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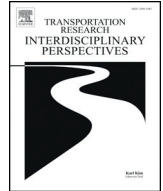
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## Evaluate the impact of COVID-19 prevention policies on supply chain aspects under uncertainty



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### ABSTRACT

Supply chain operations are disrupted due to natural disasters or epidemics. In the recent period, the supply chain suffers from obstacles and major challenges that affect its stages directly due to the spread of the COVID-19 epidemic around the world. The impact of this epidemic on supply chain performance is clear in terms of supply, demand, or logistics. This epidemic is characterized by a rapid spread, so countries have taken preventive policies in an attempt to limit its spread. These policies are direct impacts on the performance of the supply chain in all scopes. The extent of its impact varies from one supply chain to another, according to the activities that the supply chain provides. In order to provide a more accurate study of the impact of the measures taken to limit the spread of the epidemic, this research presents a proposed framework that evaluates the impact of these policies on the three main aspects of the supply chain (supply, demand, and logistics). The proposed framework is build using BWM and TOPSIS based on plithogenic set. Plithogenic set provides a more accurate evaluation result that addresses the uncertainty problem. Supply chain aspects were evaluated for the food industry, electronics industry, pharmaceutical industry, and textile industry.

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### 1. Introduction

The world began facing the most sophisticated challenges ever since December 2019, starting from the Chinese city of Wuhan and spreading to all countries of the world at all. 27 cases of unknown pneumonia began to appear at the end of December 2019 in Wuhan city (Lu et al., n.d.). This virus has infected many people in China in a very short time and has spread across the world. The World Health Organization (WHO) has asserted

that the COVID-19 outbreak comprises an international public health emergency.

As a result of the extent of this epidemic around the world, countries began to take some preventive policies to limit its spread and try to control the situation. WHO works carefully with leading experts, governments, and associates to develop a scientific understanding of this novel virus and provide a useful guidance on regulations to conserve human health and inhibit this outbreak from spreading. From the business side, companies' procedure

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considerations should be focused on both the readiness to protect the safety of your staff and clients and the extent of community-based spread of disease. In a survey released on 21 February 2020, [Fortune \(2020\)](#) reported that 94% of the businesses included on the Fortune 1000 list experienced supply chain disturbances owing to COVID-19 ([Fortune, 2020](#)). The economic consequences of the pandemic are not insignificant in comparison to the human losses and fatalities caused by COVID-19 ([Bloom and Canning, 2004](#)). One of the most important and apparent obstacles is the reduction in market demand for goods and services in most countries due to absolute or partial lockdown. This lockdown has also disrupted both domestic and foreign supply chains. As a result of that, this pandemic causes significant job losses which will drive down demand, going to lead to a serious comprehensive economic crisis ([De Vito and Gómez, 2020](#)).

One of the first precautions taken at the beginning of the COVID-19 pandemic is the dumping of international air traffic to and from the Chinese city of Wuhan. The procedures persisted with increased cases of infection such as disruption of schools and colleges, disruption of work in certain governmental and private institutions, closure of stores, restaurants and cafés, and other actions to reduce the interaction between people and observe the spread of the virus. Such measures have unintended effects of interrupting the multinational supply chains, halting companies' activities, and declining revenues.

Supply chains may be influenced by multi-way policies to avoid the spread of the disease, either in supply, demand, or logistics. This study will evaluate the influence of the safety policies on the supply chain aspects under the uncertainty environment. A questionnaire was conducted for four different industries, namely the food industry, the electrical industry, the pharmaceutical industry, and the textile industry, to assess the effect of the measures on the supply chains in different fields. The problem was formulated as a multi-criteria decision-making problem using the Best-Worst method (BWM) and Technique in Order of Preference by Similarity to Ideal Solution (TOPSIS) based on the plithogenic set. The main contribution of the proposed framework is the combination of the two methods under plithogenic environment. The integration of these methods provide a more consistent and accurate framework. The BWM weight the policies that prevent the spread of the virus, while TOPSIS ranks the supply chain aspects (supply, demand, and logistic) according to the four industries. The evaluation of the impact of the policies on the supply chain will be applied under plithogenic environment in order to ensure more accurate results. The problem that have been solved in this research is considering the uncertainty of the evaluation process. The results that gained by this article is highly accurate evaluation of the supply chain aspects according to COVID-19 prevention policies effect.

This article is structured as follows: [Section 2](#) represents a literature review on COVID-19 and its impact on supply chain performance. [Section 3](#) shows the definitions and methods that build the proposed framework. [Section 4](#) is the application of the proposed framework to evaluate the impact of COVID-19 on the supply chain aspects. [Section 5](#) is the managerial implications of the study. The conclusion of the work is present in [Section 6](#).

## 2. Literature review

The COVID-19 pandemic that rocked supply and business significantly in the last period, which obviously affects the global economy in general, is characterized by long-term disruption and high uncertainty. The supply chain risks to which you are exposed as a result of a pandemic similar to the COVID-19 pandemic are characterized as a long-term disruption that cannot be estimated, a supply chain disruption occurs in conjunction with the spread of the epidemic among the population, and concurrent disruptions occur between supply, demand, and logistics ([Ivanov, 2020](#)). As a result of Lynton's study, it has been proven that the world's largest 1000 supply chains are possessed most of their facilities in quarantine areas. As a result of Linton & Vakil study, it has been proven that the world's largest 1000 supply chains possess most of their facilities in quarantine areas, and with the extension of the affected areas all affected countries are quarantined, further exacerbating the problem ([Linton and Vakil, 2020](#)).

The attention of researchers in the field of supply chains during the COVID-19 pandemic period has focused on studying the negative effects of policies imposed around the world to reduce the consequences of this crisis. In particular, the industries that serve the needs of the medical field need to be studied closely to ensure the continuity of the stability of these supply chains in light of this pandemic. [Shokrani et al. \(2020\)](#) studied the prominence of discovering alternative supply chains to manufacture some medical equipment, such as the face shields, which are among the most important protective equipment ([Shokrani et al., 2020](#)). While Cappelli & Cini are proven through their study of food supply chains and local productions that they are the least affected by the international policies that have been imposed to limit the spread of the epidemic, as it is the closest to the consumer ([Cappelli and Cini, 2020](#)). One of the most prominent risks faced by supply chains in the COVID-19 pandemic period in various areas is to make ideal decisions in determining the amount of demand for services and goods. This is what [Govindan et al. \(2020\)](#) presented in their research, which contributed to the process of demand management through a decision-making system based on fuzzy inference system (FIS) ([Govindan et al., 2020](#)). The participation of [Ivanov and Dolgui \(2020\)](#) study lies in the categorization of a new Intertwined Supply Network (ISN) viability decision-making environment motivated by COVID-19 pandemic ([Ivanov and Dolgui, 2020](#)).

It is worth noting that the occurrence of disruptions in the supply chains results in a decrease in its performance, which enhances the importance of observing the handling of such disruptions in order to ensure effectively and successfully the consistency of operation of the supply stages. This point was addressed in [Aldrighetti et al. \(2019\)](#) study, which specializes in looking at disturbances that affect the performance of the healthcare supply chain especially in terms of financial and operational performances to ensure the highest service level ([Aldrighetti et al., 2019](#)). [Calnan et al. \(2018\)](#) described the experience gained during the Ebola phase and illustrate the need to develop a structure for decision-making support to aid forecast the effects of infectious outbreaks on supply chains and manage operational and logistics policies during and after the crisis ([Calnan et al., 2018](#); [Büyüktaktakın et al., 2018](#)). In the field of fresh food supply chain, [Mitchell et al. \(2020\)](#) investigated the reaction and resistance to COVID19 of the UK fruit and vegetable food supply chain, and to evaluate this empirical evidence in the sense of an adaptive cycle-based resistance system ([Mitchell et al., 2020](#)). [Attaran \(2020\)](#) study explored the vital roles that technology plays in bridging the essential void in healthcare supply chains during the latest outbreak ([Attaran, 2020](#)). Although supply chains throughout the world have always been disrupted by pandemics, they have lately been significantly impaired by an unforeseen, much-reaching devastating COVID-19 outbreak, with catastrophic consequences ([Boccaletti et al., 2020](#)).

## 3. Proposed framework

### 3.1. Methods overview

This study contributes to the process of assessing aspects of the supply chain and the impact of the policies imposed to reduce the consequences of the COVID-19 pandemic facing the world. The motivation of the proposed study lies on the huge impact of this pandemic that leads to disturbances in the performance of supply chains in various fields after imposing preventive policies, the most prominent of which is the quarantine which the world has witnessed recently. Most decision-making problems are characterized by uncertainty and ambiguity in the problem information. This often increases the problems related to new crises and pandemics, which are difficult to measure the extent of its spread and recognize all its facets. Hence, an integrated framework has been proposed to measure the impact of policies deployed around the world to reduce the COVID-19 pandemic on supply, demand, and logistics of supply chains in an environment of uncertainty.

The proposed framework integrates the Best-Worst method (BWM) and Technique in Order of Preference by Similarity to Ideal Solution (TOPSIS)

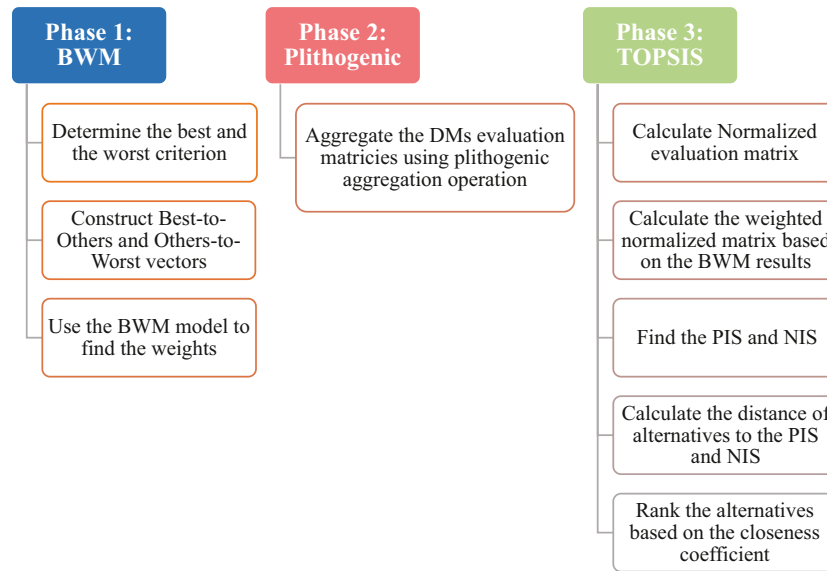


Fig. 1. Proposed framework phases.

based on the plithogenic set. The evaluation of the impact of the policies on the supply chain will be applied under plithogenic environment which is useful for dealing with uncertainty in decision-making problems. The BWM weight the policies that prevent the spread of the virus, while TOPSIS ranks the supply chain aspects (supply, demand, and logistic).

The BWM is a multi-criteria decision making (MCDM) method, which is an appropriate methodology to construct complex problems so that decision-makers would be able to better understand the problem as a whole (van de Kaa et al., 2020). This method allows decision-makers to quantitatively determine the value of the variables that form the system's total outputs (Rezaei et al., 2015). The BMW is based on pairwise comparison, whether a value is more or less worthy than the other, and how significant it is compared to another. Decision-makers define the most important value, then the least important value of the set of defined values. Based on these two reference values, the remaining values are then compared.

TOPSIS is a simple MCDM technique which assist to choose the best solution between the wide ranges of alternatives based on the closeness to the ideal solution (Srinivasan et al., 2020). The TOPSIS approach considers all positive and negative potential solutions, utilizing a measurement procedure that is fairly straightforward and quick to understand. Additionally, there is no restriction on the number of parameters and attributes it will handle and differentiates between the beneficial and non-beneficial parameters in its algorithm (Rashidi and Cullinane, 2019).

In reality, decision-makers (DMs) tend to use linguistic terms instead of using the exact numbers due to complexity and the vagueness of human cognition. In particular, the COVID-19 pandemic is one of the disruptions confronting supply chains in an unexpected way, which increases ambiguity in the information that may contribute to find solutions to maintain the stability of supply chain performance. The policies decided by countries to limit the effects of this pandemic differ from one country to another and from one region to another in the same country, and also these policies

Table 1  
Neutrosophic linguistic scale.

Scale explanation	Neutrosophic triangular scale
Very weakly influential (VWI)	((0.10, 0.2, 0.3), 0.1, 0.3, 0.1)
Weakly influential (WI)	((0.25, 0.3, 0.50), 0.6, 0.2, 0.3)
Partially influential (PI)	((0.45, 0.3, 0.40), 0.6, 0.1, 0.2)
Equal influential (EI)	((0.5, 0.5, 0.50), 0.9, 0.1, 0.1)
Strong influential (SI)	((0.65, 0.7, 0.80), 0.9, 0.2, 0.1)
Very strongly influential (VSI)	((0.85, 0.8, 0.95), 0.8, 0.1, 0.2)
Absolutely influential (AI)	((0.95, 0.95, 0.95), 0.9, 0.10, 0.10)

are changed in response to the extent of the epidemic in the region, thus this problem is considered one of the most ambiguous problems for decision-making in the field of a supply chain. Accordingly, the proposed framework for this study is applied in an environment of uncertainty based on plithogenic set. Plithogenic is a generalization of crisp, fuzzy, intuitionistic fuzzy, and neutrosophic set introduced by Smarandache (2017). A plithogenic set  $(P, A, V, d, c)$  is a set that comprises elements characterized by attributes' value  $V = \{v_1, v_2, \dots, v_n\}$ , for  $n \geq 1$ , each attribute value has an appurtenance degree concerning some given criteria. The set attributes denoted as  $A = \{\alpha_1, \alpha_2, \dots, \alpha_m\}$ ,  $m \geq 1$  (Smarandache, 2017; Smarandache, 2018a).

### 3.2. Proposed framework phases

In this research, we construct a framework based on BWM and TOPSIS under plithogenic set to improve the consistency of the assessment process. This framework includes the merits of the plithogenic set with BWM and TOPSIS. Plithogenic set focuses in considering uncertainty, BWM evaluates the optimal weights of the policies, and TOPSIS determine the ranking of the SC aspects. This framework consists of three main phases. The first phase is to weight the policies using BWM. The second phase is to evaluate the policies according to the decision-makers and aggregate them based on plithogenic set operation. Finally, the last phase is to evaluate the supply, demand, and logistics of the supply chain using the TOPSIS method based on the results of the first and the second phases. As all decision-making problems, a set of criteria  $C = \{c_1, c_2, \dots, c_n\}$ , and alternatives  $A = \{a_1, a_2, \dots, a_m\}$  must be defined. In our study, the set of criteria are the prevention policies, while the alternatives are the three supply chain aspects. The steps of this proposed framework in details as follows (Fig. 1):

- **Phase 1:** Weight the policies using the BWM:
    - Step1: Determine the Best  $C_B$  and Worst  $C_W$  criterion (policy) based on the decision-makers perspectives.
    - Step 2: Build the best-to-other vector  $C_B = \{c_{B1}, c_{B2}, \dots, c_{Bn}\}$ , and the others-to-worst vector  $C_W = \{c_{w1}, c_{w2}, \dots, c_{wn}\}$ , where  $c_{Bn}$  is the preference of criteria  $n$  compared by the Best criterion  $B$  and  $c_{wn}$  is the preference of criteria  $n$  compared by the Worst criterion  $W$ . The comparison scale from 1 to 9 (where 1 is equally serious and 9 is extremely serious).
    - Step 3: Use the BWM model to compute the optimal weights of the criteria  $w_n$
- Min  $a_j^l \epsilon$   
s.t.

**Table 2**  
Best-to-others vector.

Best to others	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Policy 1	1	3	8	7	6	2	5	4	9

$$\begin{aligned} & \left| \frac{w_j}{w_j} - a_{Bj} \right| \leq \epsilon, \text{ for all } j \\ & \left| \frac{w_j}{w_w} - a_{jW} \right| \leq \epsilon, \text{ for all } j \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \tag{1}$$

• **Phase 2:** Evaluate the criteria (policies) according to the decision-makers (DMs) based on the neutrosophic linguistic scale (Table 1) and aggregate them based on plithogenic set aggregation operation in order to build an evaluation matrix  $\tilde{D}$ .

**Definition 1.** Let  $\tilde{a} = (a_1, a_2, a_3)$  and  $\tilde{b} = (b_1, b_2, b_3)$  be two plithogenic sets.

The plithogenic intersection is (Smarandache, 2018b; Rana et al., 2019):

$$\begin{aligned} & ((a_{i1}, a_{i2}, a_{i3}), 1 \leq i \leq n) \wedge p((b_{i1}, b_{i2}, b_{i3}), 1 \leq i \leq n) \\ & = \left( \left( a_{i1} \wedge_F b_{i1}, \frac{1}{2}(a_{i2} \wedge_F b_{i2}) + \frac{1}{2}(a_{i2} \vee_F b_{i2}), a_{i2} \wedge_F b_{i3} \right) \right), 1 \leq i \leq n. \end{aligned} \tag{2}$$

The plithogenic union is:

$$\begin{aligned} & ((a_{i1}, a_{i2}, a_{i3}), 1 \leq i \leq n) \vee p((b_{i1}, b_{i2}, b_{i3}), 1 \leq i \leq n) \\ & = \left( \left( a_{i1} \vee_F b_{i1}, \frac{1}{2}(a_{i2} \wedge_F b_{i2}) + \frac{1}{2}(a_{i2} \vee_F b_{i2}), a_{i2} \wedge_F b_{i3} \right) \right), 1 \leq i \leq n. \end{aligned} \tag{3}$$

where

$$a_{i1} \wedge p b_{i1} = [1 - c(v_D, v_1)].t_{norm}(v_D, v_1) + c(v_D, v_1).t_{conorm}(v_D, v_1) \tag{4}$$

$$a_{i1} \vee p b_{i1} = [1 - c(v_D, v_1)].t_{conorm}(v_D, v_1) + c(v_D, v_1).t_{norm}(v_D, v_1) \tag{5}$$

where,  $t_{norm} = \alpha_F b = ab$ ,  $t_{conorm} \alpha \vee_F b = \alpha + b - ab$

• **Phase 3:** Rank the alternatives (supply chain aspects) using TOPSIS method:

**Table 3**  
Others-to-worst vector.

Others to the worst	Policy 9
Policy 1	9
Policy 2	7
Policy 3	2
Policy 4	3
Policy 5	4
Policy 6	8
Policy 7	5
Policy 8	6
Policy 9	1

**Table 4**  
Weights of the policies using BWM.

Weights	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
	0.3146	0.1276	0.0478	0.0547	0.0638	0.1915	0.0766	0.0957	0.0273

- **Step 1:** Based on the aggregated evaluation matrix  $\tilde{D}$ , calculate the normalized matrix using Eqs. (6) and (7).

$$\tilde{N} = [x_{ij}]_{m \times n} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}_{m \times n} \tag{6}$$

where

$$(x_{ij})_{m \times n} = x_{ij} / \left( \sqrt{\sum_{i=1}^m x_{ij}^2} \right) \tag{7}$$

where  $i$  is the alternative and  $j$  is the criteria

- **Step 2:** Calculate the weighted normalized matrix as Eq. (8) shows, where  $w_j$  is the weight of each criterion that calculated from Phase 1 using the BWM. One of these study contributions in this step that combine the advantages of the BWM with the TOPSIS to find more accurate evaluation results.

$$V = (v_{ij})_{m \times n} = w_j \times x_{ij} \tag{8}$$

- **Step 3:** Find the positive ideal solution and negative ideal solution using Eqs. (9)–(12).

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\} \tag{9}$$

$$v^+ = \{(\max_i v_{ij} | j \in J_b), (\min_i v_{ij} | j \in J_{nb}) | i \in [1 \dots m]\} \tag{10}$$

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\} \tag{11}$$

$$v^- = \{(\min_i v_{ij} | j \in J_b), (\max_i v_{ij} | j \in J_{nb}) | i \in [1 \dots m]\} \tag{12}$$

where  $J_b$  is a set of beneficial criteria, and  $J_{nb}$  is a set of non-beneficial criteria.

- **Step 4:** Calculate the distance of each alternative from PIS and NIS using Eqs. (13) and (14):

$$d_i^+ = \sqrt{\sum_{j=1}^m (V_i - V_j^+)^2} \tag{13}$$

$$d_i^- = \sqrt{\sum_{j=1}^m (V_i - V_j^-)^2} \tag{14}$$

- **Step 5:** Rank the alternatives according to the closeness coefficient  $CC_i$  for each alternative using Eq. (15):

$$CC_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{15}$$

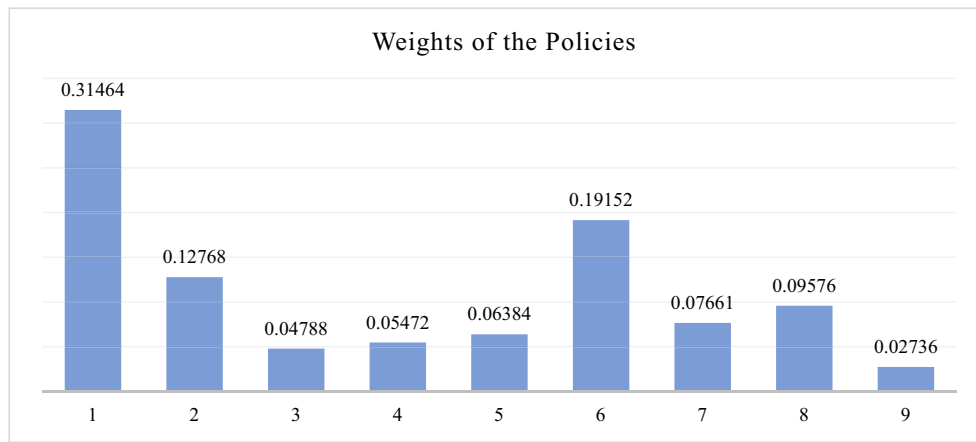


Fig. 2. Weights of the Policies using the BWM.

**4. Application of the proposed framework: evaluation of supply chain aspects under COVID-19 prevention policies**

COVID-19 is the most serious issue all over the world from the beginning of 2020 until today, due to the spread of its negative effects on all aspects of life. Countries have different protective policies to such impacts in an attempt to maintain life running normally. However, countries agree on several international and domestic policies that guarantee the general safety of citizens. Among the most important of these policies pursued by most countries are:

- Policy 1: International and domestic air suspension
- Policy 2: Close the commercial centres, shops, restaurants, cafes and nightclubs
- Policy 3: Suspending tourist activities
- Policy 4: Suspension of religious rites
- Policy 5: Internal transportation and High-Speed Rail train services have been suspended.
- Policy 6: Postponing studies in schools and universities
- Policy 7: Reducing the employment rate in some jobs determined by the state
- Policy 8: Converting the work system to remote work from home
- Policy 9: Suspension of maritime traffic

Certainly, these policies to mitigate the impact of the COVID-19 pandemic affect the international and domestic economies detrimentally and noticeably. Due to its impact on the performance of supply chains in general. It is evident that the magnitude of the effects varies between supply, demand and logistics based on the particular field of the supply chain. Consequently, the effect of such policies on the three facets of the supply chain has been investigated in the fields of food, electronics, pharmaceutical, and textile industries. This evaluation was conducted on the basis of a survey of four company owners in these four fields that are specifically impacted by this pandemic.

In this study, we proposed a framework based on the uncertainty in evaluating alternatives to obtain the optimal decision. The steps of this framework applied to rank the supply, demand, and logistics according to their influence by the COVID-19 prevention policies.

Phase 1: The first stage of the framework is based on the calculation of the weights of the prevention policies of the COVID-19 by relying on a pairwise comparison between the (most influential) best and the worst (least influential) policy with the rest of the policies. The international and domestic air suspension (Policy 1) is the most influencing policy (best) on supply chain performance. While Suspension of maritime traffic policy (Policy 9) is the least influencing policy (worst). According to that, best-to-others vector and others-to-worst vector are constructed as Tables 2 and 3 show, respectively.

**Table 5**  
Evaluation matrix of the supply chain aspects.

Electronics	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	VSI	SI	WI	WI	AI	WI	SI	SI	VSI
Logistics	VSI	EI	WI	WI	AI	WI	SI	SI	VSI
Demand	EI	VSI	SI	WI	SI	WI	SI	SI	EI
Pharmaceutical	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	SI	EI	WI	WI	VSI	WI	SI	VSI	PI
Logistics	SI	WI	WI	WI	AI	WI	SI	SI	EI
Demand	EI	EI	WI	WI	SI	WI	SI	SI	EI
Textile	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	VSI	EI	WI	WI	AI	WI	SI	SI	VSI
Logistics	VSI	EI	WI	WI	AI	WI	SI	SI	AI
Demand	EI	VSI	WI	WI	EI	WI	EI	SI	PI
Food	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	SI	EI	EI	EI	VSI	WI	SI	SI	VSI
Logistics	AI	EI	EI	EI	AI	WI	SI	PI	AI
Demand	EI	AI	EI	EI	VSI	SI	EI	SI	WI

**Table 6**  
Aggregated evaluation matrix based on plithogenic aggregation operation.

Contradiction degree	0	0.11	...	0.89
4 business owners	Policy 1	Policy 2	...	Policy 9
Supply	((0.31, 0.75, 0.99), 0.85, 0.15, 0.15)	((0.1, 0.55, 0.96), 0.9, 0.13, 0.1)	...	((0.36, 0.68, 0.99), 0.75, 0.1, 0.2)
Logistics	((0.45, 0.81, 0.99), 0.85, 0.13, 0.15)	((0.04, 0.45, 0.92), 0.83, 0.13, 0.15)	...	((0.46, 0.8, 0.99), 0.88, 0.1, 0.13)
Demand	((0.06, 0.5, 0.94), 0.9, 0.1, 0.1)	((0.35, 0.76, 0.99), 0.85, 0.1, 0.15)	...	((0.13, 0.4, 0.8), 0.75, 0.13, 0.18)

**Table 7**  
Crisp values of the aggregated evaluation matrix.

	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	0.6551	0.5371	0.3585	0.3556	0.8861	0.3109	0.6491	0.6926	0.6234
Logistics	0.7270	0.4500	0.3585	0.3556	0.9457	0.3109	0.6491	0.5905	0.7485
Demand	0.5063	0.6871	0.4230	0.3556	0.6473	0.3714	0.5866	0.6555	0.4042

**Table 8**  
Normalized evaluation matrix.

	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	0.2084	0.1708	0.1140	0.1131	0.2818	0.0989	0.2065	0.2203	0.1983
Logistics	0.2198	0.1361	0.1084	0.1075	0.2859	0.0940	0.1962	0.1786	0.2263
Demand	0.2003	0.2718	0.1673	0.1407	0.2561	0.1469	0.2321	0.2593	0.1599

**Table 9**  
Weighted normalized evaluation matrix.

Weight	0.3146	0.1277	0.0479	0.0547	0.0638	0.1915	0.0766	0.0958	0.0274
	Policy 1	Policy 2	Policy 3	Policy 4	Policy 5	Policy 6	Policy 7	Policy 8	Policy 9
Supply	0.0656	0.0218	0.0055	0.0062	0.0180	0.0189	0.0158	0.0211	0.0054
Logistics	0.0692	0.0174	0.0052	0.0059	0.0183	0.0180	0.0150	0.0171	0.0062
Demand	0.0630	0.0347	0.0080	0.0077	0.0163	0.0281	0.0178	0.0248	0.0044

By applying the BWM model according to the best-to-others vector and others-to-worst vector the weights of the prevention policies are shown in Table 4. As the results show, we found that the international and domestic air suspension (Policy 1) has the highest weight which is 0.3146 followed by postponing studies in schools and universities (Policy 6) with weight 0.1915. Close the commercial centres, shops, restaurants, cafes and night-clubs (Policy 2) and Converting the work system to remote work from home (Policy 8) are in the third and fourth rank of the most influential policies with weights 0.1276 and 0.0957, respectively. The rest of policies are ranked as follows: Reducing the employment rate in some jobs determined by the state (Policy 7) with weight 0.0766, internal transportation and the High-Speed Rail train services have been suspended (Policy 5) with weight 0.0638, suspension of religious rites (Policy 4) with weight 0.0547, Suspending tourist activities (Policy 3) with weight 0.0478, and Suspension of maritime traffic (Policy 9) with weight 0.0273. Fig. 2 shows the weights of the policies and their ranking.

Phase 2: At this phase, the uncertainties in the evaluation process are taken into account in a focused manner, because it is considered one of

**Table 10**  
Ranking of the supply chain aspects according to the policies.

Alternatives	$d^+$	$d^-$	$CC_i$	Rank
Supply	0.017057	0.0069	0.288026	2
Logistics	0.021944	0.006688	0.233587	3
Demand	0.006688	0.021944	0.766413	1

the most important gaps that occur in the assessment-based decision-making processes, particularly in the case of the COVID-19 pandemic because it is one of the emerging phenomena that the world does not yet have enough knowledge about. In our study, the assessment of the three aspects of the supply chain is based on four business owners in different four supply chain fields. These fields are food, electronics, pharmaceutical, and textile industries, and their evaluation is based on the neutrosophic linguistic scale in Table 1. The assessment of the four business owners on the aspects of the supply chain is gathered from a survey. In this questionnaire, the extent of the impact of each of the nine policies on the three aspects of the supply chain at the level of the four different industries was compared. The evaluation through the neutrosophic linguistic scale is one of the ways that gives the decision maker a greater tolerance for evaluation. The assessment by business owners of the policy's effect on their supply chains is shown in Table 5.

The contribution of the study is to use the plithogenic aggregation operation to aggregate the four business owner's assessments and to build a single evaluation matrix. According to Eqs. (3), (4), and (5), the aggregated evaluation matrix as Table 6 shows. One of the main contributions of the plithogenic aggregation operation is the contradiction degree that describes the relationship between attribute values and the dominant attribute value. Therefore, this framework is considered to be better at observing uncertainty compared to other models.

Phase 3: In this stage, the TOPSIS is applied to rank the supply chain aspects according to the influence of the COVID-19 prevention policies on its performance. With the aim of simplification of calculations, the aggregated evaluation matrix is converted to crisp values rather than neutrosophic

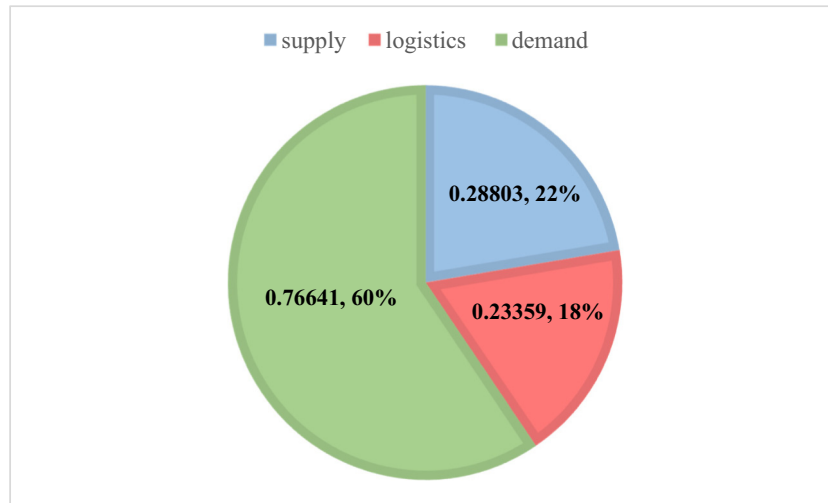


Fig. 3. Influence of the supply chain aspects by the prevention policies.

numbers using Eq. (16). The evaluation matrix in the crisp form shows in Table 7.

$$S(a) = \frac{1}{8}(a_1 + b_1 + c_1) \times (2 + \alpha - \theta - \beta) \tag{16}$$

Then, normalize the evaluation matrix and calculate the weighted normalized matrix based on the results of the BWM as Tables 8 and 9 shows. The weight of the policies is based on the BWM which provide more accurate evaluation rather than using the traditional TOPSIS. This step enhances the efficiency of TOPSIS by combining the results of the BWM in its steps.

The TOPSIS ranking is based on the distance of the alternatives to the positive ideal solution and the negative ideal solution. Thus, the ranking of the supply chain aspects based on TOPSIS as Table 10 shows, the demand is the most influenced aspect by the COVID-19 prevention policies with closeness coefficient 0.76641. Then, the supply and the logistics are in the second and third rank as TOPSIS result shows in Fig. 3 with closeness coefficient 0.28803 and 0.23359, respectively. It is evident that the demand of the four fields that have been examined by the business owners' opinions on the impact of prevention policies on their performance, have been clearly influenced by 60%. Moreover, the supply and logistics of the supply chain influence by 22% and 18%, respectively. The drawback of this research is that not all sectors impacted by the pandemic are included in the review, since this research discusses four of the more relevant industries.

### 5. Managerial implications

The managerial implications of this study is to recognize the presence of strategies that restrict the effects of this pandemic on supply chains demand to ensure the continuity of their effective performance. That means that the performance of the supply chain is affected by demand, supply, and logistics consecutively. This is the time where supply chains pass through measures and policies imposed by countries from the most challenging periods that involve effective strategies and approaches that maintain the continuity of their performance as required until this pandemic is safely passed. Administrative and business owners should consider the reasons for the large impact of demand due to the policies imposed by countries to reduce the risks of the COVID-19 pandemic.

### 6. Conclusion

COVID-19 pandemic is deemed one of the most important problems to be tackled, which presents a significant challenge to the supply chains in all fields. All countries are seeking from all directions to confront this

pandemic to reduce its side effects by imposing strict policies and laws that work on the safety and security of countries. This study is concerned with the impact of these policies on the supply chain in terms of supply, demand, and logistics. Like all evaluation and decision-making problems, data are not available with complete certainty, and decision-makers opinions vary according to their beliefs and opinions. Therefore, this study considered the uncertainties in the evaluation process, based on the plithogenic set.

Through this study, a framework was proposed to assess the effect of the protective policies of the Corona pandemic on supply chain aspects, based on BWM and TOPSIS under plithogenic environment. The contributions of this study focus on the consideration of the uncertainty in the evaluation process by applying the plithogenic aggregation operation. The plithogenic aggregation operation is considering the contradiction degree among the elements which ensure more accurate results. Moreover, the integration of the BWM and TOPSIS provides high consistency of the evaluation by combining the strength of the two methods. It is obvious in the results that the market for the four areas explored by the perceptions of business owners on the effect on their efficiency of prevention policies was strongly affected by 60% followed by supply and logistics.

In brief, the proposed framework composed of three main phases. The first phase is to find the weights of the COVID-19 prevention policies using the BWM. The second phase is to build the evaluation matrix of the decision-makers based on plithogenic set. It is worth noting that this evaluation is applied in four industries they are food, electronics, pharmaceutical, and textile industries. The last phase is the ranking of the supply, demand, and logistics by the TOPSIS method. The results show that demand is the most affected aspect of the supply chain by the COVID-19 prevention policies. The limitation in this study is that the evaluation does not include all industries affected by the pandemic, as this study address four of the most important industries.

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