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ANALYSIS OF THE DIGITAL DIVIDE IN ASIA-ISLAMIC COUNTRIES: A TOPSIS APPROACH

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ABSTRACT

The tremendous advances in information and communication technology and its concrete manifestations in the form of modern communication tools and techniques have created a deep transformation at different levels of social life and daily activities of people in society. Some of these differences are due to the recognition and utilization of new technologies that had not been available for all people in the past. The same difference in access and utilization of information and communication technologies makes the digital divide between generations. There are many definitions of the Digital Divide (DD), but the term refers to the gap between individuals, companies, regions and countries when accessing and using information and communication technology. The notion of the digital divide can be used to explain the socioeconomic differences arising from information and communication technonlogy (ICT) use, and social, demographic and economic characteristics of the users. The aim of this study is to analyze the digital divide in Muslim countries. After examining the digital divide and its impact parameters, the Islamic countries were ranked using the TOPSIS method. The results if this study showed that Malaysia is ranked first and Afghanistan is ranked last. On the other hand, the difference of similarity index shows that the digital divide in Asian- Islamic countries has very high from the highest rank to the lowest rank.

Keywords: Information and communication technology, Digital divide, Digital divide indicators, Digital divide measurement, Asia-Islamic countries, TOPSIS method.

Contribution/ Originality

The purpose of this study was to determine the digital divide gap between Asia-Islamic countries in terms of the usage of information and communication technology. Then, using

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TOPSIS method and the digital divide indicators are determine the rank of each country in Asia, and in the previous research has not been compared in terms of ICT indicators the Muslim world.

1. INTRODUCTION

In the now established information society, it is crucial that people have access to the new media and know how to use the new ICTs. Without access to the internet and without the necessary skills that regularly go along with the attitude to use the new information technologies, people can neither inform themselves electronically nor can be informed by organisations and institutions using IT. This is why issues concerning the digital divide are of striking importance in this context, as pointed out by Elizabeth C. Boyd, "*As information technology is fast becoming a major tool for disseminating and obtaining information, gaps between those who have access to this tool and those who do not is a major concern*" [1].

The ''Digital Divide'' is a concept coined a decade ago by former US Assistant Secretary of Commerce for Telecommunications and Communication, Larry Irving, Jr, in order to focus public attention on the existing gap in access to information services between those who can afford to purchase the computer hardware and software necessary to participate in the global information network, and low-income families and communities that cannot [2].

Several definitions and descriptions were made of digital divide that show various points of view in addition to the overall similarity of these definitions together. The digital divide refers to the gap between those who can effectively use the new information and communication tools like the Internet and those who cannot [3].

The digital divide is not only limited to the deprivation of people of a community from computers and electronic devices, but also it includes all other prerequisites such as poverty, underdevelopment, illiteracy, lack of public health and social security, etc. Accordingly, the digital divide is a reflection of the existing IT infrastructure landscape and the distribution of wealth [4].

2. DIGITAL DIVIDE INDICATORS

Though more than half of the world's inhabitants have access to ICT, the distribution of resources has not been uniform throughout the world. For example, there is more communication fiber in the Asian, North American and European continents than in the African continent. Even within the same continent though, there are different levels of ICT access for different countries and regions. As ICT plays a key role in economic growth, the disparities have created many socio-economic imbalance problems in the world. The phrase digital divide, in particular, has caught the attention of academic researchers and policy-makers worldwide. The digital divide refers to the gap between those who have access to IT and those who do not [5]. The OECD [6] defined digital digital divide as ''the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies and to their use of the Internet for a wide variety of activities.'' Thus, the concept of digital divide has two key components: granularity and contents. Granularity refers to the level of entities such as individuals, businesses, countries and regions where the gap occurs.

Contents refer to activities that define the gap, for example, in terms of ICT development and use of the Internet [6].

Alleviation of the global digital divide has been a major task of international organizations such as the United Nations (UN), the World Bank, and the G8 countries (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States). These organizations have endeavored to explore how ICT impacts the development of a country. They have analyzed the status quo of the development of ICT in countries, and have provided practical evidence year by year. In addition, various researchers have applied different approaches to studying the digital divide [7]. Research on digital disparity can be divided into the study of the global digital divide (the gap between countries) and the domestic digital divide (the gap between groups within countries) [8]. A summary of some studies on the digital divide is listed in Table 1. These studies have been conducted to measure the digital divide, use the wireless technologies, computers, the Internet and ICT indicators (ICT). In these studies, a large set of variables affecting the digital divide as been collected.

Table-1. Studies on the digital divide

Authors	Measurement of digital divide	Variables
Kauffman and Techatassanasoontorn [9]	Digital wireless technology diffusion	Wealth, telecom infrastructure, market competition, access cost, standards
Dewan, et al. [10]	IT penetration (mainframes, PCs, Internet)	Density of main telephone line, average monthly telephone subscription cost, average cost of local call, size of urban population, GDP per capita, average year of schooling, size of trade in goods in the economy
Crenshaw and Robinson [11]	Internet	Internet hosts, telephone mainlines, employment in service sector, political openness, global urban share
Cuervo and Menendez [12]	ICT-related indicators	Computers, main telephone lines, broadband connections, secure servers, business with a website, business buying online, Internet dial up access cost, households connected to the Internet, public service online, active population using a computer for professional purposes
Dewan, et al. [13]	PC and Internet	GDP, PCs, Internet users, average PC unit price, average monthly cost of telephone access
Emrouznejad, et al. [8]	ICT opportunity index	Main telephone lines, mobile cellular subscribers, International Internet bandwidth, adult literacy rates, gross enrolment rates, primary secondary tertiary, Internet users, household with a TV, computers, broadband Internet subscribers, International outgoing telephone traffic
		Continue

Banker, et al. [14]	Digital trading platform	Raw grade indicator, premium grade indicator, coefficient of variation, sell transaction indicator, click and book indicator, order book management indicator, seller/buyer is a trader, number of seller/buyer transaction
Talukdar and Gauri [15]	Internet access and usage	Internet adoption level at home, annual household income, education level

Previous studies suggest that an opportunity for access to information and communication technologies is an important factor in measuring the digital divide. In addition, factors such as Internet access, access to personal computers, digital capabilities of users, and government policies make up the measurement indices of the digital divide. Measurements related to ICT are important indicators that show the differences between rich and poor countries [16].

With the advent of global media and global market of media and communications, it cannot be expected to enter the communication policy-making into the global policy-making. Obviously, the new scheme of global communication has a lack of balance for rich and poor nations and classes. From another viewpoint, the importance of raising the issue has been cited by experts from the perspective of quantitative data. For example, the issue of access to communication equipment and measuring its standards has attracted sociologists in social justice of information area. Since the early 1960s, some criteria were outlined by the UNESCO about the development standards of media that consisted of at least 10 daily newspapers, 5 radio receivers, two cinema seats, 2 TV receivers for 100 people in the community. In the 1980s, the telephone penetration rate per 100 inhabitants was considered highly, and the Asian and African countries in the decade lacked even one telephone for every 100 people and were considered as underprivileged countries in the area of communication [4].

Kent Knutson has raised four concepts of the digital divide. In his opinion, the first kind of divide is in each country, including industrialized and developing countries, and among rich, educated, powerful, and those who do not benefit from these blessings.

The second digital divide that is considered less, is linguistic and cultural divide. In many countries, this divide separates the English speakers or the Western Europe speakers from the others. According to the estimates, about 60 to 80 percent of websites around the world are in English. The third digital divide is between rich and poor countries and is associated to the above two divides. And the fourth divide refers to the difference between the lifestyle of people in the context of information technology or similar emerging industries such as biotechnology and the people who have other jobs [17].

Berrtot integrated important points of view in the field of digital divide which express the multidimensional nature of the digital divide. He identified five key themes that go beyond a simple definition of the digital divide. In his opinion, the digital divide has various aspects of technology, economics, information and communication that are shown in Table 1 [18].

Table-2. Dimensions of the digital divide [18]

Dimensions	Definition
Technology	A divide between those with access to technology and those without.
Economic dimensions	A divide between those with the ability and resource availability to develop a more sophisticated information infrastructure.
Information literacy	A dimension involving the use of a minimal set of skills to use information-seeking tools, to locate appropriate sources and retrieve useful information, to evaluate and access informational relevance, and to synthesize that information into a mechanism capable of solving an information problem.
Telecommunications	A dimension that impacts the divide between those with access to more advanced ICT, such as broadband Internet service, and those with access to more basic forms of ICT, such as telephone lines.
Information access	The idea that there exists some kind of divide between those with the tools and societal protections required to access and exchange information and those lacking such rights.

A group of researchers know the digital divide as having three dimensions: divide in access to information and communication technology, using ICT and ICT application programs [19].

According to Rao, there are different aspects of digital divide such as economic level of people, economic prosperity of nations, race, age (young or old), rural or urban, gender, geographic location, quantitative and qualitative aspects, and access the Internet through dial-up and broadband [20].

There are different perspectives on the problem-solving strategies for the digital divide. Many people believe that access to information technology reduces the distance and leads to human progress, enhances the living standards and the benefits from the information economies. This view suggests that everyone should have the possibility of participating in benefits provided in the information society and must not be deprived of his/her right [21].

Proponents of this view argue that the societies that have realized the importance of using the technology will face a cheap and quick access to the industrialization provided that the transferring speed of industry and technology is synchronized with training the national experts [22]. From this perspective, the lack of internet access and the Internet divide between rich and poor people can be considered as an indicator of poverty that leads to the technology divide potentials in achieving benefits and revenue.

Today, many governments are trying to promote the digital economy and e-business by supporting the information superhighway infrastructure and there is a general feeling is that people who do not agree on the Internet interaction and digital economy are known as traitors to the community [23].

From this perspective, the digital divide can be solved only with universal access to the Internet. Accordingly, when the connection is established, other suitable things like proper use, content creation and etc. are created spontaneously and there is no need for planning [3].

3. METHODOLOGY

In this study, according to the indicators related to the digital divide in the studies of other scholars as well as the information contained in the World Bank, the following criteria were studied

1. Telephone lines (per 100 people) (TL): Telephone lines are fixed telephone lines that connect a subscriber's terminal equipment to the public switched telephone network and that have a port on a telephone exchange. Integrated services digital network channels ands fixed wireless subscribers are included.
2. Mobile cellular subscriptions (per 100 people) (MC): Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service using cellular technology, which provide access to the public switched telephone network. Post-paid and prepaid subscriptions are included.
3. Internet users (per 100 people) (IU): Internet users are people with access to the worldwide network.
4. Fixed broadband Internet subscribers (per 100 people) (FB): Fixed broadband Internet subscribers are the number of broadband subscribers with a digital subscriber line, cable modem, or other high-speed technology.
5. Secure Internet servers (per 1 million people) (SI): Secure servers are servers using encryption technology in Internet transactions.
6. ICT goods exports (% of total goods exports) (GE): Information and communication technology goods exports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded.
7. ICT goods imports (% total goods imports) (GI): Information and communication technology goods imports include telecommunications, audio and video, computer and related equipment; electronic components; and other information and communication technology goods. Software is excluded.

Table-3. Digital Divide Indicators in Asia-Islamic Countries [24]

Country	TL	MC	IU	FB	SI	GE	GI
Iran	36.81	74.30	21	2.35	1.007	0.011	4.59
Turkey	20.82	89.41	43.07	10.37	143.63	1.65	3.82
Indonesia	15.83	102.46	12.28	1.12	3.36	3.85	7.40
Brunei	19.64	109.01	56	5.70	113.15	0.28	4.11
Bangladesh	0.63	55.19	5	0.30	0.62	0	0
Azerbaijan	18.29	109.97	50	10.30	4.68	0.003	3.45
Pakistan	3.24	61.81	9	0.41	1.11	0.23	3.55
Turkmenistan	10.71	68.75	5	0.021	0.19	0	0
Tajikistan	4.86	80.92	13.03	0.064	0.511	0	0
Afghanistan	0.046	60.32	5	0.005	0.75	0	0.33
Kyrgyzstan	9.29	116.16	20	0.68	2.53	0.23	3.82
Malaysia	15.72	127.47	61	7.43	54.62	29.43	25.62
Uzbekistan	6.84	90.37	30.2	0.52	0.44	0	0

4. TOPSIS METHODOLOGY

TOPSIS was proposed by Hwang and Yoon [25] to determine the best alternative based on the concepts of the compromise solution. The compromise solution can be regarded as choosing the solution with the shortest Euclidean distance from the ideal solution and the farthest Euclidean distance from the negative ideal solution. The procedures of TOPSIS can be described as follows.

(1) Determine of Decision Matrix: Given a set of alternatives, $A = \{A_k \mid k = 1,\ldots, m\}$, and a set of criteria, $C = \{Cj \mid j = 1,\ldots, n\}$, where $X = \{x_{kj} \mid k = 1,\ldots, m;\ j = 1,\ldots, n\}$denotes the set of performance ratings and $w = \{w_j \mid j = 1,\ldots, n\}$ is the set of weights.

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \cdots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad , \quad i = 1,2,...,m \quad , \quad j = 1,2,...,n \qquad \text{Eq. (1)}$$

$$W = \begin{bmatrix} w_1 & w_2 & \cdots & w_n \end{bmatrix}$$

(2) Calculate the normalized decision matrix. The normalized value r_{ij} is calculated as:

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \cdots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \quad , \quad r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad \text{Eq. 2}$$

(3) Calculate the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as:

$$v_{ij} = w_j * r_{ij} \quad , \quad i = 1,2,...,m \quad , \quad j = 1,2,...,n \qquad \text{Eq. 3}$$

where w_j is the weight of the ith attribute or criterion, and $\sum_{j=1}^{n} w_j = 1$

(4) Determine the positive ideal (PIS) and negative ideal solution (NIS):

$$A^+ = \left\{v_1^+, v_2^+, \cdots, v_j^+, \cdots, v_n^+\right\} = \left\{\left(\max_j v_{ij} \middle| i \in I\right), \left(\min_j v_{ij} \middle| i \in J\right)\right\} \qquad \text{Eq. 4}$$

$$A^- = \left\{v_1^-, v_2^-, \cdots, v_j^-, \cdots, v_n^-\right\} = \left\{\left(\min_j v_{ij} \middle| i \in I\right), \left(\max_j v_{ij} \middle| i \in J\right)\right\} \qquad \text{Eq. 5}$$

where I is associated with benefit criteria, and J is associated with cost criteria.

(5) Calculate the separation measures, using the n-dimensional Euclidean distance. The separation of each alternative from the ideal solution is given as:

$$S_i^+ = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^+)^2} \qquad \text{Eq. 6}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (V_{ij} - V_j^-)^2} \qquad \text{Eq. 7}$$

(6) Calculate the relative closeness to the ideal solution. The relative closeness of the alternative A_i with respect to A^+ is defined as:

$$C_i = \frac{S_i^-}{S_i^- + S_i^+} \qquad \text{Eq. 8}$$

Finally, the preferred orders can be obtained according to the similarities to the PIS (C_i) in descending order to choose the best alternatives [26].

5. DATA ANALYSIS

According to the multi-criteria decision-making concepts and the study subject, a hierarchical tree is depicted in Figure 1. As shown in figure, the digital divide indicators are as the options for countries.

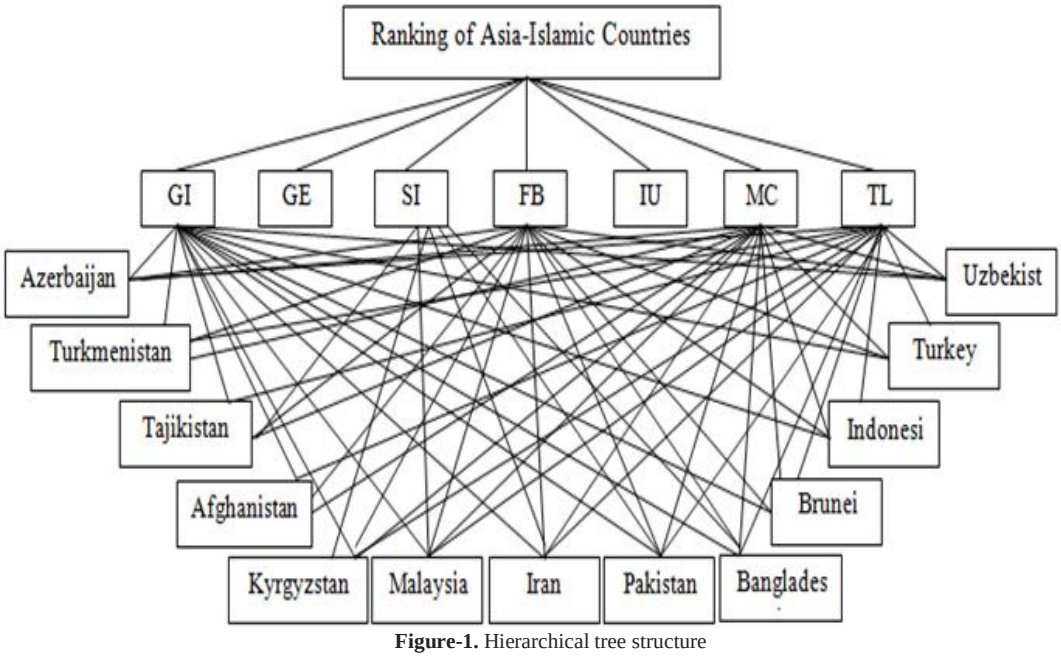

Figure-1. Hierarchical tree structure

Using TOPSIS decision making approach, matrix derived from research data (Table 3) de-scaled according to the equation 2. By multiplying each value of the de-scaled matrix in corresponding weight (according to Equation 4), the weighted de-scaled matrix is obtained. According to a report by the International Telecommunication Union (ITU), the weight of each digital divide parameter can be considered identical. Thus, the weight of all criteria will be 0.143.

Table-4. Weighted decision matrix

GI	GE	SI	FB	IU	MC	TL	Country
0.023	0	0.001	0.019	0.026	0.032	0.092	Iran
0.019	0.008	0.108	0.084	0.053	0.039	0.052	Turkey
0.037	0.019	0.003	0.009	0.015	0.045	0.039	Indonesia
0.021	0.001	0.085	0.046	0.069	0.048	0.049	Brunei
0	0	0	0.002	0.006	0.024	0.002	Bangladesh
0.017	0	0.004	0.084	0.062	0.048	0.046	Azerbaijan
0.018	0.001	0.001	0.003	0.011	0.027	0.008	Pakistan
							Continue

0	0	0	0	0.006	0.03	0.027	Turkmenistan
0	0	0	0.001	0.016	0.035	0.012	Tajikistan
0.002	0	0.001	0	0.006	0.026	0	Afghanistan
0.019	0.001	0.002	0.006	0.025	0.051	0.023	Kyrgyzstan
0.129	0.142	0.041	0.06	0.075	0.056	0.039	Malaysia
0	0	0	0.004	0.037	0.039	0.017	Uzbekistan

Calculations according to equations 2 to 8 were carried out and the results are expressed in the tables below.

A^+ = {0.092,0.056,0.075,0.084,0.108,0.142,0.129}

A^- = {0,0.024,0.006,0,0,0,0}

Table-5. Positive ideal and negative ideal solution

	TL	MC	IU	FB	SI	GE	GI
A^+	0.092	0.056	0.075	0.084	0.108	0.142	0.129
A^-	0	0.024	0.006	0	0	0	0

S^+ = {0.223,0.180,0.216,0.188,0.262,0.214,0.249,0.255,0.256,0.263,0.238,0.088,0.249}

S^- = {0.099,0.156,0.062,0.129,0.003,0.114,0.021,0.027,0.019,0.003,0.045,0.222,0.039}

Table-6. The relative closeness to the ideal solution

Country	S^+	S^-	C
Iran	0.223	0.099	0.3066
Turkey	0.180	0.156	0.4639
Indonesia	0.216	0.062	0.2236
Brunei	0.188	0.129	0.4069
Bangladesh	0.262	0.003	0.0107
Azerbaijan	0.214	0.114	0.3481
Pakistan	0.249	0.021	0.0768
Turkmenistan	0.255	0.027	0.0965
Tajikistan	0.256	0.019	0.0697
Afghanistan	0.263	0.003	0.0106
Kyrgyzstan	0.238	0.045	0.1579
Malaysia	0.088	0.222	0.7158
Uzbekistan	0.249	0.039	0.1349

Based on the obtained similarity index in Table 6, ranking the countries is done on the digital divide. According to this table, Malaysia is ranked first with the value of 0.7158 and Afghanistan is ranked last with the value of 0.0106. Figure 2 shows the ranking of countries.

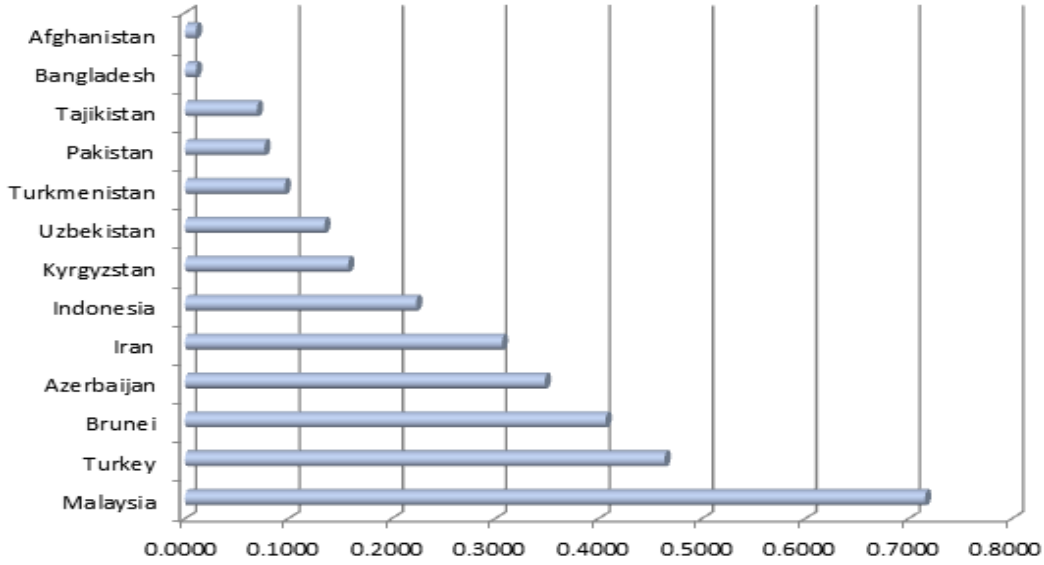

Figure-2. Ranking Asia-Islamic Contries in Digital Divide Indicators

Using TOPSIS method, in ranking the Asian-Islamic countries from the perspective of the digital divide indicators, differences between Malaysia and Turkey that are ranked first and second is enormous with the countries of Afghanistan, Bangladesh and Pakistan.

6. CONCLUSIONS

One of the major challenges facing the international community is the determination and interpretation of the causes of development and underdevelopment. Today, along with the information age, knowledge, and the information technology are known as the most important factor of development and the development level of countries is measured with respect to access to and benefit from the use of this technology. In fact, at the present era the countries are able to gain the high ranks of economic and social development at the national level and these two important factors use development in order to manufacture hardware and software and their required institutions. More importantly, they are able to be one of the most important producers of content in the virtual environment. Unfortunately, many Third World countries, including most Muslim countries are weak in this area and are faced with a problem that is called the digital divide at the present time and according to the most important factors in the development at this time. In this study, using TOPSIS method and the information contained in the World Bank and the International Telecommunication Union, the Asian-Islamic countries were examined on the digital divide indicators. Given the similarity index obtained by TOPSIS method, Malaysia is ranked first with the value of 0.7158, Turkey is ranked second with the value of 0.4639, and Brunei is ranked third with the value of 0.4069 among Islamic countries in Asia. As indicated in similarity index table, the difference between Malaysia and other countries is enormous. Future researchers can analyze and compare the results using other decision-making methods such as VIKOR, FUUZY, ELECTRE and etc.

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