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CONTRIBUTION OF KNOWLEDGE AND INFORMATION SYSTEMS MANAGEMENT TO THE INNOVATIVE DEVELOPMENT OF THE DIGITAL ECONOMY

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A B S T R A C T

In this paper, we elaborated on the features of the formation of knowledge and information systems management in the countries that are leaders in this sphere and assessed the influence of their transformations on the innovativeness of the digital economy.

The goal of this work was to find the key features of the contribution of the components of knowledge and information systems management to the improvement of the innovative development and digitalization of countries.

We revealed that achievement of high results in these components is possible in case of the formation of a favourable environment for them, the key position in which belongs to Internet quality and coverage and government support. The presented ways to search for opportunities for implementing infrastructural projects in the creation of favourable conditions for the implementation of knowledge and information systems management will allow developing economies to ensure significant growth.

The novelty of this research is connected with the determination of the features of knowledge and information systems management, which allow countries to ensure growth in the sphere of innovations and the digital economy.

1. INTRODUCTION

The high level of innovative development of the digital economy is peculiar to countries with a high level of economy. Innovativeness of the digital economy, which is measured as a state of digital intellectual capital of subjects (companies, groups of companies, countries), is formed due to the contribution of various components, an important place among which belongs to the management of knowledge and information systems. These components may have different levels of manifestation depending on the strategies of

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digitalization, the level of opportunities for further implementation, and their integration in the research and practical spheres. Knowledge management in the age of the digital economy involves the formation and support of the systems of information data and knowledge which are necessary for the use at the level of subjects. Accordingly, this process is connected with operationalization, which uses database analysis that is conducted with the help of various tools of digitalization. Information systems management and knowledge management are implemented with the use of digital tools. The impact of the two components on the level of the innovative development of the digital economy is predetermined by the scale of their use and subjects' expenditures for innovations in this sphere. Experience and features of implementing these components in developed and quickly developing countries can help other countries achieve their strategies of digitalization in the long term.

The goal of this paper was to find the main features of the contribution of knowledge and information systems management to the improvement of the innovative development of countries' digitalization. In this context, we sought the following tasks: revealing the list of countries with a high level of the management of knowledge and information systems, as well as the innovative development of the digital economy; establishing the influence of these components on the indicator of the innovative development of the digital economy in the considered countries.

2. EXPERIMENTAL SECTION

We tested the hypothesis on the connection between the improvement of the management of knowledge and information systems and the improvement of the level of innovative development of digital economies in the leading countries.

The experimental base is represented by countries that are leaders in the sphere of the digital economy, which demonstrate efficiency in the context of the main indicators.

The methodological base includes a range of methods. The index method allowed finding the value of each considered indicator (level of knowledge and information systems management) of the Global Innovation Index and the Digital Economy and Society Index. The ranking method was utilised to assess the level of countries in the achievement of the considered indicators. Comparative analysis was applied to compare the efficiency of the considered countries in the context of the assessed indicators. The cause-and-effect analysis was used to consider the connection between these components and the indicator of the innovative development of the digital economy.

The experimental basis also includes the materials of scientific works and empirical research.

Apte et al. (2022) presented a study of the specifics and organisational adaptation of the system of knowledge management in the conditions of the emergence of remote communications during the COVID-19 pandemic and revealed that this reform allowed the subjects of the economy and infrastructure to become more resilient against challenges and threats. Kiisler et al. (2020) dwelt on the results of the impact of the improvement of approaches to information systems management in Denmark as a factor of an increase in the digitalization of information and communication interaction. Tsang et al. (2022) analysed the capabilities of digital information systems in the sphere of the activities of Hong Kong's social sector, with a focus on the sphere's employee's perception of the advantages of digitalization for the interests of consumers and self-realisation and execution of professional competencies. Chukreev (2023) considered the impact of the quality of education on economic growth and the realisation of citizens' needs in the conditions of Industry 4.0.

We revealed the necessity for systematisation of arguments on the connection between the considered components and the innovativeness of the digital economy, which was performed in this research.

3. RESULTS

To establish the list of leaders in the considered sphere, it is necessary to determine countries that are leaders in knowledge management (including with the use of digitalization tools).

The first considered component is knowledge management. It is studied with the use of the Global Knowledge Index (GKI). The data of this indicator for countries of the world are presented in the annual reports that are prepared by the UN in collaboration with the Mohammed Bin Rashid Al Maktoum Knowledge Foundation.

Leaders in the sphere of knowledge management demonstrate mainly several priority components. It should be also noted that leaders in knowledge management are from economically developed countries. The level of these countries' economic potential is supported by an effective system of knowledge management. Implementation of the digital economy tools allowed this system to remain effective in the conditions of the COVID-19 pandemic. According to Apte et al. (2022), quick reconsideration of the models of management organisation allowed the subjects of the economy and infrastructure to sustain uninterrupted functioning during the pandemic. This involved the necessary reforms in the sphere of culture and the selection of tools and processes of knowledge management.

Table 1. Ranking of countries by GKI

	Country	GKI Rank	Features of knowledge management
1	Norway	2023 – 10, 2022 – 8, 2021 – 9, 2020 - 13	The system of knowledge management is presented by the following components: formation of a favourable environment for the development of knowledge; economy; ICT; higher education; R&D and innovations; technical and professional education; pre-higher education. The development of the system of knowledge management is a precondition for the formation of an environment for all types of knowledge and the system of knowledge for university graduates according to their specialisation.
2	Austria	2023 – 9, 2022 – 10, 2021 – 14, 2020 - 16	Over 2020-2023, higher education and technical and professional education.
3	United Kingdom	2023 – 8, 2022 – 9, 2021 – 8, 2020 - 9	Over 2020-2023: R&D and innovations and higher education. In this case, the systems of knowledge management are aimed at the creation of intellectual pools of knowledge for higher school and the sphere of R&D.
4	Luxembourg	2023 – 7, 2022 – 6, 2021 – 12, 2020 - 6	Over 2020-2023: formation of a favourable environment for the development of knowledge; ICT; and higher education. The country improves the environment for the development of knowledge, with the creation of innovative systems of knowledge management for students and teachers in universities. A high level of ICT is ensured at the level of all spheres of knowledge management.
5	Denmark	2023 – 6, 2022 – 7, 2021 – 7, 2020 - 8	Over 2020-2023: creation of favourable conditions for knowledge management, systems of the management of data and information in the economy, knowledge management systems in the sphere of R&D and innovations (at the level of innovative clusters), and knowledge management systems for higher education.
6	United States	2023 – 5, 2022 – 1, 2021 – 3, 2020 - 2	Over 2020-2023: economy (systems of information flows management in economic sectors); ICT; R&D; and higher education (systems of knowledge management for students, which ensure a high level of training).
7	Netherlands	2023 – 4, 2022 – 5, 2021 – 5, 2020 - 5	Over 2020-2023: ICT; technical and professional education; pre-higher education.
8	Sweden	2023 – 3, 2022 – 3, 2021 – 2, 2020 - 4	Over 2020-2023: creation of conditions for knowledge management in various spheres (e.g., infrastructural support); ICT; R&D and innovations (innovative and R&D clusters dealing with the commercialisation of R&D).
9	Finland	2023 – 2, 2022 – 4, 2021 – 4, 2020 – 3	Over 2020-2023: favourable conditions of the functioning of the systems at all levels (effective and innovative information & communication and R&D infrastructure); ICT (creation of national digital applications and software that allows for the effective knowledge management); R&D and innovations; technical and professional education (effective and comprehensive systems of knowledge management within each speciality); pre-higher education (national systems of pre-school and secondary education).
10	Switzerland	2023 – 1, 2022 – 2, 2021 – 1, 2020 - 1	In 2020-2023, effective formation of the main components of knowledge management systems was observed.

Source: Prepared by the authors based on Knowledge4all (2024), Knowledge4all (2023), UNDP.org (2021), UNDP.org (2020), and Finnish National Agency for Education (2024)

The second assessed component is information systems management. We analysed it through the country's ranking in the ICT Development Index. This indicator for 2023 was compiled according to a new methodology of the International Telecommunication Union (ITU) and presented in the annual report (ITU, 2024). The previous data (2020, 2021, and 2022) are given according to the materials of the annual report of the Global Innovation Index.

It is possible to see that some leaders in the sphere of information systems management (Table 2) are also leaders in the sphere of knowledge management: Denmark, the United States, and Finland.

Table 2. Ranking of countries by the indicator of the ICT Development Index

	Country	ICT Development Index Rank	ICT Development Index Score	Characteristics of information systems management
1	Kuwait	2023 – 1, 2022 – 21, 2021 – 31, 2020 - 51	2023 – 98.2, 2022 – 86.5, 2021 – 80.4, 2020 -73.4	The market of information systems, presented at ICT platforms, grows annually. In 2023, it equalled USD 22.5 billion. The annual growth of this indicator is 9.5-9.8%. The government's focus on the dissemination of digitalization in the main sectors of the economy and life activities is the main stimulus for an increase in the level of information systems management. The growth of the quality of information systems management is connected with the creation of a favourable environment (quality of Internet coverage) and an increase in the adaptability of subjects using the systems in the process of national digitalization.
2	Singapore	2023 – 2, 2022 – 6, 2021 – 7, 2020 - 7	2023 – 97.4, 2022 – 92.5, 2021 – 90.5, 2020 – 90.6	The market of information systems management was growing over 2014-2023: USD 16.23 billion in 2014, USD 16.23 billion in 2015, USD 18.21 billion in 2016, USD 19.11 billion in 2017, USD 20.18 billion in 2018, USD 22.92 billion in 2019, USD 26.13 billion in 2020, USD 30.31 billion in 2021, USD 33.62 billion in 2022, and USD 36.33 billion in 2023. Development of information systems management in the country is conducted by world leaders in the IT sphere, namely Huawei, IBM, Alibaba, Facebook, and Google. These companies cooperate with regional leaders, which include Razer, Lazada, Grab, and Garena. The quick growth of ICT and an increase in the quality of solutions in information systems were connected with the following: 1) High level of talented specialists in the sphere of digitalization and their training (partnership of the regional school of computational technology NUS and IBM innovations centre in blockchain, etc.); 2) Ease of doing business; 3) High qualification of employees and job applicants; 4) High level of digital literacy of the population, high level of digitalization of the sectors of the economy and infrastructural sphere; 5) Innovative infrastructure of ICT; 6) High level of investments in the sphere of innovative solutions on the management and use of information systems.
3	Qatar	2023 – 3, 2022 – 60, 2021 – 57, 2020 - 46	2023 – 97.3 2022 – 75.4 2021 – 70.8 2020 – 75.2	Information systems management is conducted within the market of ICT platforms, which demonstrates an annual growth of 8.5 %. Information systems management in the country has the following features: - Focus on the needs of all categories of companies (small, medium, and large); - Focus on sectorial needs for managerial solutions; - Main segments (telecommunications, IT services, software and hardware). The high level of information systems management within the main directions was ensured by the following: - Quality of infrastructural support (Qatar is notable for the highest level of quality and coverage of the Internet in the Middle East, including 5G); - Government's focus on the growth of citizens' well-being. Focus on the energy sector's transition to innovative solutions ensured by digital information systems (smart energy). This facilitates saving, control, and accounting of consumers' energy. Technologies of energy saving are implemented; they allow accumulating energy in case of serious failures in the energy system, for supporting national consumers and temporary support for partner countries.

Table 2. Ranking of countries by the indicator of the ICT Development Index (continued)

	Country	ICT Development Index Rank	ICT Development Index Score	Characteristics of information systems management
4	Denmark, Estonia	Denmark: 2023 – 4, 2022 – 3, 2021 – 3, 2020 – 3. Estonia: 2023 – 4, 2022 – 4, 2021 – 5, 2020 – 20.	Denmark: 2023 – 96.9 2022 – 93.8, 2021 – 91, 2020 – 92.4. Estonia: 2023 – 96.9, 2022 – 93.6, 2021 – 90.7, 2020 – 86.	1) Denmark: Information systems management is connected with the highly developed innovative infrastructure of ICT. In 2023, the ICT market equalled USD 35 billion, with further prospects for growth. The top priority direction is the development of software and services. Hardware is mainly imported from the USA. Information systems in Denmark are mainly the following: hardware management in the public sector (around 25-30 % of the entire market); information support for the activities of wholesale and retail trade (around 10%), provision and management of information flow in the financial sector (15 %); software support for other sectors of the economy (around 30-35 % of the market). It is necessary to note a new "green" trend in the sphere of an assortment of the spheres of information systems management. This direction is widely developed in the energy support for industry, infrastructural sectors, and private sector. Information systems are utilised in the sphere of the circular economy and housing and communal services. 2) Estonia. The priority implementation of information systems management is observed in public governance, the use of e-government service (in the English and Estonian languages), and support for cyber security of economic subjects and the government. There is also the transfer of technologies of this category – from traditional channels of communications at the level of company-consumer, consumer-company, company-company, company-government, and government-company to digital forms, adapted within ICT platforms.
5	Finland	2023 – 5, 2022 – 5, 2021 – 17, 2020 – 18	2023 – 96.7, 2022 – 92.7, 2021 – 86.8, 2020 – 87.7	Information systems management in Finland is mostly presented in the sector of public governance, cyber security, and management of artificial intelligence. The effectiveness of implementing information systems at ICT platforms is ensured by the following: - Creation of favourable infrastructural support (high quality of the Internet and Internet coverage, mass use of 5G (integration of world technological giants for pilot experimental projects before introducing them in the world markets); - High level of training of labour resources in the sphere of ICT (as of year-end 2021, this indicator equalled 7.4 %); - All economic segments striving towards digitalization of the main management solutions (small, medium, and large companies and key sectors). This is a stimulus for the growth of the offer in the market of information systems management. As of year-end 2021, more than 80 % of small and medium companies had conducted the digitalization of the main processes. All categories of companies conducted digitalization with the use of digital information systems, at the level of 97 %. Around 60 % of companies of all segments purchase cloud services, which is a sign of a high level of information systems management in the economy; - Government's support in the sphere of creation of innovative start-ups which offer new information services.
6	USA	2023 – 6, 2022 – 7, 2021 – 9, 2020 – 9	2023 – 96.6, 2022 – 92.1, 2021 – 90.1, 2020 – 90.4	The volume of the market of information systems, based on ICT platforms, equalled USD 1,230.84 billion in 2022. The growth of the market is expected at the level of 8.66 % by 2027. Until 2027, the following is expected: implementation of 133 products (services) and 18 IT management decisions, which will allow taking the leading positions in the world in the implementation of a wide range of information systems. The key factors of the effectiveness of information systems and demand for them in the market are large-scale digitalization, attractive infrastructure, and a high level of personnel training.

Table 2. Ranking of countries by the indicator of the ICT Development Index (continued)

	Country	ICT Development Index Rank	ICT Development Index Score	Characteristics of information systems management
7	Bahrain, Hong Kong	Bahrain: 2023 – 7, 2022 – 40, 2021 – 41, 2020 – 36. Hong Kong: 2023 – 7, 2022 – 10, 2021 – 10, 2020 – 17	Bahrain: 2023 – 96.5 2022 – 81.9 2021 – 77.7, 2020 – 78.5. Hong Kong: 2023 – 96.5, 2022 – 90.6, 2021 – 89.6, 2020 – 88.2	1) Bahrain: The market of information systems accounted for USD 3.8 billion in 2022, with an expected growth rate of 10.7% until 2027. Dissemination of information systems is presented within the main sectors of the economy and infrastructural sectors. The largest number of solutions in the sphere of information systems management is found in the following spheres: - Network management of subjects (for business, government, infrastructural support, communications, education, and science) (18 offers); - Security (17 offers); - Edge computing (11 offers); - Information technologies management (11 offers); - Cooperation and communications (10 offers); - Client computing (10 offers); - Digital applications for process management in the business environment (9 offers). 2) Hong Kong: The volume of revenue of the market of information systems management equalled USD 12.3 billion in 2021 (3.3 % of the GDP). 2.99% of labour resources are involved in the sphere of information systems management.
8	Saudi Arabia	2023 – 8, 2022 – 47, 2021 – 48, 2020 - 41	2023 – 94.9, 2022 – 80.1, 2021 – 74.5, 2020 – 76.4	The volume of the market of information systems accounted for USD 41 billion in 2022. The high level of dissemination and quality of information systems are due to the following: - Favourable infrastructure (average speed of mobile Internet is twice as much as the world average value; 5G coverage of the country's territory is 53 % - 94 %); - Government's effective support and cooperation within public-private partnerships.
9	Poland	2023 – 9, 2022 – 22, 2021 – 24, 2020 – 30	2023 – 94.6, 2022 – 86.4, 2021 – 82.7, 2020 – 81.1	The volume of the information systems market accounted for USD 8.8 billion in 2022, with an expected annual growth of 6% until 2027. The priority direction of information systems management is software support for internal and external consumers.
10	Malaysia	2023 – 10, 2022 – 30, 2021 – 35, 2020 - 35	2023 – 94.5, 2022 – 84.6, 2021 – 79.2, 2020 – 79.4	The volume of the market of information systems was USD 27.2 billion in 2024, with an expected annual growth of 7.6% until 2029.

Source: Prepared by the authors based on ITU (2024), Mordor Intelligence (2024a), Mordor Intelligence (2024b), Mordor Intelligence (2024c), WIPO (2021), WIPO (2022), WIPO (2020), Statista (2024), Edb.gov.sg (2024), Trade.gov (2024a), Trade.gov (2024b), Trade.gov (2023), Stateofgreen (2024), Tradewithestonia (2024), Kiisler et al. (2020), GlobalData (2023a), GlobalData (2023b), Lo (2023), Tsang et al. (2022). Hammad ur Rehman (2024), and The Polish Investment & Trade Agency (2022)

Let us determine the leaders in the sphere of the innovative development of the digital economy, using the indicators of the Global Innovation Index and IMD World Digital Competitiveness Ranking.

Table 3. Leading countries by the Global Innovation Index

	Country	Global Innovation Index Rank
1	Republic of Korea	2023 – 10, 2022 – 6, 2021 – 5, 2020 - 10
2	Denmark	2023 – 9, 2022 – 10, 2021 – 9, 2020 - 6
3	Germany	2023 – 8, 2022 – 8, 2021 – 10, 2020 - 9
4	Netherlands	2023 – 7, 2022 – 5, 2021 – 6, 2020 - 5
5	Finland	2023 – 6, 2022 – 9, 2021 – 7, 2020 - 7
6	Singapore	2023 – 5, 2022 – 7, 2021 – 8, 2020 - 8
7	United Kingdom	2023 – 4, 2022 – 4, 2021 – 4, 2020 - 4
8	United States	2023 – 3, 2022 – 2, 2021 – 3, 2020 - 3
9	Sweden	2023 – 2, 2022 – 3, 2021 – 2, 2020 – 2
10	Switzerland	2023 – 1, 2022 – 1, 2021 – 1, 2020 - 1

Source: Prepared by the authors based on WIPO (2023), WIPO (2021), WIPO (2022), and WIPO (2020).

Over 2020-2023, Switzerland remained the leader in the sphere of innovative development, with strong positions in the sphere of knowledge management. The USA, Finland, and Denmark are among the top 10 countries that also have strong positions by the indicator of knowledge and information systems management.

Table 4. Leading countries by the indicator of the digital economy

	Country	IMD World Digital Competitiveness Ranking
1	Hong Kong	2023 – 10, 2022 – 9, 2021 – 2, 2020 - 5
2	Taiwan	2023 – 9, 2022 – 11, 2021 – 8, 2020 - 11
3	Finland	2023 – 8, 2022 – 7, 2021 – 11, 2020 - 10
4	Sweden	2023 – 7, 2022 – 3, 2021 – 3, 2020 - 4
5	Republic of Korea	2023 – 6, 2022 – 8, 2021 – 12, 2020 - 8
6	Switzerland	2023 – 5, 2022 – 5, 2021 – 6, 2020 - 6
7	Denmark	2023 – 4, 2022 – 1, 2021 – 4, 2020 - 3
8	Singapore	2023 – 3, 2022 – 4, 2021 – 5, 2020 - 2
9	Netherlands	2023 – 2, 2022 – 6, 2021 – 7, 2020 – 7
10	USA	2023 – 1, 2022 – 2, 2021 – 1, 2020 - 1

Source: Prepared by the authors based on IMD.org (2023), IMD.org (2022), IMD.cld.bz (2021), IMD.cld.bz (2021)

The USA is the leader in the sphere of the digital economy and among the top 10 countries in the management of knowledge and information systems and innovative development. Finland and Denmark, similar to the USA, have high positions in all considered components, which is a sign of their comprehensive approach to the management of knowledge and information systems.

4. DISCUSSION

The considered results of the study of the components of knowledge and information systems management and the level of the innovative development of the digital economy confirm the research hypothesis that the improvement of the former influences the growth of the latter. The mentioned complex approach, demonstrated by the USA, Denmark, and Finland, allows these countries and the subjects of their economy to receive additional material and cultural results and social benefits from the created economic environment, which is aimed at quick development in the conditions of innovative digitalization. The quality priority of such an approach consists in the focus on not only the economic growth of the country but also human-centrism, as the basis of the modern innovative digital economy (Chukreev, 2023).

The key factors that facilitate the contribution of knowledge and information systems management to an increase in the innovative development of the digital economy are a favourable environment of infrastructural support, namely the quality and coverage of the Internet, and the government's support for the initiatives in the preparation of new products (services). Achievement of results that are demonstrated by the three leading countries, is not easy for developing countries, which do not have the capital for the creation of a favourable environment in this direction. However, there are exceptions, which were demonstrated during the analysis of the indicators of information systems management (Table 2): dynamically developing economies of Kuwait and Saudi Arabia showed improvement, which allowed them to demonstrate good results and rankings.

The ways of improving the environment of infrastructural support for developing countries might include participation in international partnerships, which will allow the implementation of large-scale projects. One such partnership for developing countries could be participation in China's global initiative "One Belt One Road", where China could be an investor in various projects, which will help it, in turn, achieve its integration goals.

5. CONCLUSION

In this study, we considered the features and contribution of knowledge and information systems management to the innovative development of the digital economy. The established characteristics of knowledge and information systems management in the age of digitalization demonstrate the need to invest in science, education, and R&D in the conditions of global challenges and threats. These components are the intellectual capital of the subjects of science, education, and business. Their improvement allows adapting to new and quickly changing external conditions. One of the recent global challenges of the world economy – the COVID-19 pandemic – introduced risks, crisis phenomena, and problems in the system of healthcare, entrepreneurship, and social and economic spheres (Litvinova, 2022). It also stimulated people, companies, and governments to a quick adaptation to the new environment. This raised the level of the innovative development of the digital economy.

In the conditions of digitalization, developing countries can implement strategies of extensive growth, preserving non-renewable resources and focusing on new opportunities: new managerial and user solutions in

the sphere of knowledge and information systems management and exchange of knowledge and technologies with partners for the creation of innovative solutions.

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