Contemporaneity of Language and Literature in the Robotized Millennium
Vol: 1(5), 2019
REST Publisher
ISBN: 978-81-936097-3-6
Website: http://restpublisher.com/books/cllrm/

Analysis of Information and Communication Technology Development in Emerging Countries Using the TOPSIS Method

Vichare Jeevan Pandurang
SSt College of Arts and Commerce, Maharashtra, India
Email: jeevanvichare@sstcollege.edu.in

Abstract.
"Information and communication technology (ICT)" has had a considerable impact on society, the economy, and the environment in recent decades. ICT adoption and access are significantly influenced by two knowledge-driven factors: national economic growth and social development. Globally, ICT has assimilated into every aspect of our life and is a key technology in national and international policies. ICT is now clearly having an impact on social and economic development as a result of its quick development and penetration into numerous industries. Governments are constantly attempting to provide improved regulations and proposals to strengthen their ICT infrastructures, taking into account both positive and negative aspects. Evaluation of a country's success in terms of ICT development is crucial in this regard. This study uses an MCDM technique to assess the development of ICT using social and economic factors. Using actual data from OECD statistics, various significant Developed and Developing Countries are examined to establish a real-world benchmark. The result of the TOPSIS analysis shows that Canada is second, the Czech Republic is fourth, Germany is seventh, Denmark is third, Spain is first, Finland is fifth and France is sixth. Results show that Spain and Canada are the top countries in terms of ICT development, whereas France and Germany are determined to have the lowest performance and should improve their ICT policies to increase it.
Keywords: ICT, employment, goods exports, investment, value-added and MCDM.

Introduction

"Information and communication technology (ICT)" has a remarkable impact on many facets of contemporary civilizations. ICT is now clearly having an impact on social and economic development as a result of its quick development and penetration into numerous industries. Governments are constantly attempting to provide improved policies and proposals to upgrade their ICT infrastructures, taking into account both positive and negative aspects. [1].ICTs has been transforming how business is done in the hotel and tourist sectors ever since the 1980s. "The development of ICTs" has significantly changed corporate practices, industry structures, and strategy. In addition to creating a new paradigm shift, the advent of "computer reservation systems (CRSs) in the 1970s, global distribution systems (GDSs) in the late 1980s, and the internet in the 1990s" altered operating procedures in the respective industries. [2].Information and Communication Technology (ICT) A great deal about the analysis of outcomes and an ever-expanding literature Written, it's mostly from the 1990s Begins at the end. ICT investment U.S. Total Productivity and Labor How productivity affected growth that is most of the research. [3].The goal of information and communication technology (ICT) for development (ICT4D) research and practice is to better understand how ICT contributes to development. Over the years, both research and practice have grown, with the latter possibly outpacing the former, but "we are yet to establish a clear and coherent narrative that would help us answer the question of how ICT encourages development," according to the report. To create such a story, it is necessary to comprehend the fundamentals of ICT4D [4].improvement in education ICT is one crucial sign of a nation's modernizing educational system. China's rapid societal development necessitates ongoing improvements to its educational system, where ICT usage has been growing. The improved ICT application is expected to contribute to the modernization of Chinese primary and secondary education. [5]. the modern Indian educational system has changed from the aftermath of "the development of information, communication, and technology (ICT)". "India's higher education system" is regarded as one of the most advanced in the world. Numerous universities around the country, including IITs, IIMs, B Schools, and other technical and non-technical institutions, provide a wide variety of courses. [6]. According to reports, there are now twice as many universities as there were in 1990–1991—a pivotal year in India's economic history. The democratization of education is a result of "information, communication, and technology (ICT) enabled learning". The question at hand is whether "information and communication technology (ICT)", which is playing a significant role in producing knowledge in many facets of Indian society, has helped to advance higher educational chances for people who have long suffered from disadvantages. [7]. In this paper, five major indicators such as ICT employment, ICT goods exports, ICT investment, ICT value-added, and internet access are considered to comparatively evaluate performance. Canada, Czech Republic, Germany, Denmark, Spain, Finland and France are used as alternative parameters.

Materials and Methods

Researchers and practitioners have focused a lot of attention on "multi-criteria decision aid (MCDA)" or "multi-criteria decision making (MCDM) methods" for assessing, analyzing, and rating across several industries. "The Technique for

Order Preference by Similarity to Ideal Solution (TOPSIS)" is one of multiple "MCDA/MCDM" approaches created to address real-world decision issues, and it continues to function effectively in a variety of application domains. [8]. "TOPSIS" is an evaluation technique that is frequently applied to MCDM issues. It has a variety of practical uses, including comparing business performance, analyzing financial ratio performance within a certain industry, and investing money in modern manufacturing processes, among others. [9]. There are certain restrictions, though. Up until now, efforts to enhance the original TOPSIS approach have mostly focused on increasing the weight to increase the R value's sensitivity. To comprehend the fundamental connection between the R-value and alternative evaluation, a better and easier method is needed due to the complexity of evaluation difficulties. [10].
According to this approach, the optimum option is the one that is farthest from the counterintuitive ideal solution and closest to the desirable ideal solution (NIS). PIS is a fictitious choice that simultaneously lowers the cost criteria (C) and raises the benefit criteria (B) [11]. While concurrently increasing the cost criteria, NIS simultaneously reduces the benefit criteria. "The option with the shortest Euclidean distance from PIS and the greatest distance from NIS" is the best choice. After each alternative's proximity coefficient has been calculated in the last stage, the options are arranged using the closeness coefficient (CCi) in descending order. [12,13].

Step 1: The decision matrix X, which displays how various options perform concerning certain criteria, is created.

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & x\cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Step 2: Weights for the criteria are expressed as

$$w_j = [w_1 \cdots w_n], \quad (2)$$

Here, $\sum_{j=1}^{n}(w_1 \ \cdots \ w_n) = 1$

Step 3: The matrixx_{ij}'s normalized values are computed as

$$n_{ij} = \frac{x_{ij}}{\sqrt[2]{\sum_{i=1}^{m} x_{ij}^2}} \quad (3)$$

Weighted normalized matrix N_{ij} is calculated by the following formula

$$N_{ij} = w_j \times n_{ij} \quad (4)$$

Step 4: We'll start by determining the ideal best and ideal worst values: Here, we must determine whether the influence is "+" or "-." If a column has a "+" impact, the ideal best value for that column is its highest value; if it has a "-" impact, the ideal worst value is its lowest value.

Step 5: Now we need to calculate For $i \in [1, m]$ and $j \in [1, n]$ the difference between each response from the ideal best,

$$S_i^+ = \sqrt{\sum_{j=1}^{n}(N_{ij} - A_j^+)^2} \quad (5)$$

Step 6: Now we need to calculate For $i \in [1, m]$ and $j \in [1, n]$ the difference between each response from the ideal worst,

$$S_i^- = \sqrt{\sum_{j=1}^{n}(N_{ij} - A_j^-)^2} \quad (6)$$

Step 7: Now we need to CCi of i_{th} alternative

$$CC_i = \frac{S_i^-}{S_i^+ + S_i^-} \text{Where } 0 \le CC_i \le 1, i \in [1, m] \quad (7)$$

CCi value illustrates how superior the alternatives are in comparison. A larger CC_i denotes a substantially better alternative, whereas a smaller CC_idenotes a significantly worse alternative.

In this paper, five major indicators such as ICT employment, ICT goods exports, ICT investment, ICT value-added, and internet access are considered to comparatively evaluate performance. Canada, Czech Republic, Germany, Denmark, Spain, Finland and France are used as alternative parameters. To obtain realistic and applicable results, real data from these

countries are used from OECD datasets.
ICT Employment: Employment in "the information and communication technology (ICT)" industry is referred to as ICT employment. This indicator is expressed as a proportion of employment in the business sector. [14].ICT Goods exports: Exports of ICT products are based on the Harmonized System (HS) of the World Customs Organization (including ICT goods). ICT products must either be designed to perform the function of electronic information processing and communication, including transmission and display, or they must employ electronic processing to identify, measure, and/or record physical occurrences or direct a physical process. [15]. “ICT Investment”: "ICT investment" is defined as the purchase of hardware and software that is put to use in production for a longer period. ICT consists of three parts: software, communications equipment, and information technology equipment (computers and related hardware). The software can be purchased as pre-packaged software, customized software, or internally generated software. [16].ICT Value-added:"The information and communication technology" sector's gross production minus intermediate consumption is known as ICT value added [17].ICT Internet access:The proportion of households reporting having access to the Internet is referred to as internet access. This connection is almost always done using a personal computer utilising dial-up, ADSL, or cable broadband access [18].

Analysis and Discussion:

TABLE 1.ICT Development indicators

Countries	Internet access	goods exports	employment	investment	value added
Canada	94.2	10249	2.605	17.01837	5.1
Czech Republic	95.50906	3247	5.363	18.50669	7.447
Germany	91.4079	61850	3.941	12.69039	5.139
Denmark	95.1559	3680	4.437	24.57366	5.208
Spain	96.0847	3609	2.656	13.76342	4.563
Finland	97.5855	2899	6.427	15.51983	6.427
France	92.5296	22606	3.33	16.33962	5.1

Table 1 shows the value of the dataset of ICT developing indicators. ICT employment, ICT goods exports, ICT investment, ICT value-added, and internet access are considered evaluation parameters. Canada, Czech Republic, Germany, Denmark, Spain, Finland and France are used as alternative parameters.

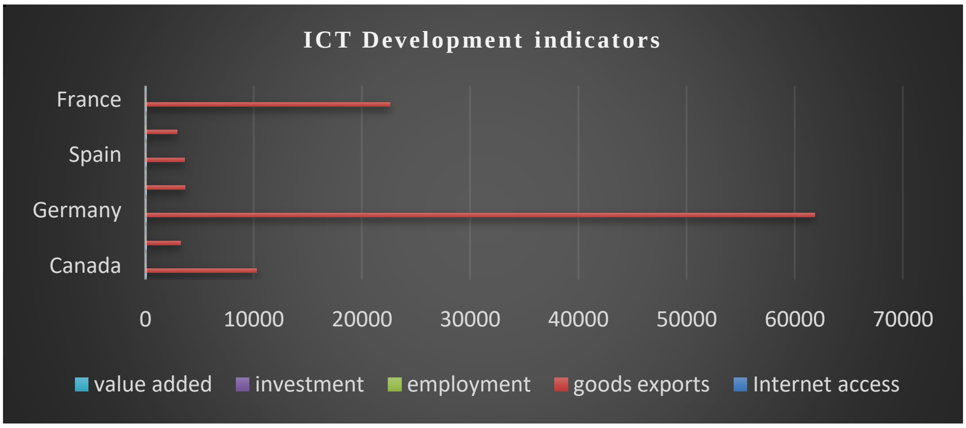

Figure 1 ICT Development indicators

Figure 1 illustrates the value of the dataset of ICT developing indicators. ICT employment, ICT goods exports, ICT investment, ICT value-added, and internet access are considered evaluation parameters. Canada, Czech Republic, Germany, Denmark, Spain, Finland and France are used as alternative parameters.

TABLE 2. Normalized Data

0.376131	0.153004	0.228284	0.371875	0.341416
0.381358	0.048473	0.469976	0.404397	0.498534
0.364982	0.923339	0.345362	0.277303	0.344027
0.379948	0.054938	0.388828	0.536969	0.348646
0.383656	0.053878	0.232753	0.30075	0.305467
0.389649	0.043278	0.563218	0.33913	0.430251
0.369461	0.337478	0.291818	0.357044	0.341416

The normalized matrix of the ICT Development indicators is displayed in Table 2 above. This matrix was produced using equation three.

TABLE 3. Weight

0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2
0.2	0.2	0.2	0.2	0.2

The preferred weight for the evaluation parameters is shown in Table 3. In this case, weights are equally distributed among ICT-developing indicators. ICT employment, ICT goods exports, ICT investment, ICT value-added, and internet access. The sum of weights distributed equals one.

TABLE 4. Weighted normalized decision matrix

0.075226	0.030601	0.045657	0.074375	0.068283
0.076272	0.009695	0.093995	0.080879	0.099707
0.072996	0.184668	0.069072	0.055461	0.068805
0.07599	0.010988	0.077766	0.107394	0.069729
0.076731	0.010776	0.046551	0.06015	0.061093
0.07793	0.008656	0.112644	0.067826	0.08605
0.073892	0.067496	0.058364	0.071409	0.068283

Table 4 shows the weighted normalized matrix of the decision matrix and it is calculated by table 2 and table 3 using equation 4.

TABLE 5. Positive Matrix

0.07793	0.184668	0.112644	0.107394	0.099707
0.07793	0.184668	0.112644	0.107394	0.099707
0.07793	0.184668	0.112644	0.107394	0.099707
0.07793	0.184668	0.112644	0.107394	0.099707
0.07793	0.184668	0.112644	0.107394	0.099707
0.07793	0.184668	0.112644	0.107394	0.099707
0.07793	0.184668	0.112644	0.107394	0.099707

Table 5 shows the positive matrix calculated by using table 4. The ideal best for a column is the maximum value of that column in table 4.

TABLE 6. Negative matrix

0.072996	0.008656	0.045657	0.055461	0.061093
0.072996	0.008656	0.045657	0.055461	0.061093
0.072996	0.008656	0.045657	0.055461	0.061093
0.072996	0.008656	0.045657	0.055461	0.061093
0.072996	0.008656	0.045657	0.055461	0.061093
0.072996	0.008656	0.045657	0.055461	0.061093
0.072996	0.008656	0.045657	0.055461	0.061093

Table 6 shows the negative matrix calculated by using table 4. The Ideal best for a column is the minimum value in that column in table 4.

TABLE 7. SI Plus and Si negative

	SI Plus	**Si Negative**
Canada	0.174094	0.029933
Czech Republic	0.177958	0.066974
Germany	0.074664	0.17773
Denmark	0.179677	0.061782
Spain	0.195784	0.006421
Finland	0.180921	0.072714
France	0.137747	0.062693

Table 7 shows the Si plus and Si negative values. difference of each response from the ideal best (S_i^+) is calculated using equation 5 and the difference between each response from the ideal worst (S_i^-) is calculated using equation 6.

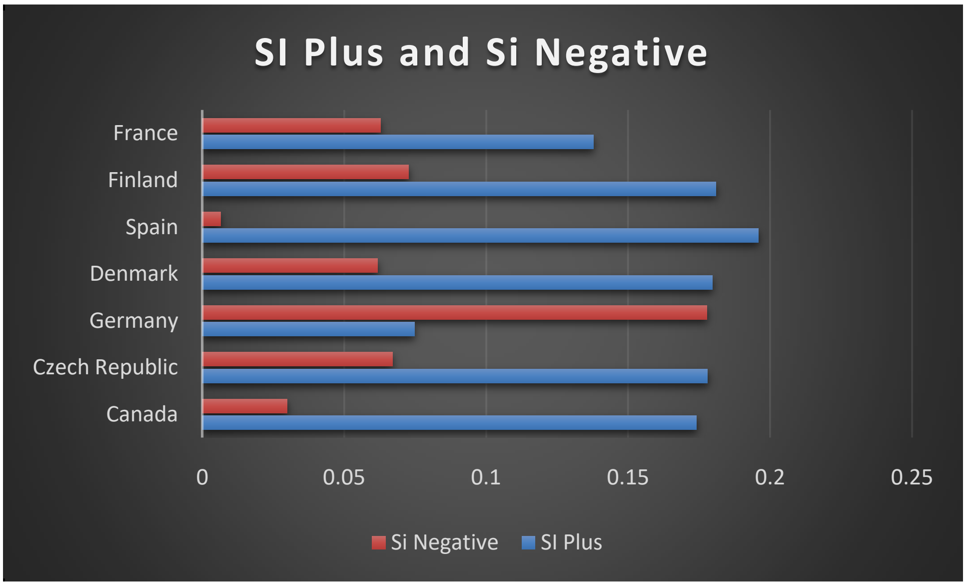

FIGURE 2. SI Plus and Si negative

Figure 2 illustrates the graphical representation of the Si plus and Si negative values. S_i^+ is calculated using equations 5 and S_i^- is calculated using equation 6.

TABLE 8. Closeness coefficient

	CCi
Canada	0.853287
Czech Republic	0.726561
Germany	0.295823
Denmark	0.744131
Spain	0.968244
Finland	0.713313
France	0.687223

The proximity coefficient values of the alternatives are displayed in Table 8. Equation 7 is employed in the calculation. Here Closeness coefficient value for Canada is 0.853287, the Czech Republic is 0.726561, Germany is 0.295823, Denmark is 0.744131, Spain is 0.968244, Finland is 0.713313 and France is 0.687223.

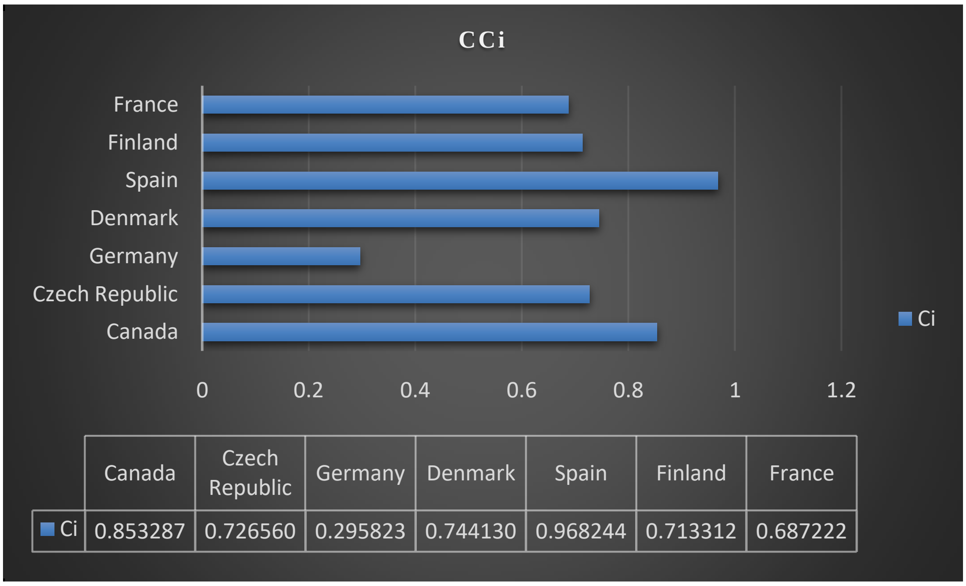

FIGURE 3. Closeness Coefficient (CCi)

Figure 3 illustrates the graphical representation of CCi. It is calculated by using equation 7. Here Closeness coefficient value for Canada is 0.853287, the Czech Republic is 0.726561, Germany is 0.295823, Denmark is 0.744131, Spain is 0.968244, Finland is 0.713313 and France is 0.687223.

TABLE 9. Rank

	Rank
Canada	2
Czech Republic	4
Germany	7
Denmark	3
Spain	1
Finland	5
France	6

Table 9 shows the rank of ICT Development. Here rank of the countries according to ICT development for Canada is second, the Czech Republic is fourth, Germany is seventh, Denmark is third, Spain is first, Finland is fifth and France is sixth.

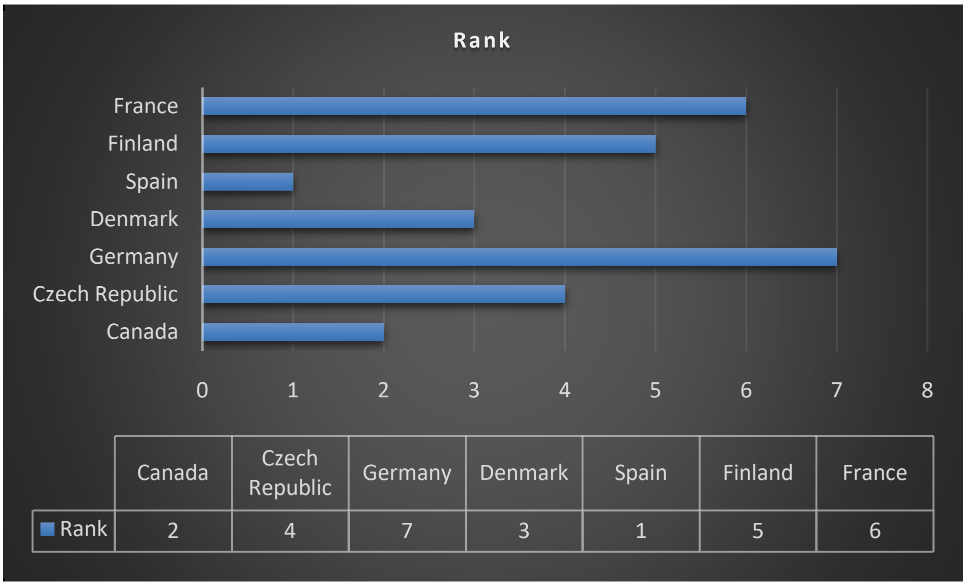

Figure 4 Rank

Figure 4 illustrates the ranking of CCi from Table 9. The result of the TOPSIS analysis shows that Canada is second, the Czech Republic is fourth, Germany is seventh, Denmark is third, Spain is first, Finland is fifth and France is sixth. Results indicate that Spain along with Canada is the top country based on their ICT development while countries such as France and Germany are found to have the weakest performance which should upgrade their ICT policies to maximize their performance.

Conclusion

"Information and communication technology (ICT)" has had a considerable impact on society, the economy, and the environment in recent decades. In terms of access to and use of ICTs, national economic growth and social development are two crucial knowledge-driven drivers. Information, communication, and technology (ICT) has expanded the adaptability of how education is delivered to students in elementary and higher education, allowing for simple access to information at any time and from any location. It is believed that the advancement of ICTs will result in social change. It is thought to be an element that, by empowering the populace through education and economic advancement, might greatly ignite their social and psychological well-being. Given the important roles that ICT plays in all facets of government, adopting similar technology has emerged as one of the major challenges for governments seeking to advance their social and economic sustainability. This study uses the TOPSIS approach to assess the growth of ICT using social and economic factors. Using actual data from OECD statistics, various significant Developed and Developing Countries are examined to establish a real-world benchmark. The result of the TOPSIS analysis shows that Canada is second, the Czech Republic is fourth, Germany is seventh, Denmark is third, Spain is first, Finland is fifth and France is sixth. Results show that Spain and Canada are the top countries in terms of ICT development, whereas France and Germany are determined to have the lowest performance and should improve their ICT policies to increase it.

References:

1. Ip, Crystal, Rosanna Leung, and Rob Law. "Progress and development of information and communication technologies in hospitality." *International journal of contemporary hospitality management* (2011).
2. Jiménez-Rodríguez, Rebeca. "Evaluating the effects of investment in information and communication technology." *Economics of Innovation and new Technology* 21, no. 2 (2012): 203-221.
3.

4. Unwin, P. T. H., and Tim Unwin, eds. *ICT4D: Information and communication technology for development*. Cambridge University Press, 2009.
5. Yusuf, Mudasiru Olalere. "Information and communication technology and education: Analysing the Nigerian national policy for information technology." *International education journal* 6, no. 3 (2005): 316-321.
6. Sarkar, Sukanta. "The role of information and communication technology (ICT) in higher education for the 21st century." *Science* 1, no. 1 (2012): 30-41.
7. Zhang, Jianwei. "A cultural look at information and communication technologies in Eastern education." *Educational Technology Research and Development* 55, no. 3 (2007): 301-314.
8. Behzadian, Majid, S. Khanmohammadi Otaghsara, Morteza Yazdani, and Joshua Ignatius. "A state-of the-art survey of TOPSIS applications." *Expert Systems with applications* 39, no. 17 (2012): 13051-13069.
9. Ren, Lifeng, Yanqiong Zhang, Yiren Wang, and Zhenqiu Sun. "Comparative analysis of a novel M-TOPSIS method and TOPSIS." *Applied Mathematics Research eXpress* 2007 (2007).
10. Papathanasiou, Jason, and Nikolaos Ploskas. "Topsis." In *Multiple criteria decision aid*, pp. 1-30. Springer, Cham, 2018.
11. García-Cascales, M. Socorro, and M. Teresa Lamata. "On rank reversal and TOPSIS method." *Mathematical and computer modelling* 56, no. 5-6 (2012): 123-132.
12. Jahanshahloo, Gholam Reza, F. Hosseinzadeh Lotfi, and A. R. Davoodi. "Extension of TOPSIS for decision-making problems with interval data: Interval efficiency." *Mathematical and Computer Modelling* 49, no. 5-6 (2009): 1137-1142.
13. Ginting, Garuda, Mesran Fadlina, Andysah Putera Utama Siahaan, and Robbi Rahim. "Technical approach of TOPSIS in decision making." *Int. J. Recent Trends Eng. Res* 3, no. 8 (2017): 58-64.

