progress. The index was developed in 2013 by the international research project Social Progress Imperative, under the leadership of its chairman, Michael Porter (Michael E. Porter), Professor at Harvard University, a specialist in strategic management and international competitiveness. The editorial board of the Index includes representatives of a number of leading universities

[264] Social Progress Imperative / Social Progress Index. URL: https://www.socialprogress.org/

and research centres, including Harvard Business School and the Massachusetts Institute of Technology.

The authors of the study believe that the key advantage of excluding economic variables in the Social Progress Index is that it makes the concept of social progress one of the most important areas of research in sociology, psychology, economics and public administration. Social development indicators are often seen as a certain alternative to economic development indicators, which are a necessary but not sufficient condition for social progress. The index does not include indicators of economic development of countries (such as GDP and GNI), but assesses social progress relative to the level of economic development of a country.

The Index covers countries for which reliable data are available and is based on a combination of data from public opinion polls (12%), development experts' assessments (25%) and statistical information from international organisations (61%). The report's country-by-country analysis of social development factors provides information for comparisons and contains detailed profiles of each country, including details of their final ranking position and a guide to their key strengths and weaknesses.

More than 50 indicators, grouped into three main groups, are taken into account when determining the success of a country in the field of social progress: Basic Human Needs - nutrition, access to basic healthcare, housing, access to water, electricity and sanitation, and personal security; Fundamentals of Human Wellbeing - access to basic knowledge and literacy, access to information and communication, healthcare, and environmental sustainability; and Human Development Opportunities - the level of personal and civil liberties, ensuring people's rights and opportunities to make decisions and realise their potential. The index measures each country's achievements on a scale from 0 (least sustainable) to 100 (most sustainable) based on the data obtained in the three basic categories mentioned above. All countries are grouped into six clusters based on the data obtained.

The list of flagship countries according to the Social Progress Index (cluster 1), which is essentially becoming a measure of the harmonious development of civil

society at the current stage of economic development, is presented in the table below (Table 4.13).

Table 4.13.

Countries in cluster 1 of the Social Progress Index, 2021[265]

№	Countries	Indexc
1	Norway	92.63
2	Finland	92.26
3	Denmark	92.15
4	Iceland	91.78
5	Switzerland	91.78
6	Canada	91.41
7	Sweden	91.20
8	Netherlands	90.57
9	Japan	90.44
10	Germany	90.32
11	Australia	90.28
12	New Zealand	90.02
13	Ireland	89.47
14	Austria	89.44

Cluster 2 includes 28 countries with a much wider range of scores, from Luxembourg (15th at 88.75) to Hungary (42nd at 80.15). France, Great Britain, Italy and the United States — the rest of the G7 rich countries — fell to the second level of the Social Progress Index. Most Tier 2 countries are high income. Ukraine is in 48th place (cluster 3) with an index value of 75.78.

An important aspect of modern life is the ecological development. As mentioned above, the environmental component is part of many modern approaches to assessing the progress of countries. Moreover, it can even be argued that without it the evaluation of progress is not possible at all. Practically all approaches, starting with the Human Development Index, have certain indicators for measuring the environmental component.

[265] Social Progress Index. Executive summary. URL: https://www.socialprogress.org/static/9e62d6c031f30344f34683259839760d/2021%20Social%20Progress%20Index%20Executive%20Summary-compressed_0.pdf

It is clear that approaches have also been developed to directly assess the green economy, which at the current stage of development is acquiring new characteristics. Such approaches include not only environmental indicators, but also parameters of comfortable living and characteristics of well-being. So, for example, the key indices of ecologization of the economy include social parameters. We can note that the concept of smart economy is quite closely intertwined with the concept of green economy in terms of certain indicators, especially regarding social inclusion and greening. The Green Economy Progress Index (Green economy progress) is quite well-known in international analytics, the components of which are the following parameters: gender equality, education, life expectancy, income inequality and 8 purely environmental indicators (export of eco-goods, percentage of eco-innovations, share of renewable sources energy, energy consumption per 1,000 USD of GDP, access to resources (water, electricity, sanitary facilities), average annual pollution, consumption of biotic and abiotic resources, total area of protected and marine protected areas) (Table 4.14).

Another index that assesses various aspects of environmental development is the Green Growth Index, which measures the performance of governments in achieving sustainable development goals. The index includes four main aspects, including efficient use of resources, protection of natural resources, opportunities for environmental initiatives and social integration. The Green Growth Index is calculated separately for each region: Africa, the Americas, Asia, Europe and Oceania[266].

Table 4.14.

Indicators of the Green Growth Index [267]

Indicator	Description of the indicator	Number of countries to be measured	Resource
1	**2**	**3**	**4**

[266] Green Growth Index. URL: http://greengrowthindex.gggi.org/#cover

[267] Green economy progress measurement framework application. *United Nations Environment Programme.* 2017. URL: https://www.un-page.org/files/public/general/green_economy_progress_measurement_framework_application.pdf

Green trade	Exports of eco-goods according to OECD and APEC standards (% of total exports)	128	COMTRADE, OECP, ATEC
Environmental patents	As a measure of green technology innovation (% of total patents)	61	WIPO
Renewable energy sources	Share of renewable energy sources (in total energy supply)	129	WDI
Energy use	Energy consumption (kg of oil equivalent) per $1,000 of GDP	132	WDI
Jose Gabriel Palm's scorecard	Ratio of the richest 10% of the population in terms of income divided by the poorest 40%	121	OECP, WDI
Access to basic services	Access to improved water sources (% of total population), access to electricity (% of total population), access to sanitation (% of total population)	198	WDI
Air pollution	Average annual PM2.5 pollution (micrograms per cubic metre)	186	WDI
Ecological footprint	Consumption of biotic and abiotic resources (tonnes per person)	175	OOH
Marine and terrestrial protected areas	Total protected area (% of total land area) and marine protected area (% of territorial waters)	195	UNEP-WCMC
Gender inequality index	Indicator reflecting the inequality in achievements between women and men in three dimensions: reproductive health; empowerment; labour market	129	OOH
Pension coverage	Share of the population above the statutory retirement age receiving a contributory old-age pension	102	МОП
Education	Average number of years of education received by people aged 25 and over, converted from level of educational attainment to official duration of each level	170	OOH
Life expectancy	Life expectancy at birth indicates the number of years a newborn infant will live if prevailing mortality patterns at the time of birth remain unchanged throughout life	200	WDI

The Green Growth Index is often compared in terms of conceptual content to the UNEP[268]. Green Economy Progress Index. However, there are differences in the methodologies of the Green Growth Index and the Green Economy Progress Index, which are reflected in individual indicators (Table 4.15).

Table 4.15.

[268] Green economy progress measurement framework application. *United Nations Environment Programme.* 2017. URL: https://www.un-page.org/files/public/general/green_economy_progress_measurement_framework_application.pdf

Differences in the concepts of the Green Growth Index and the Green Economy Progress Index

	Green Growth Index	Green Economy Progress Index
Definition	Green growth is a development approach that ensures environmentally friendly and socially inclusive economic development.	An inclusive green economy is a pathway to address three major global challenges: poverty, overuse of natural resources, and inequitable distribution of wealth.
Thematic focus	The index measures the performance of countries in achieving sustainable development goals: efficient and sustainable use of resources, protection of natural capital, environmental opportunities and social inclusion.	An analysis of the country's progress based on 13 indicators on resource efficiency, economic, social and environmental aspects, and analysis of 6 of the 9 planetary boundaries.
Time focus	Current indicators.	Progress over time.

Source: developed by the authors on the basis of [269]

It is important to note that the UNEP Green Economy Progress Index (GEP) does not remain unchanged and is constantly being improved and filled with new content to measure progress towards an inclusive green economy[270]. The Green Economy Progress Index is a key tool for policymakers, analysts and other stakeholders to understand the progress of the green economy. The GEP measurement framework complements the previously developed UN Green Economy Indicator Framework (UNEP, 2012; UNEP, 2014; and UNEP, 2015) at different stages of policymaking.

The GEP measurement framework has four objectives:

- To help countries track progress towards nationally defined targets in priority areas.

- Introduce greater transparency in policy-making and provide policymakers with the tools they need to develop policies that support the transition to an inclusive green economy.

- Measure and compare green economy efforts across countries.

[269] Assessment of complementarities between gggi's green growth index and unep's green economy progress index. *GGGI Technical Report*. 2019. No 10. URL: http://greengrowthindex.gggi.org/wp-content/uploads/2020/04/TR10_Assessment-of-Complementarities_Final.pdf

[270] Green economy progress measurement framework application. *United Nations Environment Programme.* 2017. URL: https://www.un-page.org/files/public/general/green_economy_progress_measurement_framework_application.pdf

The GEP measurement framework aims to understand the extent to which an inclusive green economy addresses three major global challenges, namely (a) persistent poverty; (b) exceeding planetary boundaries; and (c) the inequitable distribution of growing wealth. It includes measuring the accumulation of capital - whether natural, low-carbon and resource-saving, human or social - that serves as an input for the production of goods and services in an environmentally sound manner. It also seeks to capture the shift of consumption, investment, government spending and trade towards such goods and services.

- To support the assessment of progress towards the implementation of a selection of the SDGs under the 2030 Agenda for Sustainable Development and to establish direct linkages with them.

In its initial version, the GEP Measurement Framework consists of the GEP Index and an accompanying dashboard of sustainability indicators. These components can be analysed individually or in combination to provide a country-by-country ranking of progress (GEP+).

The first pillar, the GEP Index, measures progress made in improving the well-being of current generations in terms of economic opportunity, social inclusion and environmental protection. It consists of 13 indicators that cover important issues facing the transition to an inclusive green economy, such as material footprint and inequality. The GEP Index focuses on the progress made by countries against the target set for each indicator. The GEP Index is constructed using a weighting system that allows for an assessment of a country's distance from the global threshold for a particular component of an inclusive green economy (indicator) and an assessment of the relative importance of one component (indicator) relative to others from a country's perspective.

The Sustainability Dashboard includes six indicators that track the sustainability of any progress that has been made, as measured by the GEP Index. Its role is to

monitor the long-term sustainability of the factors that underpin the present and future well-being of humanity[271].

Thus, we can observe that environmental indicators make significant adjustments to the ranking of the world's leading countries. The countries that drive modern progress determine the trends of globalisation and economic development, but their list does not always coincide with the countries that are leaders in terms of environmental performance. As noted earlier, one of the indicators of the level of environmental awareness in countries is the Green Development Index, which indicates the level of attention of the governments of these countries to the issue of environmental safety. Table 4.16 presents data on the top EU countries.

Table 4.16.

Green Growth Index of the top 15 EU countries[272]

Indicators of green growth					Green growth index		
Countries	Efficient and sustainable use of resources	Protecting natural capital	Opportunities in the green economy	Socially inclusive development	Points	Level	Place in the rating
Denmark	75.50	72.52	63.84	92.07	75.32	High	1
Sweden	75.79	77.26	57.96	93.70	75.09	High	2
Austria	71.57	79.56	52.27	91.92	72.32	High	3
Finland	67.36	72.25	58.86	92.23	71.69	High	4
Czech Republic	63.04	78.40	61.85	84.48	71.29	High	5
Italy	58.31	83.15	57.63	87.01	70.22	High	6
Germany	55.02	81.52	60.55	88.65	70.04	High	7
Estonia	62.02	69.31	59.12	86.66	68.50	High	8
Latvia	72.05	74.43	49.40	81.87	68.24	High	9
Slovakia	61.57	83.35	49.51	82.21	67.60	High	10
Portugal	58.77	80.40	47.25	86.66	66.32	High	11
Belgium	46.51	75.74	55.88	90.34	64.94	High	12
Hungary	49.04	82.52	55.10	79.20	64.82	High	13
France	55.80	77.74	45.39	88.77	64.66	High	14
Croatia	64.05	81.37	44.29	74.94	64.49	High	15

[271] Upravlinnja transportom, transportna logistica, TMS systema -ABM Rinkai. URL: https://tms.abmcloud.com/uk/
[272] Acosta, L. A, K. Hartman, R. J. Mamiit, N.M. Puyo. *Green growth index*. 2019. URL: http://greengrowthindex.gggi.org/wp-content/uploads/2019/12/Green-GrowthIndex-Summary-Report_20191216.pdf.

The highest scores and highest positions are occupied by European countries, with Denmark, Sweden, Austria and Finland topping the TOP-rating, but the leader is determined separately for each region (Table 4.17).

Table 4.17.

Comparative analysis of the Green Growth Index results, 2019[273]

Region	The leading country	Index
Asia	Singapore	58,43
Americas	Dominican Republic	55,1
Africa	Botswana	45,88
Oceania	New Zealand	52,17
Europe	Denmark	75,32

However, it is worth noting that regional leaders lag far behind global leaders, although they have fairly high scores in their regions. Another index that indicates the level of greening of the economy is the Global Green Economy Index, which summarises trends in the development of environmental aspects of the economy in individual countries. The Global Green Economy Index™ (GGEI) measures the effectiveness of a country's green economy through expert assessment.

The GGEI uses quantitative and qualitative indicators to measure each country's performance across four key dimensions: leadership and climate change, performance sectors, markets and investment, and environment. The GGEI Perception Survey then gathers practitioner assessments of these same four dimensions.

The GGEI was first launched in 2010 and is now the most widely used product of its kind internationally, used by policymakers, international organisations, civil society and the private sector. Like many other indices, the GGEI is used to benchmark performance, communicate areas for improvement, and show various stakeholders how they too can contribute to progress. The GGEI is also useful as a basis for creating customised sustainability measurement systems for a diverse range of stakeholders. The GGEI is prepared by Dual Citizen LLC, a private consulting firm in the United States (Table 4.18).

[273] Acosta, L. A, K. Hartman, R. J. Mamiit, N.M. Puyo. *Green growth index*. 2019. URL: http://greengrowthindex.gggi.org/wp-content/uploads/2019/12/Green-GrowthIndex-Summary-Report_20191216.pdf.

Table 4.18.

Global Green Economy Index (GGEI), top 10 countries in the ranking, 2014-2018[274]

Country	2014	place in the ranking	2016	place in the ranking	2018	place in the ranking
Sweden	0,681	1	0,7761	1	0,7608	1
Switzerland	0,631	6	0,6763	4	0,7594	2
Iceland	0,626	9	0,6368	7	0,7129	3
Norway	0,659	2	0,6911	2	0,7031	4
Finland	0,629	8	0,6783	3	0,6997	5
Germany	0,636	4	0,6601	5	0,689	6
Denmark	0,632	5	0,6184	9	0,68	7
Taiwan	0,475	30	0,4837	47	0,6669	8
Austria	0,63	7	0,6523	6	0,6479	9
France	0,564	13	0,5676	13	0,6405	10

In general, Sweden, Switzerland, Iceland, Norway, Finland, Germany and Denmark are among the top ten countries, but the latter slightly worsened their positions in 2018, and France entered the top ten in the same year, improving its position by three points since 2014. In general, analysing the scores of these countries, we can note the stability and gradual growth of the indicators of countries that set trends in the development of environmental attitudes and environmental awareness.

Thus, measuring the progress of countries in the modern world should take into account many different aspects and not focus on just one aspect of life or functioning. Taking into account complex characteristics that include both indicators of welfare, environmental friendliness and human development or awareness of oneself as part of civil society becomes an evaluative measure of the formation of a new quality of economy at the current stage of its formation. A galaxy of countries is being formed that are becoming drivers of the formation of the smart economy in its complex expression.

At the same time, as noted above, the key driver of the formation of the smart economy is the spread of the latest ICTs. Therefore, taking ICTs into account should

[274] The global green economy index GGEI. 2014. URL: https://dualcitizeninc.com/GGEI-Report2014.pdf

be a mandatory element in any approach to assessing the development of the country's economy or other entities.

4.3. An integrated approach to assessing the development of the smart economy in the global space

It is worth noting that indicators for assessing the smart economy in general may differ in different approaches, but the conceptual approach remains quite similar and is determined by key parameters in the sustainable development paradigm.

Let's try to systematise and summarise the main approaches to measuring various aspects of the smart economy at the country level. Above, we have already presented various approaches to assessing the progress of countries and the results of their ranking.

Generalised, comprehensive approaches: human development index; country prosperity index; happy planet index; SDG index. To some extent, the Social Progress Index can also be included in this group. Although its name refers to the social aspects of progress, it touches on many other aspects of life.

The innovative aspects of countries' development are assessed by the following indices: Global Innovation Index (Global innovation index), global competitiveness index (Global Competitiveness Index), global knowledge index (Global Knowledge Index).

The environmental aspects of country development are reflected in such analytical approaches as: Green Economy Progress Index (Green economy progress - GEP), Green growth index (Green growth index), Global Green Economy Index (The global green economy index - GGEI), Eco-innovation index (Eco-innovation index). The dynamics of the spread of ICTs in countries around the world is currently assessed by the Network Readiness Index (Networked Readiness Index). The processes of

formation of modern digitalised forms of governance in countries are measured by the e-Government Development Index (E-Government Development Index).

Each of the above-mentioned approaches annually (or every 2 years) determines its own ranking of countries according to certain criteria (specialised or comprehensive). As noted above, the smart economy is an extremely complex phenomenon with many components. Therefore, no single index takes into account all its aspects. That is why it is possible to determine the ranking of countries with the most developed aspects of the smart economy based on a generalisation of existing approaches. To this end, it is proposed to define a "rating of ratings", i.e. a list of countries that occupy the highest places in the rating, which is the result of a combination of different approaches. This means that among the entire set of existing indices, those are selected that cover a large number of countries (more than 100) and have a certain time series.

The list of such indices includes the following:

- Human Development Index (1)[275];
- SDG Index (53)[276];
- Happy Planet Index (15)[277];
- Prosperity Index (8)[278];
- Social Progress Index (25)[279];
- Global Competitiveness Index (51)[280];
- Global Innovation Index (52)[281];
- Global Knowledge Index (24)[282];
- E-Government Development Index (49,50)[283];

[275] Human Development Index. URL https://hdr.undp.org/data-center/human-development-index#/indicies/HDI
[276] Sustainable Development Report 2022 & Rankings. 2020. URL: https://dashboards.sdgindex.org/rankings
[277] Who is behind the Happy Planet Index? *Happy Planet Index*: вебсайт. URL: http://happyplanetindex.org/about
[278] Rankings. *The legatum prosperity index*: website. URL: https://www.prosperity.com/rankings
[279] Social Progress Imperative / Social Progress Index. URL: https://www.socialprogress.org/
[280] Global Competitiveness Report Special Edition 2020: How Countries are Performing on the Road to Recovery. URL: https://www.weforum.org/reports/the-global-competitiveness-report-2020/
[281] Global innovation index 2020. URL: https://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2020.pdf
[282] Global Knowledge Index / Infographics. 2021. URL: https://knoema.com/infographics/aomssce/global-knowledge-index?origin=ru.knoema.com
[283] UN E-Government Survey 2020. URL: https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-GovernmentSurvey-2020

- Global Green Economy Index (35)[284];

- Green Growth Index (27)[285];

- Network Readiness Index (48)[286].

In all these indices, data for 2016-2021 were collected and the countries occupying the top 100 positions were selected. The following weighting values were assigned to the rankings: first place in the ranking - 1 point, 100th place - 0.01 points. Each ranking has an average value for the period 2016-2021 for the respective country. Thus, each country received a number of points that is the sum of the points corresponding to its places in the various rankings (listed above). As a result, the ranking of rankings was determined: 100 countries with the highest number of points. We have every reason to believe that these are the countries that have made the most progress in the development of the smart economy, and that these countries have the greatest potential for the establishment of a smart economy.

For the purpose of a more in-depth analysis of the results, the main focus will not be on all one hundred countries. The following countries were selected as the subject of the study: 38 OECD countries plus 5 partner countries, plus Ukraine and Singapore. This choice was made because we are interested in Ukraine's position relative to the world's leading countries. We also consider it necessary to include Singapore, given that it is present in almost all the rankings (Table 4.19).

Table 4.19

Ranking of countries by major indices

Rank	Country	Rank	Country	Rank	Country	Rank	Country
1	Denmark	13	Iceland	25	Korea	37	Mexico
2	Sweden	14	France	26	Slovenia	38	China
3	Finland	15	Canada	27	Lithuania	39	Brazil
4	Switzerland	16	Ireland	28	Portugal	40	Colombia
5	Netherlands	17	Belgium	29	Slovakia	41	Turkey
6	Norway	18	Japan	30	Poland	42	Ukraine
7	Germany	19	Czech Republic	31	Israel	43	Indonesia

[284] The global green economy index GGEI. 2014. URL: https://dualcitizeninc.com/GGEI-Report2014.pdf
[285] Green economy progress measurement framework application. *United Nations Environment Programme.* 2017. URL: https://www.un-page.org/files/public/general/green_economy_progress_measurement_framework_application.pdf
[286] Legatum Prosperity Index. URL: https://nonews.co/directory/lists/countries/legatum-prosperity-index

8	GB	20	Singapore	32	Latvia	44	South Africa
9	Austria	21	Spain	33	Chile	45	India
10	New Zealand	22	Estonia	34	Hungary		
11	USA	23	Luxembourg	35	Costa Rica		
12	Australia	24	Italy	36	Greece		

Source: systematized by the authors

We consider the next step to be an analysis of how many smart cities there are in each of the countries of the obtained rating. Moreover, both their absolute number and the ratio of the population of smart cities to the total population of the country are important. The smart city index was chosen for the study, which evaluates a sufficiently significant number of cities and allows a certain time series to be followed. This is the SIMI index, based on which data for 2018, 2019 and 2020 were selected. Countries with a high value of the index - from 40 to 100 points - were selected from the entire data set.

Based on the population in individual cities and the country as a whole, the share of the population living in this city relative to the total population of the country was calculated - popular city / popular country. The value of the CIMI index was adjusted according to this share and the total share of the population in the country living in smart cities was determined for each country (sum_share_popul2018, sum_share_popul2019, sum_share_popul2020). Based on this, the Weighted CIMI Index for the country was determined (weigCIMIcountry_2018, weigCIMIcountry_2019, weigCIMIcountry_2020). This index is mathematically calculated as the ratio of sum_share_popul2018 to sum_weigCIMI_2018 (and so on for each year - 2019 and 2020).

Thus, the calculations showed that our new ranking included 58 countries in 2020, 56 countries in 2019, and 55 countries in 2018. The results are shown in Appendix A. There are 60 countries in this table - this is due to the fact that in some years countries were not included in the ranking.

Based on the calculated Weighted CIMI Indices by country (abbreviated to weigCIMIcountry_2020), a dot plot was also created to visualise the relationship

between the total share of the population living in smart cities (sum_share_popul2020) and the weighted index weigCIMIcountry_2020: the larger the point size, the higher the value of weigCIMIcountry_2020; the lighter the colour of the point, the higher the total share of the population (by country) living in smart cities sum_share_popul2020. The algorithm also added a new legend element, which compares the size of the point and the length of the braking distance (Figures 4.2 - 4.4).

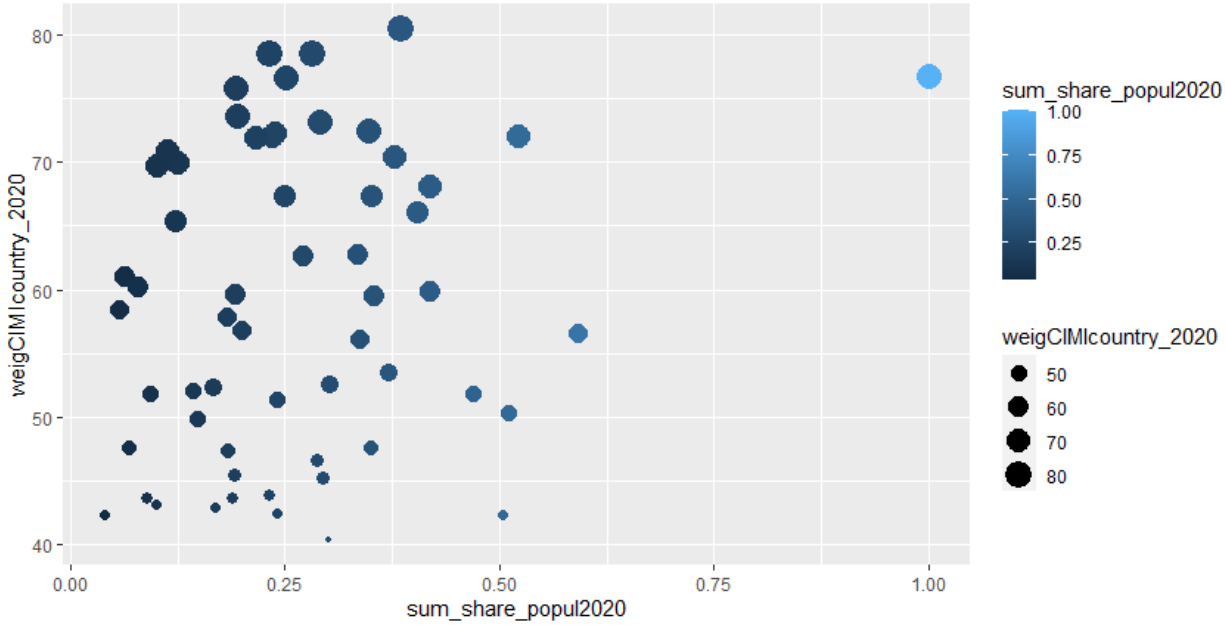

Figure 4.2. The relationship between the total share of the population living in smart cities in a country (sum_share_popul2020) and the weighted index (weigCIMIcountry_2020) according to 2020

Source: calculated and constructed by the authors

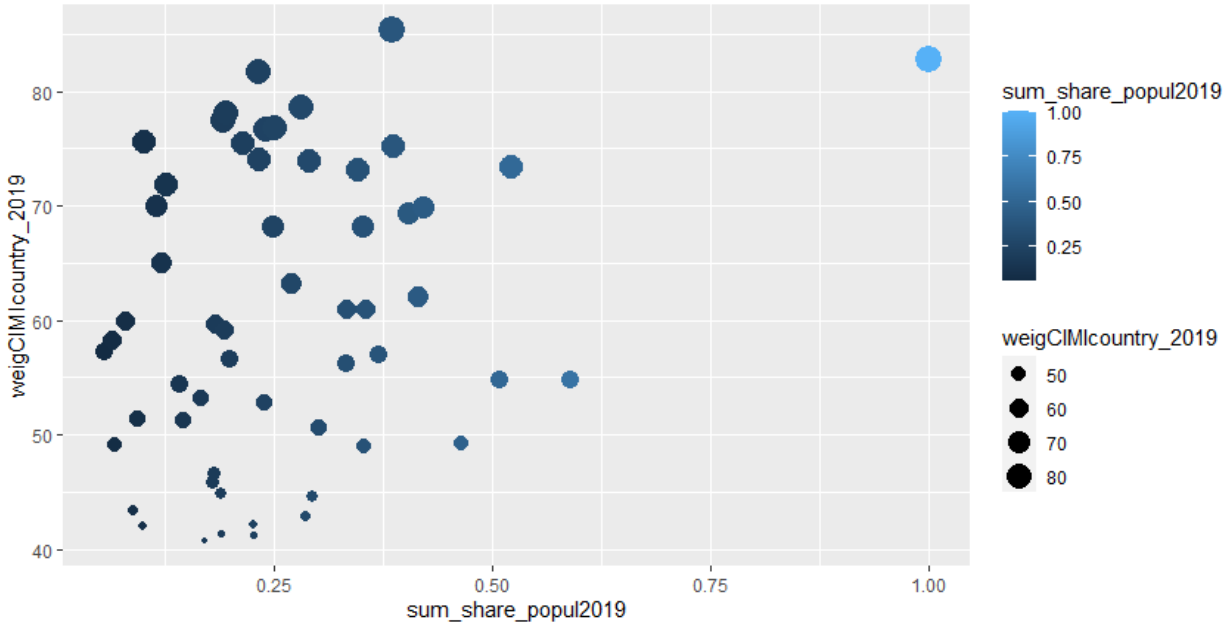

Figure 4.3. The relationship between the total share of the population living in smart cities in a country (sum_share_popul2019) and the weighted index (weigCIMIcountry_2019) according to 2019

Source: calculated and built by the authors

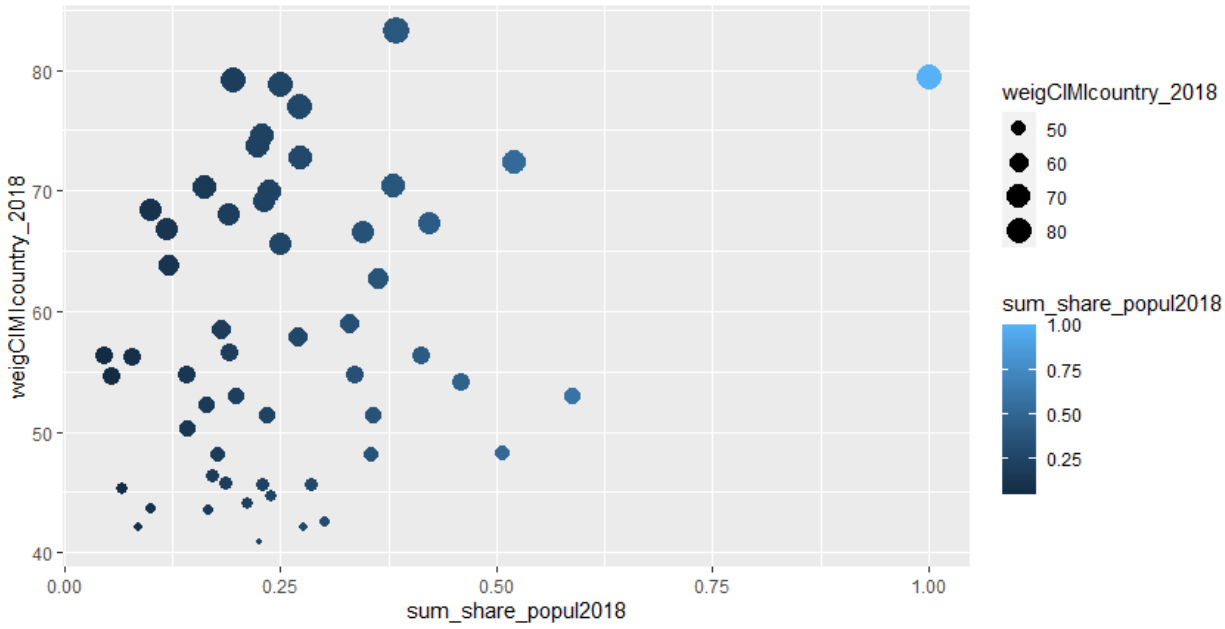

Figure 4.4. Relationship between the total share of the population living in smart cities (sum_share_popul_2018) and the weighted index weigCIMIcountry_2018

Source: calculated and built by the authors

As can be seen from the diagrams (see Fig. 4.2 - Fig. 4.4), the optimal number of clusters for clustering for the entire study period is the same. Therefore, for further generalisation of the calculations, all the results were divided into 4 clusters. Thus, we have: in 2018, a total of 55 countries were obtained: 1st cluster - 8 countries; 2nd cluster - 13 countries; 3rd cluster - 15 countries; 4th cluster - 19 countries. In 2019, a total of 56 countries were identified, including: Cluster 1 - 11 countries; Cluster 2 - 12 countries; Cluster 3 - 16 countries; Cluster 4 - 17 countries. In 2020, a total of 58 countries were identified: Cluster 1 - 14 countries; Cluster 2 - 11 countries; Cluster 3 - 16 countries; Cluster 4 - 17 countries. The full list of countries and their cluster assignment is provided in Appendix B.

The following countries remained the leaders of Cluster 1 in 2018-2020: Iceland, WB, Denmark, Singapore, France, and Korea.

It is interesting to compare the results with the previous conclusions based on the summary of various smart city indices presented in Table 5.20. The countries of the 1st cluster in 2020 and the TOP countries of the generalised result are almost identical (Table 4.20):

Table 4.20

Comparison of smart city index results, 2020

№	Countries of the 1st cluster according to the Weighted SIMI	TOP 14 countries by the generalised rating
1	Iceland	Denmark
2	GB	Sweden
3	Denmark	Finland
4	Singapore	Switzerland
5	France	Netherlands
6	Norway	Norway
7	Korea	Germany
8	USA	GB
9	Switzerland	Iceland
10	Austria	France
11	Japan	Canada
12	Finland	Ireland
13	Sweden	Belgium
14	Taiwan	Japan

Source: compiled by the authors

Thus, the undisputed leaders in the development of smart cities are the following countries: Iceland, Great Britain, Denmark, France, Norway, Switzerland, Japan, Finland and Sweden.

The study conducted with the help of mathematical tools proved that countries with successful smart cities are most successful in developing the smart economy. It is the example of such cities, where a significant part of the country's population lives, that becomes an important impetus for the country's successful sustainable development based on technological and environmental imperatives.

However, the presence of smart cities alone is one of the possible methods of studying the smart economy. Based on the methodology of defining the smart economy as a synergistic combination of the processes of ecologisation, digitalisation, socialisation, institutionalisation, etc., we consider it necessary to carry out mathematical modelling of the readiness of countries for the smart economy. The purpose of such modelling is to analyse whether such processes as digitalisation, environmentalisation and socialisation have quantitative dependencies and what impact they have on the economy of countries as a whole and its readiness for the smart economy. Based on this, the algorithm of the modelling process of the Smart Economy Readiness Index will consist of the following steps:

Stage 1 - comprehension and collection of input data, which, in our opinion, will characterise various aspects of the readiness of the country's economy for the state of the smart economy.

Stage 2 - calculation of complex characteristics that are integrated as partial indicators of the smart economy. At this stage, we used PCA and EFA to determine the outcome and factor variables.

Stage 3 - we build a system of structural equations in the context of each outcome variable and related factors. This system allows us to identify general patterns based on the relationship between different factors and their impact on the result.

Stage 4 - we calculate the rating integral score of the Smart Economy Readiness Index for countries based on the endogenous variables obtained in the previous stage.

Stage 5 - grouping countries by the Index's integrated score.

The main purpose of economic and mathematical modelling is to build such applied models that would describe the patterns of development of economic systems or objects under study. Changes in the states of economic objects and the relationships within them depend on a large number of parameters that form multidimensional data sets. Therefore, special attention in economic research, including in the macroeconomic sector, is paid to the study of the relationships between the indicators of this array.

Stage 1: The input dataset contained 4 groups of different indicators (environmental, technological, economic and social, 27 indicators in total) and 9 global indices by country for 2017-2020 (Appendix C). The input set of 60 countries was obtained after we grouped countries by the composite CIMI index (these studies are presented above).

Stage 2 - Thus, the main task at the stage of data collection and primary processing is to move from more to fewer factors by reducing the dimensionality of the analytical task, but without losing the informativeness of the input data space. For this purpose, there are two related but different methods for exploring and simplifying multidimensional data: Principal Component Analysis (PCA) and Exploratory Factor Analysis (EFA). PCA is a data reduction technique that transforms a large amount of correlated data into a much smaller set of uncorrelated variables called principal components. In contrast to PCA, Exploratory Factor Analysis (EFA) combines methods that find hidden structure in arrays of variables. This method allows to find a smaller set that is the basis of latent structural components that can explain the relationships between variables.

In order to achieve this goal, we believe it is necessary to use both of the above methods (PCA and EFA). This allowed us to structure the data by reducing the array of input variables to a smaller number that would explain most of the variation in the values of the outcome data. In addition, exploratory factor analysis (EFA) allowed us to identify a set of outcome variables and related independent variables.

Thus, three indices were identified and selected as outcome variables: The Human Development Index (Y1), The Legatum Prosperity Index (Y2) and DiGiX (The

Digitisation Index, Y3). As a result, the following indicators were selected as factor variables: GDP per capita (current international dollars, X1), high-tech exports (current US dollars, X2), Global Knowledge Index (GKI, X3) and life expectancy (years, X4).

The practical significance of the transition from a larger number of input variables to a smaller number, but without significant loss of information content, is explained by the following:

1) elimination of duplication of information between closely interrelated indicators, which allows simultaneously getting rid of multicollinearity in the set of factor variables;

2) elimination of uninformative indicators that are not related/change little when moving from one object to another (low variability of the indicator).

The resulting data set is presented in (Appendix D).

Step 3 - As mentioned above, the EFA method showed that it is reasonable to select three outcome variables in our set of input indicators and indices: The Human Development Index (Y1), the Legatum Institute Prosperity Index (Y2) and DiGiX (Y3). In this case, the use of an isolated econometric regression equation is inappropriate to explain the mechanisms of functioning and analyse the interaction of components in complex systems, including the smart economy. Based on the PCA method, it has become clear that a change in one outcome variable cannot occur autonomously, i.e. without changing the others. Such problems are solved with the help of a system of interrelated equations (also called a system of structural equations).

In econometric modelling, several types of systems of equations are used, depending on the relationships between the endogenous and exogenous variables under study:

- systems of independent equations - when each endogenous (dependent/resultant) variable Y is a function of the same set of exogenous variables (factors) X;

- a system of recursive equations - when the endogenous variable Y of one equation is an exogenous variable of the second equation; the number of exogenous variables in all equations is the same;

- system of interrelated (simultaneous/structural) equations - when the same endogenous variables in different equations can be both endogenous and exogenous variables.

Based on the above analysis, we can conclude that the third type of system is suitable for us - a system of interrelated (/simultaneous/structural) equations. We have built such a model for each year for the period 2017-2018.

Let us identify the variables of the model:

- Endogenous variables: Y1 - Human Development Index, Y2 - Legatum Institute Prosperity Index and Y3 - DiGiX index;

- exogenous variables: X1 - GDP per capita (current dollars), X2 - Global Knowledge Index, X3 - life expectancy (years).

In general, the model that will be built on the basis of our data is as follows:

$$Y_1 = f(Y_2, Y_3, X_1, X_2, X_3, u_1); \quad (4.1)$$

$$Y_2 = f(Y_1, Y_3, X_1, X_2, X_3, u_2). \quad (4.2)$$

$$Y_3 = f(Y_1, Y_2, X_1, X_2, X_3, u_3). \quad (4.3)$$

Equations 4.1-4.3 show that the exogenous variables Y_1, Y_2, Y_3 in one equation are exogenous variables in the others. This interdependence of the selected characteristics is real, and the econometric model describes this dependence without excluding other factors that also affect these indicators.

The following model specification in structural (linear) form was obtained experimentally:

$$\begin{cases} Y1 = b_{10} + b_{11}X1 + b_{12}X2 + b_{13}X3 + u1 \\ Y2 = b_{20} + a_{22}Y3 + b_{21}X1 + b_{23}X3 + u2 \\ Y3 = b_{30} + a_{31}Y2 + b_{31}X1 + b_{32}X2 + u3 \end{cases} \quad (4.4)$$

The first equation describes the quantitative relationship between the Human Development Index (Y1) and such factors as GDP per capita (X1), the Global Knowledge Index (X2) and life expectancy (X3). The second is a quantitative relationship between the Legatum Institute's Prosperity Index (Y2) and such factors as the DiGiX Index (Y3*), GDP per capita (X1), and life expectancy (X3). And the third

equation is the relationship between the DiGiX index (Y3) and the Legatum Prosperity Index (Y2*), GDP per capita (X1) and the Global Knowledge Index (X2).

The next step in developing the model is to move from the structural form (4.4) to the reduced form, which is necessary to calculate unbiased estimates of the parameters of the structural form of the model and to carry out economic and mathematical analysis based on it. The reduced form of the econometric model (4.4) will be as follows:

$$\begin{cases} Y1 = r_{10} + r_{11}X1 + r_{12}X2 + r_{13}X3 + \varepsilon 1 \\ Y2 = r_{20} + r_{21}X1 + r_{22}X2 + r_{23}X3 + \varepsilon 2 \\ Y3 = r_{30} + r_{31}X1 + r_{32}X2 + r_{33}X3 + \varepsilon 3 \end{cases} \quad (4.5)$$

In the reduced form of structural equations, only exogenous variables should be included as explanatory variables. But at this stage, the problem of identification may arise, so each equation of the structural model (4.4) must be checked for identification (unambiguous correspondence of model parameters when switching from the reduced to the structural form).

Structural models can be of three types: identified, unidentified, and overidentified. The type of model identification affects the method of calculating the parameters of the structural form (4.4).

The condition of model identification is checked for each equation separately. An equation is identified if the number of unobserved variables that are not present in the equation (but are present in the model) is equal to the number of endogenous variables in the equation without one.

Let us assume that H is the number of endogenous variables in the equation and D is the number of missing exogenous variables in the equation but present in the overall model. Then the identification condition for a particular equation will be as follows:

- if D +1 = H, then the equation is identified;
- if D +1 > H, then the equation is overidentified;
- if D +1 < H, the equation is not identified.

In our case, for model (4.4):

- in equation 1, we have H = 1, D = 0, so 0+1 = 1, i.e. the equation is identified;

- for the second and third equations, this calculation is the same: H = 2, D = 1, so 1+1 = 2, these equations are also identified.

Thus, all three equations are identified, so we choose the two-step least squares method (2LSM) to solve this system.

The 2MSK method is applicable to both identified and overidentified systems of structural equations. When using this method, all equations of the system are analysed sequentially, while the usual 1MSC method is applied twice, hence the name of this method. The 2MNK algorithm requires two steps:

Step 1. Conversion of the structural system (4.4) to the reduced form (4.5) of the model. Estimation of the parameters of each equation of the model (4.5) is carried out using 1MNK.

Step 2. Calculate the new values of the endogenous variables using the reduced form of the model. Next, the endogenous variables on the right-hand side of each equation are replaced with the new (estimated) values, and the 1MNC is applied again.

Since we have an identified system, the model parameters obtained by the 2MSC method will coincide with the results of the OLS (indirect least squares). An important note on the use of 2MSC is that this method will be effective only if the coefficient of determination (R^2) of the reduced equations in model (4.5) is sufficiently large ($R^2 \geq 0,7$), otherwise the newly calculated values of the endogenous variables in the structural form (as factors) will be insignificant.

All variables were logarithmised before performing numerical calculations of the model. This was necessary to eliminate differences in data measurements. In addition, the logarithmisation procedure allows the regression residuals to be closer to normally distributed and increase accuracy/quality.

The results of the calculation of the reduced form of model (4.5) based on the 2017 data obtained by the 1MNC method for each system equation separately are presented below:

- Human development index (Y1)

$$\begin{gathered} Y1 = 0{,}122X1 + 0{,}061X2 + 0{,}763X3 + \varepsilon 1 \\ (0{,}054) \quad (0{,}013) \quad (0.034) \\ R^2 = 0{,}989 \qquad Froz = 24{,}775 \end{gathered} \tag{4.6}$$

- Legatum Institute Prosperity Index (Y2)

$$\begin{gathered} Y2 = 0{,}557X1 - 0{,}060X2 + 0{,}318X3 + \varepsilon 2 \\ (0{,}082) \quad (0{,}020) \quad (0{,}051) \\ R^2 = 0{,}995 \qquad Froz = 74{,}412 \end{gathered} \tag{4.7}$$

- DiGiX index (Y3)

$$\begin{gathered} Y3 = 1{,}53X1 + 0{,}238X2 - 1{,}048X3 + \varepsilon 2 \\ (0{,}292) \quad (0{,}072) \quad (0{,}181) \\ R^2 = 0{,}998 \qquad Froz = 34{,}063 \end{gathered} \tag{4.8}$$

Let's find the estimated values $\widehat{Y_1}$ (based on the first equation), $\widehat{Y_2}$ (based on the second equation) and $\widehat{Y_3}$ (based on the third equation). On the basis of these data, using the 1MNC once again, we will build the model in structural form. The array of exogenous variables remains unchanged. The resulting model in structural form will have the form:

$$\begin{cases} Y1 = 1{,}591 + 0{,}161X1 + 0{,}075X2 + 0{,}328X3; \\ \quad (0{,}56) \quad (0{,}053) \quad (0{,}014) \quad (0{,}156) \\ Y2 = -1{,}666 - 0{,}598Y3^* + 0{,}243X1 + 0{,}243X3; \\ \quad (0{,}877) \quad (0{,}096) \quad (0{,}026) \quad (0{,}224) \\ Y3 = -1{,}57 + 0{,}621Y2^* + 0{,}151X1 + 1{,}316X2. \\ \quad (0{,}698) \quad (1{,}147) \quad (0{,}106) \quad (0{,}376) \end{cases} \tag{4.9}$$

The coefficients of determination and Fisher's criteria for each equation of the system are respectively: for the first equation $R^2 = 0{,}871$, $F = 113{,}10$, for the other $R^2 = 0{,}886$, $F = 93{,}7$ and for the third $R^2 = 0{,}789$, $F = 63{,}92$. The statistical characteristics of the equations indicate that the model based on structural equations is of high quality and reliable. In the equations of the models (4.6-4.9), the corresponding values of the standard errors of each parameter of the constructed equations are given in brackets. According to the Student's criterion, the model parameters are statistically significant, which also confirms the reliability of the model and the possibility of its further use.

The data were recalculated after each year to avoid missing important indicators. It turned out that an exogenous variable was added as a significant factor in 2019 and 2020 - the unemployment rate in the country (% of the total labour force, X4). In addition, the components of the equations in the structural form of model (4.10) have changed in the model compared to model (4.4).

Identification of model variables based on 2019 data: endogenous variables: Y1 - Human Development Index, Y2 - Legatum Institute Prosperity Index, and Y3 - DiGiX Index; exogenous variables: X1 is GDP per capita (current international dollars), X2 is the Global Knowledge Index, X3 is life expectancy (years), and X4 is the unemployment rate in the country (% of the total labour force).

Model specification in structural (linear) form based on 2019:

$$\begin{cases} Y1 = b_{10} + b_{11}X1 + b_{12}X2 + b_{13}X3 + b_{14}X4 + u1 \\ Y2 = b_{20} + a_{22}Y3 + b_{21}X1 + b_{23}X3 + b_{24}X4 + u2 \\ Y3 = b_{30} + b_{31}X1 + b_{32}X2 + b_{34}X4 + u3 \end{cases} \quad (4.10)$$

The first equation describes the quantitative relationship between the Human Development Index (Y1) and such factors as GDP per capita (X1), the Global Knowledge Index (X2), life expectancy (X3) and the unemployment rate in the country (X4). The second is the quantitative relationship between the Legatum Prosperity Index (Y2) and such factors as the DiGiX Index (Y3*), GDP per capita (X1), life expectancy (X3), and the country's unemployment rate (X4). And the third equation is the relationship between the DiGiX index (Y3) and GDP per capita (X1), life expectancy (X3) and the unemployment rate in the country (X4).

The test of the identification condition of the model (4.10) gave the following results:

in equation 1 we have H=1, D=0, then 0+1=1, i.e. the equation is identified;

for equation 2, we have H=2, D=1, then 1+1=2, i.e. the equation is identified;

for equation 3, we have H = 1, D = 1, so 1+1 > 1, i.e. the equation is overidentified.

Thus, if at least one equation of the system is overidentified, the entire model will be overidentified. In this case, the use of the two-step least squares method (2LSM) is also appropriate.

All further calculations were carried out according to the algorithm described above (for model (5.9)).

The system of generalised equations of the model based on 2019 data is as follows:

$$\begin{cases} Y1 = \underset{(0,013)}{0,623X1} + \underset{(0,049)}{0,087X2} + \underset{(0,063)}{0,624X3} + \underset{(0,059)}{0,163X3}; \\ Y2 = \underset{(0,02)}{0,042X1} + \underset{(0,073)}{0,535X2} + \underset{(0,094)}{0,267X3} + \underset{(0,088)}{0,11X4}; \\ Y3 = \underset{(0,043)}{0,117X1} + \underset{(0,157)}{1,328X2} - \underset{(0,166)}{0,206X3} + \underset{(0,176)}{0,286X2}. \end{cases} \quad (4.11)$$

The array of exogenous variables remains unchanged. After calculating the new estimated values $\widehat{Y_1}$ (based on the first equation), $\widehat{Y_2}$ (based on the second equation) and (based on the third equation), applying the 1MNC once again, we will build the model in structural form. The model in the structural form for the 2019 data will look like this:

$$\begin{cases} Y1 = \underset{(0,541)}{1,235} + \underset{(0,014)}{0,073X1} + \underset{(0,5)}{0,121X2} + \underset{(0,149)}{0,314X3} + \underset{(0,055)}{0,136X}; \\ Y2 = \underset{(0,806)}{-1,608} + \underset{(0,056)}{0,37Y3^*} \underset{(0,025)}{-0,015X1} + \underset{(0,217)}{0,768X3} + \underset{(0,086)}{0,25X4}; \\ Y3 = \underset{(0,074)}{-0,696} + \underset{(0,047)}{0,112X1} + \underset{(0,156)}{1,295X2} - \underset{(0,193)}{0,342X3}. \end{cases} \quad (4.12)$$

The coefficients of determination (R^2) and Fisher's criteria (F) for each equation of the system are respectively:

- for the equation1 : $R^2 = 0,878$, $F = 91,61$,
- for the equation2 : $R^2 = 0,897$, $F = 111,01$, (4.13)
- for the equation3 : $R^2 = 0,871$, $F = 117,12$.

The statistical characteristics of the equations indicate that the model based on structural equations is of high quality and reliable, and it can be used for further research.

The structural model based on 2020 data has a similar structure to model (4.13) and is also adequate and reliable in terms of statistical characteristics (Appendix E).

Step 4 - The next step in modelling the Smart Economy Readiness Index (*IRSmartE*) is to determine (calculate) an integral rating score for each country. It should be noted that the rating assessment can be carried out taking into account the weight (priority) of individual indicators or their subset and has several modifications.

We used a weighted geometric mean (multiplicative approach) to calculate this integrated rating score. The formula for calculating the IRSmartE integral score is as follows:

$$\text{IRSmartE} = \sqrt[3]{\prod_{i=1}^{3} Y^*{}_i} \tag{4.14}$$

where Y^*_i are the estimated values of the endogenous variables according to models (4.9) and (4.12).

The results of the integral rating assessment as the Smart Economy Readiness Index based on 2019 data are presented in Appendix F. The grouping of countries by different indices (weigCIMIcountry and IRSmartE) was carried out using the same methodology.

If we compare the results of deviations (differences) in the country's placement in a group (Table 4.21), we have 36 matches (out of 56 available groups) and 19 mismatches.

Table 4.21.

Results of the comparison of compliance/non-compliance of countries to certain groups

Deviation	Frequency	Probability
0	36	0,643
1	15	0,268
2	0	0,000
-1	4	0,071
-2	1	0,018

That is, the probability of matching group numbers for a country is 0.643. Yes, this is not a very high quality (good) indicator. However, if we analyse the results of

Appendix F more thoroughly (in terms of economic indicators), our ranking is much more accurate and reflects the real state of the economies of the countries under study.

Appendix G and **Appendix H** present similar results of the IRSmartE Smart Economy Readiness Index for 2018 and 2020, respectively.

CONCLUSIONS

The phenomenon of smart economy is associated with the spread of new smart technologies in the management of economic, social and environmental processes. There are fundamental changes in the principles and mechanisms of the modern economy under the influence of accelerated intellectualisation and the widespread penetration of ICTs. The transformation of the economic basis of modern society is accompanied by increased attention to the problems of personal development, the environment, environmental protection and, at the same time, the emergence of new governance institutions. It is common to perceive the smart economy in a narrow sense, as an economic system of a certain location (city), the development of which is ensured by the latest technologies on the basis of sustainable development and social responsibility. At the same time, it is necessary to understand it in a broader sense, as a system of economic relations that is formed at the national and international levels, based on the large-scale use of the most advanced smart technologies, the implementation of the principles of sustainable development and social responsibility, and subordinated to the goals of creating comfortable and safe living conditions for the country's population.

The evolution of theoretical views on the conceptualisation of social development has led to the emergence of the phenomenon of smart economy as a way of organising society in which the interconnectedness of economic, environmental, socio-psychological, technological and institutional development is ensured with the help of modern information and communication technologies. In economic science, the perception of smart economy as an ecosystem in which all components (economic, environmental, socio-psychological, institutional, information, etc.) are balanced, and the management of all processes is ensured on the basis of the latest smart technologies and the balance of key processes (political, economic, financial and social) is becoming widespread. A generalisation of theoretical approaches to understanding the phenomenon of smart cities has confirmed their evolution: smart city 1.0 (technology-

centric approach); smart city 2.0 (government-centric approach); and smart city 3.0 (dominated by the citizen and human-centric approach).

The development of the smart economy is the result of the complex action of key imperatives: digitalisation (large-scale spread of information and communication technologies in all spheres of human activity), socialisation (increasing importance of human social problems), ecologisation (growing attention to environmental problems, preservation of the environment), institutionalisation (formation of new institutional mechanisms for managing social development processes), intellectualisation (increasing role of intellectual factors of progress), etc. The combined effect of these imperatives, together with the unprecedented penetration of information and communication technologies, leads to the formation of new forms of interconnections, governance institutions, and the emergence of a smart environment, which includes socially responsible business; comfortable living conditions for the population; smart community; and clean nature. The technological basis of the smart economy is large-scale digitalisation, the spread of the latest ICTs in all spheres of life, and the formation of new principles of economic activity and human life.

The acceleration of urbanisation, the growth of the urban population, and the number of large and extra-large cities raise the issue of managing their functioning and life support. The most active players in the formation of the smart economy are the leading cities that are gaining global influence and shaping the smart space. In general, effective mechanisms are being created for the participation of various actors in governance: private business, citizens, NGOs, educational and cultural institutions, infrastructure units, etc. in the process of city management. Information and communication technologies make it possible to develop software tools that actually replace certain public services. Thus, collective intelligence (which embodies the synergistic interaction of all stakeholders), together with the active penetration of modern technologies, forms and becomes the basis for a new quality of the city.

The smart economy is being driven by the spread of the latest technologies (artificial intelligence, the Internet of Things and the industrial Internet of Things, cyber-physical systems, Big Data, cloud computing, additive manufacturing,

augmented reality, etc.) that are transforming the entire economy and creating new business models based on integrated intelligent control systems. The flexibility and adaptability of production is ensured by combining all parts of the production and logistics processes into a single system of operation, driven by innovative technologies in real time. These new business models focus on individual customer requests, affordable and transparent prices, and free delivery. All of these processes, combining the virtual and real worlds, create a global space characterised by flexibility, adaptability, interactivity, a significant reduction in transaction costs and the transition to virtual, intangible forms of economic interaction, a special way of thinking and lifestyle. The point of the smart economy is to provide this space with a reasonable vector of development. In the process of implementing the goals of sustainable inclusive development, climate protection, human centrism, etc., the smart, intelligent nature of modern production and the economy in general is being formed on the principles of intellectual self-development, energy resource autonomy, circular self-sufficiency, platform and networking.

An important imperative of the smart economy is also consistent greening, the development of a green economy aimed at ensuring low-carbon, resource-saving and socially inclusive development, improving the well-being of the population and reducing environmental risks. In today's developed smart cities, the widespread use of ICTs (water, heat, energy, air and water quality, security sensors, etc.) is an important tool for building an environmentally conscious economic environment. The smart economy is being formed on the basis of digitalisation, ecologisation, socialisation, networking, etc. at all levels: at the state, local, and individual enterprise levels. The large-scale penetration of ICTs into all spheres of life is also reflected in the development of the governance system at all levels, the emergence of new forms and tools of governance (involvement of community members in solving important issues, electronic petitions, etc.).

Assessing the development of smart cities and the smart economy in general is an important scientific issue. The most well-known and developed approaches to assessing the success of smart cities are: Smart Cities Index; City Development Index;

City Prosperity Index; Global Cities Index. Countries with successful smart cities are most successful in developing the smart economy. It is the example of such cities, where a significant part of the country's population lives, that becomes an important impetus for its successful development based on technological and environmental imperatives.

The active use of modern ICTs on a smart basis creates opportunities for all countries of the world to breakthrough the development of smart cities and the smart economy. An example is the dynamic growth in the number of smart cities in other regions of the world, particularly in Asian countries. The determining factor for the success of global cities and their leading positions in the rankings is intellectual factors: the quality of human capital, the latest technologies, and research and development costs.

Appendix

Appendix A

Weighted CIMI Indices by country (weigCIMIcountry_20**) for 2018-2020 (ranking based on 2020 data)

Rank	Country	sum_share_popul2018	weigCIMIcountry_2018	sum_share_popul2019	weigCIMIcountry_2019	sum_share_popul_2020	weigCIMIcountry_2020
1	2	3	4	5	6	7	8
1	Iceland	0,384	**83,26**	0,3841	**85,34**	0,3842	**80,46**
2	United Kigdom	0,2709	**76,96**	0,2806	**78,63**	0,2821	**78,54**
3	Denmark	0,2297	**74,54**	0,2311	**81,81**	0,2324	**78,51**
4	Singapore	1	**79,52**	1	**82,73**	1	**76,71**
5	France	0,249	**78,91**	0,2497	**76,78**	0,2504	**76,59**
6	Norway	0,1896	**68,13**	0,1909	**77,46**	0,192	**75,80**
7	Korea	0,1947	**79,21**	0,1945	**78,12**	0,1943	**73,68**
8	United States	0,2727	**72,67**	0,2906	**73,87**	0,2906	**73,16**
9	Switzerland	0,3458	**66,55**	0,3464	**73,13**	0,3469	**72,49**
10	Austria	0,2382	**69,91**	0,2389	**76,65**	0,2395	**72,28**
11	Japan	0,5209	**72,36**	0,5217	**73,39**	0,5227	**72,05**
12	Finland	0,2316	**69,16**	0,2336	**74,06**	0,2355	**71,97**
13	Sweden	0,1619	**70,32**	0,2151	**75,36**	0,2168	**71,87**
14	Taiwan	NA	**NA**	0,1141	**70,04**	0,1142	**70,81**
15	Australia	0,2235	**73,67**	0,386	**75,17**	0,3774	**70,38**
16	Germany	0,1184	**66,81**	0,1259	**71,88**	0,1262	**69,89**
17	Netherlands	0,1002	**68,41**	0,1006	**75,58**	0,1009	**69,65**
18	New Zealand	0,4216	**67,38**	0,4206	**69,84**	0,4188	**68,10**
19	Ireland	0,2492	**65,63**	0,2488	**68,20**	0,2487	**67,39**
20	Spain	0,363	**62,71**	0,3503	**68,14**	0,3513	**67,35**
21	Canada	0,3816	**70,43**	0,4033	**69,31**	0,4032	**66,12**
22	Czech Republic	0,1218	**63,83**	0,122	**64,95**	0,1221	**65,37**
23	Estonia	0,3303	**58,97**	0,3326	**60,96**	0,3353	**62,72**
24	Belgium	0,2703	**57,94**	0,2708	**63,13**	0,271	**62,59**
25	Poland	0,0466	**56,35**	0,0638	**58,34**	0,064	**60,95**
26	Slovakia	0,0789	**56,15**	0,0793	**59,96**	0,0797	**60,24**
27	Portugal	0,4128	**56,36**	0,4158	**62,07**	0,4188	**59,87**
28	Lithuania	0,1908	**56,57**	0,1926	**59,14**	0,1929	**59,61**
29	Chile	0,3567	**51,44**	0,3548	**60,96**	0,354	**59,45**
30	China	0,0543	**54,64**	0,0554	**57,29**	0,0563	**58,44**
31	Hungary	0,1812	**58,57**	0,1821	**59,66**	0,183	**57,88**
32	Italy	0,1986	**53,00**	0,1991	**56,64**	0,1998	**56,88**
33	Israel	0,5867	**53,02**	0,5894	**54,86**	0,5907	**56,54**
34	Latvia	0,3302	**58,99**	0,3325	**56,26**	0,3362	**56,18**
35	Argentina	0,337	**54,68**	0,3702	**56,97**	0,3705	**53,52**
36	Greece	0,2999	**42,56**	0,3011	**50,71**	0,3025	**52,58**
37	Croatia	0,1649	**52,30**	0,1659	**53,29**	0,1672	**52,34**
38	Slovenia	0,1424	**54,72**	0,1424	**54,40**	0,1424	**52,10**

39	Romania	NA	**NA**	0,0928	**51,49**	0,0927	**51,88**
40	United Arab Emirates	0,4601	**54,17**	0,4651	**49,27**	0,4696	**51,81**
41	Malaysia	0,2335	**51,37**	0,2372	**52,82**	0,2409	**51,42**
42	Uruguay	0,5069	**48,25**	0,509	**54,75**	0,5109	**50,38**
43	Thailand	0,1428	**50,34**	0,1451	**51,37**	0,1474	**49,84**
44	Ukraine	0,0668	**45,24**	0,0677	**49,14**	0,0683	**47,57**
45	Costa Rica	0,3553	**48,07**	0,3532	**49,01**	0,3514	**47,56**
46	Bulgaria	0,1787	**48,10**	0,1811	**46,70**	0,1835	**47,30**
47	Georgia	0,2855	**45,69**	0,2856	**42,96**	0,2863	**46,67**
48	Serbia	0,1868	**45,74**	0,1884	**44,85**	0,19	**45,42**
49	Colombia	0,2129	**44,11**	0,2929	**44,58**	0,2943	**45,28**
50	Qatar	0,2288	**45,69**	0,2269	**42,14**	0,2322	**43,86**
51	Brazil	0,1663	**43,60**	0,1884	**41,41**	0,1888	**43,62**
52	Vietnam	0,0858	**42,09**	0,0874	**43,49**	0,089	**43,61**
53	Kazakhstan	0,0987	**43,71**	0,0993	**42,06**	0,0999	**43,08**
54	Mexico	0,171	**46,36**	0,1699	**40,78**	0,1689	**42,87**
55	Turkey	0,2388	**44,64**	0,1794	**45,84**	0,2403	**42,41**
56	Paraguay	NA	**NA**	NA	**NA**	0,5042	**42,34**
57	Indonesia	NA	**NA**	NA	**NA**	0,0396	**42,27**
58	Dominican Republic	NA	**NA**	NA	**NA**	0,3016	**40,39**
59	Azerbaijan	0,2252	**40,91**	0,226	**41,25**	NA	**NA**
60	Macedonia	0,2763	**42,04**	NA	**NA**	NA	**NA**

NA - no data were available, or the city was not in the ranking for the respective year

Source: calculated and compiled by the authors

Appendix B

Results of clustering countries by the weighted CIMI Index, 2018-2020

Years	Claster 1	Claster 2	Claster 3	Claster 4
2018	**Iceland** **Singapore** **Korea** **France** **United Kigdom** **Denmark** **Australia** **USA**	Japan Canada Sweden Austria Finland Netherlands Norway New Zealand Germany Switzerland Ireland Czech Republic Spain	Latvia Estonia Hungary Belgium Lithuania Portugal Poland Slovakia Slovenia Argentina China United Arab Emirates Israel Italy Croatia	Chile Malaysia Thailand Uruguay Bulgaria Costa Rica Mexico Serbia Georgia Qatar Ukraine Turkey Colombia Kazakhstan Brazil Greece Vietnam Macedonia Azerbaijan
2019	**Iceland** **Singapore** **Denmark** **United Kigdom** **Korea** **Norway** **France** **Austria** **Netherlands** **Sweden** **Australia**	Finland USA Japan Switzerland Germany Taiwan New Zealand Canada Ireland Spain Czech Republic Belgium	Portugal Chile Estonia Slovakia Hungary Lithuania Poland China Argentina Italy Latvia Israel Uruguay Slovenia Croatia Malaysia	Romania Thailand Greece UAE Ukraine Costa Rica Bulgaria Turkey Serbia Colombia Vietnam Georgia Qatar Kazakhstan Brazil Mexico
2020	**Iceland** **United Kigdom** **Denmark** **Singapore** **France** **Norway** **Korea** **United States** **Switzerland** **Austria** **Japan** **Finland** **Sweden** **Taiwan**	Australia Germany Netherlands New Zealand Ireland Spain Canada Czech Republic Estonia Belgium Poland	Slovakia Portugal Lithuania Chile China Hungary Italy Israel Latvia Argentina Greece Croatia Slovenia Romania United Arab Emirates Malaysia	Uruguay Thailand Ukraine Costa Rica Bulgaria Georgia Serbia Colombia Qatar Brazil Vietnam Kazakhstan Mexico Turkey Paraguay Indonesia Dominican Republic

Source: compiled by the authors

Appendix C

Indicators for the Smart Economy Readiness Index (Smart економіка)

№	Key groups of indicators	Indicators
1	2	3
1	environmental	CO2 emissions (metric tons per capita)
		Electric power consumption (kWh per capita)
		Renewable energy consumption (% of total final energy consumption)
		Total greenhouse gas emissions (kt of CO2 equivalent)
2	technological	Mobile cellular subscriptions (per 100 people)
		Secure Internet servers (per 1 million people)
		Public private partnership investment in ICT (current US$)
		High-technology exports (current US$)
		Research and development expenditure (% of GDP)
		Patent applications, residents
		Researchers in R&D (per million people)
3	economic	GDP per capita, PPP (current international $)
		GDP per capita growth (annual %)
		Foreign direct investment, net inflows (BoP, current US$)
		Industry (including construction), value added (% of GDP)
		Medium and high-tech manufacturing value added (% manufacturing value added)
		Imports of goods and services (% of GDP)
		Time required to start a business (days)
		Total tax and contribution rate (% of profit)
4	social	Government expenditure on education, total (% of GDP)
		School enrollment, secondary (% gross)
		School enrollment, tertiary (% gross)
		Unemployment, total (% of total labor force)
		Life expectancy at birth, total (years)
		Gini index
		Income share held by highest 10%
		Income share held by lowest 10%
		Population in the largest city (% of urban population)
		Population living in slums (% of urban population)
		Urban population (% of total population)
		Population in urban agglomerations of more than 1 million (% of total population)

Source: compiled by the authors

Appendix D

Indices for modelling the Smart Economy Readiness Index

№	Title Content	Title Content
1	HDI	Human Development Index
2	SDG	Index Sustainable Development Goals
3	PLegI	The Legatum Prosperity Index
4	WHapI	World Happiness Report
5	HapPI	Happy Planet Index
6	GCI	Global Competitiveness Index 4.0, earlier Global Competitiveness Index (2015 – 2017 pp)
7	GKI	Global Knowledge Index
8	DiGiX	DiGiX
9	GInnovI	Global Innovative Index

Source: compiled by the authors

Appendix E

The model in structural form will look like this (as of 2020):

$$\begin{cases} Y1 = 1{,}912 + 0{,}117X1 + 0{,}217X2 + 0{,}026X3 + 0{,}104X4; \\ \quad (0{,}440) \quad (0{,}044) \quad (0{,}122) \quad (0{,}005) \quad (0{,}013) \\ Y2 = -0{,}378 + 0{,}340Y3^{*} + 0{,}042X1 + 0{,}625X3 + 0{,}031X4; \\ \quad (0{,}728) \quad (0{,}056) \quad (0{,}023) \quad (0{,}198) \quad (0{,}009) \\ Y3 = -2{,}889 + 0{,}296X1 + 0{,}913X2 - 0{,}021X3. \\ \quad (1{,}374) \quad (0{,}056) \quad (0{,}639) \quad (0{,}002) \end{cases}$$

The coefficients of determination (R2) and Fisher's criteria (F) for each equation of the system are respectively: for equation 1: R2 = 0.908, F = 133.3, for equation 2: R2 = 0.886, F = 104.01, for equation 3: R2 = 0.771, F = 47.53.

The statistical characteristics of the equations indicate that the model based on structural equations is qualitative and reliable, and it can be used for further research.

Source: compiled by the authors

Appendix F

Comparison of the results of grouping by the weighted CIMI Index (weigCIMIcountry) by country and the Smart Economy Readiness Index (IRSmartE) according to 2019 data

Country	weigCIMIcountry_ 2019	CIMI19 _group	IRSmartE	IRSmartE _grop	differences
1	2	3	4	5	6
Denmark	81,81	4	86,31	4	0
Finland	74,06	4	87,01	4	0
Netherlands	75,58	4	87,04	4	0
Norway	77,46	4	85,28	4	0
Singapore	82,73	4	91,71	4	0
Switzerland	73,13	4	92,55	4	0
United Kingdom	78,63	4	84,99	4	0
United States	73,87	4	88,72	4	0
Ireland	68,20	3	86,76	4	-1
Sweden	75,36	4	87,12	4	0
UAE	49,27	2	84,16	4	-2
Australia	75,17	4	80,13	3	1
Austria	76,65	4	83,79	3	1
Canada	69,31	3	79,37	3	0
France	76,78	4	80,82	3	1
Germany	71,88	3	83,40	3	0
Japan	73,39	4	83,09	3	1
Korea	78,12	4	80,15	3	1
Belgium	63,13	3	83,42	3	0
Czech Republic	64,95	3	75,57	3	0
Estonia	60,96	3	76,86	3	0
New Zealand	69,84	3	80,40	3	0
Portugal	62,07	3	76,32	3	0
Slovenia	54,40	2	76,27	3	-1
Spain	68,14	3	75,35	3	0
Israel	54,86	2	79,68	3	-1
Iceland	85,34	4	83,85	3	1
Hungary	59,66	3	70,05	2	1
Italy	56,64	2	74,76	2	0
Lithuania	59,14	2	72,95	2	0
Poland	58,34	2	71,19	2	0
Chile	60,96	3	67,39	2	1
Croatia	53,29	2	67,57	2	0
Latvia	56,26	2	70,96	2	0
Malaysia	52,82	2	71,34	2	0
Slovakia	59,96	3	70,78	2	1

China	53,79	2	66,92	2	0
Costa Rica	49,01	2	66,71	2	0
Qatar	42,14	1	74,92	2	-1
Argentina	56,59	2	58,21	1	1
Bulgaria	46,70	1	64,30	1	0
Greece	50,71	2	64,58	1	1
Mexico	40,78	1	62,28	1	0
Romania	51,49	2	65,41	1	1
Thailand	51,37	2	62,77	1	1
Uruguay	54,75	2	65,93	1	1
Azerbaijan	41,25	1	59,67	1	0
Brazil	39,24	1	59,66	1	0
Colombia	44,58	1	59,44	1	0
Georgia	42,96	1	60,55	1	0
Kazakhstan	42,06	1	62,79	1	0
Macedonia	33,88	1	58,99	1	0
Serbia	44,85	1	64,01	1	0
Turkey	44,32	1	61,06	1	0
Ukraine	49,14	2	59,83	1	1
Vietnam	43,49	1	58,06	1	0

Source: caculated and compiled by the authors

Appendix G

Comparison of the results of grouping by the weighted CIMI Index (weigCIMIcountry) by country and the Smart Economy Readiness Index (IRSmartE) according to 2018 data

Country	weigCIMIcountry_2018	CIMI18_group	IRSmartE_2018	IRSmartE_grop	різниця
1	2	3	4	5	6
Norway	68,0	3	86,85	4	-1
Singapore	79,8	4	93,64	4	0
Switzerland	66,7	3	88,37	4	-1
Ireland	65,4	3	89,6	4	-1
Qatar	45,6	1	88,82	4	-3
Australia	73,7	4	81,49	3	1
Austria	70,1	3	82,71	3	0
Canada	70,1	3	80,85	3	0
Denmark	74,4	4	82,31	3	1
Finland	69,4	3	80,76	3	0
France	79,0	4	80,35	3	1
Germany	66,7	3	81,61	3	0
Japan	72,2	4	80,1	3	1
KoreaRep	79,0	4	79,12	3	1
Netherlands	68,7	3	83,17	3	0
UnitedKingdom	76,7	4	79,7	3	1
UnitedStates	73,0	4	81,9	3	1
Belgium	58,0	2	81,43	3	-1
CzechRepublic	64,1	3	75,61	3	0
Italy	53,0	2	79,53	3	-1
NewZealand	67,4	3	78,33	3	0
Portugal	56,3	2	75,02	3	-1
Slovenia	54,6	2	76,63	3	-1
Spain	62,8	3	78,72	3	0
Sweden	70,1	3	82,58	3	0
UnitedArabEmirates	54,1	2	82,36	3	-1
Israel	53,0	2	78,11	3	-1
Iceland	83,1	4	83,72	3	1
Estonia	59,1	2	73,33	2	0
Hungary	58,6	2	69,83	2	0
Lithuania	56,8	2	67,17	2	0
Poland	56,3	2	70,94	2	0
Argentina	53,0	2	65,66	2	0

Chile	51,4	2	69,54	2	0
Croatia	52,5	2	69,86	2	0
Greece	42,5	1	72,66	2	-1
Latvia	59,1	2	68,46	2	0
Malaysia	51,4	2	68,21	2	0
SlovakRepublic	56,3	2	70,38	2	0
Uruguay	48,4	2	67,04	2	0
CostaRica	47,9	2	67,26	2	0
Kazakhstan	43,8	1	64,99	2	-1
Turkiye	44,7	1	68,73	2	-1
Bulgaria	47,9	2	64,75	1	1
Mexico	46,5	1	63,07	1	0
Thailand	50,4	2	63,41	1	1
Azerbaijan	40,9	1	57,95	1	0
Brazil	35,9	1	60,11	1	0
China	54,6	2	61,32	1	1
Colombia	44,3	1	60,95	1	0
Georgia	45,6	1	58,54	1	0
Macedonia	42,1	1	61,95	1	0
Serbia	45,6	1	62,23	1	0
Ukraine	45,2	1	55,73	1	0
Vietnam	42,1	1	55,23	1	0

Source: caculated and compiled by the authors

Appendix H

Comparison of the results of grouping by the weighted CIMI Index (weigCIMIcountry) by country and the Smart Economy Readiness Index (IRSmartE) according to 2020 data

Country	weigCIMIcountry_2020	CIMI20_group	IRSmartE_2020	IRSmartE_grop	різниця
1	2	3	4	5	6
Denmark	84,26	4	83,37	4	0
Norway	83,67	4	84,57	4	0
Singapore	79,22	4	91,72	4	0
Sweden	82,92	4	83,99	4	0
Switzerland	83,14	4	88,06	4	0
Ireland	80,00	3	89,38	4	-1
Netherlands	82,26	3	83,58	4	-1
Australia	79,10	4	81,88	3	1
Austria	80,39	4	81,95	3	1
Finland	82,95	4	82,85	3	1
France	76,73	4	80,37	3	1
Germany	80,88	4	81,56	3	1
Iceland	80,68	4	82,48	3	1
Japan	77,64	4	80,11	3	1
KoreaRep	73,65	4	80,17	3	1
UnitedKingdom	79,98	4	79,64	3	1
UnitedStates	77,45	4	82,82	3	1
Belgium	76,57	3	81,16	3	0
Canada	79,43	3	79,46	3	0
CzechRepublic	73,57	3	74,82	3	0
Estonia	77,61	3	74,83	3	0
NewZealand	81,06	3	79,12	3	0
Portugal	74,19	3	75,03	3	0
Spain	75,75	3	76,86	3	0
Israel	72,14	2	78,08	3	-1
Italy	72,11	2	77,41	3	-1
Slovenia	74,94	2	75,48	3	-1
UnitedArabEmirates	67,83	2	82,23	3	-1
Qatar	66,44	1	82,19	3	-2
Chile	69,15	3	69,42	2	1
Lithuania	70,83	3	72,21	2	1
Poland	69,96	3	70,94	2	1
SlovakRepublic	70,23	3	70,66	2	1
Croatia	67,04	2	69,01	2	0

Greece	67,41	2	70,04	2	0
Hungary	66,38	2	70,2	2	0
Latvia	71,62	2	70,17	2	0
Malaysia	67,73	2	69,16	2	0
Romania	65,26	2	67,96	2	0
Uruguay	68,89	2	67,13	2	0
CostaRica	68,90	1	68,58	2	-1
Turkiye	55,85	1	67,69	2	-1
Argentina	61,27	2	63,47	1	1
China	62,51	2	65,11	1	1
Thailand	60,86	2	62,86	1	1
Azerbaijan	57,36	1	59,22	1	0
Brazil	59,82	1	61,05	1	0
Bulgaria	64,75	1	64,85	1	0
Colombia	58,24	1	61,55	1	0
DominicanRepublic	58,57	1	60,41	1	0
Georgia	62,03	1	60,33	1	0
Indonesia	61,00	1	56,3	1	0
Kazakhstan	60,35	1	64,02	1	0
Macedonia	60,61	1	61,9	1	0
Mexico	59,71	1	62,67	1	0
Paraguay	57,39	1	57,04	1	0
Serbia	62,18	1	63,43	1	0
Ukraine	56,36	1	58,06	1	0
Vietnam	58,77	1	57,21	1	0

Source: caculated and compiled by the authors