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Comparison of Individuals' Computer Skills with Multi-Criteria Decision-Making Methods: Turkey-European Countries

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Abstract: Great changes have occurred in today's society in the last 50 years. Information has become the most important resource. With the spread of individual computer ownership since the 1990s, the transformation into an information society has accelerated. With the development of multimedia tools, especially with the creation of the internet infrastructure, not only difficulties have arisen in accessing information, but also conditions suitable for the production of new information have been provided. These developments accelerated the economic and social developments of societies. In this context, computer skill levels, which should be in qualified manpower, have also been a subject of interest in the academic field. In this study, multi-criteria decision-making methods and individual computer skill levels of Turkey and European countries are discussed. The data set used in the study was obtained from the individual computer skills level research on the European Statistical Office website. The criteria in the data set are weighted by the Entropy method. Comparison of individual computer usage levels by countries was carried out with the ARAS method. Considering the limitations of the research and the findings obtained by the Aras method, it can be said that Iceland, Finland and the Netherlands, which were found to be the most successful in the ranking of individual computer skills, were followed by other countries.

Keywords: Computer skills, Multi-criteria, Decision making

Introduction

The information age we live in can be thought of as a period that information and communication technologies manage and direct. In this period, every work done, every process developed and every product produced is developed by using information and communication technologies (Güner, 2020). In this context, when we evaluate today's processes in terms of efficiency, it can be thought that it is necessary to develop individuals' computer skills. Developments in information technologies have affected many sectors. With Industry 3.0, where nanotechnology, biotechnology, new materials and recycling technologies lead, machine learning, data-cyber physical systems-3 D printers etc. Industry 4.0 technologies, which show themselves with titles, produce new technological breakthroughs in the 21st century (Haseski, 2019). Developing digital skills is seen as a prerequisite for the realization of digital transformation and economic growth in the world, increasing the welfare level of citizens and creating a digital economy strategy(Gülbahar and Kalelioğlu,2018). Individuals' attitudes towards information technologies are important for the development of digital skills. In this study, individual computer skill levels of Turkey and European Countries were compared with Entropy and ARAS methods.

The studies conducted in the literature to compare countries with multi-criteria decision-making methods are as follows. Ayçin and Çakın (2019) evaluated the innovation performance of countries with Entropy and MABAC

methods. Tunca et al. (2016) examined OPEC country performances using Entropy and MAUT methods. Çakır and Perçin (2013) discussed the R&D performances of EU countries with Entropy and TOPSIS methods.

Method

The aim of the study is to compare the individual computer usage skills, which are one of the criteria of the information society, between Turkey and EU countries. The criteria in the data set created in the study were weighted by the entropy method. The ARAS method, which is one of the multi-criteria decision-making methods, was used to compare individual usage skills according to countries.

Entropy Method

The concept of entropy was first proposed by Rudolf Clausius in 1865 and is known as a criterion of disorder and distribution in thermodynamics. Entropy, which is one of the methods that determines criterion weights in Multi-Criteria Decision-Making Problems, produces objective results based on the values of alternatives without the need for decision makers' evaluations. Entropy method process steps (Ömürbek, et al. 2016):

- Creating the Decision Matrix
- Obtaining the Normalized Decision Matrix
- Calculating the Degree of Differentiation of Information (d_j)
- Calculation of Entropy Criterion Weights

Additive Ratio Assessment (ARAS) Method

Additive Ratio Assessment (ARAS), one of the Multi-Criteria Decision Making methods, was presented as a new approach to its solution by Z. Turskis and E. K. Zavadskas. Generally, the structure of a MCDM problem is related to the problem of ordering a finite number of decision alternatives clearly defined by different decision criteria. According to the ARAS method, the value of the utility function, which determines the complex relative efficiency of a viable alternative, is directly proportional to the relative effect of the decision criteria values and weights considered in the problem.(Turskis and Zavadskas, 2010). ARAS method operation steps:

- Creating the Decision Matrix: Determining the optimization direction of the criteria and preparing the alternatives in matrix form according to the criteria.
- Generating the Normalized Decision Matrix: Eliminating the inconsistencies in different measurement units between the criteria.
- Construction of the Weighted Normalized Decision Matrix: Rearrangement of the normalized decision matrix according to the criterion weights.
- Calculation of Optimality Function Values: In the last step of the ARAS method, the optimality function value is calculated for each alternative and the evaluation of the alternatives is performed. S_i, i. optimality of the alternative function value, S_o is the optimal function value, K_i is (S_i / S_o) the utility value. Alternatives are ranked in descending order of Ki value.

Table 1. Criteria and explanations used in the study

ID	Criteria	Unit	Benefit/Cost
C1	Individuals who have written code in a programming language	%	Benefit
C2	Individuals who have copied or moved files between folders, devices or on the cloud	%	Benefit
C3	Individuals who downloaded or installed software or apps	%	Benefit
C4	Individuals who changed the settings of software, app or device	%	Benefit
C5	Individuals who used word processing software	%	Benefit
C6	Individuals who have created files integrating elements such as text, pictures, tables, charts, animations or sound	%	Benefit
C7	Individuals who used spreadsheet software (3 months)	%	Benefit
C8	Individuals who used advanced features of spreadsheet software to organise, analyse, structure or modify data	%	Benefit
C9	Individuals who edited photos, video or audio files	%	Benefit

Data Collection

The data used in the study were obtained from the Individuals' computer skills level survey on the European Statistical Office website. Based on the annual survey of ICT use by households and individuals since 2002, the EU survey aims to collect and disseminate consistent and comparable information on ICT use by households and individuals. Information on the criteria included in the study is given in Table 1.

Data Analysis

In the analysis of the data, applications of entropy and intermediate methods were carried out in Microsoft Excel program.

Table 2. Decision matrix

Country	C1	C2	C3	C4	C5	C6	C7	C8	C9
Belgium	5	50	45	18	56	45	44	21	27
Bulgaria	1	39	25	19	28	20	14	6	19
Czechia	5	57	48	17	53	30	40	20	28
Denmark	11	64	65	53	46	58	48	29	32
Germany	5	53	44	25	47	24	34	25	31
Estonia	6	55	50	39	50	36	42	26	34
Ireland	8	63	60	46	59	51	47	26	45
Greece	3	56	41	24	53	30	36	16	19
Spain	8	65	61	45	54	48	42	25	41
France	6	69	58	45	59	49	44	23	41
Croatia	4	81	43	35	41	27	67	46	23
Italy	6	51	49	42	42	39	33	21	29
Cyprus	5	54	50	40	53	33	40	19	15
Latvia	5	58	46	38	44	34	33	16	23
Lithuania	5	53	45	40	46	32	40	16	37
Luxembourg	9	65	58	41	58	47	45	26	44
Hungary	4	49	35	30	47	26	36	21	23
Malta	9	53	60	31	53	39	45	34	35
Netherlands	10	71	71	60	71	55	54	32	45
Austria	10	65	55	45	60	49	46	26	46
Poland	5	51	44	36	43	34	28	10	24
Portugal	7	38	35	18	51	43	38	18	38
Romania	1	34	25	17	21	25	19	5	17
Slovenia	6	49	41	31	55	39	33	15	27
Slovakia	4	65	39	27	52	36	40	21	24
Finland	10	71	70	60	70	54	51	33	54
Sweden	10	62	65	49	67	49	45	18	34
Iceland	10	65	74	57	78	48	67	48	43
Norway	12	63	75	58	77	63	56	27	38
Switzerland	9	81	62	43	66	43	53	24	40
Montenegro	7	79	49	22	58	34	33	21	21
North Macedonia	3	36	26	8	23	19	8	5	9
Albania	6	22	27	7	18	15	11	5	21
Serbia	2	61	49	31	50	25	24	8	20
Turkey	3	28	34	23	15	16	14	7	24
Bosnia and Herzegovina	2	55	31	16	37	23	18	6	10

Source: Eurostat Data Browser

Results and Discussion

Criteria Weights

The criteria used in the study were calculated by the entropy method given in Table 3. When Table 3 is examined, the three most important criteria are respectively (C8;C1;C4), people who use advanced features of

spreadsheet software to organize, analyze, configure, or manipulate data (19.6%); people who write code in a programming language (17.9%); people change software, application, or device settings (14.1%).

When other criteria weights are examined, use of spreadsheet software is 11.4% (C7), editing photos, video or audio files 10,2% (C9), created files integrating elements such as text, pictures, tables, charts, animations 8.4% (C6), word processing software using 7.5% (C5), using downloaded or installed software or applications 6.2% (C3), handling files copied or moved on folders, devices or the cloud 4.2% (C2).

Table 3. Criterion weights

Value	C1	C2	C3	C4	C5	C6	C7	C8	C9	
E_J	0,966	0,991	0,988	0,974	0,986	0,984	0,979	0,963	0,981	Sum
D_J	0,034	0,009	0,012	0,026	0,014	0,016	0,021	0,037	0,019	0,187
w_i	0,179	0,047	0,062	0,141	0,075	0,084	0,114	0,196	0,102	1

Comparison of Country Performances

In the comparison of country performances, the decision matrix, which is also the data set, is normalized (Table 4).

Table 4. Normalized decision matrix

Country	c1	c2	c3	c4	c5	c6	c7	c8	c9
Optimal Value	0,051	0,346	0,321	0,256	0,333	0,269	0,286	0,205	0,231
Belgium	0,021	0,214	0,192	0,077	0,239	0,192	0,188	0,090	0,115
Bulgaria	0,004	0,167	0,107	0,081	0,120	0,085	0,060	0,026	0,081
Czechia	0,021	0,244	0,205	0,073	0,226	0,128	0,171	0,085	0,120
Denmark	0,047	0,274	0,278	0,226	0,197	0,248	0,205	0,124	0,137
Germany	0,021	0,226	0,188	0,107	0,201	0,103	0,145	0,107	0,132
Estonia	0,026	0,235	0,214	0,167	0,214	0,154	0,179	0,111	0,145
Ireland	0,034	0,269	0,256	0,197	0,252	0,218	0,201	0,111	0,192
Greece	0,013	0,239	0,175	0,103	0,226	0,128	0,154	0,068	0,081
Spain	0,034	0,278	0,261	0,192	0,231	0,205	0,179	0,107	0,175
France	0,026	0,295	0,248	0,192	0,252	0,209	0,188	0,098	0,175
Croatia	0,017	0,346	0,184	0,150	0,175	0,115	0,286	0,197	0,098
Italy	0,026	0,218	0,209	0,179	0,179	0,167	0,141	0,090	0,124
Cyprus	0,021	0,231	0,214	0,171	0,226	0,141	0,171	0,081	0,064
Latvia	0,021	0,248	0,197	0,162	0,188	0,145	0,141	0,068	0,098
Lithuania	0,021	0,226	0,192	0,171	0,197	0,137	0,171	0,068	0,158
Luxembourg	0,038	0,278	0,248	0,175	0,248	0,201	0,192	0,111	0,188
Hungary	0,017	0,209	0,150	0,128	0,201	0,111	0,154	0,090	0,098
Malta	0,038	0,226	0,256	0,132	0,226	0,167	0,192	0,145	0,150
Netherlands	0,043	0,303	0,303	0,256	0,303	0,235	0,231	0,137	0,192
Austria	0,043	0,278	0,235	0,192	0,256	0,209	0,197	0,111	0,197
Poland	0,021	0,218	0,188	0,154	0,184	0,145	0,120	0,043	0,103
Portugal	0,030	0,162	0,150	0,077	0,218	0,184	0,162	0,077	0,162
Romania	0,004	0,145	0,107	0,073	0,090	0,107	0,081	0,021	0,073
Slovenia	0,026	0,209	0,175	0,132	0,235	0,167	0,141	0,064	0,115
Slovakia	0,017	0,278	0,167	0,115	0,222	0,154	0,171	0,090	0,103
Finland	0,043	0,303	0,299	0,256	0,299	0,231	0,218	0,141	0,231
Sweden	0,043	0,265	0,278	0,209	0,286	0,209	0,192	0,077	0,145
Iceland	0,043	0,278	0,316	0,244	0,333	0,205	0,286	0,205	0,184
Norway	0,051	0,269	0,321	0,248	0,329	0,269	0,239	0,115	0,162
Switzerland	0,038	0,346	0,265	0,184	0,282	0,184	0,226	0,103	0,171
Montenegro	0,030	0,338	0,209	0,094	0,248	0,145	0,141	0,090	0,090
N.Macedonia	0,013	0,154	0,111	0,034	0,098	0,081	0,034	0,021	0,038
Albania	0,026	0,094	0,115	0,030	0,077	0,064	0,047	0,021	0,090
Serbia	0,009	0,261	0,209	0,132	0,214	0,107	0,103	0,034	0,085
Turkey	0,013	0,120	0,145	0,098	0,064	0,068	0,060	0,030	0,103
Bos. and Herz.	0,009	0,235	0,132	0,068	0,158	0,098	0,077	0,026	0,043

With the weights obtained from the entropy method, the normalized decision matrix is transformed into a weighted normalized decision matrix (Table 5). The optimal function values (Si) and utility degrees (Ki) of the alternatives (countries) are calculated and given in Table 6. The rankings of countries are presented in Table 6 in descending order of utility degrees.

Table 5. Weighted normalized decision matrix

Country	c1	c2	c3	c4	c5	c6	c7	c8	c9
Optimal Value	0,009	0,016	0,020	0,036	0,025	0,023	0,033	0,040	0,023
Belgium	0,004	0,010	0,012	0,011	0,018	0,016	0,022	0,018	0,012
Bulgaria	0,001	0,008	0,007	0,011	0,009	0,007	0,007	0,005	0,008
Czechia	0,004	0,011	0,013	0,010	0,017	0,011	0,020	0,017	0,012
Denmark	0,008	0,013	0,017	0,032	0,015	0,021	0,023	0,024	0,014
Germany	0,004	0,011	0,012	0,015	0,015	0,009	0,017	0,021	0,013
Estonia	0,005	0,011	0,013	0,023	0,016	0,013	0,021	0,022	0,015
Ireland	0,006	0,013	0,016	0,028	0,019	0,018	0,023	0,022	0,020
Greece	0,002	0,011	0,011	0,014	0,017	0,011	0,018	0,013	0,008
Spain	0,006	0,013	0,016	0,027	0,017	0,017	0,021	0,021	0,018
France	0,005	0,014	0,015	0,027	0,019	0,018	0,022	0,019	0,018
Croatia	0,003	0,016	0,011	0,021	0,013	0,010	0,033	0,038	0,010
Italy	0,005	0,010	0,013	0,025	0,014	0,014	0,016	0,018	0,013
Cyprus	0,004	0,011	0,013	0,024	0,017	0,012	0,020	0,016	0,007
Latvia	0,004	0,012	0,012	0,023	0,014	0,012	0,016	0,013	0,010
Lithuania	0,004	0,011	0,012	0,024	0,015	0,011	0,020	0,013	0,016
Luxembourg	0,007	0,013	0,015	0,025	0,019	0,017	0,022	0,022	0,019
Hungary	0,003	0,010	0,009	0,018	0,015	0,009	0,018	0,018	0,010
Country	0,007	0,011	0,016	0,019	0,017	0,014	0,022	0,028	0,015
Malta	0,008	0,014	0,019	0,036	0,023	0,020	0,026	0,027	0,020
Netherlands	0,008	0,013	0,015	0,027	0,019	0,018	0,023	0,022	0,020
Austria	0,004	0,010	0,012	0,022	0,014	0,012	0,014	0,008	0,010
Poland	0,005	0,008	0,009	0,011	0,016	0,015	0,019	0,015	0,017
Portugal	0,001	0,007	0,007	0,010	0,007	0,009	0,009	0,004	0,007
Romania	0,005	0,010	0,011	0,019	0,018	0,014	0,016	0,013	0,012
Slovenia	0,003	0,013	0,010	0,016	0,017	0,013	0,020	0,018	0,010
Slovakia	0,008	0,014	0,019	0,036	0,023	0,019	0,025	0,028	0,023
Finland	0,008	0,012	0,017	0,029	0,022	0,018	0,022	0,015	0,015
Sweden	0,008	0,013	0,020	0,034	0,025	0,017	0,033	0,040	0,019
Iceland	0,009	0,013	0,020	0,035	0,025	0,023	0,027	0,023	0,017
Norway	0,007	0,016	0,016	0,026	0,021	0,015	0,026	0,020	0,017
Switzerland	0,005	0,016	0,013	0,013	0,019	0,012	0,016	0,018	0,009
Montenegro	0,002	0,007	0,007	0,005	0,007	0,007	0,004	0,004	0,004
N.Macedonia	0,005	0,004	0,007	0,004	0,006	0,005	0,005	0,004	0,009
Albania	0,002	0,012	0,013	0,019	0,016	0,009	0,012	0,007	0,009
Serbia	0,002	0,006	0,009	0,014	0,005	0,006	0,007	0,006	0,010
Turkey	0,002	0,011	0,008	0,010	0,012	0,008	0,009	0,005	0,004
Bos. and Her.	0,009	0,016	0,020	0,036	0,025	0,023	0,033	0,040	0,023

Conclusion

In this study, the computer skills levels of individuals in Turkey and European countries were compared with multi-criteria decision making methods. The criteria used in the study were weighted by the entropy method. According to the findings obtained by the entropy method, advanced use of spreadsheet software to analyze and configure data, writing code in a programming language, and realizing software, application or device type come to the fore. This situation coincides with the order of importance in today's computer education issues.
In the findings obtained by the ARAS method, it can be said that Iceland, Finland and the Netherlands are the three most successful countries, respectively.

Table 6. Calculation of optimal function values and ranking

Si	Ki	Rank	Country	Rank	Country
0,2255	1				
0,1216	0,539330373	19	Belgium	1	Iceland
0,0629	0,279121058	33	Bulgaria	2	Finland
0,1145	0,507755248	26	Czechia	3	Netherlands
0,1676	0,743288399	5	Denmark	4	Norway
0,1159	0,514002447	24	Germany	5	Denmark
0,1384	0,613776461	15	Estonia	6	Switzerland
0,1639	0,72686551	7	Ireland	7	Ireland
0,1059	0,46963676	28	Greece	8	Austria
0,1563	0,692957365	11	Spain	9	Luxembourg
0,1560	0,691844026	12	France	10	Sweden
0,1559	0,691217792	13	Croatia	11	Spain
0,1269	0,562671713	16	Italy	12	France
0,1228	0,544752191	18	Cyprus	13	Croatia
0,1164	0,516078501	22	Latvia	14	Malta
0,1257	0,557630127	17	Lithuania	15	Estonia
0,1584	0,702293698	9	Luxembourg	16	Italy
0,1098	0,487069058	27	Hungary	17	Lithuania
0,1488	0,65982652	14	Malta	18	Cyprus
0,1921	0,851968114	3	Netherlands	19	Belgium
0,1635	0,72488618	8	Austria	20	Montenegro
0,1059	0,469573611	29	Poland	21	Slovakia
0,1151	0,510427778	25	Portugal	22	Latvia
0,0610	0,270598587	34	Romania	23	Slovenia
0,1161	0,514652405	23	Slovenia	24	Germany
0,1199	0,531643942	21	Slovakia	25	Portugal
0,1944	0,862309009	2	Finland	26	Czechia
0,1578	0,699676932	10	Sweden	27	Hungary
0,2085	0,924777559	1	Iceland	28	Greece
0,1905	0,844661597	4	Norway	29	Poland
0,1655	0,733806961	6	Switzerland	30	Serbia
0,1211	0,537104366	20	Montenegro	31	Bos. and Herz.
0,0474	0,210385243	36	N. Macedonia	32	Turkey
0,0502	0,222777276	35	Albania	33	Bulgaria
0,0976	0,43267873	30	Serbia	34	Romania
0,0644	0,285784694	32	Turkey	35	Albania
0,0687	0,30475035	31	Bosn. and Herz.	36	N. Macedonia

Recommendations

In future studies, comparisons can be made with multi-criteria decision-making methods different from the methods used in this study. Relationships between other variables in computer software and individual computer use skills can be investigated by country.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

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