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Toward Supply Chain 5.0: An Integrated Multi-Criteria Decision-Making Models for Sustainable and Resilience Enterprise

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ABSTRACT

The enterprises and their supply chain (SC) have undergone significant changes because of the highly complex business environment, dynamism, environmental change, ideas like globalization, and increased rivalry of enterprises in the national and worldwide arena. Additionally, pandemics and crises caused SC disruptions for enterprises. Thus, an enterprise's SC must constantly be ready to face various obstacles and unpredictable environmental changes. In an era of growing technological advancement, enterprises and their strategies are transforming toward sustainable and resilient SC. For this reason, this study embraces the notion of utilizing technologies such as Artificial intelligence (AI) and big data analytics (BDA) as branches of intelligence techniques of Industry 4.0 (Ind 4.0) and, thereafter, Industry 5.0 (Ind 5.0). Thus, the study contributes to constructing an appraiser model for appraising the enterprises that employ these technologies and techniques in their SC to be sustainable resilience in another meaning resilience supply chain (ReSSC). This model utilized best worst method (BWM) under the governing of Single-valued triangular neutrosophic sets (SVTNSs) to generate an appraiser model. Whereas SVNSs applied in the comparative analysis as a comparative model with the cooperation of AHP, TOPSIS, and WSM to validate our constructed model. The findings of the appraiser model based on MCDM merging with SVTNSs and the comparative model based on MCDM integrated with SVNSs agreed that the optimal key indicator six is securing of data (KI6); otherwise, Key Indicator three is transparency (KI3). Also, these models agreed to recommend enterprises from optimal to worst as En1> En4> En2> En3. From the results of the two models, En1 is the most sustainable and resilient. Contrary, En 3 is the least.

1. Introduction

Supply Chain (SC) management has grown in importance inside every enterprise in the modern era due to an enormous spike in market. As a result, effective SC management is crucial to the enterprise's success. This is due to [1] its contribution in assisting the enterprise in attaining its objectives, which include maximizing profitability and ensuring client satisfaction through controlling

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and organizing material, monetary, and information flows as elements or partners within the supply network in an effective manner.

Despite the importance of SC, it faces many obstacles and disturbances. For instance [2], business globalization adversely influences SCs by lengthening and complicating SC. Also [3] highlighted internal disturbances that SCs suffer from as resource shortages like labors, materials, and funding, establishing rigid or fixed strategies not resilience in light of the fluctuating business environment, equipment that is obsolete or malfunctions, and absence of competent personnel. Others as [4] investigated the difficulty of designing a network for a multi-tiered blood supply network that consists of hospitals, blood centers, blood facilities, and donors. It also suffers from external disturbances according to [5] as natural calamities like earthquakes , epidemics as Covid-19, international disputes as wars and international counties, and Disturbance of public customer's taste and the impact on supply and demand that effect negatively on profit.

Thes disturbances led to cessation of supply and demand and the production operations were halted that led to the loss of a competitive edge. Evidence regarding this, [6] where sustainability of SC (SSC) was adversely impacted by COVID 19. According to [7] the term of sustainability reveals to set of aspects as environment, social, and economic. This epidemic threatens SSC [3] as environmentally fluctuations in supply and demand Contributed to the stagnation of the product and its transformation into waste. Economically, such epidemic led to closure, unemployment, and collapse economic. Ultimately, socially where it decreases in the number people employed and rises in the unemployment rate.

Hence, in order to mitigate and avoid these disturbances damages toward robust SSC and to be proactive SC, the scholars as [3] stressed the importance of sustainability after being disrupted, a SC capacity to either go back to its pre-disrupted condition or to a new, more desired state. That is achieved through ability of SC to resilience. In a similar vein, ReSSC described in [1] as the adaptability of the supply chain to anticipate events, react to interruptions, and recover from them by keeping activities running continuously at the required degree of connectivity and structural and functional control.

Shorten that [8] who emphasized that embracing the term of sustainability can result in durable and constancy, also, the term of resilience can result in sturdiness in SC. Thus, through his point of view, for contemporary SCs, research on resilience and sustainability is a particularly intriguing topic as we speak.

Recent studies substantial advances in revolutions of information technology and industry motivated earlier scholars to exploit these revolutions in contemporary domains in dynamic and disturbance business environments. For instance, [9] indicated that the industrial revolutions also had an impact on social and cultural life, business life, and the field of organizational performance is upgraded, which emerged in the Ind 4.0 era. Also, [10] put forward utilizing big data analytics (BDAs) as a cutting-edge Ind 4.0 technologies in the healthcare business environment. Others as [11] leveraged artificial intelligence (AI) as branch of Ind 4.0 in manufacturing enterprises through increasing its productivity in order to achieve its sustainability. [12] highlighted that Ind 4.0 declined humanity's role in sectors in [10] this is due [13] the utilization of acceptance of alternative technologies such as artificial intelligence (AI), blockchain technology (BlT), Internet of Things(IoTs) etc. concentrate on improving operating efficiency, lessening operational expenses, and boosting productivity in order to further enhance economic aspects.

Hence, Industry 5.0 (Ind 5.0) introduced via the authors in [14] in order to release Ind 4.0's cons through taking into consideration main three aspects sustainability, resilience, and human-centeredness. Through [15] which employed technology as 3D printing in manufacturing sector to manage waste resources to achieve sustainability through protecting environment. Also, BDA helps in analyzing collected data and BIT distributed the analyzed data through distributed ledger (DiL) in security manner to achieve resilience. As that implementing industrial robot (IR) or robot to support human to perform hazard tasks to protect human.

As result this study contributes to enhance SC especially logistics services through leveraging capabilities of Ind 5.0's aspects to acquire a competitive edge over rivals in a corporate context. toward ReSSC and SSC. That's why this study analysis and evaluate extent efficiency Ind 5.0's aspects through applying Industry 5.0 technologies in real enterprises for logistics services as partner of SC toward Sus En and ReEn to boost its SC.

By means of which we had to construct an appraiser model to appraise extent of sustainability and resilience for enterprises in Egypt which embracing Ind 5.0 to investing its three aspects in its chain. The first and main stage is identifying a set of indicators where decision makers (DMs) exploit it to appraise enterprises based on. The identification process has been done based on three aspects of Ind 5.0 (i.e., Sustainability, resilience, and human-centeredness). Secondly, MCDM techniques are used to treat conflicting of identified indicators entailed in BWM. In light of applying this model in reality that increases the probability of uncertainty, fluctuating and ambiguate of business climate. Thus, Table 1 exhibited and aggregated earlier studies that treat with fluctuating of business environment. Hence, we are volunteering SVTNSs as branch of neutrosophic uncertainty theory in this study to treat with such environment. Due to its ability to subsidy DMs in indeterminacy situations as well as settled situations in other word truth and false. This is considering motivator for applying SVTNSs as subsidized for MCDM techniques during appraising process for logistics enterprises based on applied Ind5.0 for strengthen SC's logistics enterprises toward sustainability and resilience. Briefly, the study contributes to emerge the importance of deploying digital technologies toward transformation traditional SC into smart SC for enterprises to be more resilience and sustainable. Hence, we determined our objectives based on earlier studies toward achieving the study's objectives as seen in Figure 1.

Herein, the contributions of these study highlighted in following points:

1. We determine enterprises which embrace Ind5.0 aspects to actively indulge in appraising process as nominees to obtain most sustainable En and resilience En.
2. The surveyed process for earlier studies contributed to determine Ind 5.0's indictors which used as metrices for sustainability and resilience of nominees' enterprises.
3. For appraising these nominees, appraiser model has been constructed using MCDM techniques entailed in BWM is applied to obtain indicators' weights which volunteering in ranker techniques (TOPSIS-WSM) to rank the nominees' enterprises.
4. The main contribution in this study united with the previous techniques SVTNSs uncertainty theory to subsidy it and DMs into indeterminacy and uncertainty situations. Due to neutrosophic theory isn't take into its consideration truth and false only, but also, take into its consideration indeterminacy.
5. We conducted comparative analysis for proposed appraiser model with another constructed model (i.e., corresponding model) to validate proposed appraiser model.

Table 1
Earlier studies related to our scope

Ref #	Methodology	Objectives
Palanikumar *et al.* [16]	Log Fermatean vague normal weighted averaging (log FVNWA)	The study supported experts in decision making (DM) process through uncertainty theories for recommending most success robot.
Branch *et al.* [17]	A new systematic methodology is represented with a combination of Delphi, Kano and AHP methods	Describe the mental paradigms that are used by managers to rank the needs of their staff.
Nayeri *et al.* [10]	BWM is combined with Fuzzy Vlse Kriterijumsk Optimizacija Kompromisno Resenje (FVIKOR)method	Compute attributes' weight to contribute to rank alternatives
Mohammed *et al.* [1]	MABAC-OCRA-TOPSIS-VIKOR(MOTV) have been proposed	These methods are applied for ranking resilience suppliers

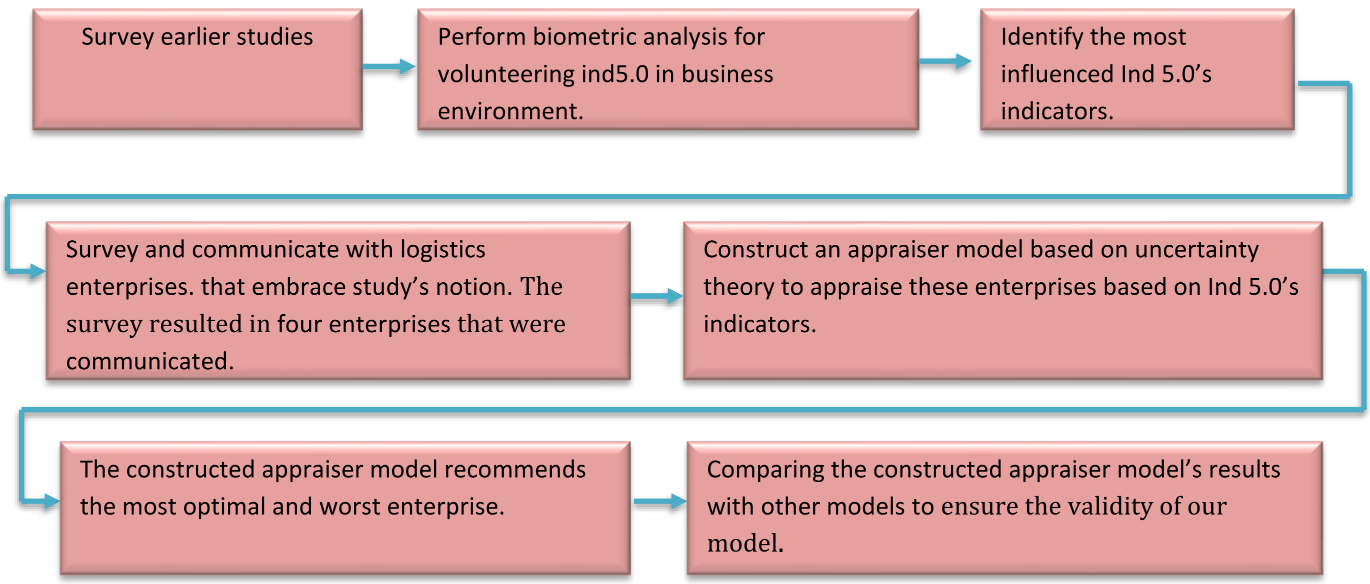

Fig. 1. The objective of our study

2. Related Work

This section includes an analysis for utilized key concepts to find out what the earlier studies used for these concepts have found through bibliometrics analysis. Also, it showcases various scholars' perspectives for utilized and common theoretical underpinning as in this study.

2.1 Systematic Analysis for Utilized Key Conceptual

Inside this sub section, bibliometrics analysis is conducted based on web of science (WoS) database. By analyzing total citations and trending publications based on the number of citations received each article over the last five years, bibliometrics reveals the most influential research on leveraging revolution industrial entails Ind 4.0 and 5.0 towards ReSSC. In a similar vein of [18] exhibited the literature studies which relevant to key concepts are contributed in our scope. In the present study, bibliometric analysis and mapping were carried out using the VOS viewer software. According to [19] this software can present large bibliometric maps in a clear manner when compared to other bibliometric methods. The process of analysis is conducted based on certain keywords such as (“Resilience Supply Chain” AND “sustainability Supply Chain”) And ((“Industry 4.0) AND (“Industry 5.0)) OR “Intelligent Techniques” OR “Artificial Intelligence” OR “Big Data Analytical” OR “Cloud Computing” OR “Internet of Things”. The findings of this process showcase as following:

2.1.1 Co-occurrence based Keyword Analysis.

In VOS viewer, a co-occurrence analysis of author keywords for a variety of publications was conducted to find issues that would be relevant to the role of revolution industrial in ReSSC study. The findings of this query for keywords mentioned previously are represented into network visualization in Figure 2. The analysis of keywords' co-occurrences determines how frequently each keyword is used as well as how pairs of keywords interact. The size of each node, which represents a keyword, is determined by how often that keyword appears. The thickness of the linkages, which represent the way that keywords interact with one another, shows how frequently a given pair of terms is used together. We set the minimum number occurrences to obtain the visualized network is 3. This network in Figure 2 is divided into 5 clusters where cluster 1 includes 17 items whereas cluster 2 includes 16 items, cluster 3 has 15 items, cluster 4 encompasses 13 items, 12 items in cluster5; also, cluster 6 has 8 items eventually, 2 items belong to cluster 7.

2.1.2 Co-Citation Analysis

Herein, we are analyzing the prior studies for sources which are related to determined keywords. We determine the minimum number of citations of sources is 10 where 1617 source meets 70 thresholds. This process led to generate map of visualized network for sources which exhibits in Figure 3. The generated map includes 70 items are fall under 4 clusters. In this context, cluster 1 has 31 items and 20 items belong to cluster 2 while cluster 3 has 17 items ultimately cluster 4 includes 12 items.

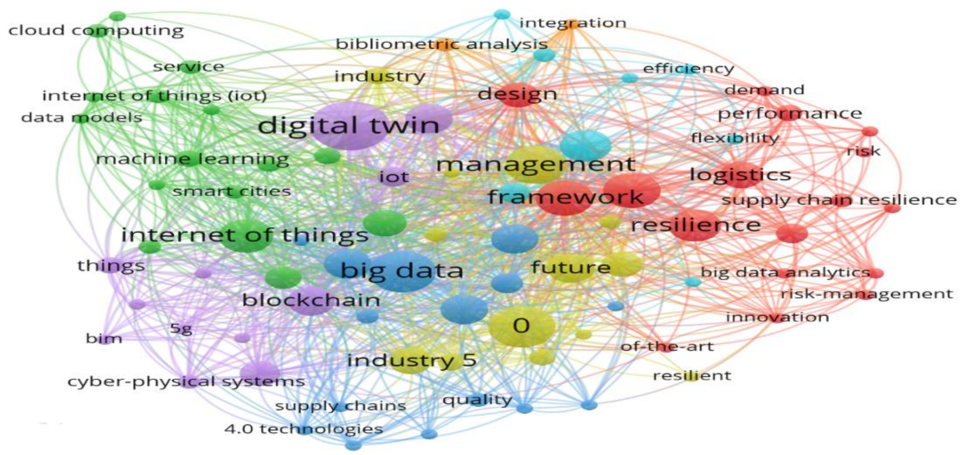

Fig. 2. Visualization network for Co-occurrence based Keyword.

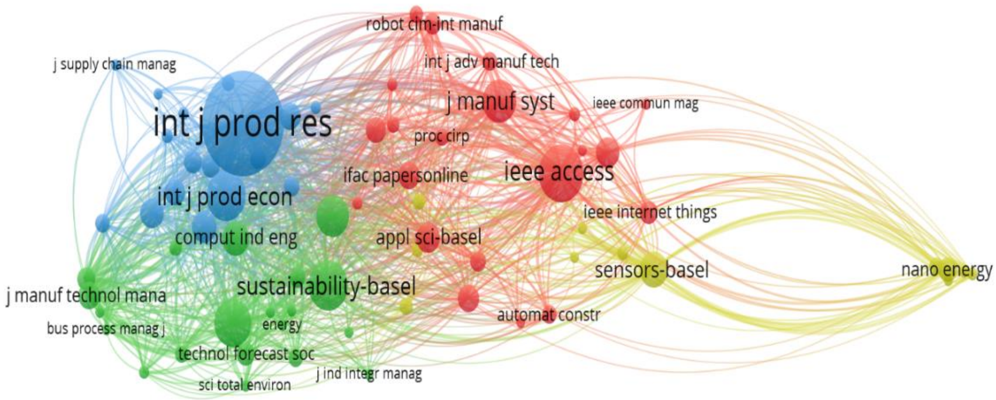

Fig. 3. Visualization network for Co-citation based on Co-Sources.

While Figure 4 showcases 87 items included in 4 cluster for co-citation based on co-authors. These items are distributed into 4 clusters as 36 items in cluster 1, cluster 2 has 27 items while 20 items in cluster 3and finally cluster 4 includes 4 items.

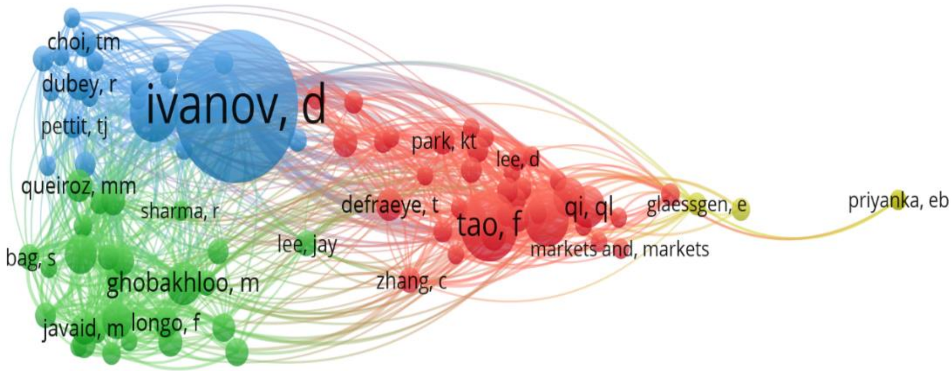

Fig. 4. Visualization network for co-citation based on co-authors.

2.2 Theoretical Foundation

Herein, we exhibit the basic concepts which are related with our study's scope.

2.2.1 Resilience Supply Chain

The concept of resilience has many different expressions according to various scholars in earlier studies. The author [20] described this concept as enterprise's or a SC's capacity to withstand interruptions while simultaneously improving is crucial from the standpoint of supply chain management. Also, [3] described resilience as how to swiftly create and use constructive, situation-appropriate behaviors while under minimal tension. Thus, resilience utilize in many disciplines, including economics, industry, architecture, environmental science, and social sciences Generally speaking, [21] enterprise's resilience refers to its capacity to resume normal operations after a significant disruption to its production and services. To narrow the focus, Datta stated ReSSC in [22] as agile way of managing activities that shield the enterprise from disruptions to be proactive where, in the event that a disruption does occur, set off an extremely quick response that keeps the enterprise in a dynamically stable state or restores it. This enables operations to be adjusted to the new requirements before the competition. In order to improve customer satisfaction, market share, and financial success, ReSSC through [23]either moves back to its initial setting or develops by shifting to a new, more enticing state. Due to [24] When resilience ideas are put into SC, a network is able to dynamically respond and carry out operational tasks under unanticipated circumstances, such as disturbances and hazards. Enterprises and its SCs [25] become more resilient since resilience may strengthen the inherent ability of the supply chain to carry out its duties with flexibility. As a result of the importance of adopting ReSSC, there are many definitions of ReSSC based on earlier studies (see Ref [3]). Also, according to [9] the concept of ReSSC reveals to sustainability of SC (SSC).

2.2.2 Sustainability of Supply Chain

Generally, the term of sustainability in [26] revealed into three aspects of social, environmental, and economic. So, [27] emphasized that for any enterprise to have a sustainable long-term economy, there must be economic growth that does not harm the social and environmental aspects. Due to [9] where sustainability is often intended to minimize and control waste at all feasible production and distribution stages. evidence for this [28] where the primary objective of environmental sustainability is to balance the use of natural resources while preserving the ecological system. Last but not least, social sustainability focuses on protecting human welfare and takes into account social equality and justice as well as fundamental liberties like hours of labor and security as well as safety. So overall to establish SSC, three aspects need to be considered holistically.

Present-day stakeholders and customers are increasingly demanding, and enterprises are under pressure to provide environmental and social concerns with higher priority attention. Because of how crucial it is to adopt sustainability [29], this caused a shift in consumer purchasing habits, causing them to start demanding more sustainable products and services. Moreover [30] placed emphasis that collaboration amongst SC stakeholders is an essential aspect of improving sustainability. Study of [28] highlighted another important aspect entailed in enterprise' willingness for cooperation with other supply chain participants.

Sustainability may improve the network's capacity to utilize resources efficiently whilst resilience can help the network handle many shocks. As a result, studies gave the adoption of sustainability and resilience in SC a lot of thought, which gave rise to several studies that blended both notions in SC as [31, 32].

Regarding the significance of SSC and ReSSC, academics as [11] have utilized the enormous advancements in information technology to integrate sustainability and resilience into SC. These technologies constituted Ind 4.0. After that Ind 5.0 with its aspects and technologies toward sustainable and ReSSC 5.0 or in other word smart sustainable and resilience SC5.0.

2.2.3 Shifting from Traditional Supply Chain to Supply Chain 5.0: Toward Sustainable and Resilience supply chain.

Diverse lists of factors which elevate and enhance SC can be obtained from prior studies. For instance, concentrated [32] on Agility, flexibility, velocity, visibility, availability, redundancy, resource mobilization, cooperation, and understanding of SC structure are the most crucial components of ReSSCs. Authors of [33] realized that 27 factors are necessary to develop ReSCs abilities whenever surveying 103 publications released during the years 2003 and 2015.According to the mentioned study, 13 substantial factors are chosen from among these 27 factors to facilitate the five resilient aptitudes. The elements of awareness, robustness, increasing visibility, and knowledge are serving SC to be able to anticipate. Whilst flexibility and building redundancy are supporting SC to be adapt. Also, SC to be respond, collaboration and agility is taken into consideration. Building social capital as well as expertise management, which came last to aid SC to be able to learn. The conceptualization of ReSSCs as a multidimensional phenomenon was summed up by Marinagi *et al.,* 2023 [3]as economic, psychological, and social aspects. There are other elements as risk management is mentioned in [34] through a series of actions designed to improve capacity to foresee danger, react to it, and recuperate from its effects.

Since disturbances might have a substantial impact on SC's capabilities and its contributing facets. Moreover, this might culminate in reputational harm [35].

To release these issues, scholars suggest solutions as [36] It is crucial to have access to reliable information before, during, and after disturbances. SC partners may communicate information in real time to accomplish this. The evidence of it [37] through the prism of accurate and timely data, information, and knowledge exchange among partners, new technologies may considerably enhance strengthening.

According to the literature, a SC becomes a SC 4.0 or ReSSC 4.0 or smart SC when Ind 4.0 technologies are merged into it. The major methods for putting SC 4.0 into practice revolve around transparency, real-time data, and effective demand management, as well as improving cooperation between SC's partners to meet market demands. The importance of SC 4.0 was highlighted by [38] based on global survey report, that indicated the majority of specialists to be in agreement that new technologies including cloud computing (82.7%), robots (73.3%), blockchain (60.1%), and additive manufacturing (59.3%) are important underlined the transformation. The SC's performance and responsiveness are positively impacted by Internet of Things (78.7%) and Big Data (86%).

As previously stated, Ind 4.0 has flaws, such as disregarding some important aspects of sustainability. That served as the catalyst for the inauguration of Ind 5.0. As it turns out, SC embracing Ind 5.0 technologies to shift from SC 4.0 into SC5.0 or ReSSC 5.0 or smart ReSSC.

Herein, we exhibit the role of Ind 5.0 technologies in SC to be ReSSC 5.0 through Table 2 according to prior studies as[39, 40, 3]

Table2
Role of Industry 5.0 technology toward Resilience and Sustainable Supply Chain

SC's Factors	Ind 5.0 Technologies in SC					
	IoTs	BDAs	DT	BlT	IR	CC
Agility	When an unforeseen event is noticed, give precise details to facilitate quick	-Collected data of IoT is analyzing to predict events to make SC proactive. -Easy to access to data any time.	predict trends and can also be flexible in dynamic environments. due to ability of DT to construct a virtual SC as mirrored for physical SC	Information is available throughout the chain and can be accessed by members	-Support in collecting data via sensors and uploading to CC. -Collected data stored to analysis and prediction	SC's partners easy to access information through digital channels with aid CC, BDA
Risk Management	Monitoring and trace labors and things to control disturbance events	Forecasting behavior of SC and its partners	Simulating physical SC as virtual to reduce and control losses with aid of IoTs, BDA	Members utilize DiL to obtain real-time data and make decisions.	Perform hazard and difficult tasks	Stored data applied to forecast and plan demand
Security				Available data in DiL is encrypted to prevent any vulnerability or attack. Also, any change require		

SC's Factors	Ind 5.0 Technologies in SC					
	IoTs	BDAs	DT	BlT	IR	CC
				consensus amongst chain's members		
Visibility	Permit to SC's members to tracking products and people throughout chain	Easy access to stored data as well as real time data	Utilizing IoTs and BDA with DT that reflects the real-time network status at any given time.	Partners who authenticated can access data in DiL. Thus, BlT characterized by transparency		Stored data can be exchange amongst devices and stakeholders that contribute to boost decision
Eco-friendly chain	Attached products with sensors to track product and return waste to new material	Based on collected data for client's behaviors and analyze it to forecast quality of demand products		Needed information is available in DiL for any process toward waste reduction	Utilizing for various purpose instead machines and reduce harmful of Fuel	
Cost Reduction	Making timely decisions is made possible for stockholders by tracking equipment and products.				Labor is reduced by using robots	
Safety and human rights	Tracking laborers to recognize the number of hours they work. Also protect them from any hazard	Availability of information about number of hours that employees work.			Conduct hazard and critical tasks instead of human	

3. Preliminaries

In this section, the basic concepts of TSVNSs and its operations are illustrated as following:

Definition 1 [41]**.** The neutrosophic set $\widetilde{Ne}$ denoted by three membership functions are the truth (Tr), indeterminacy (In), and falsity (Fa). Assum that $x \in X$ and X be a space of points where x in the real non-standard] $^{-}0$, 1^{+} [. Hence, $(\mathrm{Tr}_{\widetilde{Ne}}(x) + \mathrm{In}_{\widetilde{Ne}}(x) + \mathrm{Fa}_{\widetilde{Ne}}(x))$ belongs to [$^{-}0$, 3^{+}].

Definition 2 [7].: let Single Value Triangular Neutrosophic Sets demonstrated as $\widetilde{Ne} = \langle(\mathrm{Lo}, \mathrm{Mi}, \mathrm{Hi}); \mathrm{Tr}, \mathrm{In}, \mathrm{Fa}\rangle$ where $\mathrm{Lo}, \mathrm{Mi}, \mathrm{Hi}$ represent lower, middle, and upper of neutrosophic number.$\widetilde{Ne}$ set is classify to membership functions are truth-membership function (Tr), indeterminacy-membership function (In) and falsity-membership function (Fa) and formed as:

$$\mathrm{Tr}_{\widetilde{\mathrm{Ne}}} = \begin{cases} Tr\left(\frac{x-Lo}{Mi-Lo}\right) & Lo \le x \le Mi \\ Tr & x = Mi \\ Tr\left(\frac{Hi-x}{Hi-Mi}\right) & Mi \le x \le Hi \\ 0 & otherwise \end{cases} \tag{1}$$

$$\mathrm{In}_{\widetilde{\mathrm{Ne}}3} = \begin{cases} \mathrm{In}\left(\frac{\mathrm{Mi-x}}{\mathrm{Mi-Lo}}\right) & \mathrm{Lo \le x \le Mi} \\ \mathrm{In} & \mathrm{x = Mi} \\ \mathrm{In}\left(\frac{\mathrm{x-Hi}}{\mathrm{Hi-Mi}}\right) & \mathrm{Mi \le x \le Hi} \\ 1 & \mathrm{otherwise} \end{cases} \tag{2}$$

$$\mathrm{Fa}_{\widetilde{\mathrm{Ne}}} = \begin{cases} \mathrm{Fa}\left(\frac{\mathrm{Mi}-x}{\mathrm{Hi-Lo}}\right) & \mathrm{Lo} \le x \le \mathrm{Mi} \\ \mathrm{Fa} & x = \mathrm{Mi} \\ \mathrm{Fa}\left(\frac{x-\mathrm{Hi}}{\mathrm{Hi-Mi}}\right) & \mathrm{Lo} \le x \le \mathrm{Hi} \\ 1 & otherwise \end{cases} \tag{3}$$

Definition3 [41]. Let $\widetilde{\mathrm{Ne}_1}$=$\langle(\mathrm{Lo}_{1,}, \mathrm{Mi}_{1,}\mathrm{Hi}_1); \mathrm{Tr}_{1,}, \mathrm{In}_{1,}, \mathrm{Fa}_1\rangle$and $\widetilde{\mathrm{Ne}_2}$=$\langle(\mathrm{Lo}_{2,}, \mathrm{Mi}_{2,}\mathrm{Hi}_2); \mathrm{Tr}_{2,}, \mathrm{In}_{2,}, \mathrm{Fa}_2\rangle$ two TSVNSs

I. Addition of two SVTNSs: $\widetilde{\mathrm{Ne}_1}+\widetilde{\mathrm{Ne}_2}$=

$$\langle(\mathrm{Lo}_1+\mathrm{Lo}_2, \mathrm{Mi}_1+\mathrm{Mi}_2, \mathrm{Hi}_1+\mathrm{Hi}_2);\ \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2\rangle. \tag{4}$$

II. Subtraction of two SVTNSs: $\widetilde{\mathrm{Ne}_1}$- $\widetilde{\mathrm{Ne}_2}$=

$$\langle(\mathrm{Lo}_1-\mathrm{Lo}_2, \mathrm{Mi}_1-\mathrm{Mi}_2, \mathrm{Hi}_1-\mathrm{Hi}_2);\ \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2\rangle. \tag{5}$$

III. Division of two SVTNSs: $\frac{\widetilde{\mathrm{Ne}_1}}{\widetilde{\mathrm{Ne}_2}}$ =

$$\begin{pmatrix} \langle\left(\frac{\mathrm{Lo}_1}{\mathrm{Hi}_2}, \frac{\mathrm{Mi}_1}{\mathrm{Mi}_2}, \frac{\mathrm{Hi}_1}{\mathrm{Lo}_2}\right), \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2 \text{ if } (\mathrm{Hi}_1>0, \mathrm{Hi}_2>0)\rangle \\ \langle\left(\frac{\mathrm{Hi}_1}{\mathrm{Hi}_2}, \frac{\mathrm{Mi}_1}{\mathrm{Mi}_2}, \frac{\mathrm{Lo}_1}{\mathrm{Lo}_2}\right), \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2 \text{ if } (\mathrm{Hi}_1<0, \mathrm{Hi}_2<0)\rangle \end{pmatrix} \tag{6}$$

IV. Multiplication of two TSVNSs: $\widetilde{\mathrm{Ne}_1}*\widetilde{\mathrm{Ne}_2}$=

$$\begin{pmatrix} \langle(\mathrm{Lo}_1\mathrm{Lo}_2, \mathrm{Mi}_1\mathrm{Mi}_2, \mathrm{Hi}_1\mathrm{Hi}_2);\ \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2 \text{ if } (\mathrm{Hi}_1>0, \mathrm{Hi}_2>0)\rangle \\ \langle(\mathrm{Lo}_1\mathrm{Hi}_2, \mathrm{Mi}_1\mathrm{Mi}_2, \mathrm{Hi}_1\mathrm{Lo}_2); \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2 \text{ if } (\mathrm{Hi}_1<0, \mathrm{Hi}_2<0)\rangle \\ \langle(\mathrm{Hi}_1\mathrm{Hi}_2, \mathrm{Mi}_1\mathrm{Mi}_2, \mathrm{Lo}_1\mathrm{Lo}_2); \mathrm{Tr}_1\wedge\mathrm{Tr}_2, \mathrm{In}_1\vee\mathrm{In}_2, \mathrm{Fa}_1\vee\mathrm{Fa}_2 \text{ iif } (\mathrm{Hi}_1<0, \mathrm{Hi}_2<0)\rangle \end{pmatrix} \tag{7}$$

4. Appraisal Methodology

Herein, we showcase methodology for appraising the enterprises which embrace BDA and AI techniques whether inside or outside its chain for boosting resilience of its chain toward sustainability. The appraisal process has been conducted for nominees of enterprises based on a set of key indicators which related to usage of Ind 5.0 technologies. Thus, the appraisal of enterprises is influenced by several direct and indirect criteria, just as with a typical decision-making problem. Thereby, MCDM techniques are adopted and bolstered by uncertainty theory referred to neutrosophic theory to bolster MCDM techniques' capacity to cope with ambiguous situations and in complete data. Hence, this study mingles Single-valued triangular neutrosophic set as branch of neutrosophic theory with BWM-TOPSIS also BWM-WSM (as comparative ranker technique). These hybrid techniques of MCDM based Single-valued triangular neutrosophic set are emerging to generate appraiser model.

Consequently, the appraisal process in this study divides into set of stages:

Stage 1: Insightfully survey

This stage entails the vital data that is collected through various methods such as field expeditions and conducted questionnaires for enterprises.

Step1.1: We identify the most influential key indicators based on prior studies as [10] . We aggregated and described these key indicators in Figure 5.

Step 1.2: We prepared questionnaires to rate the identified key indicators.

Step 1.3: Confirmed decision makers (DMs) and experts who related to our search scope. DMs are filling out the questionnaire based on crisp scale from 1 to 9 in linguistic terminology scale and these values are transforming into its corresponding neutrosophic scale as listed in Table 3.

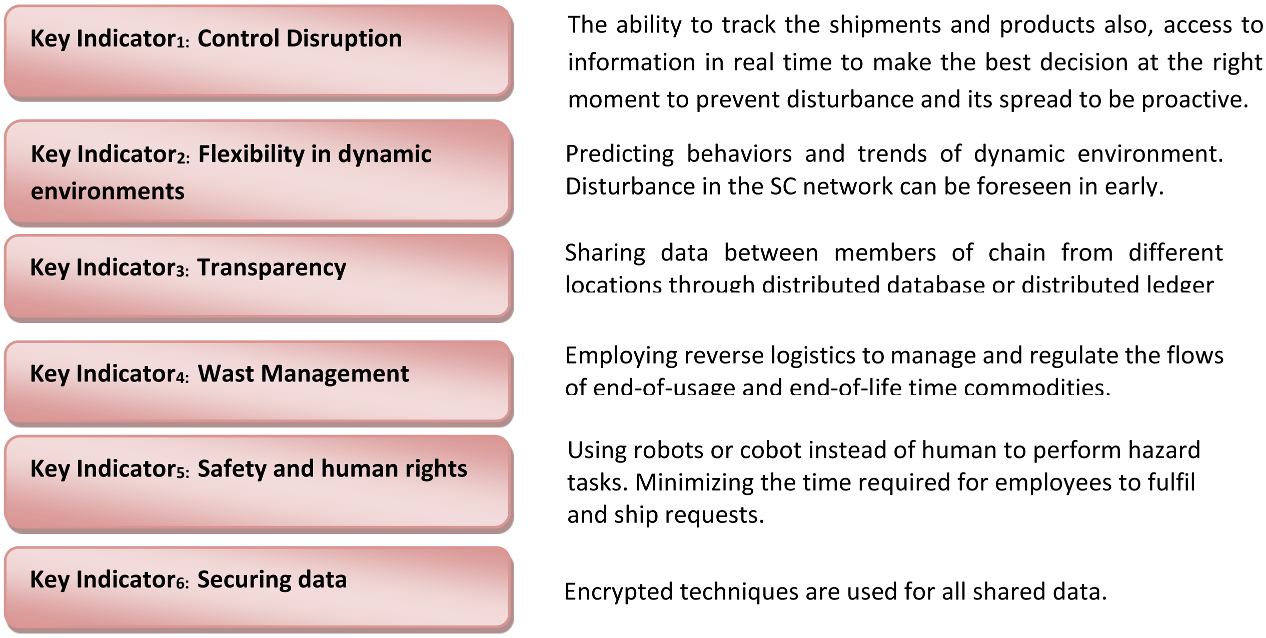

Fig.5. Identified key indicators and its description.

Table 3
Linguistic Terminology Scale

Crisp Scale	Linguistic Terminology	Acronym	SVTNSs Scale
1	Equally Essential	EE	<<1,1,1>;0.5,0.5,0.5>>
2	Slightly Moderately	SM	<<1,2,3>;0.4,0.6,0.65>>
3	slightly Essential	SE	<<2,3,4>;0.3,0.75,0.7>>
4	Minor To Strong	MTE	<<3,4,5>;0.35,0.6,0.4>>
5	Mighty Essential	ME	<<4,5,6>;0.8,0.15,0.2>>
6	Slightly Strong Essential	SSE	<<5,6,7>;0.7,0.25,0.3>>
7	High Strong Essential	HSE	<<6,7,8>;0.9,0.1,0.1>>
8	Very High Strong Essential	VHSE	<<7,8,9>;0.85,0.1,0.15>>
9	Absolutely High Essential	AHE	<<9,9,9>;0.1,0.0,0.0>>

Stage 2: Scrutinizing and adjudicating the identified key indicators.

In this stage we are collecting questionnaires from the previous stage and analyzing it. BWM of MCDM techniques is utilized in this stage as generator for key indicators' weights values subsidized by Single-valued triangular neutrosophic set (SVTNSs) through executing set of steps as in Figure 6.

Step 2.1: Getting relationships between best and worst criterion with other key indicators.

According to BWM technique the best and least desired criterion are determined. the relation between best criterion with other key indicators exhibits in the same vein of [42].

Therefore, expert panel is rating the best $\text{Key indicator}_{Best}$ over other key indicators_j as $\widetilde{\text{key indicator}}_{\text{Best}} = \left(\widetilde{\text{key indicator}}_{\text{Best 1}}, \ldots., \widetilde{\text{key indicator}}_{\text{Best 6}}\right)$.

Likewise, utilizing [42] to identify the relation between other key indicators to $\text{Key indicator}_{Worst}$. Consequently, expert panel rating key indicators_j over least desired/important $\widetilde{\text{Key Indicator}}_{Worst}$ as $\widetilde{\text{key indicator}}_{\text{Worst}} = \left(\widetilde{\text{key indicator}}_{1\text{ Worst}}, \ldots., \widetilde{\text{key indicator}}_{6\text{ Worst}}\right)$.

Step 2.2: Utilizing Eq. (8) to convert expert panel's appraisal from neutrosophic scale into crisp values. Then, the purpose of utilization of Eq. (9) to aggregate expert panel's appraisal.

$$s(a_{ij}) = \frac{(l_{ij}+m_{ij}+u_{ij})}{9} * (2 + A - B - C) \tag{8}$$

Where $\boldsymbol{s}(\mathrm{a_{ij}})$ A, B, C refers to truth, false, and indeterminacy respectively. refers to score function.

$$x_{ij} = \frac{(\sum_{j=1}^{S} a_{ij})}{S} \tag{9}$$

Where a_{ij} refers to value of criterion in matrix, S refers to number of DMs.

Step 2.3: Find the optimal weights for determining key indicators according to following Eqns.:

$$minmax_j = \left\{\left|\frac{w_B}{w_j} - key\ indicators_{Best\,j}\right|, \left|\frac{w_j}{w_w} - key\ indicators_{jworst}\right|\right\}$$

$$s.t$$

$$\sum w_j = 1 \tag{10}$$

$$w_j \geq 0\ for\ all\ j$$

$minmax_j$ *is* converted to a linear model as:

$$min\ \varepsilon^L$$

$$s.t$$

$$\left|w_B - key\ indicators_{Best\,j} w_j\right| \leq \varepsilon^L, for\ all\ j$$
$$\left|w_j - key\ indicators_{jworst} w_{worst}\right| \leq \varepsilon^L, for\ all\ j \tag{11}$$

$$\sum w_j = 1$$

$$w_j \geq 0\ for\ all\ j$$

Where w_{Best} is the weight of best criterion. w_{worst} is the weight of the worst indicator.

Stage 3: Recommend optimal resilience and sustainable alternative.

In this stage, we are leveraging the ability of MCDM techniques for ranking alternatives and obtaining optimal enterprise (En) Which embrace Ind 5.0 technologies in its SC to be resilience and sustainable based on Ind 5.0's aspects. Hence, this study employs two MCDM ranker techniques. Likewise, in stage 2 we emerge SVTNSs with two ranker techniques to strengthen it in uncertainty environment.

Two ranker techniques are applied based on SVTNSs agree and common in the steps:

Expert panel is formed for rating a set of enterprises according to linguistic terminology scale in Table 2. Consequently, a decision matrix is constructed for each partner in the panel as in Eq. (12).

$$X^{num} = \begin{pmatrix} r_{11}^{num} & r_{12}^{num} & \cdots & r_{1n}^{num} \\ \vdots & & \ddots & \vdots \\ r_{m1}^{num} & r_{m2}^{num} & \cdots & r_{mn}^{num} \end{pmatrix} \quad (12)$$

Where $numm, n$ refers to the number of alternatives and key indicators and refers to number of DMs.

Utilizing Eqns. (8) and (9) in step 2.2 to neutrosophic matrices and aggregate it into decision matrix.

After that, each ranker technique is working as following:

Step 3.1: First Ranker Technique

TOPSIS united with SVTNSs to rank alternatives of $ReEn_{(n)}$ and recommend most resilience and sustainable En as following:

3.1.1 Uni-decision matrix is normalized via employees Eq. (13) to normalize it.

$$Nor\_Agg_{ij} = \frac{elem\_Agg_{ij}}{\sqrt{\sum_{j=1}^{m}\left(elem\_Agg^2{}_{ij}\right)}} \quad (13)$$

Where $elem\_Agg_{ij}$ indicates each element in aggregated matrix.

3.1.2 The normalized matrix is contributed to produce weighted decision matrix through Eq. (14).

$$weighted\_matrix_{ij} = weight_i * Nor_{\_Agg}{}_{ij} \quad (14)$$

Where $weight_i$ are BWM's weights

3.1.3 Eqns. (15) and (16) have vital roles in this study to compute positive ideal solution and negative ideal solution, respectively.

$$Positive^* = (\, weighted\_matrix_1{}^*, \ldots.\, weighted\_matrix_n{}^*\,),\ weighted\_matrix_j{}^* = max_i\{\, weighted\_matrix_{ij}\} \quad (15)$$

$$\overline{Negative} = (weighted\_matrix_1{}^-, \ldots.\, weighted\_matrix_n{}^-\,), weighted\_matrix_j{}^- = min_i\{weighted\_matrix_{ij}\} \quad (16)$$

Where $weighted\_matrix_1{}^*, \ldots.\ weighted\_matrix_n{}^* \ldots weighted\_matrix_1{}^-, \ldots.\ weighted\_matrix_n{}^-$ are max and min values of weighted normalized key indicators per column respectively.

3.1.4 The distance between the positive ideal solution and negative ideal solution is computed through Eqns. (17) and (18) respectively.

$$distance_i{}^* = \sum_{j=1}^{n} d\left(\ weighted\_matrix_{ij}, weighted\_matrix_j{}^*\ \right) \quad (17)$$

$$distance_i{}^- = \sum_{j=1}^{n} d\left(\ weighted\_matrix_{ij}, weighted\_matrix_j{}^-\ \right) \quad (18)$$

3.1.5 The optimal alternative based on value of closeness coefficient (CC_i) that compute through Eq. (19).

$$CC_i = \frac{distance_i{}^-}{distance_i{}^* + \ distance_i{}^-} \quad (19)$$

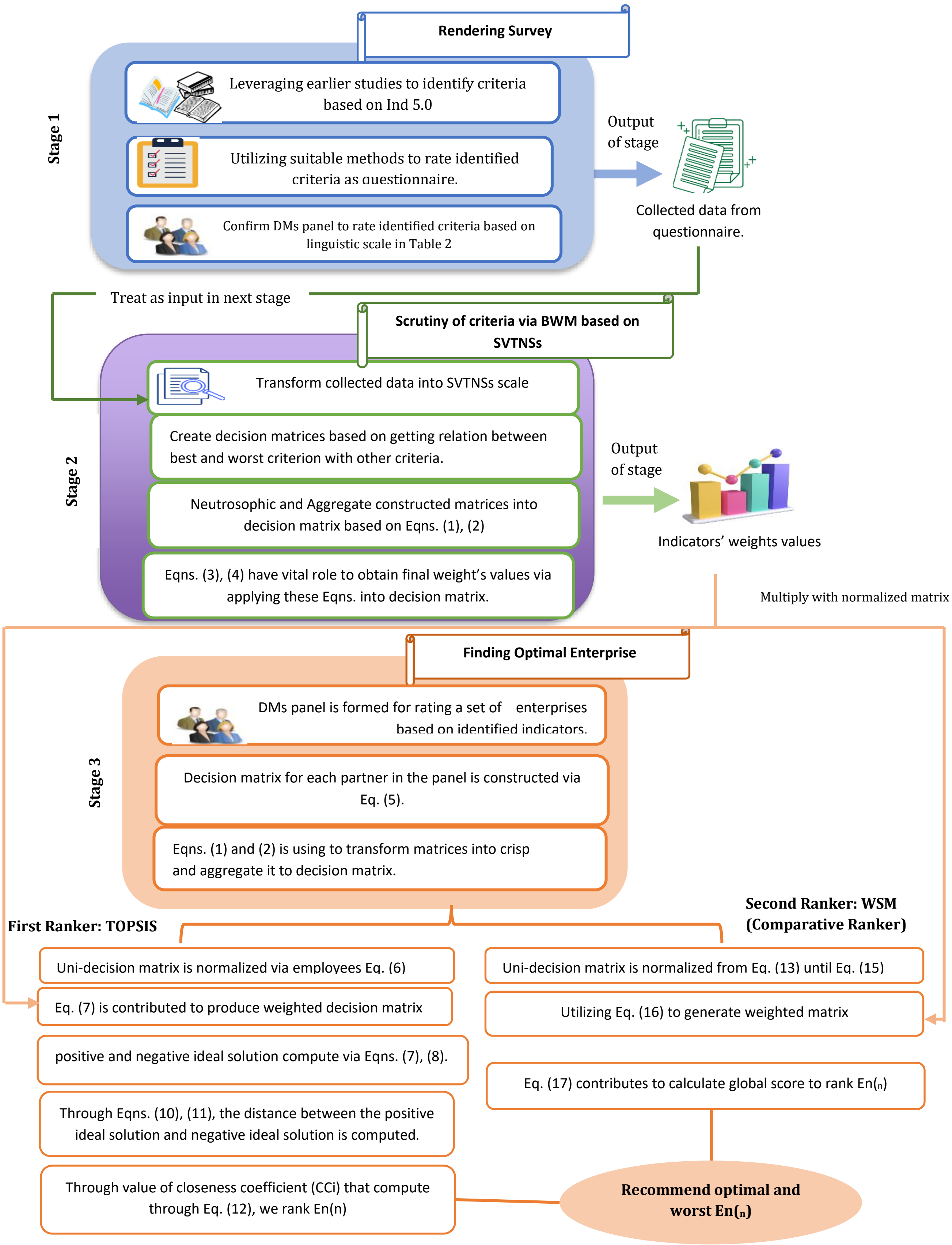

Fig. 6. Appraiser Model Schema

Step 3.2: Second Ranker Technique (Comparative Ranker with WSM)

WSM and SVTNSs are merged to rank alternatives of $En_{(n)}$ and recommend optimal one among set of $ReEn_n$ as following:

3.2.1 The aggregated decision matrix which is constructed based on applied equations in step 2.2 is normalized according to following Eq.s.

$$\mathrm{Nor}_{\mathrm{Agg\_matij}} = \frac{\mathrm{X_{ij}}}{\mathrm{sum(X_{ij})}} \quad \text{, For Benficial key indicators} \tag{20}$$

$$\mathrm{S} = \frac{1}{\mathrm{X_{Ij}}} \tag{21}$$

$$\mathrm{Nor}_{\mathrm{Agg\_matij}} = \frac{\mathrm{S}}{\mathrm{sum(S)}} \quad \text{, For Non} - \text{Benficial key indicators} \tag{22}$$

Where $\mathrm{X_{ij}}$ indicates to each element in the aggregated matrix.

3.2.2 The obtained key indicators' weights of BWM are applied in the following Eq. (23) to generate weighted matrix.

$$A_{ij} = weight_i * \mathrm{Nor}_{\mathrm{Agg\_matij}} \tag{23}$$

Where A_{ij} is weighted decision matrix.

3.2.3 Utilizing Eq. (24) contributes to calculating global score. Based on values of $V(A_{ij})$, ranking process for set of En(n) perform and obtain optimal and worst En.

$$V(A_{ij}) = \sum_{j=1}^{n} A_{ij} \tag{24}$$

Where $V(A_{ij})$ is global score values.

5. A Real-Life Instance Study: Empirical Case Study

The proposed appraiser model is applied on real enterprises which embrace Ind 5.0 techniques in its operation inside and outside its chain. The objective is to transform enterprises to Ens for enduring and sustainable in the market despite fluctuations in the business environment whether supply and demand or crises.

Herein, we are applying our appraiser model for four enterprises that offer logistic services such as transport materials and goods from origin to other places, packeting, and warehousing for products. Trusted and resilient logistics enterprises are targeted by any enterprise. Thus, any trusted logistics enterprise takes into consideration the number of R entails: Right Client, Right location, Right access time, Right goods and product, Right amount, Right price. These enterprises are in Egypt. Whilst En_1 is one of the global logistics providers that has been in business that founded 2009 that leverages labors, technology, resources, and knowledge to assist clients and be satisfied. En_2 Launched in 2010 as a shipping-SC and logistics enterprise, it has grown to become a comprehensive logistics service provider. En_3 where a group of logistics experts founded Advanced Shipping Logistics in 2014 with the goal of defining what a quality goods forwarding business should look like. En_4 where businesses in the Middle East can rely on the Egyptian container line for dependable, sustainable, and secure services. With many years of expertise and a strong dedication to upholding professional standards, this business has established a solid reputation as a reliable, flexible, and extremely quick shipping line. Ultimately, Figure 6 described the selection process for optimal ReEn has been performed by the rest of the partners in the chain, such as suppliers and manufacturers for sustainable logistics enterprises which satisfying identified key indicators based on pillars of sustainability through embracing Ind 5.0 techniques.

5.1 Identification of main principles for appraiser model: Generally Speaking.

First principal in this study, five Decision makers (DMs) have been Participated in appraisal process for these logistic enterprises this is first principle. Each DM's occupation as: DM_1 is

Administrator of IT and communications, DM_2 is logistic supervisor, DM_3 is chain manager, DM_4 is Logistics and Customer Service Coordinator, and DM_5 is General Manager. Table 4 showcases decision makers' biography who contributes to rate nominees of enterprises.

Table 4

Biography of Decision Makers

DMs	Department	Years of Experience	Qualification
DM_1	Information Technology	12	Professional Diploma
DM_2	Inventory Management	22	MBA
DM_3	Logistics Services	18	B. Sc
DM_4	Customer Services	12	B. Sc
DM_5	Operations Management	25	B. Sc

Second principle, volunteering the formed DMs panel for rating four alternatives based on six key indicators for Ind 5.0 techniques mentioned in Figure 7. According to this Figure our study identified these indicators based on their relationship with achieving three aspects of sustainability through implementing BDA, IoTs or AI. are technologies of Ind 5.0. for selecting optimal sustainable and resilience enterprise based on Ind 5.0's aspects.

5.2 Valuation of key Indicators' weight

5.2.1 Preparing for constructing decision matrices:

i. We determine the best and worst indicator. Herein, securing data (KI_6) is the best indicator, otherwise, Transparency (KI_3) is the worst indicator.
ii. DMs are appraising the best indicator over other indicators also, appraising indicators over worst one.
iii. Consequently, Eq. (9) begins to conduct its role in generating an aggregated decision matrices for indicator_{Best} (KI_6) over other key indicators_j and other indicators_j over indicator_{worst} (KI_3).

5.2.2 Generating key indicators weights

i. We employe Eqns. (10) and (11) to obtain the final indicators' weight.
ii. Figure 8 showcases these values which indicate that KI_6 is the best indicator based on the value of weight obtained from BWM based SVTNSs is 0.48. Contrary to KI_3, the worst indicator with the least weight value is 0.074.

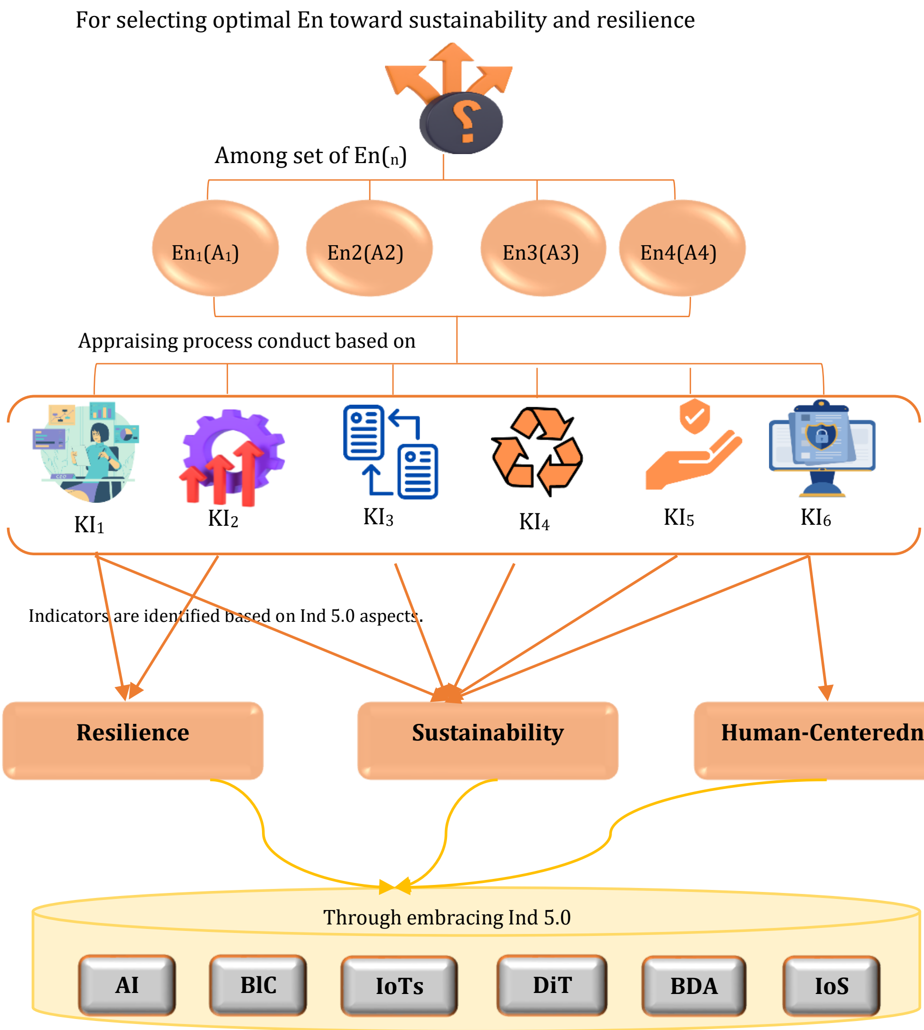

Fig.7. Hierarchal framework for selecting sustainable and resilience alternative based indicators of Ind 5.0

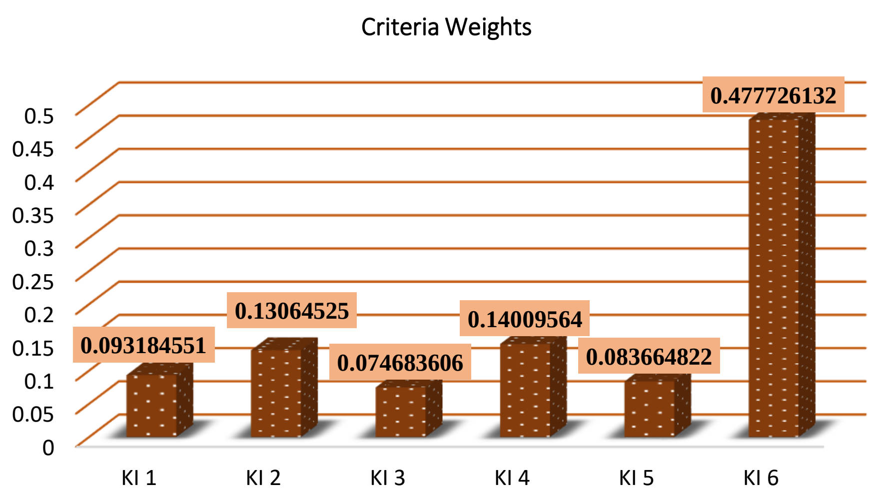

Fig. 8. weights values for criteria Based on SVTNSs-BWM

5.3 Recommendation of optimal resilience enterprise

i. Exploitation of the constituted DM panel for generating decision matrix for alternatives.
ii. Each DM contributes to constructing a decision matrix through appraising three alternatives based on identified indicators.
iii. Each decision matrix for each DM is converted into crisp value supported by score function in Eq. (8).
iv. Four decision matrices are assembled into one decision matrix through applying Eq. (9) as in Table 5.

5.3.1 First Ranker: Implementation of TOPSIS based on SVTNSs toward optimal ReEn.

i. The assembled decision matrix is normalized as in Table 6 using Eq. (12).
ii. This matrix in Table 6 is contributed to generating weighted decision matrix which represented in Table 7. through Eq. (13) normalized decision matrix multiply by weights have been obtained by BWM.
iii. Ranking alternatives of enterprises based on weighted decision matrix: Based on weighted decision matrix, we conduct various operations. Via Eqns. (14) and (15) positive ideal solution and negative ideal solution are obtained. Utilization of Eqns. (16) and (17) supported to get distance between the positive ideal solution and negative ideal solution.

Ultimately, optimal and worst enterprise can be identified through values of (cc_i) which indicated that alternative 1 (En_1) is most resilience on the contrary alternative 3 (En_3) is worst as in Figure 9.

Table 5
Aggregated Decision Matrix

	KI_1	KI_2	KI_3	KI_4	KI_5	KI_6
En_1	4.6567	6.577	5.457	4.283	5.2533	6.04
En_2	5.5833	4.1	4.7267	5.5933	6.7067	5.223
En_3	4.6833	6.08	6.1233	4.64	4.81	3.327
En_4	6.65	3.6	7.2333	5.623	5.997	5.51

Table 6
Normalized Decision Matrix based on TOPSIS-SVTNSs

	KI_1	KI_2	KI_3	KI_4	KI_5	KI_6
En_1	0.4268	0.627	0.458	0.4225	0.457	0.588
En_2	0.512	0.391	0.396	0.5517	0.5845	0.5092
En_3	0.4293	0.579	0.5139	0.4577	0.4192	0.3243
En_4	0.6096	0.3433	0.6072	0.5547	0.523	0.5372

Table 7
Weighted Decision Matrix based on TOPSIS-SVTNSs

	KI_1	KI_2	KI_3	KI_4	KI_5	KI_6
En_1	0.039	0.082	0.034	0.059	0.038	0.281
En_2	0.048	0.051	0.029	0.07	0.0489	0.243
En_3	0.040	0.075	0.039	0.064	0.0351	0.155
En_4	0.057	0.045	0.045	0.078	0.0437	0.257

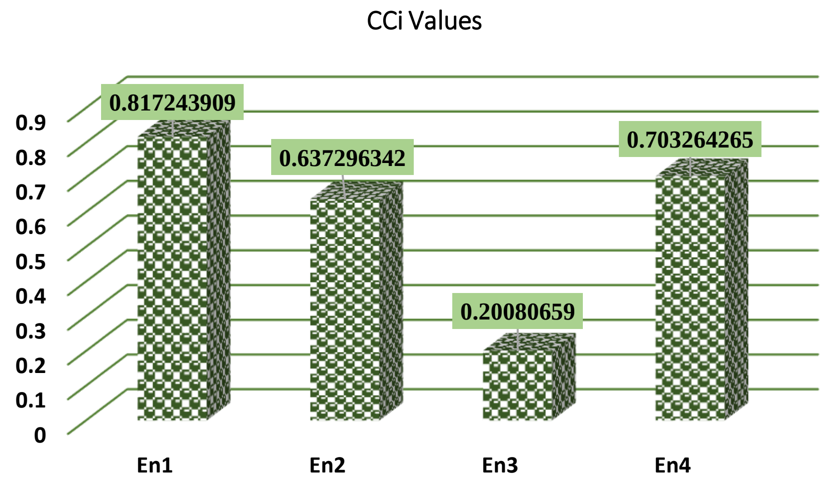

Fig. 9. Ranking enterprises from most resilience to least by TOPSIS based on SVTNSs.

5.3.2 Comparative Ranker: WSM based on SVTNSs toward optimal En.

i. Eqns. (20), (21) and (22) used to normalize the aggregated matrix which is mentioned in Table5. Table 8 represents normalized matrix.
ii. Normalized matrix and BWM's weights are contributed to generate weighted decision matrix via Eq. (23) as listed in Table 9.
iii. The values of global score $V(A_{ij})$ are computed through employing Eq. (24). According to these values the optimal and worst ReEn is determined.
iv. Figure 10 showcases that En_1 is the optimal with value 0.27. otherwise, En_3 where its value is 0.207.

Table 8
Normalized Decision Matrix based on WSM-SVTNSs

	KI_1	KI_2	KI_3	KI_4	KI_5	KI_6
En_1	0.215	0.323	0.231	0.213	0.231	0.3005
En_2	0.259	0.201	0.201	0.278	0.295	0.2599
En_3	0.217	0.299	0.260	0.230	0.211	0.166
En_4	0.308	0.177	0.307	0.279	0.263	0.27

Table 9
Weighted Decision Matrix based on WSM-SVTNSs

	KI_1	KI_2	KI_3	KI_4	KI_5	KI_6
En_1	0.020	0.042	0.017	0.029	0.019	0.144
En_2	0.024	0.026	0.015	0.038	0.025	0.124
En_3	0.020	0.039	0.019	0.032	0.0177	0.079
En_4	0.029	0.023	0.023	0.039	0.022	0.131

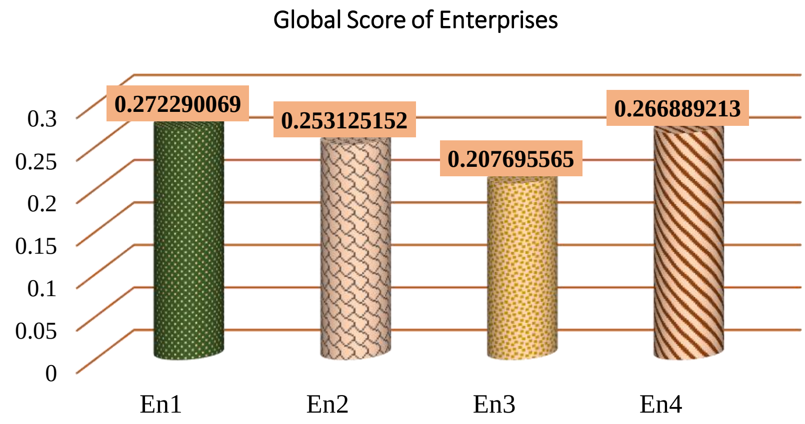

Fig.10. Ranking enterprises from most optimal to least by WSM based on SVTNSs.

6. Repercussions of The Model's Results: Discussion

Herein, this section showcases and discusses the appraiser Model's results which are obtained from applying this model in real cases of enterprises. As was previously noted, we connected with enterprises that embracing Ind 5.0 technologies in its operations and in its chain whether inside or outside to be candidates in our model. Thus, our model played avital role in appraising sustainability and resilience of the candidate enterprises. The appraisal process is performed based on a variety of indicators which related to Ind 5.0 aspects (i.e., sustainability, resilience, human- centeredness). Based on the identified indicators, the best and worst En is recommended. So, to recommend best and worst En, we leveraged MCDM methods united with SVTNSs to perform set of stages.

First Stage, we cooperated and communicated with DMs panel who related to our scope to contribute to appraising process for indicators and En_S. This panel consists of 5 members who fill out questionnaires to appraise identified indicators.

Second Stage, we received these appraises and analysis it to obtain indicators' weights. In this stage BWM technique of MCDM works to get indicators' weights under uncertainty theory represented in SVTNSs. For BWM, we determined the best and worst indicators as KI_6 and KI_3 respectively. The union of two techniques resulted in six weight values for indicators which are represented in Figure 7. That indicates KI_6 is the highest indicator with weight value is 0.477 Followed by followed by KI 4 with 0.140 weight value until least indicator KI_3 with 0.075 weight value.

Third Stage, according to the constructed mode this stage branched into 2 branches which have same goal entailed in recommend optimal En based on Ind 5.0 aspects. That means, in this stage we employed two ranker techniques of MCDM entailed in TOPSIS and WSM. These techniques work under the control of SVTNSs. The two ranker techniques are common in the following steps.

Step 1: we cooperate with DMs panel to appraise candidates of Ens.

Step 2: we are analyzing their questionnaires and aggregate their preferences as listed in Table 3. After that each ranker operates solitary in its branch toward obtaining optimal En.

The first branch includes TOPSIS based on SVTNSs.

Step 3: The aggregated matrix is normalized as in Table 4, and we leverage BWM's weights based on SVTNSs to generate weighted decision matrix as listed in Table 5.

Step 4: Table 5 aid to obtain positive ideal solution and negative ideal solution to get distance between the positive ideal solution and negative ideal solution after that CC_i alternatives values as in Figure 8. According to this Figure we ranked the candidates based on CC_i values as $En_1 > En_4 > En_2 > En_3$.

The Second branch WSM based on SVTNSs (Compared/corresponding Ranker)

Step 3: The aggregated matrix is normalized as in Table 6, and BWM's weights based on SVTNSs are utilized to generate weighted decision matrix as listed in Table 7.

Step 4: Table 7 is catalyst to rank the candidate based on obtained enterprises' global scores values $V(A_{ij})$ as mentioned in Figure 10. The candidates are ranked as En_1> En_4> En_2> En_3.

Figure 11 exhibits ranking of candidates Ens, we concluded that the enterprises' ranking is same for two ranker techniques. So, two rankers' techniques are ranking Ens as En_1> En_4> En_2> En_3. With different values of candidates but these techniques are same in ranking.

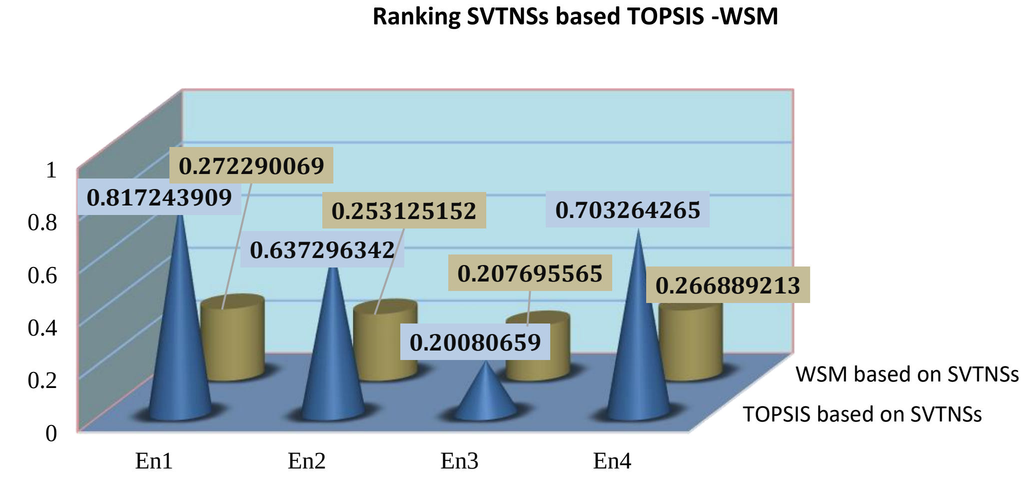

Fig.11. Ranking enterprises based on two rankers' techniques

7. Comparative Analysis

To validate our appraiser model, we applied another method after applying this model on real En_s.

Herein, we applied other techniques of MCDM with uncertainty theory Single Value Neutrosophic Sets (SVNSs) is other sub-branch of neutrosophic theory to support DMs in ambiguities and uncertainty appraising. Thus, Analytic Hierarchy Process (AHP) technique to obtain indicators' weights. Moreover, SVNSs based AHP's weights are utilized by TOPSIS and WSM based on SVNSs to rank En_s. This study follows the following stages toward resilience and sustainable En.

First Stage, we volunteered DMs who interested in our search area and leveraged them to rating identified KI_n.

Second Stage, AHP based on SVNSs is starting to perform its function through utilizing scale of [43] to obtain KI_n's weights. The results of AHP based on SVNSs for indicators are KI_1=0.12, KI_2 =0.14, KI_3=0.109, KI_4=0.16, KI_5=0.197, and KI_6= 0.28. The values indicated that KI_6 is highest indicator with 0.278value otherwise KI_3 is least indicator with 0.109 value.

Third Stage, we follow the same steps that are mentioned above. Herein, TOPSIS and WSM are utilized but under control of SVNSs. The results of ranker techniques are exhibited as En_1> En_4> En_2> En_3.

The two ranker techniques based on SVNSs are recommended and ranking the candidates as the same. Also, the recommendations of these techniques are like appraiser model's recommendations with the difference values for each candidate in each utilized technique as in Figure 12.

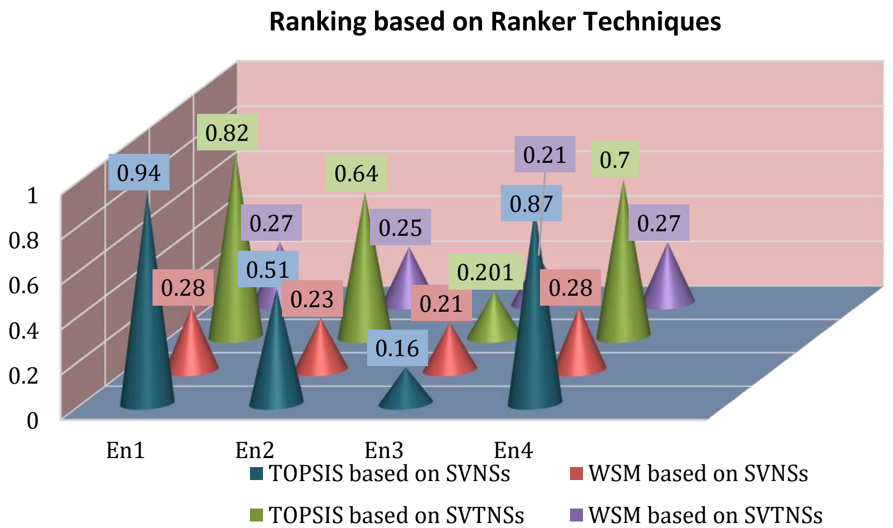

Fig. 12. Recommended enterprises based on various rankers' techniques.

8. Conclusions

SC is the backbone of the business sectors. The increasing complexity and vulnerability of global SCs has made the concept of Resilience in SC an important concept in recent years. Hence, this study can be utilized as a normative reference for the disciplines of operations and SC when examining the thematic domain of SC disruptions and enhancing it toward resilience and sustainability. To achieve that, a set of comprehensive research inquiries were delineated. The initial research inquiry examined the present condition of emerging technologies as AI and BDAs, IoTs…etc. within the SC literature over the past ten years. Whilst these technologies fall under umbrella of Ind4.0 after that Ind 5.0

The objective of this study was to examine the application of Ind 5.0's technologies in various SC industries. Additionally, the study aimed to conduct survey for the journals that publish research on our interested area through conducting bibliometric analysis. The state of the art in ReSSC research may be gained through bibliometric analysis, which can also highlight practical implications for ReSSC scholars and practitioners.

Furthermore, the study aimed to analyse the data collection techniques and research methods employed in these studies. It is important to emphasize that most of the studies examined pertain to the utilization of technologies of Ind 5.0. SC disruptions are frequently characterized by the need to make prompt and precise decisions within challenging and intricate circumstances. In the context of enhancing decision-making capabilities, the utilization of Ind 5.0 technologies has the potential to mitigate uncertainties and minimize risks by addressing informational deficiencies. However, the responsibility of transitioning from insights to actions lies with the DMs within an enterprise. These DMs must interpret the insights provided by Ind 5.0 aspects but often rely on their intuitive judgment and past experiences to determine the appropriate course of action. Nevertheless, the ultimate process of selecting the resilient and sustainable firm among the various enterprises might be positively or negatively impacted by the opinions of experts.

Hence, this study advances the field of study by providing an innovative model for appraising resilience and sustainability for logistics enterprises that embracing Ind 5.0 notion in its operation and chain. MCDM techniques as BWM, TOPSIS and WSM are utilized under authority of uncertainty theory SVTNSs in constructed appraiser model. Also, AHP, TOPSIS and WSM under authority of another type of uncertainty theory SVNSs as comparative model. Two models are applied in an industrial application as a case study for four logistics enterprises which embrace notion of this study.

8.1 Theoretical Contributions

This study attempts to cover several theoretical aspects where it is important for any sustainable enterprise to achieve theses aspects toward ReSSC:

i. Operational Aspect: we discussed the importance of emerging intelligent technologies as Ind 5.0 for enterprises in their operations especially, SC which effect by any fluctuating and dynamism environment. Implementation of such techniques are Positively affected on resilience of SC to be able to treat with unpredicted and uncertainty environment. The partners in SC can exchange information amongst themselves easily through IoS, BDAs, BiT. Although these techniques contribute to minimizing waste and labor.
ii. Financial and Profit Aspect: utilizing BDA permit for stakeholders to collect data and analysing the collected data. The outcomes for processing of analysing data are appreciate and awareness the market's overall behaviour. Through applying AI technique, the stakeholders can predict what will happen and permit them to conduct predictive analysis to be proactive.
iii. Society Aspect: through employing robot or IR or robot instead of human is Secure human life in hazard situations and jobs. Also, utilizing IEoTs equipment to attach to human for tracking his behaviors and recognize workers' working hours. Also, attached to product and machine to aid DMs to make accurate decision in suitable time.
iv. - Practical Aspect: Also, this study covered practical aspects through constructing appraiser model to appraising sustainability and resilience for enterprises which embracing Ind 5.0 aspects in its operations and chain.

- We communicated and cooperated with four enterprises which provide logistics services as mentioned previously.
- BWM united to SVTNSs are contributed to analyze indicators of enterprises based on aspects of Ind 5.0 through obtaining indicator’s weights.
- Two MCDM rankers, TOPSIS and WSM are united to SVTNSs to rank enterprises and recommend the best and worst one.
- To validate our appraiser model, we follow two ways:
  - Firstly, we applied this model to a real case study.
  - Secondly, we follow another method to ensure validity of our appraiser model where we compared this model with other models.
- The results for two ways indicated that KI_6 is the highest weight otherwise KI_3 is least one. Also, the role of TOPSIS and WSM integrated with SVTNSs no less important BWM based on SVTNSs where these techniques are recommended the optimal and least enterprise and these techniques generated the same recommendations as $En_1 > En_4 > En_2 > En_3$ where En_1 is most resilience and sustainable according to indicators of Ind 5.0 aspects.

Ultimately, after we are applying our constructed model in real enterprises also, comparing its results with comparative techniques with another branch of neutrosophic theory (i.e., SVNSs). We made sure that our appraiser model was valid.

9. Future Directions

In this section, we exhibit various directions for future studies:

First direction, Different types of neutrosophic sets, including Trapezoid, Bipolar, and Type-2 sets, can be employed in this framework for conveying uncertainty in various manners.

Second direction, exploiting other techniques as in [44] exploited cognitive computing to develop computerized paradigm to elicit human mental processes. The computer can read and perform activities that are capable of being performed by the human brain, such as natural language processing, data mining, pattern recognition, and self-learning algorithms. Moreover, appraising the enterprises that embrace these notions.

Third direction, toward resilience and sustainable logistic enterprises, it is important to take into considerations other aspects such as green financial, emerging economies, and green Production Strategies.

10. Limitations and Challenges

Like earlier studies, the current study contains several restrictions. The limitations of this study are outlined in this section. We are discussing conceptual limitations and challenges as:

i. This study focuses on a limited number of indicators related to aspects of Ind 5.0. but this limitation resulted from conducted survey for enterprises which implementing technologies of Ind 5.0. In future studies, we can release this limitation through analyzing other indicators with more aspects.
ii. Our case study was limited to logistics enterprises. We can be expanded to manufacturers, retailers and other partners involved in the chain.
iii. The constructed appraiser model is applied on the logistics enterprises in Egypt only.
iv. As [45] explained where there is no analysis of the relationships between the indicators. This weakness can be addressed in future studies through leveraging specialized techniques such as Decision-making trial and evaluation laboratory (DEMATEL) and other techniques.

Author Contributions

Conceptualization, M.M.I, A.F.A and M.M..; methodology, M.M.; software, M.M.; validation, A.F.A., M.M.I. and M.M.; formal analysis, Z.A.; investigation, A.F.A., M.M.; resources, Z.A.; data curation, M.M.I.; writing—original draft preparation, M.M., M.M.I., Z.A.; writing—review and editing, A.F.A.; visualization, M.M.; supervision, A.F.A., M.M.I.

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Data Availability Statement

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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