Barabashev, A., Makarov, I., Zarochintcev, S. (2022). How to shape government policies on high-technology development using the indicative evaluation of risks? *Administratie si Management Public*, 38, 70-89. DOI: 10.24818/amp/2022.38-04

How to shape government policies on high-technology development using the indicative evaluation of risks?

Alexey BARABASHEV[1], Ivan MAKAROV[2], Sergei ZAROCHINTCEV[3]

Abstract: *The international country-level indices of high-technology development were examined, and the indices that meet the criteria of sufficiently wide coverage of states and presence of measurement history over several years were selected. The stable group of basic (non-duplicating) indices characterizing high-technology development level and risks for national states was identified using the principal component analysis method. The rankings of states based on the basic indices of high-technology development built for the years 2014 and 2016 were studied. A proposal has been put forward to consider stepwise risk corridors of high-technology development as conventions that establish acceptable risk boundaries. An «acceptable corridor of high-technology risks» with boundaries of 10%-90% (decile of 10%) has been built. There have been identified two groups of states outside this corridor for which the risks of high-technology development turn into threats: «leading states» above the corridor, which are characterized by the excessively rapid development of high technologies associated with high risks due to excessive user confidence in the reliability of such technologies and the gaps in the development of security measures and regulation in this area; and «outsider states» below the corridor, characterized by the excessively slow development of high technologies, which leads to vulnerability to threats of high-technology development and to the appearance of a chronic lag in these areas. The location of Romania in this corridor was considered an example of assessing the state risks of high-technology development using the constructed risk corridor. For Romania, the value of the basic high-technology indices is located near the center of the risk corridor. Thus, the high-technology development in Romania from 2014-to 2016 took place at an average pace, but also without significant risks. This position leaves Romania a significant space for the relatively safe acceleration of high-technology development.*

Keywords: High-technology indices; indicative evaluation; security risks and threats management; method of the main components; corridors of risks.

[1] Professor, Department of Politics and Governance, National Research University, Higher School of Economics, 20 Myasnitskaya str., Moscow, 101000, e-mail: abarabashev@hse.ru, ORCID: 0000-0003-4746-7532

[2] Research Assistant, Institute of Governance, National Research University, Higher School of Economics, 20 Myasnitskaya str., Moscow, 101000, e-mail: ia.makarov@hse.ru, ORCID: 0000-0002-6476-390X

[3] PhD Student, Department of Politics and Governance, National Research University, Higher School of Economics, 20 Myasnitskaya str., Moscow, 101000, e-mail: szarochincev@hse.ru, ORCID: 0000-0001-5530-0455

JEL: C1, H1, O33

DOI: 10.24818/amp/2022.38-04

Introduction

The evaluation of public administration quality is shifting recently from concentration on the quality and the volume of public services, toward the quality as ability of public institutions to reduce risks and threats in the process of interaction of the state with society and business. As Guy Peters wrote, "The contemporary period then constitutes a "perfect storm" that poses immense and interconnected governance challenges. Any government, along with its social partners, confronting these issues will require an extremely high level of capacity, as well as the political will to utilize that capacity" (Peters, 2021, p. 9). It is necessary to improve the ability of states to counter threats, to respond challenges adequately and in a timely manner, as well as to create analytical tools for "stress testing" of management systems to downsize threats and measure the stability of public institutes in relation to new challenges.

The type of risks and threats associated with security among the other types of risks threats should be highlighted. The number of present research publications on security risk analytics is impressive (there are more than 693 million publications in Google Scholar on the keyword: risks and security management, as of December 1, 2021); it surpasses even the number of publications on risks in the field of climate change regulation (there are about 400 million publications, according to similar keywords: climate change risk management, request from the same date) and management risks in connection with Covid-19 by keywords covid risks management (there are about 475 million publications requested on the same date). In other words, the topic of security governance with an emphasis on risk analysis now occupies a leading position in public administration research.

The most common approach in the field of public administration to the identification and assessment of security risks is the deliberative method of risk ranking. This is an approach based on expert assessments. At the same time, the need for an objective assessment of risks, taking into account their history and dynamics, requires the accumulation of information, the development of management based on the use of evidence-based policy tools (evidence-based policymaking), the collection and processing of large amounts of data. In particular, indicative assessments, based on the identification of indices and indicators related to the scope of risks and giving an unbiased picture of how risks are evolving, how countries/states are ranked relative to the effects of risks, and what are the trends of risks, are being improved. The indicative approach to risk analysis and risks impact on security in public administration is rapidly developing and relies on massive data collection and processing and also on the accumulated experience of indices monitoring. It can improve the governance capacity in the future, when the crises of turbulent development, hopefully, will be over. However, there are several obstacles to recognize the indicative assessment of security risks as finally formed. The main obstacles are: organizational obstacles to the massive collection, processing and use of information; obstacles to uncertainty in the identification of available indices and unreasonable selection of key indices; obstacles to trust in data collection methods; obstacles to duplication of indices. These obstacles depend on the conditions and the degree of development of governance on a national level and of analytical institutes that accommodate the information and produce the recommendations. Such obstacles should be minimized.

Currently, among the security risks, the risks associated with public management, the elaboration, and the application of high technologies come to the fore. The reason for highlighting the risks of high technology (including the risks of abandoning high technology) as fundamental security risks is twofold. On the one hand, these risks are present everywhere, they are part of all other security risks for any country. Many researchers see a panacea for all threats, from food and energy crises to epidemiological threats and climate changes, mainly in the use of high technologies, especially in governance: «If embraced, the right technologies can create new opportunities for improving the efficacy and agility–and, when used well, the legitimacy–of the administrative state. The technologies of big data as well as those engagement tools that enable individual and group communication and collaboration across a distance–what we might call the technologies of collective intelligence–could enable government agencies to understand problems with greater precision and in conversation with those most affected» (Noveck, 2021, p. 123).

On the other hand, the uncontrolled use of high technologies generates risks, which causes fierce polemics, protests, and social movements in support of or against high-technology methods of combating threats. The active and unrestricted introduction of sophisticated technologies is just as dangerous as ignoring them. Accelerating technological development acts as a generator of high social, economic, and political turbulence, countries are entering the zone of instability of existing economic systems, financial instruments, social relations, and political institutions. Often, the crises themselves (for example, the migration crisis in Europe) would be impossible in the absence of sophisticated technologies, for example, without modern means of transport mobility and the movement of large human flows, without migrants' hopes for such technologies, for a higher technological and, accordingly, the standard of living of the countries to which they aspire. Modern public administration, therefore, should be built on the basis of taking into account high-technology risks that are paramount from the point of view of the security threats created. Assessment and monitoring of high-technology security risks should become a mandatory element of public administration, and not its minor, "additional" option.

In our research, we will consider the use of an indicative approach in the analysis of the risks of high-technology development for states. By the indicative approach in public administration, we mean public management based on the use and processing of data and the subsequent presentation of data in the form of indices and indicators, as an indispensable condition for decision-making, implementation, and evaluation of the consequences of state policies. The indicative approach is developing in many directions: from indicative analytics of electronic participation in public administration (Androniceanu & Georgescu, 2022) and to the indicative assessment of the quality of public services (Besharov, Baehler & Klerman, 2017), from the analysis of the indices of the influence of the state on business (Berg & Cazes, 2007) to the indicative analysis of the quality of public administration (Kaufmann, Kraay & Masruzzi, 2011).

In general, the indicative approach in public administration is a kind of public administration based on the use of evidence-based policy tools. We can say that the indicative approach acts as the central link of such public management, allowing us to present data in a form ranked accordingly to the positions of states/countries, different regions, and separate state bodies, which allows us to compare them with each other both statically and dynamically. The results of the ranking give the ground for future public policy elaboration, it is the instrument for better governance. In other words, it is possible to say that the indicative approach is included *in the instrumental paradigm of public administration* «data-based management» (Barabashev, 2016), which differs significantly from the subject (ideal state), functional (client-oriented state) and participatory (public administration) paradigms of public administration, for which the use of data is not obligatory when making decisions.

In our research, we will try to implement an indicative approach to the analysis of the risks of high-technology development of states, based on the use of country indices characterizing the risks of high-technology development. The corresponding country/state indices related to high-technology development have been selected. Further, these indices are filtered to enable high-quality statistical analysis with the possibility of comparing data for different periods. The selected indices were examined for the presence of correlation dependencies, and the basic indices that do not duplicate each other were selected. We use the principal component method, and the applicability of the principal component method will be separately justified in order to determine a set of basic indices characterizing country risks of high-technology development. The central idea of the article is to identify an acceptable corridor of high–technology risks for the countries participating in the rating according to the basic indices and to offer an assessment of such risks for the country we have chosen (Romania).

1. Literature review

There are different groups of literature on risks and threats of high-technology development:

1. General theoretical publications that study high-technology development in the context of the impact of relevant technologies on the development of the economy and society.

2. Research of digitalization and information and communication technologies, as well as the impact of certain technologies (for example, artificial intelligence) on the sphere of public administration.
3. Publications that describe methodological approaches to assess threats of high-technology development, which make up the smallest part of the total volume of sources.

The first group of publications examines high-technology development and potential risks in the social context of such processes (and as an integral part of them) as the «digital revolution» or «fourth industrial revolution» (Zemtsov, 2020), which lead to global changes and transformation of economic and social institutions (Helbing, 2019). It is argued that the Fourth Industrial Revolution (4IR) can transform developing economies into another tier of development by increasing productivity and improving the future fluidity of innovation in various industries (Nyagadza et al., 2022). This approach is characterized not only by an appeal to technological and technical issues, impact on economic cycles and processes of production, and employment but also by a broad social assessment of the changes taking place in the context of high technologies (Pollitzer, 2018).

Also, there are some publications within the framework of public administration theories, actor-network theory, and research of sociotechnical systems (STS), where network action is conceptualized in the spectrum from "uncertain governance" to "uncertainty of governance". This is largely due to the fact that information technologies have evolved towards greater interconnectedness, and with it, greater vulnerability, creating a mode of insecurity (Slayton, 2021). A separate category of publications consists of the literature about anthropological risks. It includes both socio-cultural and philosophical, civilizational aspects in relation to the peculiarities and possible changes of human existence in the era of high technologies (Skorodumova et al., 2015). This analysis reveals new conditions of human existence in the context of both positive and negative components based on the consideration of modernization processes taking place in the information age and their impact on human nature.

The second group of publications focuses mainly on the role of digital transformation processes in shaping high-technology development (Matthess & Kunkel, 2020). In the modern world, where information and communication technologies (ICT) are rapidly becoming ubiquitous and indispensable, the ICT industry plays a crucial stimulating role in social, economic, and human development. This new approach to corporate participation is described as «multistakeholder governance». Previously, the roles of governments, corporations, and civil society have already changed throughout history. Digitalization can stimulate a global dialogue around responsibilities in the global information society and become a part of a new governance paradigm (Cave et al., 2007).

Some publications, among other things, highlight regional aspects of high-technology development (Zemtsov et al., 2019; Kwet, 2019). Question of whether developing states can achieve economic prosperity through industrialization in the same way as developed states is becoming more and more important after digitalization. Different arguments show us that digitalization is likely to affect relative industry productivity, but it is unlikely that the directions of subsequent labor movements (for example, towards traditional services) will benefit equally from technological progress (Matthess & Kunkel, 2020). Attention is also drawn to the development of certain technologies as a result of digitalization – artificial intelligence (Henman, 2020; Sahbaz, 2019), blockchain (Adams, 2018), and robotics (Iphofen & Kritikos, 2021). This group of publications is the biggest in our literature review. It covers issues from the description of the effects of digitalization, risks, and opportunities, and to the consideration of ethical problems of digital technologies. It is concluded that significant risks of the development of digital technologies are in the field of their regulation and their moral component. One of the most obvious advantages of digitalization in the context of recent events related to COVID-19 is the development of digital platforms and predictive analytics systems for healthcare (Southwick et al., 2021).

Finally, the third group of publications is devoted directly to the development and application of various methods for assessing the risks of high-technology development. There are several sub-groups of publications: literature based on the assessment of various indices and quantitative methods for determining the threats and benefits of high-technology development (Maiti & Awasthi, 2020); literature with general scientific methods, which are interpreted for the high-technology sphere (Brockman & Helbing, 2013); publications about the development of a special methodology for assessing security risks of high-technology development (Helbing et al., 2012). For example, there is research that shows an attempt to develop an index for the evaluation of satisfaction in the context of ICT (Maiti & Awasthi, 2020). Using a database of 67 states representing all subcontinents from 2000-to 2014, the authors of the study concluded that the impact of ICT positively improves the overall level of the Human Development Index (HDI). In addition, it provides an opinion that high technologies taken together do not seem to have an unambiguous impact on the overall welfare and progress of the state, and, thus, it is necessary to empirically consider their resulting relationship at the aggregated level.

General scientific methods consider the global spread of epidemics, gossip, opinions, and innovations as complex, network-driven dynamic processes (Brockman & Helbing, 2013). The combined large-scale nature and internal heterogeneity of the underlying networks make it difficult to develop an intuitive understanding of these processes, distinguish relevant factors from peripheral ones, predict their time course and determine their origin.

There are several attempts to develop a special methodology for assessing specific risks of high-technology development (for example, within the framework of the

FuturICT project and relevant publications) (Helbing et al., 2012). First of all, representatives of this approach show the strong interconnection of global networks that have created highly interdependent systems (including high-technology and innovative ones), and currently, we do not understand them and cannot properly control them. As the complexity and strengths of interaction in our networked world grow, artificial systems can become unstable, creating uncontrollable situations, even when decision-makers are well qualified, have all the data and technology at their disposal and are doing their best. To make these systems governable, a fundamental redesign is needed. «The science on global systems» can create the necessary knowledge and paradigm shift in thinking (Helbing, 2013). The EU's flagship project FuturICT is a digital platform for «governing the future» based on the synthesis of ICT and social sciences. It is assumed that ICT will provide data for the advancement of social sciences in a new era. The science of complexity will shed light on emerging phenomena in socially interactive systems, and social sciences will provide a better understanding of the opportunities and risks of developed network systems, in particular future ICT systems and high-technology processes.

It should be noted that the main groups of threats to national security are analyzed in the literature at the intersection of technological, economic, political, social, and socio-cultural risks. There are also some publications that deal with the issues of anthropological (Skorodumova et al., 2015), legal (Pagallo, 2012) and psychological (cognitive) (Mazarr et al., 2019) threats as a result of the development of high technologies. It is noteworthy that in certain cases the same elements of high-tech development can be both significant risks and opportunities for stakeholders (Southwick et al., 2021; Smith & Christakis, 2008).

There are various factors that can reduce the risks of high-technology development (Zemtsov et al., 2019). First of all, they are related to retraining, the development of ICT and STEM fields, and the promotion of less automation-prone economic activities. As a result of econometric calculations, it is possible to identify specific factors contributing to the development of new industries (for example, the development of ICT), and, accordingly, to increase regional adaptability. Some publications speak of the need to move from an «engineering» approach to ensuring security in complex high-technology systems to the theory of complexity (Perrow, 1999). Followers of such «transition» believe that the traditional «engineering» approach to security – building more warnings and guarantees – fails because the complexity of systems makes failures inevitable. They believe that typical precautions, by increasing complexity, can contribute to the creation of fundamentally new categories of accidents.

The evolution of methodological approaches to the analysis of the impact of sophisticated technologies is closely related to both exact sciences and projects in the field of physics, information technology and the socio-humanitarian direction of risk assessment. At the same time, the characteristic limitations of such an assessment are noted in the form of the prevalence of scenario and «predictive» approaches, following the example of the «deliberative» (advisory) method of risk ranking (Pollitzer, 2018; Zarochintcev, 2021). This situation may be related to the general social context of the development and evaluation of high-technology areas, which in many cases are considered within the framework of «futures studies», where the future is understood through a certain set of scenarios, and not as the definition of «risk corridors». Even despite a significant degree of elaboration of the problem, understanding the dual nature of high-technology development and the development of data collection tools in the field of ICT, the «paradigm» of security risk assessment for high-technology development remains «scenario-based» and largely socially colored due to the attribution of high technologies to the trans industrial stage (Fomin, 2018).

It should be noted that we have not been able to find examples of research that would consider the risks of high-technology development comprehensively, simultaneously in various aspects, and would provide a reasonable classification of national security risks in connection with the development of high technologies.

2. Findings

The study of high-technology risks of state security was conducted by us with the help of indicative tools of public administration analysis. The main objectives of the study were: to analyze the existing indicative tools for assessing high-technology development; identify the basic indices of high-technology development; assess the level of high-technology risks in the states of the world and threats to individual states occupying extreme positions in the ranking.

We have analyzed all available international indices and statistical indicators related to high-technology development to assess the degree of development of high technologies and their implementation in economic and social processes in the states of the world and the risks associated with it, and to further identify a corridor of acceptable high-technology risks. The initial search and selection of indices for analysis were aimed at collecting a wide range of indices capable of evaluating various areas of high-technology development. In practice, it was discovered that the majority of indices available for analysis primarily reflect the development and implementation of information and communication technologies (ICT), and only partially reflect other areas of high-technology development. For this reason, this analysis, while being as complete as possible, is limited in its ability to evaluate the level and risks of high-technology development in general. However, it is able to show the level and risks of development specifically in the field of ICT, and thus can serve as an example of the application of the proposed methodology in a specific area.

The assessment of high-technology development in other technological fields will require additional data. The absence of data suitable for analysis in some areas of high-technology development is a dangerous situation: due to this the risks that may be present in these areas are relatively difficult to identify, describe and account for, and therefore the possible negative effects of excessively slow or rapid development in these areas may be much more dangerous.

The list of indices that were considered as potential candidates for analysis initially included all the indices related to high-technology development that were available to us. Relevant indices and statistical indicators calculated by the United Nations (UN), the World Bank, the International Telecommunication Union (ITU), the Organization for Economic Co-operation and Development (OECD), the statistical office of the European Union (Eurostat), Oxford Insights, the World Wide Web Foundation, the Portulans Institute, and the Institute of Higher Business Studies (IESE) Business School were considered in this research (*Digital Adoption Index*, 2016; *E-Government Development Index*, 2022; *Employed Persons Working from Home as a Percentage of the Total Employment, by Sex, Age and Professional Status (%)*, 2022; *E-Participation Index*, 2022; *Government AI Readiness Index 2017*, 2017; *Government AI Readiness Index 2019*, 2019; *Government AI Readiness Index 2020*, 2020; *Health Care Resources : Medical Technology*, 2021; *High-Technology Exports (% of Manufactured Exports)*, 2022; *ICT Access and Usage by Households and Individuals*, 2022; *IESE Cities in Motion Strategies*, 2022; *Key ICT Indicators*, 2022; *Network Readiness Index – Benchmarking the Future of the Network Economy*, 2022; *The ICT Development Index*, 2022; *The Web Index*, 2014).

An analysis of the widest possible range of indices would reveal a more complete spectrum of latent characteristics. However, due to the incompleteness of data on many of the listed indices, it was necessary to narrow down the list of analyzed indices so that data on all of them were available for a sufficiently large number of states to increase the reliability of statistical methods. To analyze the stability of the proposed basic indices over time, the basic indices were independently calculated for two different time periods. In this case, the years 2014 and 2016 were chosen in order for the analysis to cover the maximum range of various available indices, and the indices with data available for both of these years were selected.

Finally, it should be noted that the analysis included not general indices, but rather their various constituent thematic sub-indices, for a more detailed analysis of various aspects of high-technology development.

The resulting narrowed list of variables includes:

- 3 sub-indices of the E-government Development Index, as well as the E-Participation Index, calculated by the UN (both marked with the prefix “EGOV” in the data) (*E-Government Development Index*, 2022; *E-Participation Index*, 2022).
- 3 sub-indices of the Digital Adoption Index, calculated by the World Bank (prefixed “DAI”) (*Digital Adoption Index*, 2016).
- 3 sub-indices of the ICT Development Index, calculated by ITU (prefixed “IDI”) (*The ICT Development Index*, 2022).

- Statistical indicator «High-technology exports (% of manufactured exports)», published by the World Bank (prefixed "WBD") (*High-Technology Exports (% of Manufactured Exports)*, 2022).
- 10 sub-indices of the Network Readiness Index calculated by the Portulans Institute (prefixed "NRI", numbering of sub-indices based on the original data structure) (*Network Readiness Index – Benchmarking the Future of the Network Economy*, 2022).

In total, 21 indicators were analyzed. The data on these indices and indicators for all available states and territories for all available years were obtained from official sources (databases and reports available on official websites of the indices). For 2014, the number of states for which data on these indicators are available is 121, for 2016 the number of states is 122. With the exception of the share of high–technology exports, all the indicators selected for analysis are related primarily to the development and implementation of ICT - accordingly, the analysis evaluates high-technology development in this particular area. At the same time, it can serve as an example for analyzing the risks of high-technology development in a wider range of areas, provided there are sufficient data for various years.

The principal component analysis (PCA) method was applied to isolate the basic indices – composite indices where each index expresses a separate latent key characteristic of the phenomenon being evaluated. The properties of the PCA method allow it to be used to convert arrays of indices into basic indices, while eliminating statistical duplication between indices. Statistical duplication of indices, expressed in strong correlations between different indices, is observed in some indices related to various fields, including between indices that were not originally intended to be similar to each other. Duplication indicates ineffective practices of indicative evaluation and may complicate the analysis and distort its results (Barabashev et al., 2019). For the purpose of building risk corridors, it is desirable to be able to work with a limited number of variables that can clearly reflect the main dimensions of development areas and associated risks. The construction of basic indices using the PCA method is able to ensure this by turning a wide range of analyzed indices, duplication among which is likely due to its thematic composition, into a small set of key variables with minimal loss of important information.

Based on the results of applying the PCA method to the data on the above indicators for the year 2014, 3 principal components were identified, which together explain 85.5% of the total variance of the initial variables, i.e. reflecting 85.5% of the unique information contained in the analyzed indices. The first component contains most of the information, explaining 71.2% of the total variance of the initial variables, while the other two components explain another 7.6% and 6.2% of the total variance. The degree to which the 3 principal components reflect each of the original variables individually was at least 78% for 19 of the 21 variables. The exceptions were the share of high-technology exports (WBD High-Tech Exports), explained only by 41%, and one of the 10 sub-indices of the Network Readiness Index which reflects the availability of communication services (NRI B_04 Sub-index), reflected in the resulting principal components by 58.5%.

An analogous analysis was carried out on data for 2016. The PCA method also yielded 3 components. In total, they explain 86% of the total variance of the analyzed variables, of which the first component explains 74.5% of the total variance, the second explains another 6.5% and the third explains 5%. The degree to which the selected components together explain the variance of each of the original variables was at least 78% for all but two variables. These exceptions were the same: the share of high–tech exports, the variance of which is explained by 45.2%, and the availability sub-index of the Network Readiness Index, reflected by 62%.
A component matrix containing correlations between the initial variables and the resulting principal components which can be used to interpret the components is presented below (Table 1).

Table 1. Component Matrix

	2014			2016		
Analyzed sub-indices	**Component**			**Component**		
	1	2	3	1	2	3
EGOV E-Participation Index	0,754	0,141	0,499	0,842	-0,089	0,372
EGOV Online Service Index	0,846	0,167	0,382	0,873	-0,014	0,350
EGOV Human Capital Index	0,854	-0,406	0,015	0,898	-0,257	-0,125
EGOV Telecomm&Infrastructure Index	0,960	-0,126	-0,113	0,956	-0,064	-0,157
DAI Business Sub-index	0,913	-0,235	-0,122	0,922	-0,189	-0,134
DAI People Sub-index	0,944	-0,168	-0,113	0,945	-0,116	-0,165
DAI Government Sub-index	0,695	0,136	0,534	0,709	-0,076	0,522
IDI Access Sub-index	0,944	-0,216	-0,107	0,946	-0,169	-0,156
IDI Use Sub-index	0,949	-0,122	-0,098	0,955	-0,068	-0,146
IDI Skills Sub-index	0,831	-0,470	0,095	0,892	-0,338	-0,065
WBD High-Tech Exports	0,555	0,300	0,109	0,523	0,340	0,252
NRI A_01 Sub-index	0,769	0,451	-0,315	0,785	0,508	-0,109
NRI A_02 Sub-index	0,869	0,147	-0,104	0,896	0,171	-0,082
NRI B_03 Sub-index	0,943	-0,111	-0,185	0,935	-0,055	-0,190
NRI B_04 Sub-index	0,498	-0,212	0,541	0,518	-0,486	0,340
NRI B_05 Sub-index	0,870	-0,313	-0,088	0,907	-0,190	-0,097
NRI C_06 Sub-index	0,962	-0,130	-0,136	0,963	-0,082	-0,151
NRI C_07 Sub-index	0,843	0,315	-0,209	0,836	0,404	-0,106
NRI C_08 Sub-index	0,799	0,476	0,047	0,822	0,335	0,251
NRI D_09 Sub-index	0,887	0,281	-0,183	0,890	0,298	-0,109
NRI D_10 Sub-index	0,905	0,312	0,051	0,924	0,204	0,153

The first resulting component positively correlates with all the analyzed indices both in the case of 2014 and in the case of 2016. The correlation with most indices is strong, except for the share of high-technology exports (WBD High-Tech Exports) and the availability sub-index of the Network Readiness Index (NRI B_04 Sub-index). The second and third components, in turn, do not have strong correlations with any initial indices, although medium correlations are observed with some. The composition of the indices whose correlation coefficients with the second and third components have an absolute strength of at least 0.4 partially differs between the years. Nevertheless, for the most part, the correlation coefficients between the second and third components and the analyzed indices obtained from the data of 2014 and 2016 are similar – the difference between the corresponding correlation coefficients for different years never exceeds 0.3.

The key result of this analysis is that although the analyzed indices, according to their authors, reflect a wide variety of aspects of ICT development, as well as high-technology development in other areas, these indices *are mostly interconnected with each other and actually duplicate each other to a considerable extent*. This means that they largely do not give estimates of different characteristics, but rather reflect the same latent key characteristic from different sides. Therefore, these indices can be represented with a certain degree of accuracy by just one variable – the basic index, which in this case would be the first resulting principal component. As described above, this allows to eliminate statistical duplication, which can complicate the analysis and even distort its results, and at the same time preserve most of the useful information in a compressed and more convenient form for further use (Barabashev et al., 2019).

At the same time, the application of the PCA method to the data of 2014 and 2016 gave similar results, which confirms the reliability of the analysis. Although the second and third components identified by the PCA method partially differ between years in terms of which of the initial variables they are mainly associated with, the main – the first – component coincides to a large extent. This similarity, revealed by the comparison of factor loads, is also confirmed by the fact that the Pearson correlation coefficient between the first component calculated from the 2014 data and the first component calculated from the 2016 data was 0.994. The second and third components correlate with each other only somewhat weaker – the coefficients were 0.878 and 0.777. This allows us to conclude *that the principal components derived from a stable list of indices can be stable over time*, which supports the possibility of using the PCA method to create a set of basic indices representative of the risks of high-technology development.

In this case, the first component is the most important one, as it contains the vast majority of information. It apparently reflects the development and implementation of information technologies in some general, central aspect, including, inter alia, state policy in the field of ICT. This interpretation is consistent, among other things, with the fact that the indicator of the share of high-technology exports, which is related to a wider range of areas of high-technology development, consistently correlates with the first component weaker than other indicators do. Thus, the first component can be considered as a basic index of ICT development and used for further analysis of digital development and its risks in the whole world.

In turn, the second and third selected components, demonstrating only partial stability over time, serve to reflect the most significant parts of the residual information contained in the analyzed indices and not directly related to the latent characteristic reflected by the first main component. A detailed interpretation of the meaning of these components based on correlations between them and the analyzed indices is difficult. They can be considered as reflecting some specific aspects of various approaches to assessing high-technology development used in the analyzed indices. The imperfect stability of these components over time, in this case, can be explained by changes in index methodologies.

It is possible to build a corridor of high-technology risks, by which we mean the belonging to the group of states that fall within the range of acceptable index values, based on the study of the position of states in the ratings built using the basic indices of high-technology development.

Even though high-technology development is usually perceived as beneficial, the excessively rapid development of high technologies is associated with certain risks due to excessive user confidence in the reliability of such technologies and the delay in the development of security and regulatory measures in the field. At the same time, excessively slow development of high technologies can lead to vulnerability to threats of high-technology development, and to the appearance of a chronic lag in these areas, which will be more difficult to compensate in the future. Thus, *a corridor of high–technology risks is formed. It is a certain range of the level of high-technology development, in which development occurs in a balanced manner, with neither obvious lag nor risky acceleration*. It is possible to identify this corridor and construct it explicitly using a rating built using indicative assessment methods – for example, using basic indices. Certain values of the basic indices can be defined as the upper and lower boundaries of the risk corridor. States that have the values of the basic indices within these borders are included in the risk corridor, that is, they are relatively safe; and states that lie beyond these borders in terms of the values of the basic indices are considered to fall out of the risk corridor and, thus, are exposed to significant risks. In this case, when building a risk corridor, we will use only the first constructed principal component, interpreting it as a basic ICT development index (despite the fact that ICT is only one of the sides of high-technology development), and build a risk corridor based on its values. However, it is difficult to determine the corridor boundaries exactly and unambiguously. An excessive deviation of the values of the index used from the norm indicates the presence of risks; a larger deviation is associated with more significant risks. However, it remains at the discretion of the convention to set a specific boundary beyond which the deviation and the risks reflected by it become sufficiently significant to be considered outside the risk corridor. For a more detailed analysis, it is possible, instead of establishing a single set of exact borders, to construct stepwise risk corridors – to establish several borders separating states by degree of risk.

In this study, the boundaries of the risk corridor will be determined in a relative way, based on the calculation of deciles: states that fall into the lower 20% or upper 20% of the sample according to the base index value will be considered to be outside the risk corridor: due to relatively slow or rapid development in the field of ICT, they may face certain risks in that area. At the same time, among them, the states included in the lower 10% or in the upper 10% of the sample by the value of the basic index will be considered as entering the zone of increased danger.

For the first component for 2014, the boundaries of the lower and upper ten percent of the sample are at the levels of -1,321 and 1,452, respectively, and the lower and upper twenty percent are at the levels of -0.887 and 1,038, respectively. For 2016, ten percent boundaries are at the levels of -1.364 and 1.413, and twenty percent – at the levels of -1.067 and 0.981. These levels will be used as the boundaries of risk corridors. States for which the component values for the corresponding years are within these boundaries are considered to be in the risk corridor. Accordingly, states for which the component values for the corresponding years lie outside these borders are beyond the risk corridor. States that fall beyond ten percent borders are assessed as facing particularly significant risks compared to those that are between the twenty percent and the ten percent borders.

A list of states that have fallen beyond the boundaries of the risk corridor is given below (Table 2). Numerical values are the values of the first principal component - the basic index, on the basis of which these corridors and risk zones were formed. Interestingly, the list of states that left the risk corridor due to exceeding the permissible range of values turned out to be exactly the same when analyzing data for 2014 and 2016 (although some of these states switched places in the ranking with each other). The list of states that have moved beyond the boundaries of the corridor due to the excessively low value of the basic index differs for 2014 and 2016, although this is partly due to differences in the range of states for which data are available (Table 2). In the table below, states are ranked in descending order of the absolute value of the basic index, i.e. in descending order of the degree of risk they face; states with excessively high values are ranked by the value of the basic index for 2014, with the unrepresented ranking for 2016 being slightly different.

Table 2. Risk corridors

State	2014	2016	State	2014	State	2016
Zone of significant risk (upper/lower 10%):						
Singapore	2,006	1,880	Myanmar	-1,996	Guinea	-2,023
Netherlands	1,848	1,674	Burkina Faso	-1,800	Burundi	-1,921
South Korea	1,811	1,613	Benin	-1,760	Mauritania	-1,861
Finland	1,795	1,612	Madagascar	-1,681	Madagascar	-1,727
Sweden	1,741	1,587	Mozambique	-1,660	Benin	-1,690

State	2014	2016	State	2014	State	2016
Norway	1,623	1,530	Ethiopia	-1,651	Myanmar	-1,664
Great Britain	1,588	1,604	Malawi	-1,643	Mali	-1,638
USA	1,574	1,528	Cameroon	-1,473	Malawi	-1,630
Japan	1,552	1,523	Tanzania	-1,468	Mozambique	-1,598
Switzerland	1,477	1,474	Nepal	-1,465	Ethiopia	-1,467
Denmark	1,475	1,456	Uganda	-1,424	Cameroon	-1,431
Germany	1,453	1,420	Algeria	-1,324	Tanzania	-1,382
Zone of limited risk (upper/lower 20%):						
Australia	1,450	1,397	Zambia	-1,311	Lesotho	-1,322
Luxembourg	1,403	1,379	Pakistan	-1,293	Zimbabwe	-1,293
Israel	1,361	1,289	Nicaragua	-1,273	Uganda	-1,289
Estonia	1,327	1,333	Senegal	-1,239	Gambia	-1,281
France	1,319	1,296	Laos	-1,239	Pakistan	-1,233
New Zealand	1,312	1,353	Gambia	-1,233	Nicaragua	-1,221
Canada	1,308	1,276	Zimbabwe	-1,221	Cambodia	-1,221
Iceland	1,260	1,321	Nigeria	-1,206	Nigeria	-1,220
Austria	1,256	1,341	Cambodia	-1,168	Nepal	-1,201
UAE	1,124	1,063	Honduras	-1,025	Laos	-1,113
Belgium	1,117	1,172	Namibia	-0,940	Senegal	-1,108
Ireland	1,077	1,142	Guatemala	-0,919	Algeria	-1,070

We can consider the location of Romania in these rankings as an example of assessing the risks of high-technology development with the help of constructed risk corridors. In the case of Romania, the value of the basic ICT development index was 0.024 in 2014 (58th place), and 0.094 in 2016 (57th place), located near the center of the risk corridor. Thus, the development of ICT in Romania in these years occurred at an average pace, but also without significant risks. This position leaves Romania a significant space for a relatively safe acceleration of development, so additional measures to support the field of ICT to increase Romania's competitiveness on the world stage, although not critically important, are not superfluous. The full ratings are available online at this URL (links to Google Drive): https://tinyurl.com/yckr9ywp.

Thus, the states that are «above» the corridor of acceptable risks of high-technology development (as of 2014-2016) are fundamentally exposed to the threats generated by these risks: threats of the misuse of high technologies to regulate and manipulate public life, threats of the use of high technologies for obtaining market preferences and distorting the work of the private sector market, threats in the banking and stock exchange sphere, threats in the development of high biotechnologies potentially dangerous to life and health. Strengthening public control over these areas and preventive identification of risks based on data can help mitigate these risks and turn risks into potential benefits.

On the contrary, states that are «below» the corridor of high-technology risks may become unwitting victims of threats of high-technology development, as they are not adapted to combat them. The main international efforts should be aimed at helping these states to rise above the currently identified lower limit of the corridor of high-technology risks in order to prevent the actualization of high-technology threats on the territory of these states and the high-technology degradation of states.

3. Discussion of the results

The main idea of the research is that the indicative risk analytics, based on the identification of acceptable risk corridors of high-technology development, is able to warn about dangers in advance. This is different from the current situation in risk analytics, in which management systems react to risks deliberatively (personal expert assessments) and too late, and as a result, they do not neutralize risks, but only try to mitigate their final stages, threats. We believe that indicative risk analytics contributes to the identification of challenges as sets of risks and the transfer of risks from limitations to development opportunities, it helps to prevent the dangerous degeneration of high-technology security risks into threats.

We have built retrospective forecasts based on an indicative analysis of high-technology security risks and believe that for countries that go beyond the 10% decile of the high-technology development risk corridor in 2014, 2016, the transformation of risks into threats should coincide with real events: in particular, the top 12 countries (Table 5, in order of ranking): Singapore, the Netherlands, South Korea, Finland, Sweden, Norway, UK, USA. Japan, Switzerland, Denmark and Germany *are already in the zone of threats generated by excessively rapid and insufficiently controlled high-technology development in these countries*. Being in the threat zone makes the leading countries of high-technology development extremely vulnerable to manipulation based on the use of high technologies, dangerous for citizens, organizations and the state itself (although these countries have great potential to counter such threats). Moreover, these countries act as hotbeds of threats to other countries that do not have such a counteraction potential.

Some limitation of the conducted research is that the range of indices available for analysis primarily reflects the development and implementation of information and communication technologies (ICT). This limitation is due to the fact that it is information and communication technologies that form the core of modern high-technology development (in any case, the main data on high-technology development collected in the world are concentrated here).

4. Conclusion

We have selected indices that meet simple and mandatory criteria for an indicative analysis: significant country coverage; measurement history for several years (the presence of the same period for all selected indices) among all the country indices available for analysis related to high-technology development. One of the results of the study is that we were able to identify a stable group of non-duplicating basic indices using the principal component method. The applicability of the principal component method was substantiated in order to determine a set of basic indices characterizing country risks of high-technology development. The basic indices of high-technology development turned out to be stable over time: the stability of the composition of the group of basic indices was revealed in the time interval (2014, 2016), which allows us to speak about the exhaustive completeness of the analysis for this period of time. We have built an «acceptable corridor of high-technology risks», by which we mean entering the group of countries that fall within the range of acceptable index values among all countries that participated in the rating on the basic indices for the years under study, based on the study of the position of countries in the ratings on the basic indices of high-technology development. Countries located within the high-technology development risk corridor use high technologies in a balanced manner, without obvious lag and without risky acceleration. Countries outside the corridor (above the corridor - excessively rapid development of high technologies associated with certain risks due to excessive confidence of users in the reliability of such technologies and the delay in the development of security measures and regulation in this area; below the corridor - excessively slow development of high technologies, leading to vulnerability to threats of high-technology development and the emergence of a chronic lag in these areas which will be more difficult to compensate in the future) are in different ways, but they are more vulnerable. We have put forward a proposal to consider stepwise risk corridors of high-technology development as conventions that establish acceptable risk boundaries. The boundaries of the risk corridor were considered based on the calculation of deciles. The countries included in the bottom 10% or top 10% of the sample by the value of the basic index were named as entering the danger zone of particularly significant risks in the field of ICT. Countries that are in the bottom 20% or the top 20% of the sample according to the index value may face certain risks in this area.

As an example of assessing the risks of high-technology development with the help of the constructed stepped risk corridors, the location of Romania in them was considered. The value of the basic ICT development index in Romania was located near the center of the risk corridor. Thus, the development of ICT in Romania in 2014-2016 took place at an average pace, but also without significant risks. This position, in our opinion, leaves Romania a significant space for a relatively safe acceleration of high-technology development, so that measures to support the field of ICT to increase Romania's competitiveness on the world stage, although not critically important, are not superfluous.

Authors contributions

The article is written by the authors jointly.

Conflict of Interest Statement

The authors confirm that there is no conflict of interest in relation to the article.

References

Adams, R., Kewell, B., & Parry, G. (2018). Blockchain for good? Digital ledger technology and sustainable development goals. In *Handbook of sustainability and social science research* (pp. 127-140). Springer, Cham. https://doi.org/10.1007/978-3-319-67122-2_7

Androniceanu, A., and Georgescu, I. (2022). E-participation in Europe, a comparative perspective. *Public Administration Issues*, 5, 7-29.

Barabashev, A., Makarov, A., & Makarov, I. (2019). On Improvement of the Indicative Evaluations of the Quality of Governance” *Public Administration Issues*, 2, 7-38.

Barabashev, A.G. (2016). Are existing administrative paradigms capable of providing tools to resolve the contemporary administrative crisis? *Public Administration Issues*, 5, 6-25.

Berg, J., Cazes, S. (2007). *The Doing Business indicators: Measurement issues and political implications.* Geneva: ILO.

Besharov, D. J., Baehler, K. J., & Klerman, J. A. (Eds.). (2017). *Improving public services: International experiences in using evaluation tools to measure program performance.* Oxford University Press.

Brockmann, D., Helbing, D. (2013). The hidden geometry of complex, network-driven contagion phenomena. *Science*, 342(6164), 1337-1342. https://doi.org/10.1126/science.1245200

Cave, J., Marsden, C., Klautzer, L., Levitt, R., Oranje-Nassau, C. van, Rabinovich, L., & Robinson, N. (2007). *Responsibility in the Global Information Society: Towards Multi-stakeholder Governance.* RAND Corporation.

Digital Adoption Index. (2016). [Text/HTML]. World Bank. Retrieved 24 February 2022, from https://www.worldbank.org/en/publication/wdr2016/Digital-Adoption-Index

E-Government Development Index. (2022). EGOVKB | United Nations. Retrieved 24 February 2022, from https://publicadministration.un.org/egovkb/en-us/About/Overview/-E-Government-Development-Index

Employed persons working from home as a percentage of the total employment, by sex, age and professional status (%). (2022). Eurostat - Data Explorer. Retrieved 24 February 2022, from https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lfsa_ehomp

E-Participation Index. (2022). EGOVKB | United Nations. Retrieved 24 February 2022, from https://publicadministration.un.org/egovkb/en-us/About/Overview/E-Participation-Index

Fomin, M. V. (2018). Transindustrialism - upcoming social reality. *Voprosy Filosofii*, 1, 42-54.

Government AI Readiness Index 2017. (2017). Oxford Insights. Retrieved 24 February 2022, from https://www.oxfordinsights.com/government-ai-readiness-index

Government AI Readiness Index 2019. (2019). Oxford Insights. Retrieved 24 February 2022, from https://www.oxfordinsights.com/ai-readiness2019

Government AI Readiness Index 2020. (2020). Oxford Insights. Retrieved 24 February 2022, from https://www.oxfordinsights.com/government-ai-readiness-index-2020

Health Care Resources: Medical technology. (2021). OECD. Stat. Retrieved 24 February 2022, from https://stats.oecd.org/index.aspx?queryid=30184

Helbing, D. (2013). Globally networked risks and how to respond. *Nature*, 497(7447), 51-59. https://doi.org/10.1038/nature12047

Helbing, D. (2019). Societal, economic, ethical and legal challenges of the digital revolution: from big data to deep learning, artificial intelligence, and manipulative technologies. In *Towards digital enlightenment* (pp. 47-72). Springer, Cham. https://doi.org/10.1007/978-3-319-90869-4_6

Helbing, D., Bishop, S., Conte, R., Lukowicz, P., & McCarthy, J. B. (2012). FuturICT: Participatory computing to understand and manage our complex world in a more sustainable and resilient way. *European Physical Journal: Special Topics*, 214(1), 11-39. https://doi.org/10.1140/epjst/e2012-01686-y

Henman, P. (2020). Improving public services using artificial intelligence: Possibilities, pitfalls, governance. *Asia Pacific Journal of Public Administration*, 42(4), 209-221. https://doi.org/10.1080/23276665.2020.1816188

High-technology exports (% of manufactured exports). (2022). World Bank. Retrieved 24 February 2022, from https://data.worldbank.org/indicator/TX.VAL.TECH.MF.ZS

ICT Access and Usage by Households and Individuals. (2022). OECD.Stat. Retrieved 24 February 2022, from https://stats.oecd.org/Index.aspx?DataSetCode=ICT_HH2

IESE Cities in Motion Strategies. (2022). IESE. Retrieved 24 February 2022, from https://www.iese.edu/faculty-research/cities-in-motion/

Iphofen, R., Kritikos, M. (2021). Regulating artificial intelligence and robotics: Ethics by design in a digital society. *Contemporary Social Science*, 16(2), 170-184. https://doi.org/10.1080/21582041.2018.1563803

Kaufmann D., Kraay A. & Mastruzzi M. (2011). The worldwide governance indicators: methodology and analytical issues. *Hague Journal on the Rule of Law*. № 2 (3). 220-246.

Key ICT Indicators. (2022). OECD. Retrieved 24 February 2022, from https://www.oecd.org/digital/broadband/oecdkeyictindicators.htm

Kwet, M. (2019). Digital colonialism: US empire and the new imperialism in the global south. *Race and Class, 60*(4), 3-26. https://doi.org/10.1177/0306396818823172

Maiti, D., Awasthi, A. (2020). ICT exposure and the level of wellbeing and progress: A cross country analysis. *Social Indicators Research, 147*(1), 311-343. https://doi.org/10.1007/s11205-019-02153-5

Matthess, M., Kunkel, S. (2020). Structural change and digitalization in developing countries: Conceptually linking the two transformations. *Technology in Society*, 63. https://doi.org/10.1016/j.techsoc.2020.101428

Mazarr, M. J., Bauer, R. M., Casey, A., Heintz, S. A., & Matthews, L. J. (2019). *The emerging risk of virtual societal warfare: Social manipulation in a changing information environment.* RAND Corporation.

Network Readiness Index – Benchmarking the Future of the Network Economy. (2022). Network Readiness Index. Retrieved 24 February 2022, from https://networkreadinessindex.org/

Noveck, B. S. (2021). The Innovative State. *Dædalus, 150*(3), 121-142.

Nyagadza, B., Pashapa, R., Chare, A., Mazuruse, G., & Hove, P. K. (2022). Digital technologies, fourth industrial revolution (4IR) & global value chains (GVCs) nexus with emerging economies' future industrial innovation dynamics. *Cogent Economics and Finance*, 10(1). https://doi.org/10.1080/23322039.2021.2014654

Pagallo, U. (2012). Cracking down on autonomy: Three challenges to design in IT law. *Ethics and Information Technology*, 14(4), 319-328. https://doi.org/10.1007/s10676-012-9295-9

Perrow, C. (1999). *Normal Accidents: Living with High Risk Technologies.* Princeton University Press.

Peters, B. G. (2021). Governing in a time of global crises: the good, the bad, and the merely normal. *Global Public Policy and Governance, 1*(1), 4-19.

Pollitzer, E. (2018). Creating A Better Future: Four Scenarios for How Digital Technologies Could Change the World. *Journal of International Affairs*, 72(1), 75-90. Retrieved from https://www.jstor.org/stable/26588344

Sahbaz, U. (2019). Artificial Intelligence and the Risk of New Colonialism. *Horizons: Journal of International Relations and Sustainable Development*, (14), 58-71. Retrieved from https://www.jstor.org/stable/48573727

Skorodumova, O., Matronina, L., & Koval, T. (2015). Anthropological Risks of the Information Society. *Mediterranean Journal of Social Sciences*, *6*(3 S3), 295. Retrieved from https://www.mcser.org/journal/index.php/mjss/article/view/6680

Slayton, R. (2021). Governing Uncertainty or Uncertain Governance? Information Security and the Challenge of Cutting Ties. *Science, Technology, & Human Values*, *46*(1), 81-111. https://doi.org/10.1177/0162243919901159

Smith, K. P., Christakis, N. A. (2008). Social Networks and Health. *Annual Review of Sociology*, *34,* 405–429. Retrieved from http://www.jstor.org/stable/29737797

Southwick, L., Guntuku, S. C., Klinger, E. V., Pelullo, A., McCalpin, H., & Merchant, R. M. (2021). The role of digital health technologies in COVID-19 surveillance and recovery: A specific case of long haulers. *International Review of Psychiatry, 33*(4), 412-423. https://doi.org/10.1080/09540261.2020.1854195

The ICT Development Index. (2022). ITU. Retrieved 24 February 2022, from https://www.itu.int:443/en/ITU-D/Statistics/Pages/IDI/default.aspx

The Web Index. (2014). The Web Index. Retrieved 24 February 2022, from https://thewebindex.org/

Zarochintcev, S. (2021). "Anticipatory" Governance and National Security Risk Assessment. *Public Administration Issues*, *3,* 200-218.

Zemtsov, S. (2020). New technologies, potential unemployment and 'nescience economy' during and after the 2020 economic crisis. *Regional Science Policy and Practice, 12*(4), 723-743. https://doi.org/10.1111/rsp3.12286

Zemtsov, S., Barinova, V., & Semenova, R. (2019). The risks of digitalization and the adaptation of regional labor markets in Russia. *Foresight and STI Governance, 13*(2), 84-96. https://doi.org/10.17323/2500-2597.2019.2.84.96