Neutrosophic Systems with Applications, Vol. 1, 2023
https://doi.org/10.61356/j.nswa.2023.3

Toward Sustainable Emerging Economics based on Industry 5.0: Leveraging Neutrosophic Theory in Appraisal Decision Framework

Mona Mohamed [1,*], and Abduallah Gamal [2]

[1] Higher Technological Institute, 10th of Ramadan City 44629, Egypt; mona.fouad@hti.edu.eg
[2] Faculty of Computers and Informatics, Zagazig University, Zagazig 44519, Sharqiyah, Egypt; abduallahgamal@zu.edu.eg

* Correspondence: mona.fouad@hti.edu.eg

Abstract: Entrepreneurs in emerging economies (EEs) need to expand to survive in a climate of intense competition. Additionally, it must be innovative, imaginative, and open to absorbing new business techniques. Prior studies proved that Entrepreneur's success hinges on its capacity to deliver innovative items through employing cutting-edge technologies more quickly than its rivals. In recent decades, digitization—the widespread use of connected digital services by governments, businesses, and consumers—has emerged as a major economic engine that spurs expansion and makes it easier to create jobs. For instance, the next major technological shift is thought to be Industry 5.0 (Ind 5.0). In contrast to Industry 4.0, its goal is to provide manufacturing techniques that are resource-efficient and user-preferred through leveraging the creativity of human specialists in combination with effective, intelligent, and precise machines. Hence, the current study seeks to compile a comprehensive list of obstacles that suppress implementing Ind5.0, to experimentally appraise those obstacles. We construct Appraisal Decision Framework (ADF) generated from deploying Analytic Hierarchy Process (AHP) as method of multi-criteria decision-making (MCDM). Whilst AHP work with aids of neutrosophic set to overcome the vague information in the process of evaluation. Herein, interval-valued neutrosophic numbers (IVNSs) apprise the obstacles of Ind 5.0 in EEs. The neutrosophic AHP method is used to compute the weights of risks, then rank it. The findings of ADF show that cost and fund are the highest in all 12-obstacle followed by scalability, Lack of Socio-technological Planning, security, and privacy.

Keywords: Emerging Economies (EEs); Interval Valued Neutrosophic Sets (IVNSs); Industry 5.0 (Ind 5.0); Analytic Hierarchy Process (AHP); multi-criteria decision-making (MCDM); Obstacles.

1. Introduction

Emerging economies (EEs) have recently made considerable contributions to the world's gross domestic product (GDP). Evidence that this is true [1] In 2016, the growth rate for EEs is 4.2%, whereas the growth rate for developed economies is just 1.6%, according to the World Economic Outlook Report. Pursuant to this analysis, developing economies will not contribute as much to the expansion of the global economy as EEs would. EEs described by [2] as tremendous growth despite little income nations that rely on economic liberalization as their main source of growth.

Due to intense rivalry and risks from rivals brought on by accelerating technological progress, the world economy is changing quickly, relying on [3] it is necessitating and requiring organizations to be creative . In similar vein [4] the ability of businesses to innovate, invent, and uncover new business models is crucial to their survival and success. That is why organizations in [5] must concentrate on creating resources and competences to compete effectively. Organizations that can

strategically expand their technology capabilities and produce novel goods and technologies faster and cheaper than their rivals will do better in a competitive climate. Thereby [6] showcased that Information communication technology (IT) and telecommunications infrastructure are the foundation of the modern world economy, are increasingly used as a platform for regional and international growth.

To put it another way [7] emphasized that the only way to thrive in the rapidly evolving business climate , is to constantly launch new goods and services that may benefit both the company and its clients is abetted by industry 5.0 (Ind 5.0) technologies as branch of Information Communications and Technologies (ICT). Due to [8] where the collaboration of emerging technologies, such as industrial robots, 3D printers, etc., with human beings in businesses with the belief that "we use these tools as tools, do not give them the function and brain to WORK FOR US, but WORK WITH US". This results from Ind 5.0 has several technologies summarized in Figure 1.

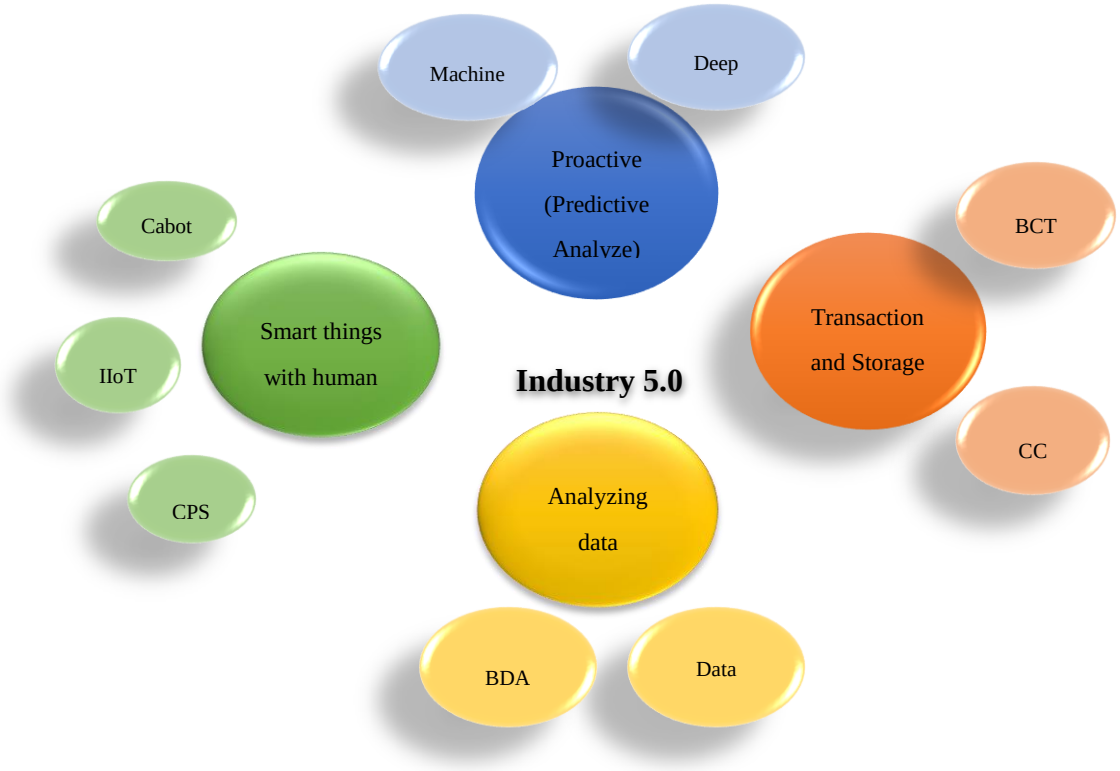

Figure 1. Role of Industry 5.0 technologies in emerging economics.

Notwithstanding the crucial act for deploying Ind 5.0 in businesses and EEs, [6] illustrated the obstacles are faced Ind 5.0 in emerging nations. Consequently, these countries' development is sluggish. Thence, this study suggests a theoretical framework that managers may utilize to overcome the obstacles preventing the broad adoption of Ind 5.0.

The suggested framework is deploying Multi-Criteria Decision-Making (MCDM). Since several apps have found success with various MCDM variations, scholars have adopted them. Since uncertainty heightens the difficulty of selecting choices, there is usually not enough data to arrive at a definitive solution to a real-world problem[9, 10, 11]. Hence, Analytic Hierarchy Process (AHP) is employed as method of MCDM and has been boosted by neutrosophic theory. Due to this theory can treat with uncertainty situations through measuring degree of truth, falsehood, and indeterminacy rather than numbers since it is usually hard to exactly discern the proportion of truth and falsity.

Herein, we are volunteering AHP in this study under neutrosophic theory especially, interval-valued neutrosophic sets (IVN) to generate robust hybrid framework so-called Appraisal Decision Framework (ADF). The objective of this framework is appraising the obstacles facing Ind 5.0 in EEs.

2. Appraisal Decision Framework (ADF)

This section clarified the proposed framework to rank and identify Ind 5.0 obstacles in EEs. Figure 2 summarized procedures of ADF. Whereas AHP method is used to compute the weights of determined obstacles. The idea of this method is building the matrix between criteria with each other's to generate the comparison matrix as following:

Procedure 1: Estimating Ind 5.0 obstacles in EEs.

Procedure 2: Obtain the scale of IVNSs. This scale is used IVNSs scale in [12] by experts for appraising Ind 5.0 obstacles.

This procedure introduced the goal and risks as a hierarchical building. The goal of this study is to rank Ind 5.0 obstacles in EEC.

Procedure 3: Setting up pairwise matrices based on experts' rates.

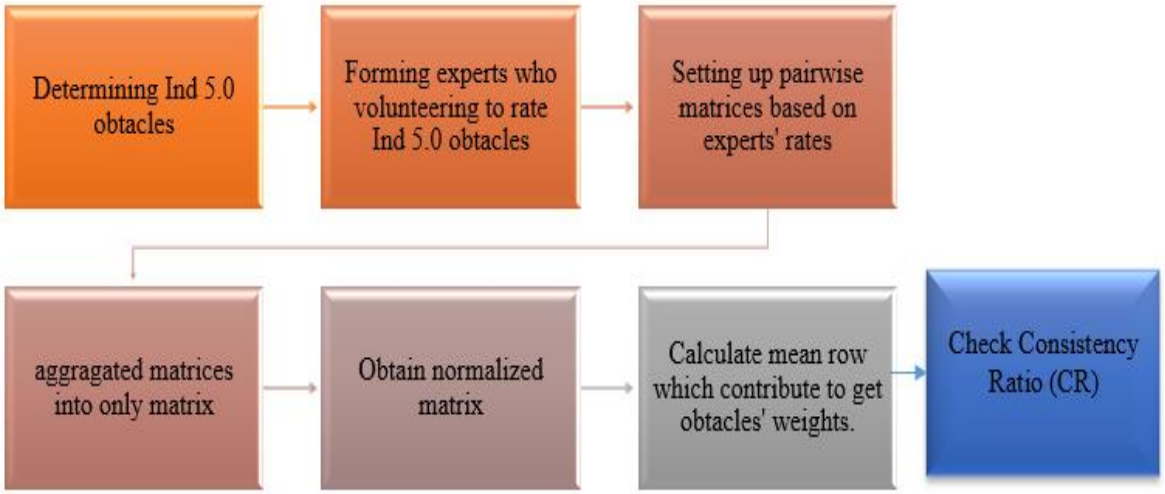

Figure 2. Summarized appraisal decision framework procedures.

This procedure is used to build the pairwise comparison matrices between obstacles as in Eq. (1). The value of this matrix is a number of IVNSs.

$$P = \begin{pmatrix} [X_{11}^L, X_{11}^U], [Y_{11}^L, Y_{11}^U], [Z_{11}^L, Z_{11}^U] & \cdots & [X_{1n}^L, X_{1n}^U], [Y_{1n}^L, Y_{1n}^U], [Z_{1n}^L, Z_{1n}^U] \\ \vdots & \ddots & \vdots \\ [X_{n1}^L, X_{n1}^U], [Y_{n1}^L, Y_{n1}^U], [Z_{n1}^L, Z_{n1}^U] & \cdots & [X_{nn}^L, X_{nn}^U], [Y_{nn}^L, Y_{nn}^U], [Z_{nn}^L, Z_{nn}^U] \end{pmatrix} \quad (1)$$

Where X, Y, Z refer to the truth, indeterminacy, and falsity values, and n refers to the number of obstacles.

Procedure 4: Convert the values of X,Y, and Z to the one value based on Eq.(2) applied in [12]

$$d = \left(\frac{X^L + X^U}{2}\right) + \left(\left(1 - \frac{(Y^L + Y^U)}{2}\right) \times Y^U\right) - \left(\left(\frac{Z^L + Z^U}{2}\right) \times (1 - Z^U)\right) \quad (2)$$

Procedure 5: Normalize the pairwise comparison matrix.

$$P_{ij}^* = \left[\left[\frac{X_{ij}^L}{\sum_{k=1}^n X_{Kj}^L}, \frac{X_{ij}^U}{\sum_{k=1}^n X_{Kj}^U}\right], \left[\frac{Y_{ij}^L}{\sum_{k=1}^n Y_{Kj}^L}, \frac{Y_{ij}^U}{\sum_{k=1}^n Y_{Kj}^U}\right], \left[\frac{Z_{ij}^L}{\sum_{k=1}^n Z_{Kj}^L}, \frac{Z_{ij}^U}{\sum_{k=1}^n Z_{Kj}^U}\right]\right] \quad (3)$$

$$P_{ij}^* = \left[\left[X_{ij}^{*L}, X_{ij}^{*U}\right], \left[Y_{ij}^{*L}, Y_{ij}^{*U}\right], \left[Z_{ij}^{*L}, Z_{ij}^{*U}\right]\right]$$

The normalization matrix can be represented as:

$$P^* = \begin{pmatrix} [X_{11}^{*L}, X_{11}^{*U}], [Y_{11}^{*L}, Y_{11}^{*U}], [Z_{11}^{*L}, Z_{11}^{*U}] & \cdots & [X_{1n}^{*L}, X_{1n}^{*U}], [Y_{1n}^{*L}, Y_{1n}^{*U}], [Z_{1n}^{*L}, Z_{1n}^{*U}] \\ \vdots & \ddots & \vdots \\ [X_{n1}^{*L}, X_{n1}^{*U}], [Y_{n1}^{*L}, Y_{n1}^{*U}], [Z_{n1}^{*L}, Z_{n1}^{*U}] & \cdots & [X_{nn}^{*L}, X_{nn}^{*U}], [Y_{nn}^{*L}, Y_{nn}^{*U}], [Z_{nn}^{*L}, Z_{nn}^{*U}] \end{pmatrix} \quad (4)$$

Procedure 6: Calculate the mean row in normalization matrix

$$P^{**} = \begin{bmatrix} \left[\frac{\sum_j X_{1j}^{*L}}{n}, \frac{\sum_j X_{1j}^{*U}}{n}\right], \left[\frac{\sum_j Y_{1j}^{*L}}{n}, \frac{\sum_j Y_{1j}^{*U}}{n}\right], \left[\frac{\sum_j Z_{1j}^{*L}}{n}, \frac{\sum_j Z_{1j}^{*U}}{n}\right] \\ \cdots \\ \cdots \\ \cdots \\ \left[\frac{\sum_j X_{nj}^{*L}}{n}, \frac{\sum_j X_{nj}^{*U}}{n}\right], \left[\frac{\sum_j Y_{nj}^{*L}}{n}, \frac{\sum_j Y_{nj}^{*U}}{n}\right], \left[\frac{\sum_j Z_{nj}^{*L}}{n}, \frac{\sum_j Z_{nj}^{*U}}{n}\right] \end{bmatrix} \quad (5)$$

$$P^{**} = \begin{bmatrix} [X_1^{**L}, X_1^{**U}], [Y_1^{**L}, Y_1^{**U}], [Z_1^{**L}, Z_1^{**U}] \\ \cdots \\ \cdots \\ \cdots \\ [X_n^{**L}, X_n^{**U}], [Y_n^{**L}, Y_n^{**U}], [Z_n^{**L}, Z_n^{**U}] \end{bmatrix} \quad (6)$$

Procedure 7: Compute the weights of Ind 5.0 obstacles.

$$w_j = \frac{d_j}{\sum_{i=1}^{n} d_i} \quad (7)$$

Procedure 8: check the consistency ratio (CR) based on Eq. (8).

$$CR = \frac{CI}{RI} \quad (8)$$

Where, $CI = \frac{\lambda_{max} - n}{n-1}$

3. Validation of appraisal decision framework

Herein, we introduced the application of constructed framework. Relying on conducted surveys for earlier studies, we gathered the obstacles of Ind 5.0 in EEs which stated in Figure 3. After that we appraise these obstacles and rank it. For achieving the study's objectives, we are making course of actions as following:

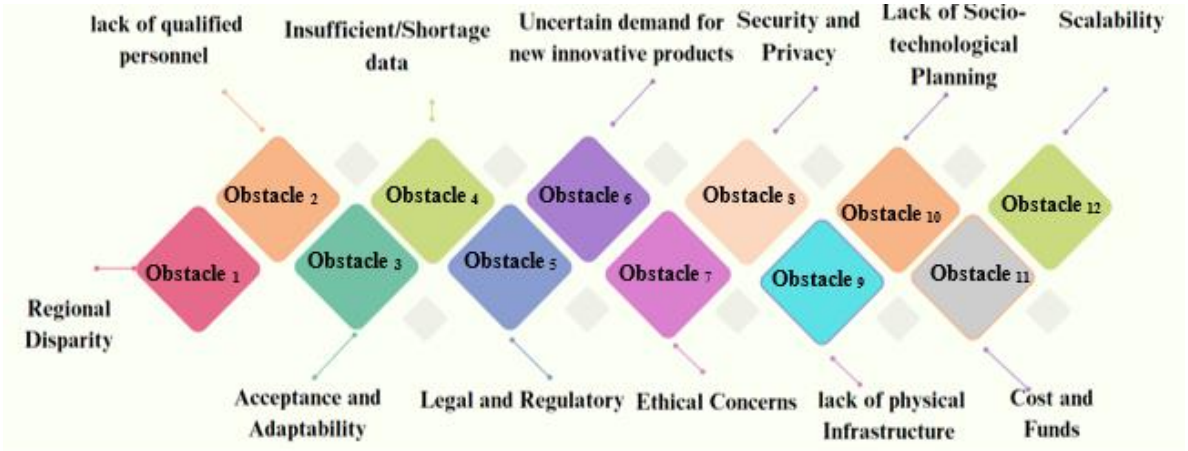

Figure 3. Applied Industry 5.0 obstacles in appraisal decision framework.

- ✓ Action 1: We conducted interviews with three experts to evaluate these risks. The experts build the pairwise comparison matrix between risks. Table 1 shows aggregated matrix.
- ✓ Action 2: We generate the normalized pairwise comparison matrix as shown in Table 2.
- ✓ Action 3: consequently, we compute the mean row in the normalization matrix. Then compute the weights of Ind 5.0 obstacles.
- ✓ Final Action: we test the CR and if its value is less than 0.1, so we sure matrix is consistent. After that we showcase the final weight for Ind 5.0 obstacles in Figure 4 and rank it based on weights' values.

Table 1. Aggregated matrix.

Obstacles	Obstacle1	Obstacle2	Obstacle3	Obtsacle4	Obstacle5	Obstacle6
Obstacle1	1	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.65,0.75],[0.20,0.30],[0.25,0.35]]
Obstacle2	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]
Obstacle3	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	1	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
Obstacle4	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
Obstacle5	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]
Obstacle6	1/[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	1/[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	1
Obstacle7	1/[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]
Obstacle8	1/[[0.75,0.85],[0.10,0.20],[0.15,0.25]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	1/[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
Obstacle9	1/[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	1/[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	1/[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]
Obstacle10	1/[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	1/[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]
Obstacle11	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]
Obstacle12	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
	Obstacle7	**Obstacle8**	**Obstacle9**	**Obstacle10**	**Obstacle11**	**Obstacle12**
Obstacle1	[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	[[0.75,0.85],[0.10,0.20],[0.15,0.25]]	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]
Obstacle2	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
Obstacle3	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]
Obstacle4	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]
Obstacle5	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	[[0.70,0.80],[0.15,0.25],[0.20,0.30]]	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]
Obstacle6	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
Obstacle7	1	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]
Obstacle8	1/[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	1	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.50,0.50],[0.50,0.50],[0.50,0.50]]

Obstacle9	1/[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	1/[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	1	[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	[[0.90,0.95],[0.00,0.05],[0.05,0.15]]	[[0.50,0.6],[0.35,0.45],[0.40,0.50]]
Obstacle10	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.65,0.75],[0.20,0.30],[0.25,0.35]]	1	[[0.80,0.90],[0.05,0.10],[0.10,0.20]]	[[0.55,0.65],[0.30,0.40],[0.35,0.45]]
Obstacle11	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]
Obstacle12	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]	1/[[0.60,0.70],[0.25,0.35],[0.30,0.40]]	1/[[0.50,0.50],[0.50,0.50],[0.50,0.50]]	1/[[0.50,0.6],[0.35,0.45],[0.40,0.50]]	1/[[0.55,0.65],[0.30,0.40],[0.35,0.45]]

Table 2. The normalization pairwise comparison matrix.

Obstacles	Obstacle1	Obstacle2	Obstacle3	Obtsacle4	Obstacle5	Obstacle6	Obstacle7	Obstacle8	Obstacle9	Obstacle10	Obstacle11	Obstacle12
Obstacle1	0.059098	0.032876	0.041935	0.045732	0.038806	0.054389	0.069377	0.07347	0.072243	0.084332	0.061671	0.07364
Obstacle2	0.111906	0.061835	0.051416	0.059263	0.046523	0.055581	0.059574	0.04437	0.052367	0.066408	0.069836	0.072065
Obstacle3	0.090167	0.075179	0.062512	0.035452	0.037621	0.054508	0.06162	0.060788	0.069529	0.076815	0.052116	0.08447
Obstacle4	0.087839	0.069575	0.118371	0.066681	0.03015	0.050095	0.064206	0.064781	0.071546	0.075329	0.066709	0.066552
Obstacle5	0.084032	0.071443	0.090775	0.121356	0.05368	0.058861	0.054259	0.059456	0.064248	0.064756	0.072963	0.08634
Obstacle6	0.077995	0.08021	0.083227	0.095858	0.065265	0.071564	0.043091	0.067443	0.068209	0.052697	0.08078	0.090721
Obstacle7	0.073466	0.094505	0.087726	0.089808	0.091707	0.143128	0.086182	0.078869	0.072389	0.063435	0.082518	0.088014
Obstacle8	0.071608	0.12367	0.091259	0.091344	0.080706	0.095455	0.09697	0.088741	0.07822	0.069382	0.092637	0.080729
Obstacle9	0.071998	0.103924	0.079367	0.082369	0.073721	0.093007	0.104781	0.099849	0.088011	0.072355	0.087121	0.077381
Obstacle10	0.069749	0.092647	0.080661	0.087808	0.08481	0.135511	0.13466	0.126887	0.120564	0.099116	0.085731	0.075609
Obstacle11	0.104216	0.092647	0.125025	0.105161	0.322096	0.093007	0.109207	0.099849	0.106207	0.120506	0.104233	0.08634
Obstacle12	0.097926	0.101489	0.087726	0.119167	0.074916	0.094894	0.116073	0.135497	0.136467	0.15487	0.143685	0.118139

According to Figure 4, the cost and funding risks are the highest obstacle followed by scalability, Lack of Socio-technological Planning, and security and privacy. Otherwise, Regional Disparity is the lowest obstacle among12 obstacles.

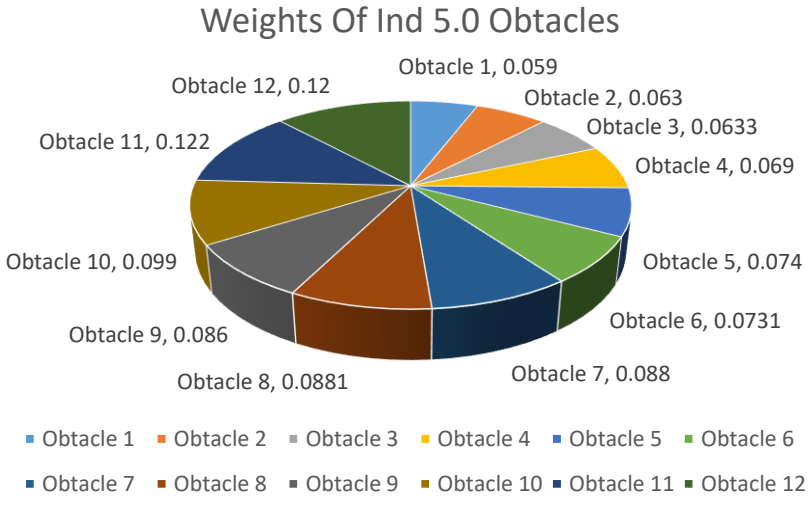

Figure 4. Final ind 5.0 obstacles' weights based on appraisal decision framework.

4. Conclusions

The current study is an ongoing investigation into and analysis and appraising of obstacles and impediments to the widespread utilization of ICT in EEs. Ind 5.0 is one of the technologies of ICT. Also, it considered the focus of current studies due to its high ability to communicate between things and people using a variety of technologies that fall under the scope of Ind 5.0. Hence, this study deployed robust approaches which contribute to generate ADF for ranking determined obstacles of implementing and employing Ind 5.0 n businesses especially, EEs. Herein, we utilize AHP as one of MCDM methods as ranker for determined obstacles through computing Ind 5.0 obstacles' weights. AHP works with aids of IVNSs as one of approaches has ability to treat of inconsistent information. Due to IVNSs that fall under neutrosophic theory. Through findings of ADF cost and funding obstacle are the highest while Regional Disparity is the lowest one.

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that there is no conflict of interest in the research.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. W. Zhang, K. Wang, L. Li, Y. Chen, and X. Wang, "The impact of firms' mergers and acquisitions on their performance in emerging economies," Technol. Forecast. Soc. Change, vol. 135, no. 2, pp. 208–216, 2018, doi: 10.1016/j.techfore.2018.05.015.
2. Z. Cao and X. Shi, "A systematic literature review of entrepreneurial ecosystems in advanced and emerging economies," Small Bus. Econ., vol. 57, no. 1, pp. 75–110, 2021, doi: 10.1007/s11187-020-00326-y.
3. P. Soto-Acosta, S. Popa, and I. Martinez-Conesa, "Information technology, knowledge management and environmental dynamism as drivers of innovation ambidexterity: a study in SMEs," J. Knowl. Manag., vol. 22, no. 4, pp. 824–849, 2018.
4. R. Dubey, T. Singh, and S. S. Ali, "The mediating effect of human resource on successful total quality management implementation: An empirical study on SMEs in manufacturing sectors," Benchmarking An Int. J., vol. 22, no. 7, pp. 1463–1480, 2015.
5. S. Hungund and V. Mani, "Benchmarking of factors influencing adoption of innovation in software product SMEs: an empirical evidence from India," Benchmarking An Int. J., 2019.
6. S. A. Ejiaku, "Technology Adoption: Issues and Challenges in Information Technology Adoption in Emerging Economies," J. Int. Technol. Inf. Manag., vol. 23, no. 2, 2014, doi: 10.58729/1941-6679.1071.
7. F. Aslam, W. Aimin, M. Li, and K. U. Rehman, "Innovation in the era of IoT and industry 5.0: Absolute innovation management (AIM) framework," Inf., vol. 11, no. 2, 2020, doi: 10.3390/info11020124.
8. X. Sun, H. Yu, W. D. Solvang, Y. Wang, and K. Wang, "The application of Industry 4.0 technologies in sustainable logistics: a systematic literature review (2012–2020) to explore future research opportunities," Environ. Sci. Pollut. Res., pp. 1–32, 2021.
9. M. Yucesan and M. Gul, "Failure modes and effects analysis based on neutrosophic analytic hierarchy process: method and application," Soft Comput., vol. 25, no. 16, pp. 11035–11052, 2021.
10. A. Vafadarnikjoo, H. Badri Ahmadi, J. J. H. Liou, T. Botelho, and K. Chalvatzis, "Analyzing blockchain adoption barriers in manufacturing supply chains by the neutrosophic analytic hierarchy process," Ann. Oper. Res., pp. 1–28, 2021.

11. A. Vafadarnikjoo and M. Scherz, "A hybrid neutrosophic-grey analytic hierarchy process method: decision-making modelling in uncertain environments," Math. Probl. Eng., vol. 2021, pp. 1–18, 2021.
12. E. Eryarsoy, H. S. Kilic, S. Zaim, and M. Doszhanova, "Assessing IoT challenges in supply chain: A comparative study before and during-COVID-19 using interval valued neutrosophic analytical hierarchy process," J. Bus. Res., vol. 147, pp. 108–123, 2022.

Received: Jun 10, 2022. Accepted: Jan 26, 2023