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Analysis of the Network Readiness Index (NRI) Using Multivariate Statistics

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Abstract

The Network Readiness Index (NRI) is one of the indicators that shows the level of digital development of countries. The NRI for 2021 shows the development of 130 countries, in contrast to the 45 countries covered by the International Digital Economy and Society Index (I-DESI) of the European Union, which measures only the most developed countries. This paper aims to determine the relationship between 12 sub-pillars of NRI. We use Principal Component Analysis (PCA) to perform a mapping of our data to a lower-dimensional space, and further analyse the causal relationships between the principal sub-pillars using partial correlation coefficients, concluding that two of the twelve main sub-pillars can be explained by ten independent sub-pillars. Thereafter, we use cluster analysis to group our objects (i.e. the 130 countries) into clusters.

Keywords

digital transformation measurement, Network Readiness Index (NRI) sub-pillars, correlation analysis, principal component analysis, partial correlation analysis

1 Introduction

Measuring the development of the digital economy is of primary importance to identifying the strategies and innovation development plans for the sustainable development of the economy at governmental, business, and individual levels. Digital development inevitably impacts the economic and social development of countries due to technological progress and the spread of digitalisation in almost all important spheres of economic and social development. Digital transformation is a term used to describe the process whereby digitalisation reshapes the economic and social development of countries. McKinsey Global Institute distinguishes between four types of digital transformation: business process, business model, domain and organisational. However, despite its advantages, there remain disadvantages to digital transformation and a balance needs to be struck between technological development and human activity in the overall process. Digital transformation represents a process that can be observed at all levels: international, national, and local; moreover, Network Readiness Index data highlights these changes. The Network Readiness Index (NRI) is presented by Portulans Institute and the report of NRI for 2021 ranks 130 countries based on 60 variables. The Networked Readiness Index (NRI) is used to determine a country's readiness for the digital economy. The index aims to represent the progress of a country's economy in terms of the adoption of digital technology improving both competitiveness and welfare; it also tries to highlight specific factors that impact the economy's digital development. The NRI measures the digital development of the countries and ranks the countries based on the development of main four pillars – technology, people, governance, and impact – and 12 sub-pillars (Table 1).

The first pillar of NRI is Technology which represents the main aspect of the network economy. This pillar includes three sub-pillars – Access, Content and Future Technologies – and contributes towards an evaluation of a country's level of technology development. The second pillar is People, which applies to measurement of ICT usage at three levels of analysis: individuals, businesses and governments. This metric reflects a country's or an organisation's access to technology resources and further contains three sub-pillars which are Individuals, Businesses and Governments. The third pillar of NRI is Governance, which reflects the effectiveness of the systems that provide

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Table 1 Pillars and sub-pillars of Network Readiness Index

Pillars	Sub-pillars	Weights of Sub-pillars
Technology	Access	1/12
	Content	1/12
	Future Technologies	1/12
People	Individuals	1/12
	Businesses	1/12
	Governments	1/12
Governance	Trust	1/12
	Regulation	1/12
	Inclusion	1/12
Impact	Economy	1/12
	Quality of Life	1/12
	SDG Contribution	1/12

Source: Own compilation

activity within the network economy and features three sub-pillars: Trust, Regulation, and Inclusion. The fourth pillar is Impact, which measures the economic, social, and human contribution to the network economy. It, too, features three sub-pillars: Economy, Quality of Life and SDG contribution (Dutta and Lanvin, 2020).

This paper aims to answer two main questions. Our first question is how the information stored in the 12 sub-pillars of NRI can be reduced by the latent variables, and what causal relationship can be revealed between the sub-pillars. The first research question draws attention to the fact that in the case of NRI the correlation between the 12 sub-pillars is high, i.e. the variables are very high correlated. The next research question seeks to explain the relatively high variance ratio explained by the two latent factors: one measures access of individuals and businesses to digital technologies, while the other component represents the further development of digital processes. We also aim to discover how the 130 countries included in the NRI can be divided into groups. We have therefore used the method of cluster analysis with this in mind.

This paper is organised according to the following structure. In the second section, we present a short literature review on the NRI and the digital transformation process. In the third section, we use multivariate statistical analysis to answer the research questions, examining the relationships between the twelve sub-pillars and grouping 130 countries according to the level and characteristics of their digital development. We analyse the correlation matrix, then we use Principal Component Analysis (PCA) to perform a mapping of our data to a lower-dimensional space (revealing two latent sub-pillars), and then map the causal relationships between the twelve principal sub-pillars based on the partial correlation coefficients. Thereafter, we use cluster analysis to group our objects (i.e. the 130 countries) into clusters. The last, fourth section of the paper draws conclusions.

2 Literature review

Silva et al. (2022) reveal the indicators which significantly impact the economic and social pillars of NRI. Further authors discuss gaps and limitations in the NRI arising from the problem of access of population to digital technologies and present policy recommendations to address the digital divide.

Miethlich et al. (2021) study enterprise management with purpose of developing a mechanism for managing digital transformation under the COVID-19 pandemic. Analysis revealed that effective digital transformation can be achieved through management restructuring. Comparison of the results achieved by companies using digital-based business models identified that the most effective ones were in COVID-19 affected environments. The analysis was implemented for Azerbaijan, Russia and Switzerland using Network Readiness Index. It implies that the most successful digital enterprise management is based on survival, self-learning, and cooperation rather than on innovation and transformation of business processes.

Goncharenko and Shynkarenko (2022) meanwhile analyse the digital development of the Norwegian economy using different digital indices as well as NRI. Results show that the small number of concentrated large databases, plus low turnover of e-commerce and cross-border online sales of technologies are obstacles for full coverage of its territory and water area with access to i5G internet. The authors give scientific and practical recommendations based on results for effective digital development of the Norwegian economy.

Moroz (2017) uses two indices, NRI (Networked Readiness Index) and DESI (Digital Economy and Society Index), to compare the digital development of Poland with other EU countries. The two indexes are comparable; however, while NRI presents Poland in a relatively positive light, the DESI index indicates that its digital economy lags behind those of other, more developed EU countries.

Mergel et al. (2019) indicate that the results of digital transformation can be grouped under three main headings: output, outcome, and impact. According to their study, output includes the quantity of a service and its quality (for instance, delivery speed and accessibility of provision, both in terms of geography and opening hours). The outcome of digital transformation represents concrete and measurable services, products, processes, or skills. Finally, the impact covers how digital transformation leads to the creation of more or better public value, contributes to digital society by providing benefits for citizens, society as a whole, culture, or the economy, as well as how this transformation leads to the implementation of systems beneficial to society (e.g. by supporting citizen inclusion, regulation, legal and political frameworks).

Sitnicki and Netreba (2020) investigate the of impact of ICT on competitiveness of Eastern European countries. For the purposes of analysis, exploratory factor analysis (EFA) was used, taking the NRI sub-index's data into account as factors affecting a country's ICT competitiveness. Moreover, their comparative analysis of Eastern European countries reveals that some of those countries have a high value of the ratio of the level of GDP to the number of working population, plus a high level of development of information and communication technologies.

Soltész and Zilahy (2020) meanwhile study the features of a popular ride-sharing platform and a related network with a network theory approach, showing that the internal structure of this network shows scale-free characteristics. However, the authors also suggest that while these networks have significant growth potential, they should eventually run out of "free nodes" and reach a saturation point.

3 Research questions and methodology of statistical analysis

Before starting the statistical investigations, we perform a reliability test of the twelve sub-pillars using Cronbach's alpha. We are looking for an answer to the question of how strong the internal consistency of the variables is. Cronbach's alpha of the model is 0.974, which indicates that the internal consistency of the twelve variables is good. This can be determined because Cronbach's alpha is above 0.80, a figure which can be used as a rule of thumb. If this value were below 0.70, the internal consistency of the variables would not be acceptable, and the results would be questionable.

In this attempt to analyse the relationship between 12 sub-pillars of NRI we use multivariate statistical analysis, implemented using two group of methods. One group of methods explores the relationship between the 12 sub-pillars (as variables) and three analyses are performed for this. The other group of method analyses how objects in our chosen countries are arranged.

For the first method of analysis, we investigate the correlation matrix of sub-pillars. Then we use principal component analysis, which divides the variables into groups according to the strength of the linear relationship between the variables. The principal component analysis starts from the correlation matrix between the variables and returns its variance as much as possible. Secondly, we map the causal relationships between the variables using partial correlation between the variables. In the latter case, we only explore the causal relationships, but no longer the direction of the causal relationship, because the method does not allow this.

The other method we use cluster analysis for grouping countries. Using cluster analysis, groups can be formed between countries using a defined distance measure. The method of analysis in the space of variables, i.e. sub-pillars, analyses how objects, i.e. countries, are arranged.

In this research, we test two hypotheses using the mathematical-statistical methods described above. Among our hypotheses, there will be one that we divide into two sub-hypotheses. The first hypothesis explores the probabilistic linear relationship between the sub-pillars. This hypothesis is presented using two sub-hypotheses (H1a. and H1b.).

H1a.: There is a strong linear relationship between the sub-pillars, i.e., the sub-pillars contain redundant information.

Hypothesis H1a. also draws attention to the fact that it is likely that the reduction in sub-pillar numbers better expresses the relationships between sub-pillars. Hypothesis H1b. draws attention to this question.

H1b.: It is sufficient to express the information content of the 12 sub-pillars with two latent variables, i.e. components.

After exploring the linear relationships between the variables, we map the causal relationships between them. This causal relationship system is described in hypothesis H2.

H2.: The sub-pillars can be divided into two causal groups using partial correlations.

Hypothesis H1a. is tested with question Research Question 1, H1b. with Research Question 2, and H2. with question Research Question 3. With the four analysis methods we want to use, we formulate four research questions (Research Questions 1–4). These are the following:

- Research Question 1. What are the linear relationships between the NRI sub-pillars? In other words, do the sub-pillars measure different variables?
- Research Question 2. How can the information content of NRI sub-pillars be reduced? What new latent

variables (components) are created and what do they mean?
- Research Question 3. What causal relationship can be revealed between the NRI sub-pillars? Which dimensions can be interpreted as causes and which as consequences?
- Research Question 4. What clusters/groups can the 130 countries we are examining be divided into?

The data of Network Readiness Index, 2021 presented by Portulans Institution was analysed by using software SPSS 28.

3.1 Research Question 1: Exploring linear relationships with correlational matrix

The first Research Question we analysed with correlation matrix to identify linear relationship between 12 sub-pillars. Results presented in Table 2 shows that there are moderate to strong correlations between the sub-pillars. Each of these correlation coefficients has a positive sign, suggesting that the movement of variables goes in one direction. We consider this to be a very important consequence of any further use of the NRI sub-pillars, in which case the following dilemma arises: how orthogonal, i.e. collinear are these dimensions in terms of our overall

Table 2 Correlation matrix between NRI sub-pillars

		Content	Future Technologies	Individuals	Businesses	Governments	Trust	Regulation	Inclusion	Economy	Quality of Life	SDG Contribution
Access	Pearson Correlation	0.827**	0.651**	0.902**	0.832**	0.806**	0.861**	0.784**	0.857**	0.731**	0.813**	0.788**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Content	Pearson Correlation		0.758**	0.745**	0.868**	0.815**	0.875**	0.790**	0.803**	0.747**	0.795**	0.808**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Future Technologies	Pearson Correlation			0.563**	0.779**	0.827**	0.781**	0.705**	0.672**	0.881**	0.644**	0.622**
	Sig. (2-tailed)			0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Individuals	Pearson Correlation				0.779**	0.720**	0.763**	0.691**	0.817**	0.660**	0.783**	0.785**
	Sig. (2-tailed)				0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Businesses	Pearson Correlation					0.836**	0.881**	0.778**	0.809**	0.775**	0.752**	0.759**
	Sig. (2-tailed)					0.000	0.000	0.000	0.000	0.000	0.000	0.000
Governments	Pearson Correlation						0.887**	0.779**	0.814**	0.824**	0.750**	0.700**
	Sig. (2-tailed)						0.000	0.000	0.000	0.000	0.000	0.000
Trust	Pearson Correlation							0.793**	0.869**	0.805**	0.759**	0.763**
	Sig. (2-tailed)							0.000	0.000	0.000	0.000	0.000
Regulation	Pearson Correlation								0.766**	0.685**	0.754**	0.732**
	Sig. (2-tailed)								0.000	0.000	0.000	0.000
Inclusion	Pearson Correlation									0.682**	0.799**	0.767**
	Sig. (2-tailed)									0.000	0.000	0.000
Economy	Pearson Correlation										0.691**	0.612**
	Sig. (2-tailed)										0.000	0.000
Quality of Life	Pearson Correlation											0.728**
	Sig. (2-tailed)											0.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Source: Own calculation

understanding of the digital economy and society? Or to put it another way, how does each of these sub-pillars add value to our assessment of the status of countries in respect of their digital transition? High correlation could be alarming in this respect, implying that some variables in the NRI structure add little value, as well as indicating multicollinearity among the sub-pillars.

The results of correlations show that the highest correlation between sub-pillars Access and Individuals is 0.902. This means that there is probably some causal relationship between the two variables/sub-pillars. We calculated 0.861 and 0.857 correlation coefficients between Access, and Trust and Inclusion, respectively. These two high correlations may suggest that Access may have some causal relationship to the two sub-pillars mentioned, namely Trust and Inclusion. However, this may also mean that the consequence of the latter two sub-pillars is the Access, which can be decided by examining the partial correlation. The Trust sub-pillar shows a strong medium correlation with the Government, Business, and Content variables. The values of the correlations are 0.887, 0.881, and 0.875, respectively. Now we do not go into the exploration of causal chains, instead, we do it in determining the partial correlation. The other correlation coefficients show a weaker correlation, so we will not go into that. We can conclude that correlation analysis suggests that the results revealed a strong linear relationship between the NRI sub-pillars. This may also suggest that the number of variables can be significantly reduced by latent variables. To reach a solution, we will cover this question in the next section.

3.2 Research Question 2: Search for latent variables with Principal Component Analysis

The second Research Question was analysed by the method of Principal Component Analysis to determine the latent components. Principal component analysis shows how those sub-pillars that are strongly correlated could be reduced. For this analysis, the principal components method is used, both with and without Varimax rotation, to determine linear relationships between the NRI sub-pillars. The studies that can be performed in principal component analysis start from the correlation matrix between variables, in our case between sub-pillars. In the method, we try to generate the correlation matrix using the eigenvalues and eigenvectors of the correlation matrix. To do this, the eigenvalues are arranged in descending order of magnitude. The eigenvalues of the correlation matrix show the amount of information found in the correlation matrix, i.e. the proportion of variance. In an acceptable principal component analysis model, it is not necessary to return the whole of the variance with the eigenvectors; rather, it is sufficient to produce two-thirds of it. The component matrix thus produced indicates which variables show the greatest correlation with which components. It also shows what groups the sub-pillars can be grouped into, i.e. what the highly correlated variables are. To make the principal components more orthogonal, the rotation method is used. In our study, we used the Varimax rotation as will shortly be shown. The appropriateness of using such principal component models can be determined by the Kaiser-Mayer-Olkin measure.

The Kaiser-Meyer-Olkin measure of sampling adequacy shows that with the 0.943 value, the model is meritorious, which confirms it to be significant. Bartlett's test of sphericity is also significant, proving that the results of the model are acceptable. The results with components are presented in Table 3.

The communality values of the analysis are between 0.7 and 0.8, which means that estimated components preserved a large proportion of the variance in the original dataset. In this analysis two components are deemed sufficient, and they have returned 85.311 percent of variance, because with this the combined variance of the two components is greater than 66 percent, a figure which is used as a rule of thumb in principal component analysis. In the principal components with rotation, the value of first component is 48.049 percent, and the second component gives 37.262 percent of variance back. The weights of the first

Table 3 Rotated component matrix

	Component	
	1	2
Individuals	**0.883**	0.298
Access	**0.844**	0.437
SDG Contribution	**0.814**	0.356
Inclusion	**0.798**	0.462
Quality of Life	**0.771**	0.436
Content	**0.698**	**0.603**
Trust	**0.669**	**0.668**
Businesses	**0.665**	**0.643**
Regulation	**0.664**	**0.558**
Future Technologies	0.310	**0.913**
Economy	0.386	**0.856**
Governments	0.563	**0.749**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
Source: Own calculation

component with boldfaced numbers are generally above 0.664, which means that each variable is strongly correlated with this component, except for Future Technologies, which shows weak correlation with 0.310 value. The second component without rotation explains 6.188 percent of variance and with rotation all variables are strongly correlated except one variable, Individuals, with a value of 0.298. The method with Varimax rotation shows more specified results, representing 85.311 percent of variance on two components.

Before we turn to the meaning of the two components, it is worth noting that four sub-pillars, Content, Trust, Business and Regulation, correlate strongly with both components, i.e., explain it to some extent. With the first component, sub-pillars Individuals, Access, SDG Contribution, Inclusion and Quality of Life shows an extremely strong correlation, while with the second component the same is true with the sub-pillars Future Technologies, Economy and Governments, meaning that those two variables can only be assigned to one of these components. Based on these observations, the first component can be interpreted as access of individuals to the digital economy, as it includes Individuals and Access, which can be interpreted as the access a population has to technologies. The second component can measure the further development of digital processes along the Future Technologies sub-pillar, because the Content, Trust, Business and Regulation sub-pillars are strongly correlated with both components, thus they can be considered outcome variables rather than inputs, as evidenced by the partial correlation coefficients.

3.3 Research Question 3: Exploring causal relationships with analysis of partial correlations

The third Research Question was analysed by Partial Correlation analysis. Partial correlations were calculated by filtering out the effects of the other two of the twelve sub-pillars of NRI. The partial correlation matrix is shown in Table 4. Each of the partial correlations marked is significant at a level of at least 6 percent. The other correlations, however, are not significant, so they can be considered zero. Based on the partial correlations in Table 4, causal relationships between the variables can be mapped.

As could already be seen from the components of principal component analysis, the "independent variables" can be identified as Access, Content, Future Technologies, and Trust. The "dependent variables" are Economy and Quality of Life.

3.4 Research Question 4: Grouping with cluster analysis

The fourth Research Question aimed to group countries using cluster analysis. Cluster analysis is a multivariate method which allows to group objects, in our case 130 countries using the 12 NRI sub-pillars into a set of clusters. This method of analysis seems to be more objective as countries could be divided to clusters based on similar points. The results of the cluster analysis are summarised in the Appendix (Table A1). Table A1 also shows how each groups is formed.

The first cluster includes European Union countries, United Kingdom, United States, Australia, New Zealand, Hong Kong (China), Korea Republic, Japan, Israel, Canada, Singapore. The second cluster consists of EU countries, UAE, Qatar, China, Saudi Arabia, Bahrain, Oman. The third cluster are countries of Latin America, CIS countries, Turkey, India, Mongolia. The fourth cluster are Kyrgyzstan, Tajikistan, Pakistan, countries of Latin America and Africa. Based on this analysis we can observe that developed countries belong to the first and second cluster which means high rankings in terms of digital development at a national level, while developing countries are grouped in the third and the fourth clusters.

4 Conclusion

This research focused mainly on identifying the stochastic linear relationship between the variables. The results of mathematical-statistical analyses led us to the conclusion that each of presented hypotheses, i.e. H1a., H2b. and H2. could be accepted. This means that the sub-pillars of NRI are redundant, i.e., two of the sub-pillars (Access and Content) do not carry significantly new information, and these aspects can be captured due to the other ten sub-pillars.

In the paper, we sought answers to two major questions. Our first question was how the information stored in the 12 sub-pillars of NRI can be reduced by the number of variables, and what causal relationship can be revealed between the sub-pillars. These two problems were answered by Research Question 1, Research Question 2, and Research Question 3. The first Research Question 1 draws attention to the fact that in the case of NRI as well, the correlation between the 12 sub-pillars is high, i.e. the variables are correlated to a significant extent. The answer to Research Question 2 can be explained by a relatively high proportion of variance with two latent factors. The two components were also named. One measures the access of individuals and business to

Table 4 Partial correlation matrix between the NRI sub-pillars

		Content	Future Technologies	Individuals	Businesses	Governments	Trust	Regulation	Inclusion	Economy	Quality of Life	SDG Contribution
Access	Pearson Correlation	0.111	−0.184*	0.553**	0.019	0.064	0.213*	0.194*	0.081	0.127	0.075	−0.016
	Sig. (2-tailed)	0.221	0.040	0.001	0.836	0.483	0.018	0.031	0.372	0.159	0.408	0.859
Content	Pearson Correlation		0.120	0.134	0.276**	−0.031	0.255**	0.045	−0.074	−0.055	0.262**	0.309**
	Sig. (2-tailed)		0.183	0.138	0.002	0.733	0.004	0.621	0.417	0.541	0.003	0.001
Future Technologies	Pearson Correlation			−0.195*	0.201*	0.271**	−0.083	0.125	0.098	0.648**	−0.055	0.131
	Sig. (2-tailed)			0.030	0.026	0.002	0.357	0.167	0.281	0.001	0.547	0.145
Individuals	Pearson Correlation				0.219*	0.008	−0.180*	−0.147	0.213*	0.179*	0.150	0.319**
	Sig. (2-tailed)				0.014	0.928	0.045	0.103	0.017	0.047	0.096	0.001
Businesses	Pearson Correlation					0.046	0.224*	0.077	−0.015	−0.040	−0.055	−0.025
	Sig. (2-tailed)					0.614	0.013	0.394	0.869	0.657	0.543	0.780
Governments	Pearson Correlation						0.291**	0.108	0.119	0.087	0.070	−0.078
	Sig. (2-tailed)						0.001	0.233	0.187	0.337	0.439	0.390
Trust	Pearson Correlation							0.019	0.379**	0.221*	−0.178*	0.051
	Sig. (2-tailed)							0.831	0.001	0.014	0.048	0.576
Regulation	Pearson Correlation								0.053	−0.080	0.185*	0.151
	Sig. (2-tailed)								0.560	0.376	0.039	0.094
Inclusion	Pearson Correlation									−0.237**	0.232**	0.050
	Sig. (2-tailed)									0.008	0.009	0.583
Economy	Pearson Correlation										0.138	-0.165
	Sig. (2-tailed)										0.125	0.067
Quality of Life	Pearson Correlation											0.000
	Sig. (2-tailed)											0.999

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
Source: Own calculation

digital technologies, while the other component displays the extent to which digital processes have been developed further. The answers to research questions Research Questions 3 and 4 are extremely consistent.

The research shows that the digital development of countries is not characterised by indicators separately, but rather that the grouping of interconnected indicators yields a holistic understanding of digital processes at a national level. These results could be used for studies, research, and policymaking decisions at a governmental or business levels. In the meantime, the authors are continuing to conduct further research to test the scoring model of NRI and examine the ranking of countries and comparisons that can be made using the Network Readiness Index.

References

Dutta, S., Lanvin, B. (2020) "The Network Readiness Index 2020: Accelerating Digital Transformation in a post-COVID Global Economy", [pdf] Portulans Institute, Washington, DC, USA. ISBN 978-1-63649-055-7 Available at: https://networkreadinessindex.org/wp-content/uploads/2020/10/NRI-2020-Final-Report-October2020.pdf [Accessed: 15 January 2022]

Goncharenko, N., Shynkarenko, O. (2022) "Digital Innovation in the Norwegian Economy with the Introduction of New Forms of Information and Communication Technology", Three Seas Economic Journal, 3(1), pp. 42–49. https://doi.org/10.30525/2661-5150/2022-1-6

Mergel, I., Edelmann, N., Haug, N. (2019) "Defining digital transformation: Results from expert interviews", Government Information Quarterly, 36(4), 101385. https://doi.org/10.1016/j.giq.2019.06.002

Miethlich, B., Belotserkovich, D., Abasova, S., Zatsarinnaya, E., Veselitsky O. (2021) "The Impact of COVID-19 on Digital Enterprise Management", IEEE Engineering Management Review, 49(4), pp. 16–29. https://doi.org/10.1109/EMR.2021.3119222

Moroz, M. (2017) "The Level of Development of the Digital Economy in Poland and Selected European Countries: A Comparative Analysis", Foundations of Management, 9(1), pp. 175–190. https://doi.org/10.1515/fman-2017-0014

Silva, D. S., Yamashita, G .H., Cortimiglia, M. N., Brust-Renck, P. G., ten Caten, C. S. (2022) "Are we ready to assess digital readiness? Exploring digital implications for social progress from the Network Readiness Index", Technology in Society, 68, 101875. https://doi.org/10.1016/j.techsoc.2022.101875

Sitnicki, M., Netreba I. (2020) "Interdependence Assessing for Networked Readiness Index Economic and Social Informative Factors", Baltic Journal of Economic Studies, 6(2), pp. 47–53. https://doi.org/10.30525/2256-0742/2020-6-2-47-53

Soltész, P., Zilahy, G. (2020) "A Network Theory Approach to the Sharing Economy", Periodica Polytechnica Social and Management Sciences, 28(1), pp. 70–80. https://doi.org/10.3311/PPso.12597

Appendix A

Table A1 Change of cluster membership

Country	4 Clusters	3 Clusters	2 Clusters	Country	4 Clusters	3 Clusters	2 Clusters
Sweden	1	1	1	Malta	2	2	2
Denmark	1	1	1	Slovenia	2	2	2
Singapore	1	1	1	Czech Republic	2	2	2
Netherlands	1	1	1	Lithuania	2	2	2
Switzerland	1	1	1	United Arab Emirates	2	2	2
Finland	1	1	1	Portugal	2	2	2
Norway	1	1	1	Italy	2	2	2
United States	1	1	1	Poland	2	2	2
Germany	1	1	1	Malaysia	2	2	2
United Kingdom	1	1	1	Slovakia	2	2	2
Luxembourg	1	1	1	Cyprus	2	2	2
Australia	1	1	1	Latvia	2	2	2
Canada	1	1	1	Qatar	2	2	2
Korea, Rep.	1	1	1	Hungary	2	2	2
Japan	1	1	1	China	2	2	2
New Zealand	1	1	1	Saudi Arabia	2	2	2
France	1	1	1	Bahrain	2	2	2
Austria	1	1	1	Croatia	2	2	2
Ireland	1	1	1	Oman	2	2	2
Belgium	1	1	1	Greece	3	2	2
Iceland	1	1	1	Bulgaria	3	2	2
Hong Kong (China)	1	1	1	Uruguay	3	2	2
Estonia	1	1	1	Russian Federation	3	2	2
Israel	1	1	1	Romania	3	2	2
Spain	2	2	2	Chile	3	2	2

Table A1 Change of cluster membership (continued)

Country	4 Clusters	3 Clusters	2 Clusters	Country	4 Clusters	3 Clusters	2 Clusters
Thailand	3	2	2	Morocco	3	2	2
Serbia	3	2	2	Kyrgyzstan	4	3	2
Kuwait	3	2	2	El Salvador	4	3	2
Costa Rica	3	2	2	Rwanda	4	3	2
Armenia	3	2	2	Lao PDR	4	3	2
Kazakhstan	3	2	2	Ghana	4	3	2
Turkey	3	2	2	Botswana	4	3	2
Montenegro	3	2	2	Senegal	4	3	2
Brazil	3	2	2	Bolivia	4	3	2
Argentina	3	2	2	Honduras	4	3	2
Mauritius	3	2	2	Namibia	4	3	2
Viet Nam	3	2	2	Cambodia	4	3	2
Mexico	3	2	2	Bangladesh	4	3	2
Ukraine	3	2	2	Guatemala	4	3	2
Belarus	3	2	2	Algeria	4	3	2
Azerbaijan	3	2	2	Venezuela	4	3	2
North Macedonia	3	2	2	Tajikistan	4	3	2
Georgia	3	2	2	Tanzania	4	3	2
Jordan	3	2	2	Pakistan	4	3	2
Jamaica	3	2	2	Benin	4	3	2
Moldova	3	2	2	Nepal	4	3	2
Colombia	3	2	2	Uganda	4	3	2
Indonesia	3	2	2	Côte d'Ivoire	4	3	2
Philippines	3	2	2	Zambia	4	3	2
Dominican Republic	3	2	2	Nigeria	4	3	2
South Africa	3	2	2	Cameroon	4	3	2
Panama	3	2	2	Gambia	4	3	2
Albania	3	2	2	Guinea	4	3	2
Iran, Islamic Rep.	3	2	2	Lesotho	4	3	2
Peru	3	2	2	Eswatini	4	3	2
Trinidad and Tobago	3	2	2	Mali	4	3	2
Kenya	3	2	2	Madagascar	4	3	2
Sri Lanka	3	2	2	Burkina Faso	4	3	2
Egypt	3	2	2	Zimbabwe	4	3	2
Ecuador	3	2	2	Malawi	4	3	2
Cabo Verde	3	2	2	Mozambique	4	3	2
Bosnia and Herzegovina	3	2	2	Ethiopia	4	3	2
India	3	2	2	Burundi	4	3	2
Mongolia	3	2	2	Angola	4	3	2
Lebanon	3	2	2	Yemen	4	3	2
Tunisia	3	2	2	Congo, Dem. Rep.	4	3	2
Paraguay	3	2	2	Chad	4	3	2