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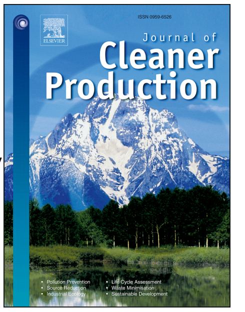

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Mohamed Abdel-Basset: Investigation, Methodology, Resources, Supervision, Visualization, Writing - original draft, Writing - review & editing.

Rehab Mohamed: Conceptualization, Methodology, Writing - review & editing.

Karam Sallam: Investigation, Validation, Writing - review & editing.

Mohamed Elhoseny: Validation, Writing - Review & Editing

A Novel Decision-making Model for Sustainable Supply Chain Finance under Uncertainty Environment

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A Novel Decision-making Model for Sustainable Supply Chain Finance under Uncertainty Environment

Abstract

Earlier studies in the sustainable supply chain (SSC) have been introduced since its submission, yet, research of sustainable supply chain finance (SSCF) is still insufficient. Also, these studies did not consider uncertainty in corresponding with the uncertain environment of the supply chain deficiencies, the integration of sustainable development and supply chain finance is essential. Hence, this paper evaluating a set of measurements to provide sustainable supply chain finance in the gas industry under uncertainty. In this paper, TODIM (acronym in Portuguese for Interactive and Multi-criteria Decision-Making) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods based on the Best-Worst Method (BWM) will be applied according to neutrosophic set to increase the accuracy of evaluation under uncertainty. According to expert evaluations, the results show that financial attributes and product/service management are the most substantial metrics for enhancing a firm's performance and obtain sustainable supply chain finance. Moreover, obtain price and cost information, consider product/service level, technology management, and demand management are important to build sustainable supply chain management.

Keywords: sustainable supply chain finance, TODIM, TOPSIS, BWM, Neutrosophic set, triple bottom line.

1. Introduction

To maintain a balance between the *triple bottom line* (TBL) in supply chain (SC) processes, SCS has involved significant attentiveness practical and academic (Dubey, Gunasekaran, Papadopoulos, Childe, Shibin, & Wamba, 2017). Sustainable development necessitates several political commitments in order to achieve equilibrium among the triple bottom line sides (economic, environmental, and social) (Tseng, Wu, Hu, & Wang, 2018). Observance of the social and environmental effects and the economic and financial results are significant to retain the sustainability of the SC.

Supply chain finance (SCF) assists in solving financial pressures with a minimum interest rate and more fixable payment conditions by providing alternate financial solutions that benefit supply chain sustainability (Wuttke, Blome, Heese, & Protopappa-Sieke, 2016). SCF ensures an efficient finance flow through the supply chain phases with the flow of goods and information (Gelsomino, Mangiaracina, Perego, & Tumino, 2016). Although the importance of goods, information and finance integration among supply chain phases, the finance flow management in the supply chain differs by comparing with goods and information flow management. Although much research has discussed SCF, still there is an absence of considering social and environmental aspects.

This study focuses on the Egyptian gas industry, which ranked within the top 20 countries globally for natural gas reserved, natural gas production and consumption. Natural gas plays a significant role in Egypt's electricity production, whereas approximately 70% of Egypt's electricity based on natural gas. Environmental and social sustainability became the most important element of gas SC management performance and its business operations as well as economic sustainability. The main contribution is to define which management properties should be developed to reinforce SSCF in the gas industry, which will be discussed in this research.

To achieve this objective, TODIM and TOPSIS methods will be adopted to identify attributes that enhance the SSCF model. Especially, this study uses a neutrosophic set to improve the recognition of uncertainty environment in the SCF field and to reduce the vagueness in expert's judgments. To boost the performance of the decision-making process (DMP), the evaluation of criteria will be determined according to the *Best-Worst method* (BWM). The concentration of this study is to evaluate the gas industry in Egypt, which is one of the most competitive industries in the country. The main contributions of this paper are listed below:

- This research illustrates the greatest importance of SCF in order to ensure the sustainability of the supply chain.
- A committee of experts in supply chain and financing evaluated the criteria weights, and the evaluation is considered the uncertainty in the DMP in the field of the supply chain by obtaining a neutrosophic evaluation scale.
- The TOPSIS method increases the attention of the alternative's performance based on the best and worst solutions.
- By evaluating the five aspects using two different decision-making methods (TOPSIS and TODIM), the decision-maker has more flexibility for making decisions.

The remainder of the paper is organized as follows: Section 2 represents a review of related studies on supply chain sustainability, supply chain finance, multi-criteria decision making, and supply chain finance measurements. Section 3 presents the proposed methodology background. The result of the study is discussed in Section 4. Finally, Section 5 concludes the implications of the study.

2. Related Works

This section provides a review of SCF, sustainable development, and explores a set of measurements that effect sustainable supply chain finance.

2.1. Supply Chain Finance (SCF)

SCF is able to enhance the performance of SC by providing the buyer's easer payment conditions and better suppliers' financing (Wuttke, Blome, Heese, & Protopappa-Sieke, 2016). With the huge internet and telecommunication technology revolution since the early 1990s, supply chain finance enhanced the sensitiveness of processing financial transactions (Zhang, Zhang, & Pei, 2019). SCF include the integration of supply chain infrastructure, supply chain parties (e.g., buyers, supplier, and banks), and supply chain phases (Chakuu, Masi, & Godsell, 2019). Liebl et al. defined SCF as a 'key term' that governing and managing the finance flow along with the supply chain phases (Liebl, Hartmann, & Feisel, 2016). The sequence of SCF starts from delivering the product/service to the buyer (the buyer payment according to dates agreed by both parties), and the buyer's finance institution confirms the delivery and provides the receipt. Following this confirmation receipt, the supplier receives its amount from the buyer's financial institution. It supports the integration of suppliers, buyers, and service providers (Caniato, Gelsomino, Perego, & Ronchi, 2016), in addition, to differentiating the alternative source of competitive advantages (Wuttke, Blome, Heese, & Protopappa-Sieke, 2016). SCF parties manage and coordinate delivery of financial services, and they are classified as primary (e.g., supplier and buyer) and supportive how provides a service to the primary (e.g., service provider and banks) (Chod, Rudi, & Van Mieghem, 2010). Du et al. built a new type of SCF platform based on blockchain technology (Du et al., 2020). In order to investigate the outcomes of the supply chain finance adoption decision, et al. developed a SCF adoption model according to three types of SCF adoption (Wang, Wang, Lai, & Liang, 2020). But most of these studies have some deficiencies in considering the uncertainty of information which is the main contribution of this research.

Some of the other studies of supply chain finance are shown in Table 1.

Table 1: Studies about supply chain finance

Authors	Scope	Methodology	Metrics
Tseng, M. L., Wu, K. J., Hu, J., & Wang, C. H. (2018)	Develop a sustainable supply chain finance model under uncertainty	Fuzzy TOPSIS	Social, environmental, and economic aspects
Tseng, M. L., Lim, M. K., & Wu, K. J. (2019)	Analyzing the benefits and costs in the textile industry	Fuzzy TODIM	Firms operational capability, financial practices, coordination among the SC, among others
Gelsomino, L. M., Mangiaracina, R., Perego, A., Tumino, A., & Ellinger, A. (2016)	Classification of SCF according to the main themes and methods	Literature review	The review is based on 119 papers (2000-2014)
Arani, H. V., & Torabi, S. A. (2018)	Studied comprehensive supply chain master planning problem by integrates physical and financial plans	Mixed possibilistic-stochastic programming	The model aims to determine the production, inventory, and outsourcing, among others.
Shen, K. Y., Hu, S. K., & Tzeng, G. H. (2017)	Financial modeling for the life insurance industry	DEMATEL, ANP, and rough set theory	Capital structure, payback, operational efficiency, revenue quality, and capital efficiency
Ma, H. L., Wang, Z. X., & Chan, F. T. (2020)	Studied the impact of supply chain collaboration factors on SCF	Interpretive structural modelling	Information sharing, decision synchronisation, integrated SC process, among others
Jia, F., Blome, C., Sun, H., Yang, Y., & Zhi, B. (2020)	How SCF providers deal with uncertainty and develop capabilities	Conceptual framework	Divided the criteria into inclusion and exclusion criteria

2.2. Sustainable Development (SD)

Sustainability indicates the business process that enhances economic, social, and environmental aspects through time (Rodriguez, Svensson, & Otero-Neira, 2019). Sustainable development is a process of Triple Bottom Line activities development (Keeys, & Huemann, 2017). As Hong et al. mentioned that organizations' competitive advantages may be achieved by using sustainable guidance as a strategic plan by integrating business models with TBL (Hong, Jagani, Kim, & Youn, 2019). In addition, environmental, social, and economic practices must be included in the organization's mission and vision (Wijethilake, 2017). While an integrated framework was built to show how SCF providers deal with uncertainty in order to improve the whole SCF sustainability (Jia, Blome, Sun, Yang,

& Zhi, B. 2020). That's why, to achieve sustainability, business models must be adjusted to sustainability direction and applied to the sustainability plans and strategies according to considering TBL principles in decision making. However, insufficiency linking strategies and sustainability practices may cause an organization to fail in their sustainability plans.

2.3. Multi-criteria Decision Making (MCDM)

MCDM techniques proved efficient results in the evaluation process in many types of research. Especially in supply chain evaluations in different issues, MCDM methods are sufficient to find the best evaluation results based on appropriate criteria. Pineda et al. provide integration between MCDM model and data mining to evaluate the airline supply chain finance performance (Pineda, Liou, Hsu, & Chuang, 2018). In the same point of airlines and airports assessments, Lu et al. proposed a framework according to *Decision Making Trial and Evaluation Laboratory* (DEMATEL) based on Analytical network process (ANP) with the aim to evaluate the performance of sustainable development of international airports (Lu, Hsu, Liou, & Lo, 2018). The socially sustainable supply chain was investigated using Best-Worst Method and applied on footwear manufacturing company by Munny et al. (Munny, Ali, Kabir, Moktadir, Rahman, & Mahtab, 2019). Moreover, a sustainable supply chain system on the gas and oil sector was evaluating environmental and social aspects by Gardas et al. (Gardas, Raut, & Narkhede, 2019).

As well as in the environment of uncertainty, supply chain management concerns were evaluated through several MCDM techniques. Sustainable supplier selection problem was identified according to the *Analytical Hierarchy Process* (AHP) under a fuzzy environment (Xu, Qin, Liu, & Martínez, 2019). According to the supplier selection problem under uncertainty, the TOPSIS technique under type-2 neutrosophic number was proposed (Abdel-Basset, Saleh, Gamal, & Smarandache, 2019). An efficient *Sustainable Supply Chain Risk Management* (SSCRM) framework based on CRITIC and TOPSIS methods under a fuzzy environment and this framework applied magnificently in a real case company (Rostamzadeh, Ghorabaee, Govindan, Esmaeili, & Nobar, 2018).

2.4. Supply Chain Finance Measurements

According to existing literature (Tseng, Wu, Hu, & Wang, 2018; Mathivathanan, Kannan, & Haq, 2018; Tseng, Wu, Lim, & Wong, 2019; Tseng, Lim, & Wu, 2019; Liao, Hu, & Ding, 2017; Wuttke, Blome, & Henke, 2013), there are several measurements that influence supply chain finance. Technology Management and Strategy (C1) includes technology forecasting and technology roadmap that collaborate to encourage sustainability performance. As a result of unexpected demand forecasting and uncertainty caused by market competition, Demand Management and Forecasting (C2) became significant to improve sustainable supply chain finance. Demand management is the ability to equilibrium customer demands accurately according to forecasting techniques. Resource Management (C3) is the process of manage equipment, time, material, finance, and people professionally. So, the right resource must be assigned to the right task. The confidence of the organization to meet the demand for products or services is known as Delivery Confidence of Demand (C4). Inventory Control and Efficiency (C5) is the process of maximize the efficiency of the company's inventory without affecting customer satisfaction. The previously mentioned measurements are considered as operational capacity (AS_1) that manages customer demand by updating forecasted demands in order to improve a customer satisfaction level.

The identification of environmental aspects (AS_2) is a significant phase to recognize the influence of specific business on our plant directly or indirectly. Environmental Policies and Practices (C6) oblige the organization according to lows and regulations to manage their activities in order to minimize water and air pollution and protect natural resources. As a result of some economic activities, some natural assets may be influenced negatively which incurs the firm extra environmental costs (C7). In order to protect the natural resources against the negative influence of economic activities, there are different electric monitoring devices and other environmental science applications that assist do this process known as green technology (C8).

The social aspects (AS_3) significantly influence sustainable supply chain finance as its one of the TBL. Supplier relationship management (C9) is the strength to manage and preserve relationships among suppliers for a long time. In order to improve the cooperative relationship between stockholders and customers, the customer/stockholder relationship (C10) must be managed and enhanced in the agreed manner that satisfies both sides. To ensure more efficient supply chain finance, the buyer-supplier relationship (C11) must be stronger that result in benefits for both parties.

The process of production, developing, marketing, and maintaining the product at all stages of the product lifecycle is considered as product/service management aspects (AS_4). Service level performance management (C12) is evaluating how well the organization able to improve and support the level of service provided to the customer. Management of the service delivery process to the customer as agreed is known as customer service availability (C13). Product renovation that covers customer segments (C14) is one of the competitive advantages that help the organization to provide differentiated service/product to different customer segments and allow service diversity according to rapid demand changes. The budgets that determined for buying raw materials and natural resources needed in the manufacturing process is known as row material procurement (C15). Product/service quality (C16) refers to the company's ability to offer products /services that suit market requirements and product /service quality standards.

The financial aspects have a critical impact on both sustainable development and supply chain finance. The information flow is one of the most important aspects that improve supply chain sustainability, especially financial information sharing (C17). Financing the supply chain through bank loans (C18) denotes to the short-term and medium-term financing. Providing price and costs information (C19) improves the competitive advantage that allows the company to determine the price according to the competitor's prices, which improves the business process. Supplier integration between service providers (C20) alludes to the unification through a progression of interoperability between providers. Supply chain risk recovery level (C21) may influence the supply chain finance while the supplier fails to pay their commitments.

3. Methods

The methods used in this research are, the Best-Worst method, TOPSIS, and TODIM. All these methods are based on the neutrosophic set in order to increase the accuracy of the evaluation process.

3.1. Neutrosophic set

Usually, in multi-criteria decision-making evaluation data may be incomplete and uncertain. Neutrosophy was introduced by Florentin Smarandache (1998) as a generalization of fuzzy set and intuitionistic fuzzy set to handle the decision-making process under uncertain environment (Long, Ali, Khan, & Tu, 2019). Many decision making improved the efficiency of neutrosophy to obtain the most accurate decision such as healthcare sector (Mondal, & Pramanik, 2015), supply chain management problems (Sarma, Das, Bera, & Hezam, 2019), and other decision support problems in project management field (Abdel-Basset, Atef, & Smarandache, 2019).

3.2. BWM

BWM is based on a pairwise comparison between best and worst criteria with the rest of the criteria. However, to handle the inconsistency of AHP comparison, DM should identify the most preferred criterion and the least preferred criterion and apply the pairwise comparison between these two criteria and the other criteria. The first vector is Best-to-

Others, and the second is Worst-to-Others. That is why the BWM value is requiring fewer comparisons than AHP. In addition to that, BWM involves less complexity of comparisons as it exploits only whole numbers. Moreover, BWM is distinguished because redundant comparisons are eradicated. The model of this method is used to find the weight of each selection criterion (Rezaei, Nispeling, Sarkis, & Tavasszy, 2016). BWM shows reliable results in many fields such as green practices and innovation (Gupta, & Barua, 2018), evaluation of the technologies for ballast water treatment (Ren, 2018), logistics performance measurements (Rezaei, van Roekel, & Tavasszy, 2018), research and development performance measurement (Salimi, & Rezaei, 2018), supplier selection (Gupta, & Barua, 2017). The steps of the BWM are five clarified as follows:

- Step 1: The set of criteria A must be defined by a group of experts $k = \{ k_1, k_2, \dots, k_m\}$ according to the nature of the evaluation problem as $A = \{c_1, c_2, \dots, c_n\}$.
- Step 2: From the set of criteria A, the Best A_B and Worst A_W criterion will be determined according to decision-maker preferences.
- Step 3: Construct the best-to-other vector $A_B = \{a_{B1\,,} a_{B2\,,} \dots a_{Bn}\}$, where a_{Bn} is the preference of criteria n compared by the Best criterion B using a (1-9) scale.
- Step 4: Construct the others-to-worst vector $A_w = \{a_{w1\,,} a_{w2\,,} \dots a_{wn}\}$, where a_{wn} is the preference of criteria n compared by the Worst criterion W using a (1-9) scale.
- Step 5: Rezaei (2015) proposed BWM model that evaluate the weight of the criteria w_n :

$$\min \max \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\}$$

s.t.

$$\sum_j w_j = 1$$

$$w_j \geq 0 \quad , \quad \text{for all } j \qquad (9)$$

The equivalent model is:

Min ε

s.t.

$$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \varepsilon \text{ , for all j}$$

$$\left|\frac{w_j}{w_w} - a_{jW}\right| \leq \varepsilon \text{ , for all j}$$

$$\sum_j w_j = 1$$

(10)

$$w_j \geq 0 \text{ , for all j}$$

3.3. Technique in Order of Preference by Similarity to Ideal Solution (TOPSIS)

Order of Preference by Similarity to Ideal Solution (TOPSIS) is an effective MCDM technique that was introduced by Hwang and Yoon (1981). TOPSIS ranks the alternatives based on the distance of alternatives to the *Positive Ideal Solution* (PIS which is the most desired solution) and *Negative Ideal Solution* (NIS which is the least desired solution) to find the best alternative (Zyoud, & Fuchs-Hanusch, 2017). The financial performance evaluation process was applied in the sector of technology companies in Turkey (Bulgurcu, 2012). The steps of TOPSIS are clearly discussed as follows:

- ❖ Step 1: Clarify the MCDM problem with its criteria and alternatives and build a decision matrix that evaluates the alternatives based on the selection criteria.
- ❖ Step 2: The decision matrix is normalized using Equation 11.

$$R = (r_{ij})_{m\times n} = {x_{ij}}\Big/\left(\sqrt{\sum_{i=1}^{m} x_{ij}^2}\right) \tag{11}$$

where x_{ij} is the degree of alternative *i* according to criterion *j*.

- ❖ Step 3: Using Equation (12), calculate the weighted normalized matrix:

$V = (v_{ij})_{m\times n} = w_j \times r_{ij}$ where w_j presents each criterion's weight. (12)

- ❖ Step 4: Using the following Equations 13-16 to recognize the positive ideal solution (PIS) and negative ideal solution (NIS) (de Farias Aires, & Ferreira, 2019):

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} \tag{13}$$

$$v^+ = \{(max_i\, v_{ij}\; |j \in J_b), (min_i\, v_{ij}|J \in J_{nb})| \;\in [1 \dots m]\,\}. \tag{14}$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} \tag{15}$$

$$v^- = \{(min_i v_{ij}\; |j \in J_b), (max_i\, v_{ij}|J \in J_{nb})| \;\in [1 \dots m]\,\}.$$

(16)

where J_b is a benefit criterion, and J_{nb} is a cost criteria

- Step 5: Compute the distance of each alternative to the PIS and NIS to evaluate the differentiation of alternative *i* using Equation 17 and 18:

$$d_i^+ = \sqrt{\sum_{j=1}^{m} (V_i - V_j^+)^2}$$

(17)

$$d_i^- = \sqrt{\sum_{j=1}^{m} (V_i - V_j^-)^2}$$

(18)

- Step 6: According to Equation 19 rank the alternatives based on the closeness coefficient of each one:

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

3.4. TODIM

TODIM is a Multi-criteria Decision-Making method that used to rank alternatives according to benefits and costs criteria. Rather than just evaluate alternatives to determine the optimal choice, TODIM is able to distinguish between risk-based alternative and the definite selection. In business decision-making issues, this method enhances the competitive advantages to the firms according to the evaluation of several attributes. Basically, the TODIM method based on pair comparison between criteria that reduce the inconsistency of the comparison process. This method adapted to the portfolio allocation process and the impact of TODIM parameters were analysed (Alali, & Tolga, 2019). In order to make an optimal decision according to online product reviews, TODIM was applied to evaluate alternate products through customer's opinion (Liu, & Teng, 2019). The steps of the TODIM method as follows:

- Step 1: Build the decision matrix that consists of the evaluation of decision-maker D_k about alternatives A_m according to corresponding criteria C_n.

$$[d_{ij}]^k{}_{m\times n} = \begin{bmatrix} d^k{}_{11} & d^k{}_{12} & \dots & d^k{}_{1n} \\ d^k{}_{21} & d^k{}_{22} & \dots & d^k{}_{21} \\ \dots & \dots & \dots & \dots \\ d^k{}_{m1} & d^k{}_{m2} & \dots & d^k{}_{mn} \end{bmatrix}_{m\times n}$$

(20)

- Step 2: Define reference criterion *r* that has the highest importance weight. Then, calculate W_{rn} by dividing the weight of criterion *n* by reference criterion *r*.

$$W_{rn} = {}^{w_n}/_{w_r}$$

(21)

- Step 3: Find the dominance of each criterion over others according to alternative *i* and alternative *j* using Equation 22 and 23 to calculate dominance matrices.

$$\delta(A_i, A_j) = \sum_{c=1}^{n} \emptyset_c(A_i, A_j), \forall(i, j)$$

(22)

where,

$$\delta(A_i, A_j) = \begin{cases} \sqrt{\frac{W_{rn}(d_{in}-d_{jn})}{\sum_{c=1}^{n} W_{rn}}} if \ (d_{in} - d_{jn}) > 0 \\ o, if \ (d_{in} - d_{jn}) = 0 \\ -\frac{1}{\theta}\sqrt{\frac{(\sum_{c=1}^{n} W_{rn})(d_{jn}-d_{in})}{W_{rn}}} if \ (d_{in} - d_{jn}) < 0 \end{cases}$$

(23)

According to Equation 23, there are three types of satisfaction. First, $(d_{in} - d_{jn})$ is positive that means there's gain. Second, $(d_{in} - d_{jn})$ is zero, and thirdly, $(d_{in} - d_{jn})$ is negative, which means there's cost. Where θ represents the reduction factor of losses according to problem nature.

- Step 4: Calculate the final dominance matrix normalization to obtain the global value of alternative *i* using Equation 24.

$$\varepsilon_i = \frac{\sum \delta(A_i, A_j) / \min \sum \delta(A_i, A_j)}{\max \sum \delta(A_i, A_j) - \min \sum \delta(A_i, A_j)}$$

(24)

- Step 5: Rank the alternatives according to ε_i values. Where the best alternative that has the highest value.

3.5. Proposed Framework

In this study, we proposed an integrated framework that evaluates a set of measurements in order to provide sustainable supply chain finance under uncertainty. The importance of this study lies in the consideration of uncertainty in the evaluation process. That is why the MCDM techniques are applied under the neutrosophic environment that considers truth membership, indeterminate membership, and falsity membership. TOPSIS focuses on comparing the alternatives with the positive and negative ideal solutions, while TODIM do the comparison based on pairwise comparison between criteria that reduce the inconsistency of the comparison process. Both methods (TOPSIS and TODIM) are based on the BWM that determine the weight of the criteria according to the pairwise comparison between the best and the worst criterion among the rest of them. Figure 1 shows the phases of the proposed framework and its details as follows:

- Step 1: apply the BWM to determine the weights of the aspects. (steps in details in section 3.2)
  - According to the decision-makers' preferences, determine the best criterion and the worst criterion.
  - Construct the best-to-other and others-to-worst vector according to the pairwise comparison.
  - Find the weight vector using the BWM model (9, 10).
- Step 2: a group of decision-makers' construct an evaluation matrix to each measurement aspects using the triangular neutrosophic scale (Table 2).
- Step 3: de-neutrosophic the evaluation matrix using Equation 25.
- Step 4: aggregate the evaluation matrices using the neutrosophic operations into a single evaluation matrix.
- Step 5: apply TOPSIS to rank the aspects. (steps in details in section 3.3)
  - Normalize the evaluation matrix.
  - Calculate the weighted normalized matrix.
  - Rank the aspects according to the distance of each one to the positive ideal solution and the negative ideal solution.
- Step 6: apply TODIM to rank the aspects. (steps in details in section 3.4)
  - Calculate the dominance matrix according to the reference criterion.
  - Rank the aspects according to the final dominance matrix normalization.

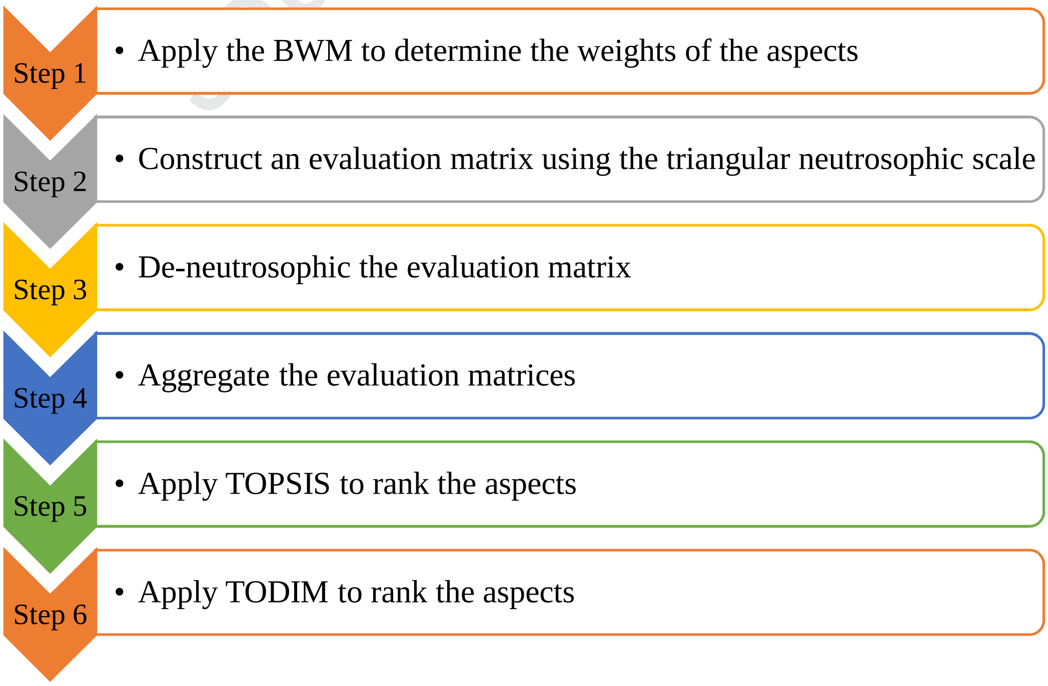

Figure 1: The steps of the proposed framework

Table 2: Triangular

Significance linguistic scale	Neutrosophic scale
Very Weakly significant (VWS)	((0.1, 0.3,0.35), 0.1,0.2,0.15)
Weakly significant (WS)	((0.15,0.25,0.1), 0.6,0.2,0.3)
Partially significant (PS)	((0.4,0.35,0.5), 0.6,0.1,0.2)
Equal significant (ES)	(0.65,0.6,0.7),0.8,0.1,0.1)
Strong significant (SS)	((0.7,0.65,0.8),0.9,0.2,0.1)
Very strongly significant (VSS)	((0.9,0.85,0.9),0.8,0.2,0.2)
Absolutely significant (AS)	((0.95,0.9,0.95),0.9,0.1,0.1)

Neutrosophic Evaluation Scale

4. Results

This section discusses the gas industry in Egypt and the results of evaluation according to BWM, TOPSIS and TODIM methods.

4.1. Gas industry background

Egypt has different significant energy resources such as wind, solar, oil and natural gas. Gas is one of the most dynamic industries in Egypt. The government of Egypt supports international oil companies (IOC) to participate in the oil and gas industry, and now more than 50 international companies are operating in the country. One of the most important transit routes from North Africa and along the Mediterranean Sea to Asia is Suez Canal. The revenue earned from these transfer points is one of the most important sources of income for the country. The Zohr field is considered the largest finding ever made in the Mediterranean Sea in the field of gas production that started production since December 2017. Moreover, Nooros Gas Field produces 32 million cubic meters per day. In addition, 350 million cubic meters per day is produced from Atoll gas field in the East Delta. Ministry Petroleum Company in Egypt consists of more than fifty companies that compose a large part of Egypt's economy.

Table 3: Hierarchy of measurements with grouping aspects

Aspects	Criteria
Operational capacity AS_1	C1. Technology management and strategy C2. Demand management and forecasting C3. Resource management

	C4. Delivery confidence of demand C5. Inventory control and efficiency
Environmental aspects AS_2	C6. Environmental policies and practices C7. Environmental costs C8. Natural resource protection
Social aspects AS_3	C9. Supplier relationship management C10. Customer/stakeholder relationship C11 Buyer-supplier relationship
Product/service management AS_4	C12. Service level performance management C13. Customers service availability C14. Product renovation that covers customer segments C15. Raw material procurement C16. Product/service quality
Financial practices AS_5	C17. Financial information sharing C18. Financing a supply chain through bank loans C19. Price and cost information C20. Supplier integration between service providers C21. Supply chain risk recovery level

Sustainable supply chain finance is significant to the gas industry as well as other industries. The hierarchy with grouping aspects that considered to evaluate the SCF of the gas industry is shown in Table 3.

4.2. Results and Analysis

By applying the recommended three analytical steps, we found that:

- Apply the BWM to weight the 21 criteria by comparing them with the most preferred criterion (price and cost information C19) and the least preferred criterion (supplier integration C20). The result of this step is shown in Table 4 and illustrates in Figure 2. The weight of the best criterion is 0.1419, while the weight of the worst criterion is 0.203.

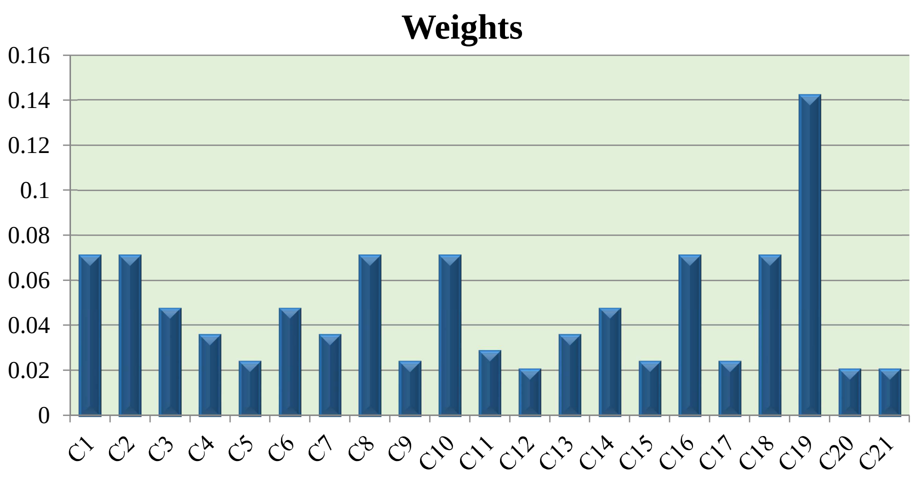

Figure 2: 21 Criteria weights using BWM

Table 4: Weights of Criteria

Criteria	Weight
C_1	0.0710
C_2	0.0710
C_3	0.0473
C_4	0.0355
C_5	0.0237
C_6	0.0473
C_7	0.0355
C_8	0.0710
C_9	0.0237
C_{10}	0.0710
C_{11}	0.0284
C_{12}	0.0203
C_{13}	0.0355
C_{14}	0.0473
C_{15}	0.0237
C_{16}	0.0710
C_{17}	0.0237
C_{18}	0.0710
C_{19}	0.1419
C_{20}	0.0203
C_{21}	0.0203

- ❖ It is clear from the obtained results that, the most significant criteria are cost and price information, technology management, demand management, green technology, customer/stakeholder relationship, product/service quality, and financing supply chain through bank loans. However, service performance management, supplier integration, and supply chain disruption risk are the least important criteria.
- ❖ As presented in Table 2, a group of four experts who have experience in supply chain and financing evaluates the five defined aspects as shown in Tables 5, 6, 7, 8, and 9.

Table 5: Criteria under Aspect 1 Evaluation

Aspect 1	Expert 1	Expert 2	Expert 3	Expert 4
C_1	VSS	SS	SS	SS
C_2	SS	VSS	VSS	AS
C_3	SS	VSS	SS	SS
C_4	VSS	VSS	SS	SS
C_5	VSS	VSS	SS	VSS
C_6	ES	ES	SS	SS
C_7	SS	ES	ES	ES
C_8	ES	ES	ES	SS
C_9	SS	ES	ES	ES
C_{10}	ES	ES	ES	PS
C_{11}	WS	WS	PS	WS
C_{12}	PS	WS	WS	WS

C_{13}	WS	WS	WS	WS
C_{14}	PS	WS	WS	PS
C_{15}	PS	WS	PS	PS
C_{16}	PS	WS	PS	PS
C_{17}	ES	SS	SS	PS
C_{18}	PS	ES	ES	PS
C_{19}	SS	SS	ES	ES
C_{20}	ES	SS	SS	ES
C_{21}	PS	ES	ES	ES

Table 6: Criteria under Aspect 2 Evaluation

Aspect 2	Expert 1	Expert 2	Expert 3	Expert 4
C_1	ES	SS	SS	ES
C_2	SS	ES	ES	ES
C_3	ES	SS	ES	ES
C_4	ES	ES	ES	ES
C_5	ES	ES	ES	PS
C_6	VSS	VSS	SS	SS
C_7	SS	VSS	VSS	AI
C_8	SS	SS	SS	SS
C_9	VSS	SS	VSS	SS
C_{10}	SS	VSS	SS	VSS
C_{11}	PS	WS	PS	PS
C_{12}	PS	PS	WS	PS
C_{13}	WS	WS	WS	WS
C_{14}	PS	PS	PS	PS
C_{15}	PS	WS	PS	PS
C_{16}	PS	PS	PS	PS
C_{17}	ES	SS	ES	ES
C_{18}	ES	SS	ES	ES
C_{19}	ES	ES	ES	ES
C_{20}	SS	SS	ES	ES
C_{21}	ES	SS	SS	ES

Table 7: Criteria under Aspect 3 Evaluation

Aspect 3	Expert 1	Expert 2	Expert 3	Expert 4
C_1	PS	PS	WS	PS
C_2	WS	WS	WS	WS
C_3	PS	PS	PS	PS
C_4	PS	WS	PS	PS
C_5	PS	PS	PS	PS
C_6	WS	WS	PS	WS
C_7	PS	WS	WS	WS
C_8	WS	WS	WS	WS
C_9	PS	WS	WS	PS
C_{10}	PS	WS	PS	WS
C_{11}	SS	VSS	SS	SS
C_{12}	VSS	VSS	SS	SS
C_{13}	VSS	VSS	SS	VSS
C_{14}	ES	ES	ES	ES

C_{15}	SS	SS	ES	ES
C_{16}	ES	SS	SS	ES
C_{17}	PS	PS	PS	PS
C_{18}	ES	ES	ES	ES
C_{19}	ES	ES	PS	PS
C_{20}	ES	PS	ES	ES
C_{21}	PS	PS	ES	ES

Table 8: Criteria under Aspect 4 Evaluation

Aspect 4	Expert 1	Expert 2	Expert 3	Expert 4
C_1	WS	PS	PS	WS
C_2	PS	WS	WS	PS
C_3	WS	PS	PS	WS
C_4	PS	WS	PS	PS
C_5	PS	PS	PS	PS
C_6	WS	WS	PS	WS
C_7	PS	WS	WS	WS
C_8	WS	WS	WS	WS
C_9	PS	WS	WS	PS
C_{10}	PS	WS	PS	PS
C_{11}	PS	PS	PS	PS
C_{12}	PS	WS	PS	PS
C_{13}	PS	PS	PS	PS
C_{14}	SS	VSS	SS	SS
C_{15}	VSS	VSS	SS	SS
C_{16}	VSS	VSS	SS	VSS
C_{17}	ES	SS	SS	PS
C_{18}	PS	ES	ES	PS
C_{19}	SS	SS	ES	ES
C_{20}	ES	SS	SS	ES
C_{21}	PS	ES	ES	ES

Table 9: Criteria under Aspect 5 Evaluation

Aspect 5	Expert 1	Expert 2	Expert 3	Expert 4
C_1	ES	SS	SS	ES
C_2	SS	SS	ES	SS
C_3	SS	ES	SS	ES
C_4	ES	ES	SS	SS
C_5	SS	SS	ES	ES
C_6	ES	ES	ES	ES
C_7	ES	ES	ES	ES
C_8	ES	ES	SS	ES
C_9	ES	ES	ES	ES
C_{10}	SS	SS	ES	ES
C_{11}	PS	WS	PS	PS
C_{12}	PS	PS	PS	PS
C_{13}	PS	WS	PS	PS
C_{14}	ES	SS	ES	SS
C_{15}	SS	SS	ES	ES
C_{16}	ES	SS	SS	ES

C_{17}	VSS	VSS	SS	VSS
C_{18}	SS	VSS	SS	VSS
C_{19}	SS	VSS	SS	SS
C_{20}	VSS	VSS	SS	SS
C_{21}	VSS	VSS	SS	VSS

- Table 10 shows the aggregation of four expert's evaluation after de-neutrosophication using Equation 25. The de-neutrosophication is applied to simplify the calculations after considering the uncertainty in the evaluation.
- Using TOPSIS method, the five aspects are ranked according to the distance of each one to the positive ideal solution and the negative ideal solution. The normalized evaluation matrix is calculated using Equation 11 and is shown in Table 11. While the weighted normalized matrix is calculated using Equation 12 and shows in Table 12. The weight that used to calculate the weighted normalized matrix is used from the result of the BWM. This step adds more consistency to the framework.
- After calculating the closeness coefficient of the aspects, as Table 13 and Figure 3 show, product/service management aspect (AS_4) is in the top of the ranking followed by the operational capacity aspect (AS_1), financial practices aspect (AS_5), and the environmental aspect (AS_2). While the social aspect (AS_3) got the last rank of gas industry SCF aspects.

Table 10: Aggregated Evaluation Matrix

Criteria	Aspect $_1$	Aspect $_2$	Aspect $_3$	Aspect $_4$	Aspect $_5$
C_1	0.76328	0.69875	0.30234	0.24531	0.69875
C_2	0.80813	0.66625	0.13125	0.24531	0.73125
C_3	0.76328	0.66625	0.35938	0.24531	0.69875
C_4	0.76281	0.63375	0.30234	0.30234	0.69875
C_5	0.76234	0.56516	0.35938	0.35938	0.69875
C_6	0.69875	0.76281	0.18828	0.18828	0.63375
C_7	0.66625	0.80813	0.18828	0.18828	0.63375
C_8	0.66625	0.76375	0.13125	0.13125	0.66625
C_9	0.66625	0.76281	0.24531	0.24531	0.63375
C_{10}	0.56516	0.76281	0.24531	0.30234	0.69875
C_{11}	0.18828	0.30234	0.76328	0.35938	0.30234
C_{12}	0.18828	0.30234	0.76281	0.30234	0.35938
C_{13}	0.13125	0.13125	0.76234	0.35938	0.30234
C_{14}	0.24531	0.35938	0.63375	0.76328	0.69875
C_{15}	0.30234	0.30234	0.69875	0.76281	0.69875
C_{16}	0.30234	0.35938	0.69875	0.76234	0.69875
C_{17}	0.63016	0.66625	0.35938	0.63016	0.76234
C_{18}	0.49656	0.66625	0.63375	0.49656	0.76281
C_{19}	0.69875	0.63375	0.49656	0.69875	0.76328
C_{20}	0.69875	0.69875	0.56516	0.69875	0.76281

C_{21}	0.56516	0.69875	0.49656	0.56516	0.76234

Table 11: Normalized Evaluation Matrix

Criteria	Aspect $_1$	Aspect $_2$	Aspect $_3$	Aspect $_4$	Aspect $_5$
C_1	0.06597	0.05722	0.03243	0.02771	0.05113
C_2	0.06985	0.05456	0.01408	0.02771	0.05351
C_3	0.06597	0.05456	0.03854	0.02771	0.05113
C_4	0.06593	0.05190	0.03243	0.03416	0.05113
C_5	0.06589	0.04628	0.03854	0.04060	0.05113
C_6	0.06039	0.06247	0.02019	0.02127	0.04637
C_7	0.05759	0.06618	0.02019	0.02127	0.04637
C_8	0.05759	0.06254	0.01408	0.01483	0.04875
C_9	0.05759	0.06247	0.02631	0.02771	0.04637
C_{10}	0.04885	0.06247	0.02631	0.03416	0.05113
C_{11}	0.01627	0.02476	0.08186	0.04060	0.02212
C_{12}	0.01627	0.02476	0.08181	0.03416	0.02630
C_{13}	0.01134	0.01075	0.08176	0.04060	0.02212
C_{14}	0.02120	0.02943	0.06797	0.08623	0.05113
C_{15}	0.02613	0.02476	0.07494	0.08617	0.05113
C_{16}	0.02613	0.02943	0.07494	0.08612	0.05113
C_{17}	0.05447	0.05456	0.03854	0.07119	0.05578
C_{18}	0.04292	0.05456	0.06797	0.05610	0.05582
C_{19}	0.06039	0.05190	0.05326	0.07894	0.05585
C_{20}	0.06039	0.05722	0.06061	0.07894	0.05582
C_{21}	0.04885	0.05722	0.05326	0.06384	0.05578

Table 12: Weighted Normalized Matrix

Criteria	Aspect $_1$	Aspect $_2$	Aspect $_3$	Aspect $_4$	Aspect $_5$	A^*	A^-
C_1	0.00468	0.00406	0.00230	0.00197	0.00363	0.004682	0.001967
C_2	0.00496	0.00387	0.00100	0.00197	0.00380	0.004957	0.000999
C_3	0.00312	0.00258	0.00182	0.00131	0.00242	0.003121	0.001311
C_4	0.00234	0.00184	0.00115	0.00121	0.00181	0.00234	0.001151
C_5	0.00156	0.00109	0.00091	0.00096	0.00121	0.001559	0.000912
C_6	0.00286	0.00296	0.00096	0.00101	0.00219	0.002956	0.000955
C_7	0.00204	0.00235	0.00072	0.00075	0.00165	0.002348	0.000717
C_8	0.00409	0.00444	0.00100	0.00105	0.00346	0.004439	0.000999
C_9	0.00136	0.00148	0.00062	0.00066	0.00110	0.001478	0.000622
C_{10}	0.00347	0.00443	0.00187	0.00242	0.00363	0.004433	0.001867
C_{11}	0.00046	0.00070	0.00232	0.00115	0.00063	0.002324	0.000462
C_{12}	0.00033	0.00050	0.00166	0.00069	0.00053	0.001659	0.00033
C_{13}	0.00040	0.00038	0.00290	0.00144	0.00079	0.002901	0.000381
C_{14}	0.00100	0.00139	0.00322	0.00408	0.00242	0.00408	0.001003
C_{15}	0.00062	0.00059	0.00177	0.00204	0.00121	0.002039	0.000586
C_{16}	0.00185	0.00209	0.00532	0.00611	0.00363	0.006112	0.001855
C_{17}	0.00129	0.00129	0.00091	0.00168	0.00132	0.001684	0.000912
C_{18}	0.00305	0.00387	0.00482	0.00398	0.00396	0.004824	0.003046
C_{19}	0.00857	0.00737	0.00756	0.01120	0.00793	0.011204	0.007367

C_{20}	0.00122	0.00116	0.00123	0.00160	0.00113	0.001601	0.001132
C_{21}	0.00099	0.00116	0.00108	0.00129	0.00113	0.001295	0.00099

Table 13: Ranking of 5 Aspects using TOPSIS

Alternatives	d^*	d^-	CC_i	Rank
Aspect $_1$	0.00726	0.00691	0.487656	2
Aspect $_2$	0.00736	0.00646	0.467467	4
Aspect $_3$	0.00814	0.00579	0.415615	5
Aspect $_4$	0.00699	0.00702	0.500794	1
Aspect $_5$	0.00602	0.00559	0.481376	3

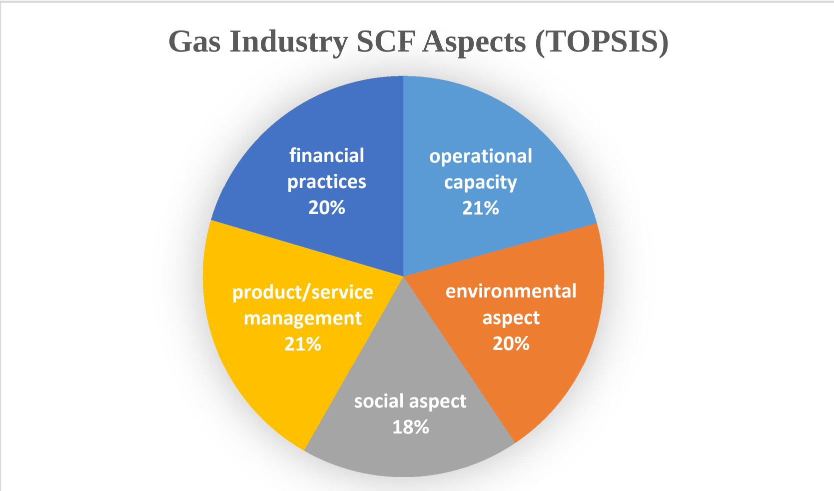

Figure 3: Evaluation of Gas Industry SCF Aspects using TOPSIS

- ❖ The result obtained from TOPSIS shows that the closeness coefficient of the aspects is product/service management aspect (AS_4) =0.500794, the operational capacity aspect (AS_1) =0.487656, financial practices aspect (AS_5) =0.481376, and environmental aspect (AS_2) =0.467467, and the social aspect (AS_3) =0.415615.
- ❖ Using TODIM method and based on the aggregated evaluation that showed in Table 10, the evaluation according to the final dominance matrix normalization **(**θ=2.25) is shown in Table 14.

Table 14: Ranking of 5 Aspects using TODIM (θ=2.25)

Aspects	Value of dominance	Rank
Aspect $_1$	-0.53144	4
Aspect $_2$	-0.65154	5
Aspect $_3$	-0.06901	3
Aspect $_4$	0.011747	2
Aspect $_5$	0.31286	1

- ❖ As Table 14 shows, the financial practices aspect (AS_5) is in the top of the ranking followed by product/service management aspect (AS_4), social aspect (AS_3), and operational capacity aspect (AS_1). While the environmental aspect (AS_2) in the last rank of gas industry SCF aspects.

- ❖ Both TOPSIS and TODIM methods provide a similar ranking that ensures that the financial practices aspect and product/service aspects are the most critical aspects that affect sustainable supply chain finance in the case of the Gas industry in Egypt. But using different evaluation methods may help the decision-maker to look to the problem from different view of points and have more flexibility in decision-making. However, the social and environmental aspects do not have that much effect on the SCF sustainability of the Gas industry. The comparison of the two methods results shows in Figure 5.
- ❖ Decision-makers may choose different values of the reduction factor of the losses based on their different risk attitudes. An analysis of the effect of the reduction factor of the losses (suggested to have a value between 1.0 and 2.4) is shown in Table 15.

Table 15: The Ranking Results of the Different θ Values

	θ=1.0		**θ**=1.1		**θ**=1.2		**θ**=1.3	
	ε	Rank	ε	Rank	ε	Rank	ε	Rank
Aspect $_1$	-0.00301	4	-0.0184	4	-0.03577	4	-0.05541	4
Aspect $_2$	-0.05158	5	-0.07186	5	-0.09483	5	-0.12084	5
Aspect $_3$	0.061801	2	0.062792	2	0.061817	2	0.059793	2
Aspect $_4$	0.057032	3	0.057798	3	0.057787	3	0.057014	3
Aspect $_5$	0.323197	1	0.322565	1	0.322252	1	0.322126	1
	θ=1.4		θ=1.5		θ=1.6		θ=1.7	
	ε	Rank	ε	Rank	ε	Rank	ε	Rank
Aspect $_1$	-0.07774	4	-0.10327	4	-0.1327	4	-0.16693	4
Aspect $_2$	-0.14932	5	-0.18086	5	-0.21666	5	-0.25758	5
Aspect $_3$	0.056246	2	0.051018	3	0.043923	3	0.034736	3
Aspect $_4$	0.055487	3	0.053212	2	0.050189	2	0.046415	2
Aspect $_5$	0.322114	1	0.322171	1	0.32227	1	0.322394	1
	θ=1.8		θ=1.9		θ=2		θ=2.1	
	ε	Rank	ε	Rank	ε	Rank	ε	Rank
Aspect $_1$	-0.20719	4	-0.25518	4	-0.31333	4	-0.38519	4
Aspect $_2$	-0.30476	5	-0.35971	5	-0.42451	5	-0.502	5
Aspect $_3$	0.023185	3	0.008938	3	-0.00841	3	-0.02937	3
Aspect $_4$	0.041885	2	0.036586	2	0.030505	2	0.023623	2
Aspect $_5$	0.322532	1	0.32058	1	0.318054	1	0.315806	1
	θ=2.2		θ=2.25		θ=2.3		θ=2.4	
	ε	Rank	ε	Rank	ε	Rank	ε	Rank
Aspect $_1$	-0.4762	4	-0.53144	4	-0.59514	4	-0.75716	4
Aspect $_2$	-0.5963	5	-0.65154	5	-0.71349	5	-0.863	5
Aspect $_3$	-0.05458	3	-0.06901	3	-0.08483	3	-0.12119	3
Aspect $_4$	0.015917	2	0.011747	2	0.007359	2	-0.00208	2
Aspect $_5$	0.313791	1	0.31286	1	0.311976	1	0.310331	1

- As Table 16 and Figure 4 show, we can see that the ranking result of the alternatives changes from θ = 1.5. When θ change from 1.0 to 1.4, the order of aspects is $AS_5>AS_3>AS_4>AS_1>AS_2$; when θ change from 1.6 to 2.4, the order of the alternatives is $AS_5>AS_4>AS_3>AS_1>AS_2$. However, the top aspect obtained with the different values of θ is the same, which is the financial aspect (AS_5). While the last aspect in the ranking is environmental aspects (AS_2).

Table 16: The Ranking According to Values of Reduction Factor of the Losses

values of reduction factor of the losses	Aspects Ranking
θ=1.0	$AS_5>AS_3>AS_4>AS_1>AS_2$
θ=1.1	$AS_5>AS_3>AS_4>AS_1>AS_2$
θ=1.2	$AS_5>AS_3>AS_4>AS_1>AS_2$
θ=1.3	$AS_5>AS_3>AS_4>AS_1>AS_2$
θ=1.4	$AS_5>AS_3>AS_4>AS_1>AS_2$
θ=1.5	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=1.6	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=1.7	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=1.8	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=1.9	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=2.0	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=2.1	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=2.2	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=2.25	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=2.3	$AS_5>AS_4>AS_3>AS_1>AS_2$
θ=2.4	$AS_5>AS_4>AS_3>AS_1>AS_2$

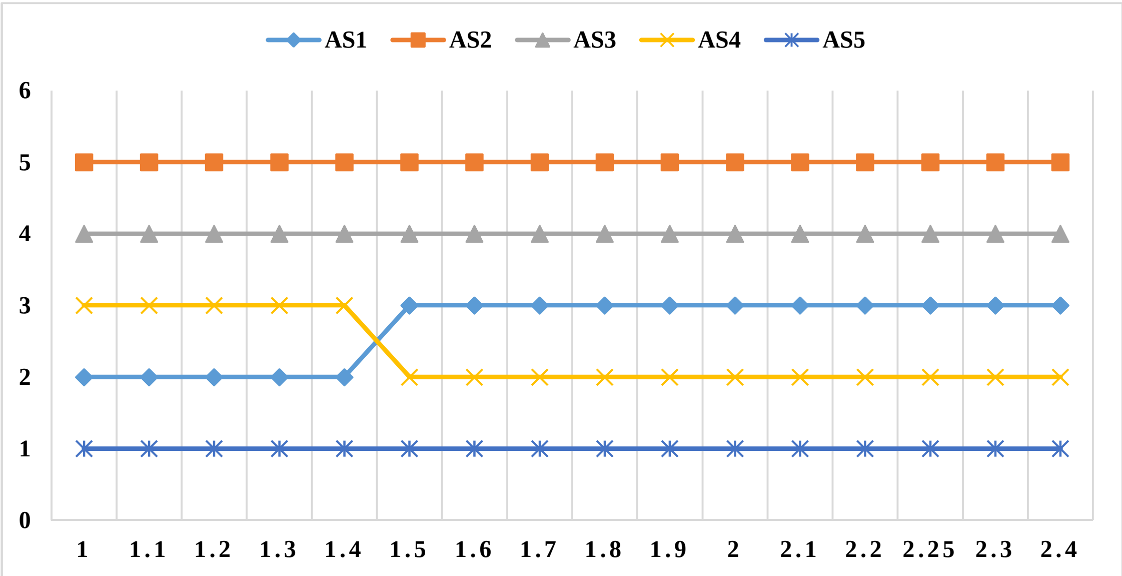

Figure 4: The Ranking Sensitivity According to Values of Reduction Factor of the Losses

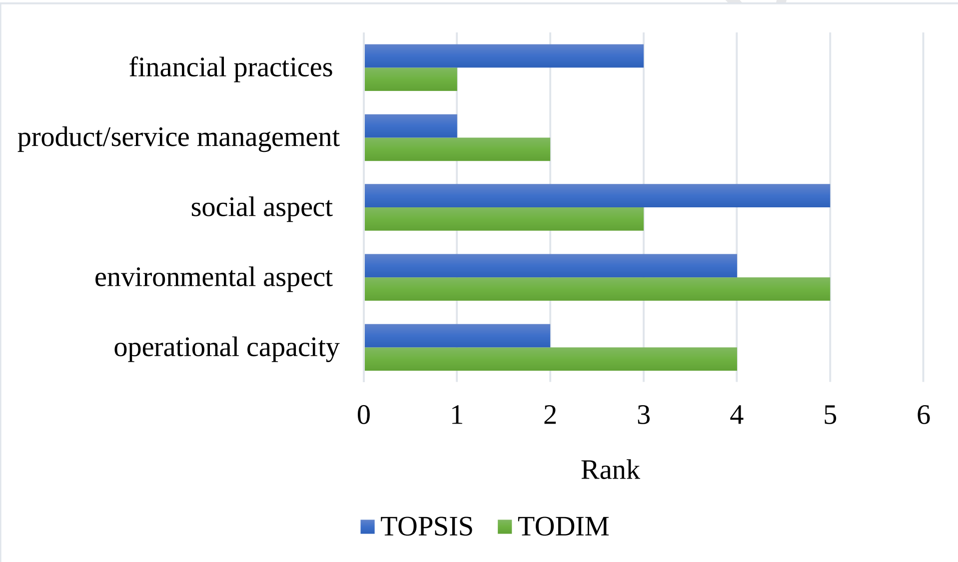

Figure 5 : TOPSIS and TODIM Evaluation

5. Conclusions and Future Works

Among several supply chain problems, supply chain finance is one of the most critical issues that may influence the whole supply chain progress for any business. According to that, this study employed BWM, TODIM, and TOPSIS methods to evaluate different supply chain finance aspects based on four experts' experience in the field of supply chain and financing. Operational capacity, environmental aspect, social aspect, product/service management, and financial practices are the five aspects that evaluated to improve the sustainable supply chain finance of the Gas industry in Egypt. These aspects include twenty-one criteria that evaluated according to the BWM. The results of the BWM show that cost and price information is the most important criteria with weight 0.14194. While service performance management, supplier integration, and supply chain disruption risk with weight 0.02028.

The importance of the five aspects was evaluated according to TOPSIS and TODIM methods. The evaluation of four experts was considered as triangular neutrosophic numbers in order to increase the accuracy of the evaluation result. Using TOPSIS method, the ranking was performed based on the distance of each one to the positive ideal solution and the negative ideal solution. The results improve that product/service management aspect and financial practices aspect are in the top of the ranking while the environmental aspects in the end ranking. On the other side, according to TODIM method, the results agreed with TOPSIS in a large percentage. The results show that the financial practices aspect and product/service aspect are at the top of the ranking while the environmental aspect in the end ranking too. So, Gas industry in Egypt requires more consideration of financial practices and product/service management in order to improve sustainable supply chain finance.

This study improved several implications in both sides either managerial or practical. We can see that this study may help the decision-maker in the evaluation process of sustainable supply chain finance which must be considered as one of the main studies that influence the entire supply chain operations. The decision that the decision-maker will take will be highly accurate because of considering the uncertainty of information in an efficient manner that neutrosophic does. Moreover, this study considered the main five aspects that may affect the evaluation of supply chain finance sustainability. This study may be applied in several fields not only specific for gas industry.

In this study, the set of criteria has relied on the literature of supply chain finance, so this set may be incomplete or insufficient. In future studies, the researcher may include more criteria that may influence the sustainability of supply chain finance. Moreover, future studies may focus on multiple different industries in different countries. Also, there are other many MCDM methods that may be applied and improve meaningful results.

Conflict of interest

Authors declare that there is no conflict of interest about the research.

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Ethical approval

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

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Declaration of interests

☒ 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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