Vol. 05, No. S2 (2023) 385-398, doi: 10.24874/PES.SI.02.015

Proceedings on Engineering Sciences

www.pesjournal.net

DATASET APPROACH TO MANAGEMENT INFORMATION SYSTEMS TO SUPPORT QUALITY AND AGILITY OF INDUSTRY 4.0 BUSINESSES

Nodirjon M. Yuldashev[1]
Raxim R. Dusbayev
Anna L. Shevyakova
Yelena S. Petrenko

Received 12.07.2023.
Accepted 06.10.2023.

Keywords:

Management Information Systems, Dataset Approach, Information Systems Management, Quality, Agility, Business Industry 4.0, Russia.

A B S T R A C T

The research focuses on the scientific search for a solution to the problem associated with the imperfection of the existing approach to the management information systems in the business of Industry 4.0, expressed in the fact that this approach does not fully ensure the agility of the business and does not make it possible to fully disclose its potential in terms of improving product quality. The research aims to identify a perspective on improving the management information systems to support the quality and agility of Industry 4.0 business. Using international statistics for 2022, the authors developed an econometric model using regression analysis to explain the important role of management information systems in ensuring the quality and agility of Industry 4.0 business. Based on this model, the authors conclude that the use of big data and analytics and knowledge transfer has a strong positive impact on the agility of companies and cyber security, more than the impact of management professionalism. The authors also prove that the use of big data and analytics and knowledge transfer is determined not only by the professionalism of management but also by digital competencies. The theoretical significance of this research is that it revealed the prospect of improving the management information systems to support the quality and agility of Industry 4.0 business through the transition to a new dataset approach to this management. The practical significance of this research is expressed in the fact that the developed dataset approach to the management information systems in the business of Industry 4.0 will make it possible to overcome the gap in the technological provision of the management information systems and in the provision of quality and agility management of Industry 4.0 business.

1. INTRODUCTION

Management information systems (MIS) are the core of Industry 4.0 business because their market success is entirely determined by the success of data collection, storage reliability, and processing efficiency (Mardani & Saberi, 2023). The root causes of the difference between the Industry 4.0 business and the evolutionary form of business that preceded it (belonging to Industry 3.0) is not just a much higher level of automation but a

[1] Nodirjon M. Yuldashev
Email: yuldashevnodirjon30@gmail.com; yuldashevnodirjon@mail.ru

new type of automation – smart automation, as well as a broad scope of automation that extends to all business processes – production and management processes (Nuttah et al., 2023).

The MIS in Industry 4.0 business largely determines the quality of its products and its agility. The importance of the MIS to the product quality of Industry 4.0 business products is explained as follows. When developing innovative products in Industry 4.0, it is necessary to consider marketing information on market capacity, the nature of competition, and the level of innovation activity in the target market of the business, its market share and competitive advantages, the current competitiveness of the business's products in the field of quality, and consumer preferences in the field of product quality (Yang et al., 2023).

The quality of innovative products developed in the Industry 4.0 business depends on the timeliness of collection, completeness, and reliability of the above marketing information, as well as on the speed and correctness of its processing. When planning and organizing the production of products in the Industry 4.0 business, it is also important to consider the above marketing information because it determines the structure of the business offer on the target market and its reputation in terms of the quality of sold products (Musti & Baporikar, 2023).

In internal product quality control in the Industry 4.0 business, it is necessary to collect and record all available information relevant to quality, including compliance with the requirements of technological processes in the production of products, equipment breakdowns, and the quality of raw materials, inputs, and components. It is also important to collect feedback from workers on why products of a certain quality are being produced and how they can be improved.

When marketing products in the Industry 4.0 business, it is important to carry out external quality control and collect customer feedback. Information about the perceived quality of products and quality revealed in the process of their consumption is important to optimize the further planning and the organization of production in Business 4.0, as well as to create and implement innovations aimed at improving product quality.

The great impact of MIS on the agility of Business 4.0 is due to the following. On the one hand, interpreting business agility as unchanged and having a strong position in the target market of Industry 4.0, it should be noted that the achievement of this state requires reliable information support and protection of the business-owned information from competitors. In doing so, the MIS are themselves a source of business agility.

On the other hand, defining business agility as the extent to which a business supports and actively implements the Sustainable Development Goals (SDGs), the importance of information support in this process should be emphasized. This support includes corporate accounting of achievements in SDG implementation, collection of statistics on potential factors to determine the cause-and-effect relationships of SDGs implementation, as well as the formation of corporate reporting and its open publication to ensure publicity of business successes in SDGs implementation (Tang et al., 2023).

The problem lies in the imperfection of the existing approach to information systems management in the Industry 4.0 business. This approach does not fully ensure the sustainability of this business and does not make it possible to fully unlock its potential for improving product quality. Due to the haphazard (unrelated data they contain) and hybrid format (combination of data on different electronic and paper media), the MIS provides insufficient support for quality and agility management in the Industry 4.0 business.

There is a gap in the technological provision of the MIS and the management of quality and business sustainability in Industry 4.0. While quality and agility management is done through forced automation based on advanced technologies (e.g., robots), management of information systems is done through limited and slowed automation while maintaining large, labor-intensive business operations of consciousness and use of management information systems.

This research aims to provide a perspective on improving information systems management to support Industry 4.0 business quality and sustainability. The novelty of this research lies in the fact that it offers an innovative solution to the problem posed –to organize the MIS through datasets. The scientific novelty of this research is the development of a dataset approach to the MIS to support the quality and agility of Industry 4.0 business.

After this introduction, the paper is followed by a literature review. It explains the role of the MIS in ensuring the quality and agility of Industry 4.0 business and presents the provisions of the existing approach to the MIS in Industry 4.0 business and the author's comments. The methods are then described, and the research results are presented, which include the following: (1) factor analysis of quality and agility in the MIS of Industry 4.0 business; (2) scenarios of changes in the quality and agility of Industry 4.0 business in Russia under alternative approaches to the MIS; (3) dataset approach to the MIS in Industry 4.0 business.

2. LITERATURE REVIEW

2.1. The role of management information systems in ensuring the quality and agility of Industry 4.0 businesses

The MIS concept, forming the fundamental basis of this research, is considerably developed and widely presented in the available literature, for example, in the works of Chatterjee et al. (2023), Jo and Park (2023), and Osovtsev et al. (2018). The authors of published works agree on the important role of the MIS in ensuring the quality and agility of Industry 4.0 business, which is as follows:

- Providing data on ongoing quantitative and qualitative, objective, and subjective assessment of quality and agility (Handayani et al., 2022);
- Information support for analytics of cause-effect relationships of quality and agility change (Hrabovskyi et al., 2022);
- Storing information on quality and agility history (Arici et al., 2022);
- Information support for quality and agility improvement through disclosure of their priorities from the perspectives of different stakeholders (Kusmantini et al., 2021);
- Gathering information on threats and opportunities to improve quality and agility (Ćurčić et al., 2019);
- Information support for benchmarking and analytics on quality and agility when benchmarked against other players in the target market (Jaouad & Bouchaib, 2023).

The difficulty in assessing quality and agility is that they are complex categories, not all elements of which can be quantified using standard statistical indicators. The quality and agility of Industry 4.0 business is most accurately and reliably characterized by the following two indicators.

The first indicator is the flexibility of businesses, that is, the agility of companies (Popkova et al., 2021; Turginbayeva et al., 2020) because quality improvement and business sustainability are achieved through flexibility. Flexibility is especially important in Industry 4.0 due to the increased speed of scientific and technological progress and innovative development.

The indicator is cyber security (Evstratov & Berezhnova, 2013; Gupta et al., 2023) because it reflects the quality of management information systems, their resistance to adverse effects of the internal and external environment, and the efficiency of their organization, which determines the information support of quality and agility management in Industry 4.0 business.

2.2. Existing approach to management information systems in Industry 4.0 business

The provisions of the existing approach to the MIS in Industry 4.0 business are sufficiently detailed in the available scientific literature. First, it provides a rationale for the established approach. The key factor (source) of quality and agility in this approach is the professionalism of management (Bogoviz et al., 2018). Accordingly, the way to improve quality and agility is to professionalize the manager as the subject of data collection and processing (Bogoviz et al., 2020; Napitupulu, 2023).

Second, the literature reveals the essence of the considered approach. The organization scheme of management information systems involves storing mixed-form data on a variety of separate media (Shrestha & Saratchandra, 2023; Stawowy et al., 2023). The approach assumes intuitive managerial decision-making with partial reliance on data from management information systems (November et al., 2023; Trevisan & Mouritsen, 2023).

Third, the available literature reflects the benefits of the studied approach. The advantage of the approach for data processing as a condition for business agility (quality) is that managers are fully aware of the data as they directly collect it, which speeds up analytics (Chen et al., 2023; Curnin et al., 2023). The advantage of data preservation (resilience) is the low risk of data leakage due to the disparate nature of the data and the difficulty of copying it from different media (Ameri et al., 2023; Horikawa et al., 2023).

2.3. Critique of an existing approach, gaps in the literature, research questions (RQs), and hypotheses (H)

A critical look at the current approach to the MIS in Industry 4.0 business from a quality and agility perspective revealed the shortcomings of this approach. These shortcomings include the increased burden on the manager, charged with the responsibility of collecting, systematizing, storing, and processing information. Due to the increased workload, managers do not have enough time for detailed data analysis, which slows the process of developing managerial decisions or leads to their intuitive adoption (Jo & Park, 2023).

Disadvantages of the current approach also include incomplete automation. On the one hand, the approach makes it possible to include digital data in management information systems. On the other hand, it does not require the mandatory submission of data in electronic form. Because of this, the MIS is a collection of heterogeneous data, the analytics of which is a complex task that requires a long time to complete due to the lack of unification (Paulus et al., 2023).

Thus, these shortcomings prevent the MIS from fulfilling its role in ensuring the quality and agility of the Industry 4.0 business. The development of the MIS is a resource-intensive management process. However, these systems provide only limited benefits. In most cases, reliance on the MIS is either difficult or ineffective for management decision-making (Wang & Yu, 2023).

A promising innovation in the MIS is datasets – collections of information organized similarly to big data, available for automated collection via the Internet of Things (IoT), and useful for smart analytics using artificial intelligence (AI) (Popkova & Sergi, 2021, 2022). The advantages of using datasets in the MIS are noted in the works of Ding et al. (2022) and Roedenbeck and Poljsak-Rosinski (2022).

These benefits are related to using big data and analytics as advanced automation tools for the MIS (Dellnitz, 2022) and improved knowledge transfer to improve the efficiency of the MIS (Popkova, 2020). However, the available literature does clearly explain how the use of datasets in the MIS affects the quality and business sustainability of Industry 4.0. This represents a gap in the literature. The research questions (RQs) of this research are as follows.

RQ_1: How does using big data and analytics and knowledge transfer affect corporate agility and cybersecurity? The point of the question posed is to find out what is more important for agility and quality in Industry 4.0 business – datasets or management professionalism. Based on Doğanay et al. (2022) and Voto (2022), which highlight the benefits of using datasets in the MIS, this research proposes hypothesis H_1 that the use of big data and analytics and knowledge transfer has a strong positive impact on the agility of companies and cyber security, more than the impact of management professionalism.

RQ_2: How is the use of big data and analytics and knowledge transfer defined? The point of this research question is to understand what determines the success of using datasets in the MIS. Based on Khakimova et al. (2020) and Vanchukhina et al. (2022), which indicate the importance of digital competencies in Industry 4.0, this paper puts forward hypothesis H_2 that digital competencies have a strong positive influence on the use of big data and analytics and knowledge transfer, more than the influence of management professionalism.

To verify the hypotheses put forward in the research, the authors carried out a factor analysis of quality and agility in the MIS of Industry 4.0 business. The analysis made it possible to compare the existing approach to this management with the perspective and alternative dataset approach.

3. MATERIALS AND METHODOLOGY

The research conducts a systemic analysis of MIS from the perspective of quality and agility of Industry 4.0 business, pursuing the following three objectives. The first task is to analyze quality and agility in the MIS of Industry 4.0 business. The authors chose the method of regression analysis for factor analysis because this method makes it possible to establish the relationship of indicators (as, for example, correlation analysis) and determine the dependence of the resulting variables on the factor variables.

That is, the advantage of the selected regression analysis method over alternative methods is the ability to study in depth and most accurately mathematically describe the cause-and-effect relationships of quality and agility in the MIS of Industry 4.0 business. The research model is as follows (Figure 1).

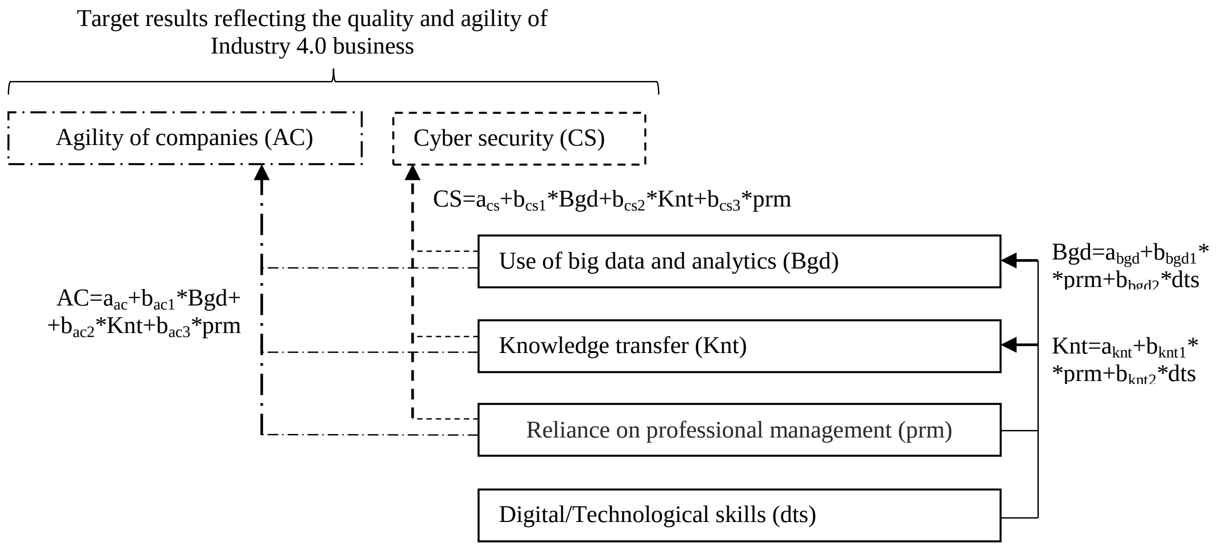

Figure 1. Research model.
Source: Developed and compiled by the authors.

As shown in Figure 1, the paper defines four regression relationships. The first one shows the dependence of agility of companies (AC) as a resultant variable reflecting the quality and agility of Industry 4.0 business on such factor variables as the use of big data and analytics (Bgd), knowledge transfer (Knt), and reliance on professional management (prm) (World Economic Forum, 2019). The regression equation is as follows:

$AC=a_{ac}+b_{ac1}*Bgd+b_{ac2}*Knt+b_{ac3}*prm$.

The second regression relationship shows the dependence of cyber security (CS) as a resultant variable reflecting the quality and agility of Industry 4.0 business on such factor variables as the use of big data and analytics (Bgd), knowledge transfer (Knt), and reliance on professional management (prm). The regression equation is as follows:

$CS=a_{cs}+b_{cs1}*Bgd+b_{cs2}*Knt+b_{cs3}*prm$.

The third regression relationship shows the dependence of the use of big data and analytics (Bgd) on such factor variables as reliance on professional management (prm) and digital/technological skills (Dts). The regression equation is as follows:

$Bgd=a_{bgd}+b_{bgd1}*prm+b_{bgd2}*dts$.

The fourth regression relationship shows the dependence of knowledge transfer (Knt) on such factor variables as reliance on professional management (prm) and digital/technological skills (Dts). The regression equation is as follows:

$Knt=a_{knt}+b_{knt1}*prm+b_{knt2}*dts$.

The source of statistics on the agility of companies, knowledge transfer, cyber security, and digital/technological skills is IMD (2022). The source of data on reliance on professional management is the World Economic Forum (2019). Data sources have not been updated in recent years and are currently up to date. The sample includes all 61 countries for which statistical records are kept in the specified data sources. The statistical basis for this research is shown in Appendix.

Hypothesis H_1 is recognized proven if the following conditions are simultaneously met: $b_{cs1}>0$, $b_{cs1}>b_{cs3}$, $b_{cs2}>0$, $b_{cs2}>b_{cs3}$, $b_{cs1}>0$, $b_{cs1}>b_{cs3}$, $b_{cs2}>0$, and $b_{cs1}>b_{cs3}$.
Hypothesis H_2 is recognized proven if the following conditions are simultaneously met: $b_{bgd1}>0$, $b_{bgd1}>b_{bgd2}$, $b_{knt1}>0$, and $b_{bgd1}>b_{knt2}$.

The second task is to identify scenarios of changes in the quality and agility of Industry 4.0 business in Russia under alternative approaches to MIS. Based on the research model (1) and the results of the regression analysis, the authors drew up three alternative scenarios:

- Realistic scenario based on the existing approach and assuming maximization of management professionalism (reaching the first place in the world);
- Pessimistic scenario based on the dataset approach with non-professional automation and assuming that management professionalism in Russia will remain at the level of 2022 (94^{th} place in the world) combined with maximization of digital skills (reaching the first place in the world).;
- An optimistic scenario based on the dataset approach to professional automation and assuming the maximization of management professionalism in Russia (bringing it to the first place in the world) and digital skills (bringing it to the first place in the world).

Each scenario defines a characteristic change in the quality and agility of Industry 4.0 business in Russia.

The third task is to propose recommendations for improving the MIS in Industry 4.0 business. The recommendations are aimed at scientific and methodological support for realizing the optimistic scenario. The recommendations are presented systemically in the form of a dataset approach to the MIS in Industry 4.0 business.

4. RESULTS

4.1. Factor analysis of quality and agility in the MIS of Industry 4.0 business

To address the first research objective (to conduct factor analysis of the quality and agility in the MIS of Industry 4.0 business), the authors conducted a regression analysis of the collected statistics. The results obtained are summarized in Tables 1–4.

The results obtained in Table 1 show that the agility of companies of 79.33% is determined by the influence of three studied factors (correlation coefficient r^2=62.93%). Consequently, the selected factor variables describe the resulting variable in sufficient detail. The regression equation took the following form:

$$AC=5.8878+0.2876*Bgd+0.3965*Knt+0.1062*prm \quad (1)$$

Equation (1) means that when the use of big data and analytics increases by 1 place, the agility of companies increases by 0.2876 places. When knowledge transfer increases by 1 place, the agility of companies increases by 0.3965 places. With the growth of reliance on professional management by 1 place, the agility of companies increases by 0.1062 places.

Table 1. Factor analysis of agility of companies

Regression statistics						
Multiple R	0.7933					
R^2	0.6293					
Adjusted R^2	0.6098					
Standard error	11.1473					
Observations	61					
Variance analysis						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	12026.4307	4008.8102	32.2607	$2.5*10^{-12}$	
Residual	57	7082.9792	124.2628			
Total	60	19109.4098				
	Coefficients	*Standard error*	*t-statistics*	*P-value*	*Lower 95%*	*Upper 95%*
Y-intercept	5.8878	3.1465	1.8712	0.0665	-0.4130	12.1886
Bgd	0.2876	0.1188	2.4212	0.0187	0.0497	0.5254
Knt	0.3965	0.1430	2.7724	0.0075	0.1101	0.6829
prm	0.1062	0.0603	1.7616	0.0835	-0.0145	0.2270

Source: Calculated and compiled by the authors.

Significance $F=2.5*10^{-1}$, in connection with which equation (1) corresponds to the significance level of 0.01. At a given significance level with 61 observations (n=61) and 3 factor variables (m=3), that is, $k_1=m=3$ and $k_2=n-m-1=61-3-1=57$, Tabular F=4.1451. It was exceeded by the Observed F=32.2607. Hence, Fisher's F-test is passed.

With 60 degrees of freedom, Tabular t=2.6618 at 0.01 significance; Tabular t=2.0010 at 0.05 significance; Tabular t=1.6706 at 0.1 significance. Considering this, Student's t-test is passed for the factor variable Knt at the significance level 0.01 (Observed t-statistics=2.7724), for the factor variable Bgd at the significance level 0.05 (Observed t-statistics=2.4212), and for the factor variable prm at the significance level 0.10 (Observed t-statistics=1.7616).

Table 2. Factor analysis of cyber security

Regression statistics						
Multiple R	0.8307					
R^2	0.6900					
Adjusted R^2	0.6737					
Standard error	10.1472					
Observations	61					
Variance analysis						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	13062.2245	4354.0748	42.2868	$1.6*10^{-14}$	
Residual	57	5869.0214	102.9653			
Total	60	18931.2459				
	Coefficients	*Standard error*	*t-statistics*	*P-value*	*Lower 95%*	*Upper 95%*
Y-intercept	4.6207	2.8642	1.6133	0.1122	-1.1148	10.3562
Bgd	0.1991	0.1081	1.8417	0.0707	-0.0174	0.4156
Knt	0.6642	0.1302	5.1018	$4*10^{-6}$	0.4035	0.9249
prm	-0.0025	0.0549	-0.0463	0.9633	-0.1125	0.1074

Source: Calculated and compiled by the authors.

The results obtained in Table 2 show that 83.07% of cyber security is determined by the influence of three studied factors (correlation coefficient $r^2=69.00\%$). Consequently, the selected factor variables describe the resulting variable in sufficient detail. The regression equation took the following form:

CS=4.6207+0.1991*Bgd+0.6642*Knt-0.0025*prm (2)

Equation (2) means that when the use of big data and analytics increases by 1 place, cyber security increases by 0.1991 places. When knowledge transfer increases by 1 place, cyber security increases by 0.6642 places. When reliance on professional management increases by 1 place, cyber security decreases by 0.0025 places.

Significance $F=1.6*10^{-14}$; equation (2) corresponds to a significance level of 0.01. At a given level of significance with 61 observations (n=61) and 3 factor variables (m=3), that is, $k_1=m=3$ and $k_2=n-m-1=61-3-1=57$, Tabular F=4.1451. It was exceeded by the Observed F=42.2868. Thus, Fisher's F-test is passed.

With 60 degrees of freedom, Tabular t=2.6618 at 0.01 significance level and Tabular t=1.6706 at 0.1 significance level. Considering this, Student's t-test is passed for the factor variable Knt at the significance level of 0.01 (Observed t-statistics=5.1018) and for the factor variable Bgd at the significance level of 0.1 (Observed t-statistics=1.8417). For the factor variable prm, Student's t-test is not passed.

The results obtained in Table 3 show that the use of big data and analytics is by 72.41% determined by the influence of the three studied factors (correlation coefficient r^2=52.43%). Consequently, the selected factor variables describe the resulting variable in a sufficiently complete and detailed manner. The regression equation took the following form:

Bgd=8.5138+0.5543*prm+0.1327*dts (3)

Equation (3) means that when digital/technological skills increase by 1 place, the use of big data and analytics increases by 0.5543 places. When the use of big data and analytics increases by 1 place, the use of big data and analytics increases by 0.1327 places.

Table 3. Factor analysis of the use of big data and analytics

Regression statistics						
Multiple R	0.7241					
R^2	0.5243					
Adjusted R^2	0.5078					
Standard error	12.4167					
Observations	61					
Variance analysis						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	9853.9059	4926.9530	31.9569	$4.4*10^{-10}$	
Residual	58	8942.1596	154.1752			
Total	60	18796.0656				
	Coefficients	*Standard error*	*t-statistics*	*P-value*	*Lower 95%*	*Upper 95%*
Y-intercept	8.5138	3.3806	2.5184	0.0146	1.7468	15.2808
dts	0.5543	0.0973	5.6983	$4.3*10^{-7}$	0.3596	0.7491
prm	0.1327	0.0521	2.5464	0.0136	0.0284	0.2370

Source: Calculated and compiled by the authors.

Significance F=$4.4*10^{-10}$, in connection with which equation (3) corresponds to the significance level of 0.01. At a given level of significance with 61 observations (n=61) and 3 factor variables (m=3), that is, k_1=m=2 and k_2=n-m-1=61-2-1=58, Tabular F=4.9910. It was exceeded by the Observed F=31.9569. Thus, Fisher's F-test is passed.

With 60 degrees of freedom, Tabular t=2.6618 at 0.01 significance level and Tabular t=2.0010 at 0.05 significance level. Considering this, Student's t-test is passed for the factor variable dts at the significance level of 0.01 (Observed t-statistics=5.6983) and for the factor variable prm at the significance level of 0.05 (Observed t-statistics=2.5464).

Table 4. Factor analysis of knowledge transfer

Regression statistics						
Multiple R	0.8084					
R^2	0.6535					
Adjusted R^2	0.6415					
Standard error	10.8620					
Observations	61					
Variance analysis						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	2	12904.1355	6452.0678	54.6864	$4.5*10^{-14}$	
Residual	58	6843.0120	117.9830			
Total	60	19747.1475				
	Coefficients	*Standard error*	*t-statistics*	*P-value*	*Lower 95%*	*Upper 95%*
Y-intercept	6.3164	2.9573	2.1359	0.0369	0.3967	12.2361
dts	0.4128	0.0851	4.8502	$9.6*10^{-6}$	0.2424	0.5831
prm	0.2830	0.0456	6.2065	$6.2*10^{-8}$	0.1917	0.3742

Source: Calculated and compiled by the authors.

The results obtained in Table 4 show that 80.84% of knowledge transfer is determined by the influence of the three studied factors (correlation coefficient r^2=65.35%). Consequently, the selected factor variables describe the resulting variable in sufficient detail. The regression equation took the following form:

Knt=86.3164+0.4128*prm+0.2830*dts (4)

Equation (4) shows that when digital/technological skills increase by 1 place, knowledge transfer increases by 0.4128 places. When reliance on professional management increases by 1 place, knowledge transfer increases by 0.2830 places.

Significance $F=4.5*10^{-14}$, in connection with which equation (4) corresponds to the significance level of 0.01. At a given level of significance with 61 observations (n=61) and 3 factor variables (m=2), that is, $k_1=m=2$ and $k_2=n-m-1=61-2-1=58$, Tabular F=4.9910. It was exceeded by the Observed F=54.6864. Thus, Fisher's F-test is passed.

With 60 degrees of freedom, Tabular t=2.6618. Considering this, Student's t-test is passed for both factor variables dts at the significance level of 0.01. Observed t-statistics=4.8502 for the variable dts and Observed t-statistics=6.2065 for the variable prm.
Thus, all necessary conditions are met, and both hypotheses (H_1 and H_2) are proved. The results suggest that the use of big data and analytics and knowledge transfer has a strong positive impact on the agility of companies and cyber security, more than the impact of management professionalism (although it is also important). Digital competencies have a strong positive impact on the use of big data and analytics and knowledge transfer, more than the impact of management professionalism (although it is also necessary).

4.2. Scenarios of changes in the quality and agility of Industry 4.0 business in Russia under alternative approaches to the MIS

To solve the second problem, relying on equations (1)-(4), the authors determined the scenarios of changes in the quality and agility of Industry 4.0 business in Russia under alternative approaches to the MIS (Table 5).

Table 5. Scenarios of changes in the quality and agility of Industry 4.0 business in Russia under alternative approaches to the MIS

Indicators	Baseline values in 2022, place	Existing approach		Dataset approach			
		Realistic scenario		Pessimistic scenario		Optimistic scenario	
		value, place	increase (improvement), %	value, place	increase (improvement), %	value, place	increase (improvement), %
Digital/Techno-logical skills	49	49	-	1	-	1	-
Reliance on professional management	94	1	-	94	-	1	-
Use of big data and analytics	31	34	-8.82 (deterioration)	21	47.62	9	244.44
Knowledge transfer	56	46	21.74	58	-3.45 (deterioration)	12	366.67
Agility of companies	57	47	21.28	61	-6.56 (deterioration)	20	185.00
Cyber security	45	41	9.76	43	4.65	15	200.00

Source: Calculated and compiled by the authors.

As shown in Table 5, the realistic scenario builds on the existing approach and assumes maximization of management professionalism (to be ranked first in the world compared to 94 in 2022). Meanwhile, digital/techno-logical skills remain in 49th place as in 2022. This leads to a reduction in the use of big data and analytics by 8.82%, improved knowledge transfer by 21.74%, agility of companies by 21.28%, and cyber security by 9.76%.

The pessimistic scenario is realized by relying on the dataset approach with non-professional automation and assumes that management professionalism in Russia will remain at the level of 2022 (94th place) combined with the maximization of digital skills (bringing it to the first place in the world). This leads to an increase in the use of big data and analytics by 47.62% and cyber security by 4.65%, but a decrease in knowledge transfer by 3.45% and agility of companies by 6.56%.

The optimistic scenario is realized with reliance on the dataset approach to professional automation and assumes maximization of management professionalism in Russia (bringing it to the first place in the world) and digital skills (bringing it to the first place in the world). This provides growth in the use of big data and analytics by 244.44% (up to 9th place), knowledge transfer by 366.67% (up to 12th place), agility of companies by 185% (up to 20th place), and cyber security by 200% (up to 15th place).

4.3. Dataset approach to the MIS in Industry 4.0 business

To solve the third problem (i.e., to propose recommendations for improving the MIS in the business of Industry 4.0), the authors developed a dataset approach to the MIS in Industry 4.0 business (Figure 2).

As shown in Figure 2, the dataset approach involves automating the MIS in Industry 4.0 businesses based on technologies such as AI, big data, and IoT. In accordance with the developed approach, the following recommendations are offered to improve the MIS in Industry 4.0 business:

- Organization of the MIS in the form of a dataset, the features of which are that it is an interactive information system, contains big data, and all data in it are integrated;
- Automating Industry 4.0 business data collection with smart business process automation tools and transferring this data to the dataset via IoT;
- Enabling and empowering employees with digital competencies to apply, monitor, and maintain smart business process automation tools, exchange data with the market environment, and transfer digital data from it to the dataset;
- Diffusion of data contained in the dataset among workers and managers;
- Smart analytics of AI dataset with subsequent intelligent support of manager's decision-making;
- Interactive manager access, checking, controlling, and securing the dataset, sharing data with the external environment, as well as managing, monitoring, controlling, team building, and collecting feedback from employees.

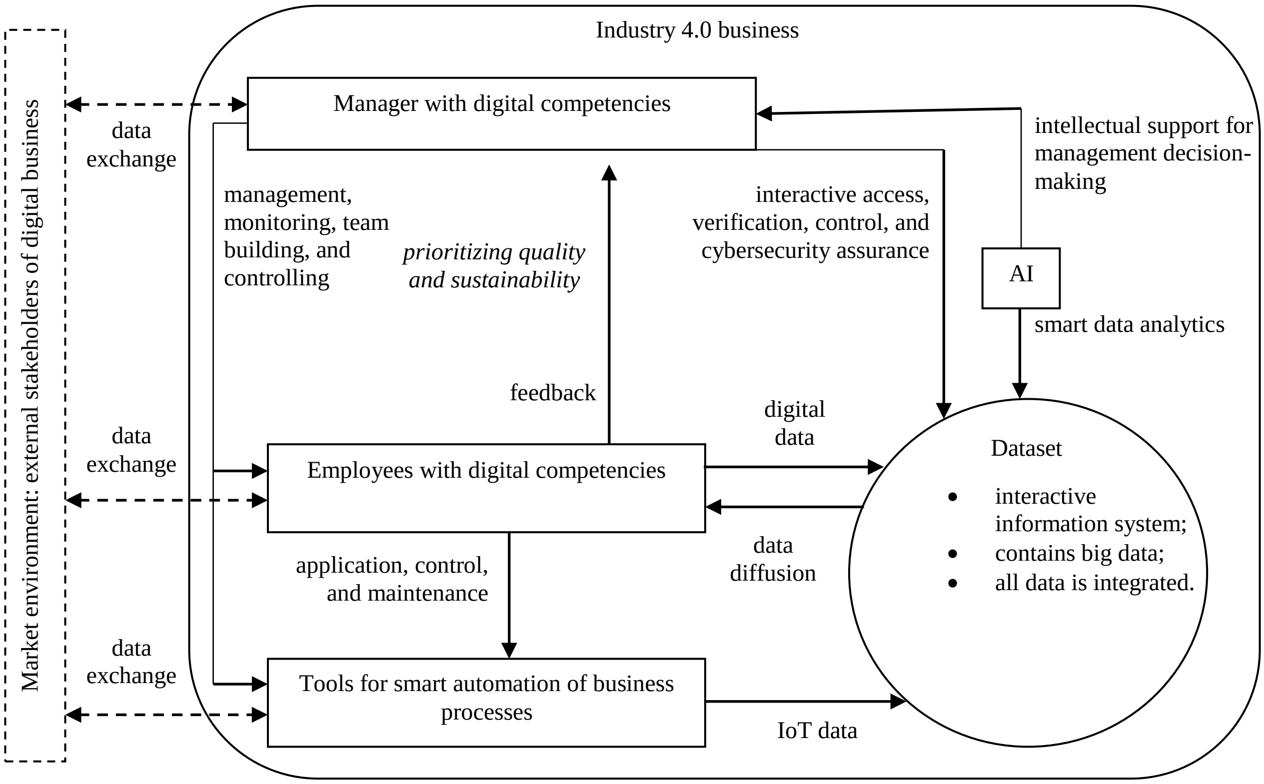

Figure 2. Dataset approach to the MIS in Industry 4.0 business.
Source: Compiled by the authors.

These recommendations provide scientific and methodological support for realizing an optimistic scenario (Table 5) of changes in the quality and agility of Industry 4.0 business in Russia under alternative approaches to the MIS.

5. DISCUSSION

This research contributes to the literature by developing the MIS concept and reinforcing the scientific basis of the works of Chatterjee et al. (2023), Jo and Park (2023), and Osovtsev et al. (2018). The authors prove hypothesis H_1 that the use of big data and analytics and knowledge transfer has a strong positive impact on the agility of companies and cyber security, more than the impact of management professionalism.

The authors also confirmed Hypothesis H_2 that digital competencies have a strong positive influence on the use of big data and analytics and knowledge transfer, more than the influence of management professionalism. Taken together, this provided the basis for the development of a dataset approach to MIS in Industry 4.0 business, a comparative analysis of which with the existing approach in terms of quality and agility is made in Table 6.

As reflected in Table 6, the rationale for the proposed dataset approach is based on the identified new key factors (sources) of quality and agility. In contrast to Bogoviz et al. (2018), these factors include not only management professionalism but also big data and analytics, as well as knowledge diffusion.

Table 6. Comparative analysis of approaches to the MIS in Industry 4.0 business from the perspectives of quality and sustainability

Criteria for comparing approaches		**Approach to the MIS in Industry 4.0 business**	
		Existing approach	**Dataset approach**
Rationale for the approach	Key factors (sources) of quality and sustainability	Only management professionalism (Bogoviz et al., 2018).	Big data and its analytics, knowledge transfer, and management professionalism
	A way to improve quality and sustainability	Only increasing management professionalism as a single subject of data collection and processing (Bogoviz et al., 2020; Napitupulu, 2023).	The development of digital competencies of the manager (as a subject of data analysis) and employees (as subjects of data collection, particularly through IoT)
Essence of the approac	Organization of information systems	Storing mixed-form data on multiple separate media (Shrestha & Saratchandra, 2023; Stawowy et al., 2023).	Combining data into a single interactive system of integrated big data – dataset
	Management decision-making	Intuitive decision-making by a manager with partial reliance on data (November et al., 2023; Trevisan & Mouritsen, 2023).	Intelligent decision support with full reliance on data and dataset analytics results
Advantages of the approach	For data processing (quality)	Managers are fully aware of the data as they directly collect it, which speeds up analytics (Chen et al., 2023; Curnin et al., 2023).	Ability to automate big data processing with AI-based smart dataset analytics
	For data security (agility)	Low risk of data leakage due to data fragmentation and difficulty in copying from different media (Ameri et al., 2023; Horikawa et al., 2023).	Low risk of data leakage by aggregating data into a common dataset, simplifying cybersecurity challenges

Source: Compiled by the authors.

In contrast to Bogoviz et al. (2020) and Napitupulu (2023), it is substantiated that increasing managerial professionalism is not the only available and sufficient way to improve quality and sustainability; the development of digital competencies is another equally important way. As opposed to the sole collection and processing of data by managers in the existing approach, the new approach separates these functions: the manager performs the data analysis and the workers collect the data, particularly through IoT.

The essence of the dataset approach is as follows. In contrast to Shrestha and Saratchandra, (2023) and Stawowy et al. (2023), the organization of information systems implies not storing mixed-form data on a multitude of separate carriers (as in the existing approach) but combining data into a single interactive system of integrated big data – dataset.

In contrast to November et al. (2023) and Trevisan and Mouritsen (2023), instead of intuitive decision-making by a manager with partial reliance on data, practiced with the existing approach, the dataset approach provides intelligent decision-making support with full reliance on data and the results of dataset analytics.

The dataset approach to the MIS provides the following benefits for the quality and agility of Industry 4.0 business. The first one is the benefit for data processing (quality). In contrast to Chen et al. (2023) and Curnin et al. (2023), the manager does not analyze the data but implements the possibility of automated processing of big data through AI-based smart dataset analytics.

The second benefit is data security (resilience). In contrast to Ameri et al. (2023) and Horikawa et al. (2023), low risk of data leakage is ensured in the dataset approach not because of their disparate nature and difficulty of copying from different media but because they are combined into a common dataset, which simplifies the task of ensuring cybersecurity.

Thus, this research supports the scientific discussion of Ding et al. (2022), Doğanay et al. (2022), Roedenbeck and Poljsak-Rosinski (2022), and Voto (2022) on the benefits of using datasets in the MIS. Additionally, it continues the discussion of Khakimova et al. (2020) and Vanchukhina et al. (2022) on the importance of digital competencies in Industry 4.0 – the research substantiates their key role in realizing the dataset approach to the MIS.

6. CONCLUSION

The key findings of the conducted research are as follows. First, the important role of MIS in ensuring the quality and agility of Industry 4.0 business is substantiated. Based on international statistics for 2022, the authors compiled an econometric model of the impact of the MIS in Industry 4.0 business on the quality and agility of this business.

Based on this model, the authors conclude that the use of big data and analytics and knowledge transfer have a strong positive impact on the agility of companies and cyber security, more than the impact of management professionalism. The authors also conclude that the use of big data and analytics and knowledge transfer are determined not only by the professionalism of management but also by digital competencies.

The model is also used to quantify the benefits of implementing the dataset approach in an optimistic scenario involving professional automation of MIS: maximizing management professionalism and digital skills. These benefits include an increase in the use of big data and analytics by 244.44%, knowledge transfer by 366.67%, agility of companies by 185% and cyber security by 200%.

The theoretical significance of the research is that it revealed the prospect for improving the MIS to support the quality and agility of Industry 4.0 business through the transition to a dataset approach to this management. The compiled scenarios of changes in the quality and agility of Industry 4.0 business in Russia revealed the cause-and-effect relationships of the realization of alternative approaches to the MIS and strengthened the scientific argumentation of the choice of the dataset approach.

The practical significance of this research is expressed in the fact that the developed dataset approach to the MIS in Industry 4.0 business will improve the quality and agility of this business. The proposed author's recommendations for implementing the dataset approach will provide highly efficient automation of MIS and thus help overcome the gap in the technological support of MIS and in this provision of quality management and business agility in Industry 4.0.

References:

Ameri, K., Hempel, M., Sharif, H., Lopez, J., & Perumalla, K. (2023). Design of a novel information system for semi-automated management of cybersecurity in industrial control systems. *ACM Transactions on Management Information Systems*, *14*(1), 4. DOI: 10.1145/3546580

Arici, T., Usta, A. T., Cigerim, E., & Gok, M. S. (2022). Mediating role of information systems on strategy and performance: innovation and competition perspective. *Proceedings on Engineering Sciences*, *4*(2), 179-190. DOI: 10.24874/PES04.02.008

Bogoviz, A. V., Ragulina, Y. V., Alekseev, A. N., Anichkin, E. S., & Dobrosotsky, V. I. (2018). Transformation of the role of human in the economic system in the conditions of knowledge economy creation. *Advances in Intelligent Systems and Computing*, *622*, 673-680. DOI: 10.1007/978-3-319-75383-6_86

Bogoviz, A. V., Shvakov, E. E., Tretyakova, O. G., Zakharov, M. Y., & Abramov, A. N. (2020). Globalization of education in the conditions of formation of the global knowledge economy: Regularities and tendencies. *Lecture Notes in Networks and Systems*, *73*, 993-1000. DOI: 10.1007/978-3-030-15160-7_99

Chatterjee, S., Chaudhuri, R., & Vrontis, D. (2023). Bright and dark side of knowledge management practices in firms using information systems: Examining different moderating impacts. *VINE Journal of Information and Knowledge Management Systems*, *53*(5), 880-900. DOI: 10.1108/VJIKMS-07-2022-0222

Chen, K. -S., Lin, S. -C., Lai, K. -K., & Wang, W. -P. (2023). Decision-making model of production data management for multi-quality characteristic products in consideration of industry 4.0. *Applied Sciences*, *13*(13), 7883. DOI: 10.3390/app13137883

Ćurčić, S., Blagojević, M., & Ristić, O. (2019). Ensuring quality for enrollment, renewal of registration and changes in agricultural farm using information technologies. *Proceedings on Engineering Sciences*, *1*(2), 869-874. DOI: 10.24874/PES01.02.092

Curnin, S., Brooks, B., Owen, C., & Brooks, O. (2023). Perceptions of strategic decision-making by crisis management teams during exercising: Establishing key dimensions. *Journal of Contingencies and Crisis Management*, *31*(3), 338-352. DOI: 10.1111/1468-5973.12442

Dellnitz, A. (2022). Big data efficiency analysis: Improved algorithms for data envelopment analysis involving large datasets. *Computers and Operations Research*, *137*, 105553. DOI: 10.1016/j.cor.2021.105553

Ding, X., Gan, Q., & Bahrami, S. (2022). A systematic survey of data mining and big data in human behavior analysis: Current datasets and models. *Transactions on Emerging Telecommunications Technologies*, *33*(9), e4574. DOI: 10.1002/ett.4574

Doğanay, M. A., Orman, A., & Dener, M. (2022). Big Data Visualization for Cyber Security: BETH Dataset. *El-Cezeri Journal of Science and Engineering*, *9*(4), 1572-1582. DOI: 10.31202/ecjse.1209586

Evstratov, A. V., & Berezhnova, A. I. (2013). Development of the market of electronic payment systems in the context of accession of the Russian Federation to the WTO. *World Applied Sciences Journal*, *23*(1), 88-93.

Gupta, B. B., Gaurav, A., & Kumar Panigrahi, P. (2023). Analysis of security and privacy issues of information management of big data in B2B based healthcare systems. *Journal of Business Research*, *162*, 113859. DOI: 10.1016/j.jbusres.2023.113859

Handayani, W., Semara, O. Y., Rahayu, F., & Shaddiq, S. (2022). Digital marketing as an integrated marketing communication strategy in village owned business agencies "badan usaha milik desa (BUMDesa)" based on local wisdom in the era of industrial revolution 4.0 and society 5.0. *Proceedings on Engineering Sciences*, *4*(2), 137-142. DOI: 10.24874/PES04.02.004

Horikawa, H., Ohtani, H., Takahashi, Y., Kato, T., Magata, F., Teshigawara, Y., … Nishigaki, M. (2023). Enhancement of a company-wide information security management system through incident learning. *SN Computer Science*, *4*(3), 211. DOI: 10.1007/s42979-023-01691-7

Hrabovskyi, Y., Kots, H., & Szymczyk, K. (2022). Justification of the innovative strategy of information technology implementation for the implementation of multimedia publishing business projects. *Proceedings on Engineering Sciences*, *4*(4), 467-480. DOI: 10.24874/PES04.04.008

IMD. (2022). *World digital competitiveness ranking 2022*. Retrieved from https://www.imd.org/centers/wcc/world-competitiveness-center/rankings/world-digital-competitiveness-ranking/ (Accessed 28 August 2023)

Jaouad, M., & Bouchaib, B. (2023). Approach for evaluating data quality projects. *Proceedings on Engineering Sciences*, *5*(2), 199-212. DOI: 10.24874/PES05.02.002

Jo, H., & Park, D. -H. (2023). Mechanisms for successful management of enterprise resource planning from user information processing and system quality perspective. *Scientific Reports*, *13*(1), 12678. DOI: 10.1038/s41598-023-39787-y

Khakimova, M. F., Kiyamov, N. S., Kuchkarova, F. H., Sadikova, F. M., & Mamatkulova, M. M (2020). Professional and personal qualities of the future teachers of vocational education. *Journal of Critical Reviews*, *7*(5), 782-784.

Kusmantini, T., Setiawan, A. I., Sin, L. G., Gusaptono, H., & Oetomo, H. (2021). Moderation effect of strategic information system development on the relationship social sustainability in the supply chain and firm performance. *Proceedings on Engineering Sciences*, *3*(3), 345-354. DOI: 10.24874/PES03.03.010

Mardani, A., & Saberi, S. (2023). Industry 4.0 adoption drivers for sustainable supply chain in the manufacturing sector using a hybrid decision-making approach under q-Rung orthopair fuzzy information. *IEEE Transactions on Engineering Management*. DOI: 10.1109/TEM.2023.3262961

Musti, K. S. S., & Baporikar, N. (2023). Industry 4.0-based enterprise information system for P2P lending. *Journal of Science and Technology Policy Management*, *14*(1), 6-24. DOI: 10.1108/JSTPM-06-2020-0093

Napitupulu, I. H. (2023). Internal control, manager's competency, management accounting information systems and good corporate governance: Evidence from rural banks in Indonesia. *Global Business Review*, *24*(3), 563-585. DOI: 10.1177/0972150920919845

November, V., Winter, T., Azémar, A., Canovas, I., Chevillot-Miot, E., & Lecacheux, S. (2023). A new approach for crisis management analysis: Considering the anticipation/decision making pair as a continuum. *Journal of Contingencies and Crisis Management*, *31*(2), 289-299. DOI: 10.1111/1468-5973.12440

Nuttah, M. M., Roma, P., Lo Nigro, G., & Perrone, G. (2023). Understanding blockchain applications in Industry 4.0: From information technology to manufacturing and operations management. *Journal of Industrial Information Integration*, *33*, 100456. DOI: 10.1016/j.jii.2023.100456

Osovtsev, V. A., Przhedetskaya, N. V., & Sagidullaeva, M. S. (2018). Conceptual model of adaptive management of strategic marketing: A system approach. *European Research Studies Journal*, *21*(2), 666-677.

Paulus, D., de Vries, G., Janssen, M., & Van de Walle, B. (2023). Reinforcing data bias in crisis information management: The case of the Yemen humanitarian response. *International Journal of Information Management*, *72*, 102663. DOI: 10.1016/j.ijinfomgt.2023.102663

Popkova, E. G. (2020). A new treatment of quality of goods and services in the conditions of the knowledge economy: Opposition of traditions and innovations. *International Journal for Quality Research*, *14*(2), 329-346. DOI: 10.24874/IJQR14.02-01

Popkova, E. G., & Sergi, B. S. (2021). Dataset modelling of the financial risk management of social entrepreneurship in emerging economies. *Risks*, *9*(12), 211. DOI: 10.3390/risks9120211

Popkova, E. G., & Sergi, B. S. (2022). Digital public health: Automation based on new datasets and the Internet of Things. *Socio-Economic Planning Sciences*, *80*, 101039. DOI: 10.1016/j.seps.2021.101039

Popkova, E. G., Bogoviz, A. V., & Sergi, B. S. (2021). Towards digital society management and 'capitalism 4.0' in contemporary Russia. *Humanities and Social Sciences Communications*, *8*(1), 77, DOI: 10.1057/s41599-021-00743-8

Roedenbeck, M., & Poljsak-Rosinski, P. (2022). Artificial neural network in soft HR performance management: new insights from a large organizational dataset. *Evidence-based HRM*, *11*(3), 519-537. DOI: 10.1108/EBHRM-07-2022-0171

Shrestha, A., & Saratchandra, M. (2023). A conceptual framework toward knowledge ambidexterity using information systems and knowledge management. *Journal of Information Systems*, *37*(1), 143-167. DOI: 10.2308/ISYS-2021-013

Stawowy, M., Duer, S., Perlicki, K., Mrozek, T., & Harničárová, M. (2023). Supporting information quality management in information and communications technology systems with uncertainty modelling. *Energies*, *16*(6), 2531. DOI: 10.3390/en16062531

Tang, Y. M., Chau, K. Y., Kuo, W. T., & Liu, X. X. (2023). IoT-based information system on cold-chain logistics service quality (ICCLSQ) management in logistics 4.0. *Information Systems Frontiers*. DOI: 10.1007/s10796-023-10393-7

Trevisan, P., & Mouritsen, J. (2023). Compromises and compromising: Management accounting and decision-making in a creative organisation. *Management Accounting Research*, *60*, 100839. DOI: 10.1016/j.mar.2023.100839

Turginbayeva, A., Nurseitova, G., Zhakupbekova, G., Doszhanov, K., & Konysbay, A. (2020). Ability to use flexible project management in the hotel business. *E3S Web of Conferences*, *159*, 04009. DOI: 10.1051/e3sconf/202015904009

Vanchukhina, L. I., Leybert, T. B., Ergasheva, S. T., Khalikova, E. A., & Khanafieva, I. R. (2022). Integration of the higher education systems of Russia and the Republic of Uzbekistan in training for the digital economy. *Education in the Asia-Pacific Region*, *65*, 3-13. DOI: 10.1007/978-981-16-9069-3_1

Voto, C. (2022). From archive to dataset. Visualizing the latency of facial big data. *Punctum International Journal of Semiotics*, *8*(1), 47-62. DOI: 10.18680/hss.2022.0004

Wang, Z., & Yu, R. (2023). Effects of time pressure, reward, and information involvement on user management of fake news on a social media platform. *Perceptual and Motor Skills*, *130*(4), 1433-1452. DOI: 10.1177/00315125231179123

World Economic Forum. (2019, October 9). *Global competitiveness report 2019*. Retrieved from https://www.weforum.org/reports/global-competitiveness-report-2019/ (Accessed 28 August 2023)

Yang, L., Zou, H., Shang, C., Ye, X., & Rani, P. (2023). Adoption of information and digital technologies for sustainable smart manufacturing systems for industry 4.0 in small, medium, and micro enterprises (SMMEs). *Technological Forecasting and Social Change*, *188*, 122308. DOI: 10.1016/j.techfore.2022.122308

Nodirjon M. Yuldashev
Tashkent University of Economics and Technology, Tashkent, The Republic of Uzbekistan
yuldashevnodirjon30@gmail.com,
yuldashevnodirjon@mail.ru
ORCID 0009-0001-1554-8787

Raxim R. Dusbayev
Tashkent Institute of Economics and Pedagogy, Tashkent, Republic of Uzbekistan
dusboyevraxim@gmail.com,
raxim_dusboyev@mail.ru
ORCID 0009-0009-4371-8702

Anna L. Shevyakova
Bolashaq Academy, Kazakhstan
shevyakova.anna@gmail.com
ORCID 0000-0002-2644-6292

Yelena S. Petrenko
Plekhanov Russian University of Economics, Moscow, Russia
petrenko_yelena@bk.ru
ORCID 0000-0001-6892-2392

Appendix

Country	Agility of companies	Cyber security	Use of big data and analytics	Knowledge transfer	Reliance on professional management	Digital/Technological skills
Argentina	57	61	41	56	68	57
Australia	39	31	30	29	6	39
Austria	14	4	44	14	18	40
Bahrain	30	11	32	25	31	13
Belgium	29	35	31	16	11	36
Botswana	60	51	49	53	49	55
Brazil	50	59	60	61	53	60
Bulgaria	62	53	54	57	106	26
Canada	18	12	4	15	16	14
Chile	26	42	45	52	39	31
China	22	10	5	20	51	12
Colombia	41	57	36	43	67	53
Croatia	45	44	51	59	127	32
Cyprus	54	36	48	44	120	29
Czech Republic	19	29	33	35	27	23
Denmark	1	14	6	4	4	5
Estonia	11	16	22	25	23	44
Finland	15	3	15	5	1	3
France	49	34	43	34	32	28
Germany	34	21	52	8	25	52
Greece	52	48	62	54	97	47
Hungary	55	47	57	38	93	54
Iceland	2	17	17	18	21	1
India	17	23	13	27	41	17
Indonesia	33	46	26	39	44	41
Ireland	6	37	18	13	9	34
Israel	24	8	8	12	22	19
Italy	38	40	47	36	107	49
Japan	63	45	63	49	12	62
Jordan	43	25	10	22	65	21
Kazakhstan	35	41	9	32	105	43
Korea Rep	16	28	34	30	54	46
Latvia	44	30	24	31	50	27
Lithuania	5	19	21	37	30	2
Luxembourg	30	24	46	24	15	38
Malaysia	42	33	29	27	17	37
Mexico	47	60	56	50	75	48
Netherlands	12	20	16	2	2	6
New Zealand	48	52	39	40	7	51
Norway	13	18	7	9	13	8
Peru	51	58	53	45	87	59
Philippines	40	54	38	47	28	42
Poland	36	55	50	55	88	61
Portugal	59	50	61	41	73	20
Qatar	23	1	3	11	29	11
Romania	56	32	37	58	99	22
Russia	57	45	31	56	94	49
Saudi Arabia	20	2	23	23	37	7
Singapore	10	6	11	6	3	9
Slovak Republic	28	43	42	60	63	35
Slovenia	27	26	35	42	46	25
South Africa	61	56	27	48	47	56
Spain	32	39	55	46	43	30
Sweden	7	13	14	3	8	4
Switzerland	9	15	25	1	5	18
Thailand	37	38	28	33	55	45
Turkey	46	49	40	51	78	50
UAE	8	5	20	21	24	16
United Kingdom	25	22	19	19	26	24
USA	21	27	1	7	10	10
Venezuela	53	63	58	62	82	63

Note: The values of all indicators are in localities and reflect the position of countries in the global ranking for 2022.