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Assessment of challenges and problems in supply chain among retailers during COVID-19 epidemic through AHP-TOPSIS hybrid MCDM technique



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ABSTRACT

Framework and objectives: COVID-19 epidemic has sparked concern and has elevated the need for therapeutic tools, health equipment's, and day-to-day necessities for healthcare workers' well-being. The goal of this study is to uncover the operational problems that suppliers encounter when it comes to offering effective services. The research also intends to offer an Industry 4.0 strategy for reducing COVID-19's effect. The problems are weighed and priority is assigned by multi-criteria decision making to identify the most essential parameter which impacts the suppliers.

Methods: A comprehensive literature assessment on the rampant eruption of COVID 19 and supply chain is conducted with the aid of literatures available on SCOPUS, Science Direct, and Google Scholar using appropriate keywords. To get further insights, certain pertinent and applicable industry reports and blogs are also used. Problems were analysed with AHP method and priority was assigned by technique for order performance by similarity to ideal solution (TOPSIS). Weights are calculated by AHP method and assigned to each criteria attribute.

Results: We recognized eleven key problems that serve as an operational obstacle in the retail industry and proposed the use of Industry 4.0 technology to address them. The contemporary study is accomplished by using hybrid combination of two Multi Criteria Estimators methods- Analytical Hierarchical Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Further, the most significant problem comes out to be Maintenance of an appropriate balance among supply and demand followed by Lack of Viability.

Key findings: Prioritization of supply chain problems are arranged in descending order Maintenance of an appropriate balance among supply and demand > Lack of Viability > Absence of government funding > Lack of access > Absence of Confidence > Scarcity of work force > Lack of security and safety > Deficiency of surplus medical amenities > Consumer attitude > Absence of Supply Chain flexibility > Communication problems.

Conclusion: In order to combat the pandemic, Industry 4.0 can play a key role in lowering the effect of identified issues on retailers. For the successful administration of healthcare basics, trust and openness are required. To enhance services, suppliers, distributors and policy makers should make informed decisions during COVID-19 and other comparable events. Therefore, suggested guidelines and framework will offer upcoming directions for research in fields of pandemic check, business logistics management, and catastrophe administration. Balance in supply and demand is the most significant attribute as its percentage contribution is the maximum (27.52%) followed by Safety of employees (26.51%). Furthermore, the research then ranks these models on the basis of their attributes with the aid of TOPSIS. Among all these problems, Maintenance of an appropriate balance among supply and demand and lack of viability are identified as the prime most and common concern for retailers in supply chain management during the COVID-19 pandemic.

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1. Introduction

Past two years have been a constant struggle for every human being across the globe. In late 2019 year, a pneumonia of unidentified origin was discovered in Wuhan, China, and was dubbed COVID-19, short for "coronavirus illness 2019" by the World Health Organization (WHO) [1]. The worldwide epidemic was predicted on March 11, 2020, when the WHO declared it a pandemic [2]. The number of verified COVID-19 cases globally increased from February 11 to April 14. It increased from forty five thousand to twenty lakh all around the world [3]. Colds, sniffles, salivary droplets, and nasal discharge are all ways for the virus to spread. As a result, it became necessary to isolate and uphold social distance in order to limit the spread of the virus. As a result, nations all over the world implemented travel bans, proclaimed nation-wide lockdowns, and restricted citizen mobility. Further repercussions were seen in the face of economic meltdown which wiped out a high share of wealth of nations.

The sudden hike and fall of requirement of items were seen in countries with higher population. Imposed lockdown presented an uncertainty in the work force with several labour workers returning to their home town for safety. Distribution centres became unavailable as a result of the lockout and restricted travel, disrupting the whole supply chain. A scenario comparable to this occurred in early 2000's, when the unexpected occurrence of severe acute respiratory syndrome (SARS) afflicted more than 20 nations and interrupted the aggregated supply [4]. The impression of the confinement was considerable, with 94% of Fortune 1000 firms and numerous small and medium-sized businesses reporting risk in SC as a result of uncertainty [5].

A sense of urgency was felt among the retailers as the COVID -19 guidelines were not very clear to people [6]. COVID-19 was differentiated from earlier SC disruptions by a seven-dimensional analysis (geography, scale, goods and services available to people, early preparation & individual influence and attitude, monetary sector, time, and event). In developing countries with technology and network connectivity issues, food supply was the worst hit during the COVID-19 pandemic probably due to unstable availability of resources, thereby causing a state of panic [7]. The eruption of this pandemic was described as a unique supply management hazard that is likely to persist for a prolonged period, spread with significant unpredictability, and have an impact on logistical infrastructure [8–12]. Multiple researches in the past have explored the applications of technology in managing supply chain achieving utmost success [13]. Studies are also incorporating a sustainability angle in supply chain managers to reduce the effects of product production with special focus on economic factors responsible [14].

Governments are actively trying to address and tackle the current problems in supply chain management in a sustainable and effective manner during the ongoing pandemic [15]. Traders and dealers are regarded as an integral component of the SC since they are closest to customers [16,17], and their participation is critical because they may be under a lot of pressure to deliver necessary products [18]. It becomes important to get items from uninfected distribution hubs to retail outlets promptly and efficiently [19]. Multiple strategies have been adopted by various researchers to explain how supply chain consistency can be managed [20,21].

As the CoV spreads, the provision of critical commodities to preserve customers' health becomes more difficult than under normal circumstances [22]. Due to shifting conditions, many retail establishments are experiencing capacity limits and excess demand issues [23]. Deloitte, KPMG, Nielsen, Forbes, and IDC are among the retail groups throughout the world who have expressed their concerns about the coronavirus outbreak. The existing research principally emphasizes to estimate the problems exerted on retailers by sudden pandemic implications identifying key problems especially in India since the population levels are extremely high.

According to research, technological usage can help control pandemic scenarios significantly. Retailers' issues can be alleviated if Industry 4.0 is implemented. Industry 4.0 is a combination of contemporary automation

such as the internet of things (IoT), cyber-physical systems (CPS), Cloud computing (CC), Bigdata, and others that provide a system [24,25]. [26, 27]; with flexibility, perceptibility, trackability, and dependability. We've also discussed how Industry 4.0, Artificial intelligence and IoT advancements can be used to combat the COVID-19 epidemic. By retrieving the above literature, it can be said that supply chain, has been seldomly explored during the pandemic. Also, the weight assignment for different problems is never taken into consideration, making the current study novel and unique. Ranking the biggest and common most problem encountered by suppliers will yield a feasible and well-established inputs to future retailers in the industry.

This fuelled our desire to learn the solutions to key investigation issues such as what problems the retail industry has in serving customers and the way these issues may be solved utilizing Industry 4.0. As stated in the study query above, the goal of this study was to investigate the problems experienced by retailers during the COVID-19 epidemic. Furthermore, comparison of such problems from dissimilar categories while ranking them best and worst based on performance attributes still remains an unexplored zone. The literature survey is process is comprehensively performed by considering several articles, case studies, expert opinions etc. as shown in Fig. 1.

The reason associated with dealers for disruption in supply is a combination of multiple parameters which can be selected from multiple categories and working on same variables and constraints. Furthermore, it is quite evident such problems are seldomly explored and compared while establishing ranking system among a set of attributes which decide the selection criteria. Keeping in consideration the above exceptions in prior studies the authors have formulated research which identify and compare multiple problems encountered from different backgrounds on a predefined set of criteria's, thereby ranking them from best to worst performing criteria.

In prior researches, identification of problems encountered by suppliers has been performed without suggesting or assigning weights to each problem. Furthermore, each criterion on which the problems are compared have been assigned equal weightage in earlier researches. But ideally some criterions have larger impact than others hence becoming a major limitation in the previous analysis. Considering the above pandemic crises, researchers were motivated to explore an accurate, precise, reliable process of identifying multiple supply chain problems which previously has not be performed by employing hybrid models.

From the literature, it appears that although a few consolidated articles pertaining to categorization of supply chain problems are available, little to no work related to the weight assignment, identification, prioritization and ranking of multiple problems of supply chain is available. Further, applications of MCDM in supply chain management are rarely available in the literature.

The authors were motivated to rank various problems encountered by retailers from different backgrounds based on a set of attributes which previously has never been addressed before, also marking the novelty of the current research. In this sense, this paper is comprehensively presenting an opportunity to see and evaluate the problems from various different categories together.

Primarily the research filtered multiple studies related to supply chain highlighting respective problems encountered during COVID-19 from different classes. Moreover, in order to establish a feasible relationship among multiple performance attributes of the models, a weightage was assigned to each criterion or variable. The models were compared on these attributes with linguistic variables being assigned to each model attribute. On the basis of score calculated by weightage assigned best and worst model is established which can be used by future researchers.

The prime objectives of the contemporary research are presented below:

- Selection and categorization of criterions will largely impact the supply chain functioning on the basis of prior literature.

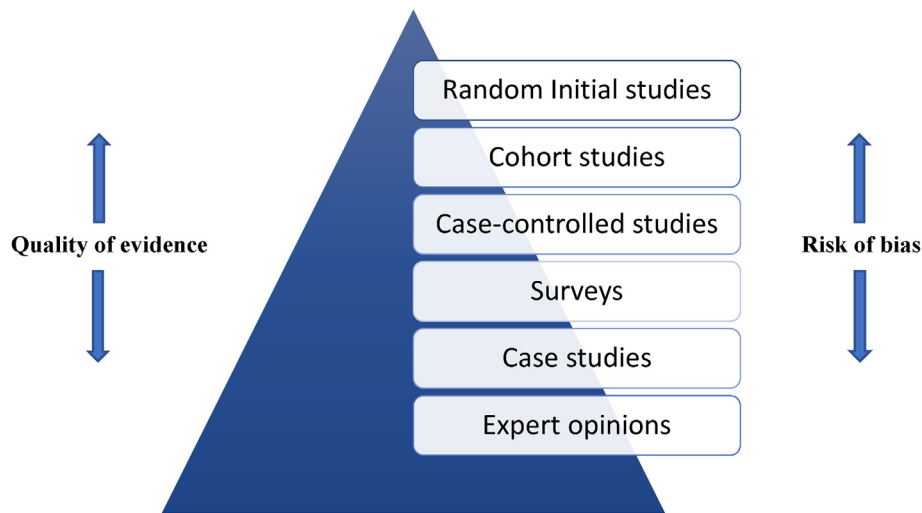


Fig. 1. Hierarchy of Literature selection and review process for the study.

- Identification and classification of supply chain problems impacting the suppliers during the pandemic through a questionnaire.
- Transforming expert reviews into linguistic variables so as to develop comparison matrix for multiple criterion weightage calculation.
- Weightage calculation by AHP method to seven criterions based on developed linguistic matrix.
- Calculation of scores for several supply chain problems and prioritizing them on the basis of rank assignment.

Considering the above pandemic crises, researchers were motivated to explore an accurate, precise, reliable process of identifying multiple supply chain problems which previously has not been performed by employing hybrid models. From the literature, it appears that although a few consolidated articles pertaining to categorization of supply chain problems are available, little to no work related to the weight assignment, identification, prioritization and ranking of multiple problems of supply chain is available. Further, applications of MCDM in supply chain management are rarely available in the literature. Consequently, authors got motivated to carry out the study with an aim to identify and rank supply chain problems on several performance constraints. To achieve this objective, AHP- TOPSIS based hybrid MCDM approach has been employed which makes this study novel and significant as to the best of authors' knowledge no previous work has been reported.

The novelty of the current work can be established by the fact that, in prior researches multiple problems were identified by seldom to none researches provided weights to multiple criterions. Moreover, equal weights were provided to all criterions which provided ineffective solutions to prioritize problems in supply chain. The exceptional implemented model applied in supply chain manufacturers, identifies and separates the prime problems experienced during pandemic by providing different weights to multiple criterions. Thereby properly predicting them before it even happens and solving it, thereby making the current work innovative, specific and accurate.

The remainder of the paper is organised as follows: Section 2 contains the literature review concentrating on the SC, merchandising, pandemic and coronavirus; Section 3 contains the literature review concentrating on the SC, trade, pandemic occurrence, and coronavirus; Section 4 contains a literature review emphasizing on the SC, market, manifestation of the pandemic, and coronavirus; Section 3 explains a plan for implementing Industry-4.0 to address COVID's stated complications.

2. Identification of problems related to supply chain

Supply Chain disruption is defined as "An indicator of an

organization's failure towards balancing the supply and demand sides," [29]. Natural and man-made catastrophes, which occur infrequently but have a large impact on the SC [30–32], are the most common causes. The SC disturbances are expensive and possibly detrimental in the extended time [14] there has been a boom in publications in the last decade, and there is a vast amount of information on the issue. Because COVID-19 is the subject of this study, this section of the study emphasizes on the disorder as a result of a pandemic outbreak in the distribution chain. The exploration and analysis involving SC and the pandemic occurrence is inadequate in nature [16,33].

2.1. SC and pandemic outbreaks

The worldwide ambiguity generated by SARS in 2003 was attributed to a scarcity of adaptability, which harmed the conventional distribution chain network as well as foreign tourism in the Asian area [34]. During the Influenza outbreak, which led in 250,000 to 500,000 fatalities yearly, SC cited operational issues such as "absence of economic cooperation" and "cost-sharing agreements." [35]. It cited "trust difficulties amongst SC participants," "deficient veterinary set-up," "dearth of an effective data sharing structure," "lack of remuneration," as well as "unlawful activities" as barriers that led to the 2006 flu epidemic [36].

Pandemic is defined as strategic uncertainty that grows increasingly dangerous as a result of decreased reactivity, unreliable facilities, and an unstable SC transit system [37]. created a modelling system to anticipate the consequences of the epidemic on the SC and propose an action plan. Self-containment, quarantine of an affected individual, proximity tracking, and proper funeral methods are among the most severe methods that have been found to limit the incidence of viral transmission.

2.2. SC & influence of the pandemic on the wholesale business

Because, the trade organizations satisfies consumer need and communicates real data with traders for future prediction, it has been regarded as the most important actor in the SC [12,38]. Despite the fact that retailers are an important stakeholder in SC [18], research on the epidemic breakout and the retail business is sparse [16]. The SC also has an inherent risk of pandemic breakout, which creates a damage of demand and disturbance in market businesses owing to product scarcity. [39]; using a closed-loop graphic, described the spread of Avian flu among the general public, store employees, and the whole SC. According to the investigation, companies should maintain track of their employees and suppliers in order to educate them of all the required measures that

can be accomplished through the serviceability term.

2.3. SC, retail, and COVID-19

CoV, which causes COVID-19, is a virus family found in people and animals, including bovines, felines, and bats. In Asia, CoV was transmitted to people for the first time., known as SARS-CoV [40], was discovered in 2003. It was different from previously recognized human CoV. In 2012, there was an outbreak of the Middle East respiratory syndrome coronavirus (MERS-CoV.) It was eventually transmitted to the humans during [41]. At the end of 2019, a new virus (SARS-CoV-2) caused a respiratory disease outbreak in China, which quickly became a significant danger to human survival [42].

COVID-19 arrived as a crisis to the distribution networks affecting worldwide SC productivity and he found that SC productivity is closely related to disruption length and that it is affected by time, disruption propagation size, and facility accessibility [43,44]. Also, it emphasised the significance of SC adaptability and viability under extreme events (like the COVID-19 pandemic). According to a study of 5800 small companies [16], 43% of retail shops are temporarily shut down due to the COVID-19 epidemic. Retailers are having trouble sustaining operational continuities offline and online as a result of travel restrictions, health quarantine programme, and industrial shutdowns.

2.4. Obstacles that affected the functioning of SC and merchants during the outbreak of the pandemic

The pandemic occurrence has been classified as a SC uncertainty hazard that can occur frequently or seldom, and for brief or extended periods of time, reducing supplier capacity and elevating consumer demand by 20% overnight. Because there is a scarcity of information on COVID-19 and SC, this portion of the article includes some online searches and organizational records. Apart from these issues, there are a slew of others that have been raised in various publications across the world, such as a lack of expertise in dealing with these situations, employee educational qualifications, consumer educational status to comprehend the situation, and so on.

The goal of the study is to determine various problems that supply chain distributors and merchants confront during an epidemic outbreak, namely the coronavirus pandemic. These essential aspects indicate the concerns that are being addressed in the context of unique situations. Beside the suggested list, the opportunity for future investigative work is deliberated in relation to the technology of Industry 4.0.

2.5. Identification of criterions

Although the above discussed problems can be compared on different parameters but after having one on one interaction with retailers some prime constraints have been recognized and considered for the present study. The following are the prime constraints on which the retailer problems depended on: Viability, balance in supply and demand, safety of employees, trust between retailer and consumer, distribution & transportation capability, shortage of manpower, consumer Behaviour,

information exchange and capacity issues. The criteria are listed in Table 1. The following constraints will be assigned weights based on the analysis performed by AHP to identify the most critical parameter which governs the problems of retailers as discussed in the next section.

3. Methodology

3.1. Identification of challenges faced by supply chain retailers

The portion of this article provides an overview of the research opportunities for the COVID-19 issues. Industry 4.0 intends to build sophisticated industries that use IoT, CPSs, big data analytics, and CC to change and update technologies. Other businesses, such as service, healthcare, agricultural, and nutrition, can benefit from Industry 4.0.

In the case of “Absence of SC adaptability (C1)” increasing adaptability has been seen to be an expensive procedure; nevertheless, developing a measure for balancing price, adaptability, and uncertainty may be interesting accomplishments. Many different forms of study work on SC threat and adaptability are accessible in research; however, investigation on contagion circumstances and SC adaptability is scarce. In past performance of multiple firms of medium to small size have been explored which employ hybrid manufacturing approaches [43].

Large data analytics, a SC prototype, can cope up with unpredictable circumstances with a great degree of flexibility. Concerning the “Absence of government funding (C2)”, the development of contracts or enticements for the unique circumstance by including all SC participants and government authorities will be interesting research paths. Blockchain has been a popular technology in recent years to address the issues of "dearth of government funding (C2)" and "Absence of confidence (C3)" since it renders the SC more accountable [46].

Also, prior literatures conveyed that the government should be prepared to move critical suppliers and inventories to the most contaminated location. This technique might be used in circumstances like disease outbreaks to monitor and track the transit of commodities. A promising topic of research might be the development of a blockchain-based, comprehensive platform for SC interruption. According to Ref. [18], blockchain may be utilised for transport of goods at the consumer's door, which opens up a world of possibilities for future study into other blockchain applications.

For “Communication problems (C4)” Industry 4.0 and the technology connected with the Cloud of Things [14] hold a lot of potential. It will be fascinating to watch how these technologies prevent misinterpretations of data given by government agencies. Effective rules and a distribution plan are required to address “Lack of security and safety (C5)” situations such as COVID-19.

Workers' pay, incentives, the safety of his or her family, and other factors can all influence policies. Implementing robotic and automated equipment in shopping centres is also an attractive research topic since it can assist and overlook circumstances that are potentially hazardous to people [22].

The main cause of the ‘Shortage of personnel (C6)’ might be a lack of work stability and the risk of infection. More research on how the world reacts to worker crises is required. Professionals that are coping with

Table 1 List of criteria on which problems will be distinguished during COVID-19 outbreak.

Criteria	Designation
Balance in supply and demand	P1
Safety of employees	P2
Trust between retailer and consumer	P3
Distribution & transportation capability	P4
Shortage of manpower	P5
Consumer Behaviour	P6
Capacity Constraints	P7

these situations require training and guidance. A favourable domain of research is creating a learning programme to handle COVID-19 or stressful circumstances. Training and education can both benefit from cloud-based solutions [20].

Research focused on consumer behaviours during times of crisis is needed to further understand “**Consumer Behaviour (C7)**”. During pandemic outbreak circumstances like COVID-19, it became critical to distinguish between what customers desire and what they require. To comprehend the pattern, data interpretation and knowledge engineering skills can be employed [19].

In the case of “**Lack of supply and demand balance (C8)**” a causality analysis of related elements would aid in gaining a thorough understanding of each issue. It’s a fine decision to identify key elements for the growth of retail SC in the event of an epidemic outbreak.

It might be contemporary technological integrations on every level of the distribution chain to improve ability and adaptability. Researchers might look into the development of rules for gaining emergency access to additional storage in private or public structures. Although numerous technologies exist to combat coronavirus, putting them into practise is the most difficult task owing to a “**lack of medical facilities (C9)**”. Small retail shops may find it difficult to use technology such as AI and blockchain due to budgetary constraints. It would be a smart option to conduct research on the barter amid technology, its uses, and price [24].

It is proposed that Artificial intelligence (AI) and the Internet of Things (IoT), can assist in identifying danger and contamination, thereby reducing production burden. In past multiple researches have discovered the role of AI in handling farming products for supply chain risk during the pandemic [44]. The use of software development with viability for the integrated SC to examine their capability to help policymakers for long-term breakdowns is one of the possible topics of study to solve “**absence of feasibility (C10)**.”

The creation of a better plan for the transfer of products without breaking movement rules is required for “**Deficiency of approach (C11)**”. The emphasis must be solely on preventing the spread of viruses and ensuring the provision of vital supplies. Supply chain 4.0, a SC-specific version of Industry 4.0, can assist with these issues.

The following identified problems are primarily found by retailers during supply chain management in COVID-19 era. These problems will now be discussed with experts who will provide their answers in linguistic variables which will aid us to identify the most common problem increasingly faced by managers.

3.2. Identification of criteria's

The following parameters are identified and considered for the analysis of supply chain during the pandemic and are explained below:

- **Balance in supply and demand**

A significant rise in demand for certain SC (e.g., food goods) that could not be met due to a limited supply due to the pandemic spreading across the world at the same time was experienced as the disease spread throughout the world.

- **Safety of employees**

It is critical to ensure the health and safety of employees who come into close touch with customers. It is essential to arrange sanitizing equipment or perform appropriate sanitization at the shop.

- **Trust between retailer and consumer**

When viruses spread via interaction with people and tainted items, credibility problems becoming a greatest difficulty for service stores, and “no-touch delivery” has been the new standards for the retail industry.

- **Distribution & transportation capability**

Resources and accessibility are constrained, resulting in restricted strengths and capabilities.

- **Shortage of manpower**

The issue develops as a result of staff relocation to their hometowns, government restrictions aimed at minimizing coronavirus transmission, and concern of illness.

- **Consumer Behaviour**

Consumer purchasing habits have shifted dramatically. It is currently concentrating on pharmaceuticals and basic everyday necessities. Collecting these items places an unneeded strain on merchants.

- **Capacity Constraints**

Scarcity of storage capacity at the commercial facility, businesses attempted to expedite their processes but were unsuccessful.

Multiple researches in the past have studied the implications of the pandemic on maintaining a consistent supply chain by developing some policies to be framed for future [28]. Henceforth, the above identified criterions are considered to be the prime constraints which impact the problems of the supply chain for retailers. These criterions are further transformed into a questionnaire which is given to the experts where their reviews are considered for weightage assignment and ranking process.

3.3. Experts' information

Expert opinion is often considered to be extremely crucial when designing attributes in linguistic terms in applications analysed by MCDM techniques. Qualified experts from industry are selected who handled the supply chain during the pandemic, also who can provide expertise easily and at will. These qualified experts check the feasibility of the weights assigned to the attributes of the problem, thereby presenting accurate and efficient results. Generally, experts are chosen among managers, industrialist, interest groups for weight assigning process which will eventually provide solid results. Weight assignment is considered to be an essential part of the MCDM problem since wrong assignment will yield improper ranking system, establishing improper preference of the lesser weightage attribute over higher weightage attribute. Initially, the weights are evaluated by AHP technique followed by TOPSIS analysis which identifies the common most problem undergone by supply chain maintainers. Expert demographic information is displayed in Table 2.

The experts were classified into individual groups based on their position in the industry each having an experience of at least more than 3 years. Several sessions were carried out with experts either in online or offline mode to gather the data regarding the attributes primarily in linguistic variables ranked between 1 and 5. 1 is very low, 2 is low, 3 is medium, 4 is high, 5 is very high.

Table 2
Experts' information.

Category	Classification	Number of experts
Industry	Senior Level	2
	Mid-level	16
	Entry Level	3
Sex	Male	15
	Female	6

3.4. Multi-criterion decision making (MCDM) techniques in supply chain- A broader outlook

Several researches in the past have explored the applications involving industry 4.0 during the pandemic to overcome the difficulties attained during multiple tasks [45]. Similarly in this research a COVID-19 operational challenges by MCDM methods are explored and have emerged a potent instrument in solving complications which deals with comparison, identification and best & worst characterisation of outcomes. It aids in solving problems associated with several conflicting conditions in an organized manner, permitting contemplation of dissimilar preferences. Identification of supply chain problem is also one of the Multi-performance Evaluation (MPE) problem. After contemplating over several other technologies, TOPSIS-AHP was selected for present examination whose working procedure is described subsequently.

The current study required assigning weights to multiple criterions. Due to the pandemic several data could not be collected due to untimely lockdowns in various states. As a result, AHP was chosen as it allows irregularity as a result of absence of data about criteria and choices, and absence of fixation amid pairwise examinations. The data gathered required utmost accuracy and precision in identifying and prioritizing the prime problem suffered by various supply chain managers. This was the prime reasons of choosing TOPSIS as the results obtained are generated with utmost simplicity, rationality, comprehensibility, good computational efficiency and ability to measure the relative performance for each alternative in a simple mathematical form.

3.4.1. AHP weightage

The concept was introduced by Saaty known as Analytic hierarchy process (AHP) which is a comparative measuring approach for qualitative and intellectual criteria. It is a computational method that might be further recognized as a judgment tool. This is a conflict-based instrument that helps in organizing complicated problems in a systematic manner by simplifying the assessment of all judgment criterions. Prime reason of adopting AHP for this research can be understood by contemplating on its numerous benefits. When addressing ranking alternatives, it incorporates the modular approach of most reliable decision. This enables us to evaluate the uniformity and consistency of the evaluation technique.

The following are the quick overview of AHP steps:

Step 1 Initially, identify the goals to accomplish, subsequently restrict- ing down possible choices.

Identifying parameters and judging them based on a quantifiable characteristic requires practical expertise of a seasoned expert who can present a proper explanation and tabulation of the available options.

Step 2 A Throughout assessments needs to be performed, which classi- fied into two sections: (i) Among Attributes of the problem (ii) Between many Alternative solutions that fulfill every prerequisite.

Experts of the required field have developed matrices which analyses attributes on a primary scale ranging from 1 to 5.

The number of interrelated vectors is calculated using the formula (nxn), where n specifies the number of attributes.

Step 3 Let Xij indicates the ith factor's priority ranking in comparison to the jth factor. After that, Xji = 1/Xij.

Step 4 Preparation of a standardized pair-wise matrix is created for the applied system in following sub-steps:

- (a). Compute the total of all columns.
- (b). Deduct the derived columns sum from each element of the matrices.
- (c). For getting the relative weights, calculate the number of rows.

Step 5 By Applying Eq. (1), we get the Evaluation matrix, highest Eval- uation result, and Criterion index (CI)

$$CI = \frac{\lambda \max - n}{n - 1} \tag{1}$$

The Eigenvector of the conjoint analysis matrices is maximum, and the number of criterion is n.

Step 6. By Using Eq. (1), the consistency ratio (CR) is calculated (2). Where RI means random index,

$$CR = \frac{CI}{RI} \tag{2}$$

3.4.2. TOPSIS assignment

Data regarding weights achieved above form another important aspect of multiple attribute performance models which further uses TOPSIS method to establish ranking among problems of supply chain. It comprises of following steps:

Step 1 Gather data from stakeholders regarding the essential evaluations of the outcome responses in linguistic terms such as extremely low, low, average, high, extremely high from the experts.

Step 2 Transforming various linguistic values into numeral valuations.

X_{abN}=(l_{abN}), Where, a = 1, 2, 3 m; b = 1, 2, 3 n, where,

$$a = \min\{l_{abN}\}, b = \frac{1}{N} \sum_{N=1}^N P_{abN}, c = \max\{u_{abN}\} \tag{3}$$

Step 3 Evaluate the outcome responses for the combined weights.

$$B = [P_{ij}]_{m \times n} \tag{4}$$

Here, i = 1, 2, 3, ..., m; j = 1, 2, 3, ..., n

$$P_{ij} = \left(\frac{a_{ij}}{c_j^*} \right); c_j^* = \max c_{ij} \tag{5}$$

$$P_{ij} = \left(\frac{a_j^-}{c_{ij}^-} \right); a_j^* = \min a_{ij} \tag{6}$$

Step 4 Standardize the overall output matrices.

$$V = [v_{ij}]_{m \times n} \text{ where, } i = 1, 2, 3, \dots, m; j = 1, 2, 3, \dots, n \tag{7}$$

$$\text{Here, } v_{ij} = p_{ij} (\times) w_j \tag{8}$$

Step 5 Compute the standardized weighted matrices.

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

$$v_j^+ = \{ \max(v_{ij}) | F_j \in J; \min v_{ij} | F_j \in J' \}, j = 1, 2, 3, \dots, n \tag{10}$$

$$A^- = \{v_1^-, \dots, v_n^-\} \text{ Where,}$$

$$v_j^- = \{ \max(v_{ij}) | F_j \in J; \min v_{ij} | F_j \in J' \}, j = 1, 2, 3, \dots, n \tag{11}$$

Step 6 Establish the optimal solutions that are both positive and negative.

$$d_i^+ = \left\{ \sum_{j=1}^n (v_{ij} - v_{ij}^+) \right\}^{1/2}; i = 1, 2, \dots, m \tag{12}$$

$$d_i^- = \left\{ \sum_{j=1}^n (v_{ij} - v_{ij}^-) \right\}^{1/2}; i = 1, 2, \dots, m \tag{13}$$

Step 7 Compute the differences between the actual data collected from the ideal both positive and negative.

$$CC_i = \frac{d_i^-}{d_i^- + d_i^+}; i = 1, 2, \dots, m \tag{14}$$

Step 8 Estimate the closeness coefficient (CC) data and evaluate the pre-experimental studies based on them, starting with the research having the maximum CC value marked with highest rank. The rank degrades with decreasing CC value.

Table 3 illustrates the linguistic equivalents assigned to the outcome reactions of the significance levels.

The essential weightage assigned to each attribute in linguistic equivalents was independently evaluated by a decision-making committee of key experts of the industry.

Table 4 gives the resulting answers' that is aggregated weighting factors. To establish the optimal situation, a standardized weighting factor was applied.

4. Results and discussion

This segment in specific analyses the reviews of experts on supply chain problems provided in linguistic terms, additionally implementing weights to each attribute with the application of AHP model. Moreover, TOPSIS analysis presents the ranking analysis based on above acquired weightages, thereby identifying the biggest and common most concerns of supply chain.

4.1. AHP weightage assignment

AHP formulation is functional in generating weights to the identified problems, thereby prioritizing prediction challenges or problems influencing supply chain.

Eleven major criteria's have been recognized that influences the supply chain capacity of retailers. The AHP is responsible for assigning

weights to multiple criteria. Furthermore, the attributes of the models are ranked and rated from based on reviews provided by experts. The suggestions are expressed in linguistic terms according to their weightages to obtain a hierarchy as depicted in Table 5.

It is evident from Table 5 that balance in supply chain is the prime characteristic which is most momentous state. Application of AHP makes global weights of the attributes, prepared in a tabular form by supplying specific weights to each criterion based on the obtained value as shown in Fig. 2.

The universal importance weights of the criteria's along with their rankings are established in Table 6.

From the AHP analysis it is found that maximum weight or importance is found in balance in supply chain attribute (28%) of all supply chain problems, while for capacity constraints it comes out to be the lowest (4%). From the investigation it can be deliberated that professionals have well-thought-out balance in supply chain to be the most significant attribute while capacity constraints is least desirable by experts.

4.2. TOPSIS ranking assignment

Ranking is accomplished conferring to the collection of the dataset as revealed in Table 5 and for all problem the multiple performance attributes were measured as per the methodology explained in the above sections. In this subcategory, numbers have been analysed and reliable by means of TOPSIS framework. Expert's views were expressed in terms of linguistic variables.

The multiple performance characteristics were altered into a single performance score by means of TOPSIS and AHP methods. AHP method, as deliberated above, is used to regulate the weight of all performance characteristic portentous their importance in this study. The weights so obtained were used in the TOPSIS method to compute a single performance score for the five-performance model ranking them from finest to foulest.

Meanwhile the units of the performance attributes were quite dissimilar, hence they were normalized to transform them into a comparable range in linguistic terms as shown in Table 7.

Matrix Further, overall performance scores were calculated based on the weightages derived from AHP process and scores of all supply chains were ranked accordingly from highest score at the top to lowest at the bottom. The values were obtained after normalizing the weights of the matrix and is shown in Table 8.

The performance score of each model was calculated after calculating the ideal best and ideal worst and Euclidean distance in respective steps as shown in Table 9.

Table 3
Linguistic equivalents assigned to the outcome reactions of the significance levels.

S.No	Challenges	(P1)	(P2)	(P3)	(P4)	(P5)	(P6)	(P7)
C1	Absence of Supply Chain flexibility	5	4	2	5	3	3	1
C2	Absence of government funding	1	2	2	4	2	4	3
C3	Absence of Confidence	3	3	5	4	1	3	1
C4	Communication problems	4	5	5	3	5	3	2
C5	Lack of security and safety	4	3	5	3	3	3	4
C6	Scarcity of work force	5	2	4	2	4	1	5
C7	Consumer attitude	5	4	3	5	2	1	3
C8	Maintenance of an appropriate balance among supply and demand	4	1	4	3	1	3	4
C9	Deficiency of surplus medical amenities	5	5	1	1	3	5	4
C10	Lack of Viability	5	2	5	1	1	1	1
C11	Lack of access	1	4	2	5	3	3	2

Table 4
Aggregated weights assignment process by experts.

Identification	Weightage	Criterion
P1	Balance in supply and demand	0.275286
P2	Safety of employees	0.265144
P3	Trust between retailer and consumer	0.099406
P4	Distribution & transportation capability	0.164123
P5	Shortage of manpower	0.095395
P6	Consumer Behaviour	0.058545
P7	Capacity Constraints	0.0421

Table 5
Weights assigned to the attributes of various models.

S.No	Challenges	(P1)	(P2)	(P3)	(P4)	(P5)	(P6)	(P7)
Weightages		0.275	0.265	0.099	0.165	0.095	0.058	0.042
Importance Criteria Rank		1	2	4	3	5	6	7
C1	Absence of Supply Chain flexibility	5	4	2	5	3	3	1
C2	Absence of government funding	1	2	2	4	2	4	3
C3	Absence of Confidence	3	3	5	4	1	3	1
C4	Communication problems	4	5	5	3	5	3	2
C5	Lack of security and safety	4	3	5	3	3	3	4
C6	Scarcity of work force	5	2	4	2	4	1	5
C7	Consumer attitude	5	4	3	5	2	1	3
C8	Maintenance of an appropriate balance among supply and demand	4	1	4	3	1	3	4
C9	Deficiency of surplus medical amenities	5	5	1	1	3	5	4
C10	Lack of Viability	5	2	5	1	1	1	1
C11	Lack of access	1	4	2	5	3	3	2

Fig. 3 shows the combined linguistic parameters of the experts and comparison between various models for optimal performance by trading off between multiple criteria's.

The modern investigation finally establishes the dominance of one problem over other and optimises the criterions for supply chain criterions based on performance attributes.

4.4. Discussion

Preceding to present-day work, it was extremely complex to contemplate which parameters has a stronger influence over supply chain especially during COVID-19 era. Identification and prioritization of attributes was another area where experts required a proper logical and efficient decision. Problem identification and generalization seems to be an extremely complex problem for retailers while managing supply chain inventories which might be solved with the aid of hybrid MCDM procedures. Hybridisation of MCDM techniques combines the benefits of AHP and TOPSIS framework and is established as a suitable approach for carrying out similar researches. The following are identified problems during pandemic for COVID-19.

• **Absence of Supply Chain flexibility**

Numerous organizations have enhanced their SCs' adaptability to react quickly and efficiently in an unpredictable climate [53]. Nevertheless, increasing flexibility is expensive; the business has struggled to strike the right mix of adaptability and contingency. COVID-19 is an example of a scenario with several other uncertainties in which an organization requires a more adaptable and responsive SC. Due to a lack of necessary flexibility and reactivity, lead times increased, thus slowing the delivery of necessities [54]. Imply that a positive connection with the provider may resolve the issue of responsiveness under adverse circumstances.

• **Absence of government funding**

Besides the administration, numerous commercial organizations strive to supply necessities to customers or the society throughout an epidemic. While both entities operated separately, the producer has been on the verge of bankruptcy due to unpredictable demand. For instance, several medical institutions went bankrupt after influenza treatment

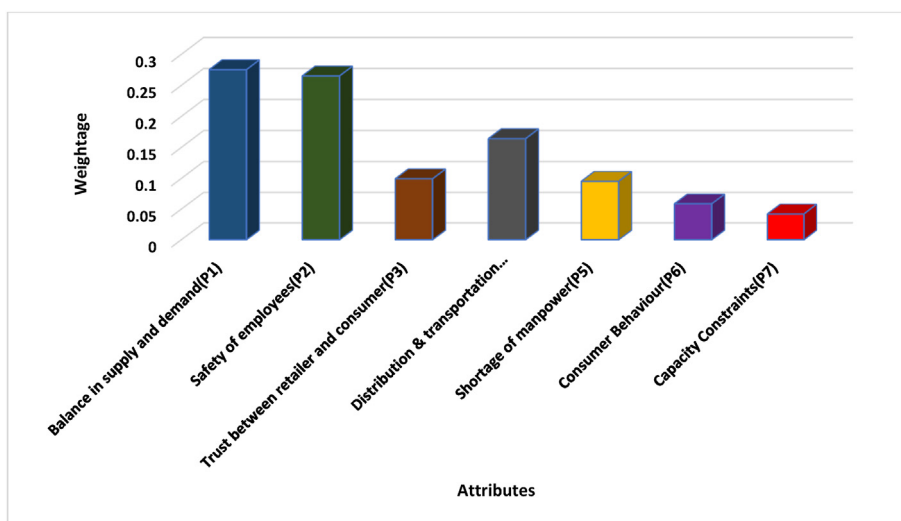


Fig. 2. Influence of multiple criterions on supply chain.

Table 6
Ranking priority of attributes/criteria based on weightage.

Attributes	Weight	Importance criteria rank
Balance in supply and demand(P1)	0.275286	1
Safety of employees(P2)	0.265144	2
Trust between retailer and consumer(P3)	0.099406	4
Distribution & transportation capability(P4)	0.164123	3
Shortage of manpower(P5)	0.095395	5
Consumer Behaviour(P6)	0.058545	6
Capacity Constraints(P7)	0.042104	7

Table 7
Normalized decision matrix.

S.No	Challenges	(P1)	(P2)	(P3)	(P4)	(P5)	(P6)	(P7)
Weightages		0.275	0.265	0.099	0.165	0.095	0.058	0.042
Importance Criteria Rank		1	2	4	3	5	6	7
C1	Absence of Supply Chain flexibility	0.37	0.35	0.16	0.42	0.32	0.30	0.10
C2	Absence of government funding	0.07	0.18	0.16	0.34	0.21	0.40	0.30
C3	Absence of Confidence	0.22	0.26	0.40	0.34	0.11	0.30	0.10
C4	Communication problems	0.29	0.44	0.40	0.25	0.53	0.30	0.20
C5	Lack of security and safety	0.29	0.26	0.40	0.25	0.32	0.30	0.40
C6	Scarcity of work force	0.37	0.18	0.32	0.17	0.43	0.10	0.50
C7	Consumer attitude	0.37	0.35	0.24	0.42	0.21	0.10	0.30
C8	Maintenance of an appropriate balance among supply and demand	0.29	0.09	0.32	0.25	0.11	0.30	0.40
C9	Deficiency of surplus medical amenities	0.37	0.44	0.08	0.08	0.32	0.51	0.40
C10	Lack of Viability	0.37	0.18	0.40	0.08	0.11	0.10	0.10
C11	Lack of access	0.07	0.35	0.16	0.42	0.32	0.30	0.20

owing to a rapid lack of order. Perhaps that is why numerous areas of the globe require the essential pharmaceutical tools to treat COVID-19 [36]

proposed that government incentives and well-adjusted capital arrangements might resolve these types of functional problems.

Table 8
Weighted normalized decision matrix.

S.No	Challenges	(P1)	(P2)	(P3)	(P4)	(P5)	(P6)	(P7)
Weightages		0.275	0.265	0.099	0.165	0.095	0.058	0.042
Importance Criteria Rank		1	2	4	3	5	6	7
C1	Absence of Supply Chain flexibility	0.10	0.09	0.02	0.07	0.03	0.02	0.00
C2	Absence of government funding	0.02	0.05	0.02	0.06	0.02	0.02	0.01
C3	Absence of Confidence	0.06	0.07	0.04	0.06	0.01	0.02	0.00
C4	Communication problems	0.08	0.12	0.04	0.04	0.05	0.02	0.01
C5	Lack of security and safety	0.08	0.07	0.04	0.04	0.03	0.02	0.02
C6	Scarcity of work force	0.10	0.05	0.03	0.03	0.04	0.01	0.02
C7	Consumer attitude	0.10	0.09	0.02	0.07	0.02	0.01	0.01
C8	Maintenance of an appropriate balance among supply and demand	0.08	0.02	0.03	0.04	0.01	0.02	0.02
C9	Deficiency of surplus medical amenities	0.10	0.12	0.01	0.01	0.03	0.03	0.02
C10	Lack of Viability	0.10	0.05	0.04	0.01	0.01	0.01	0.00
C11	Lack of access	0.02	0.09	0.02	0.07	0.03	0.02	0.01

Table 9
Positive and negative ideal solution matrix along with performance score.

S.No	Challenges	(P1)	(P2)	(P3)	(P4)	(P5)	(P6)	(P7)	P _i Score
Weightages		0.275	0.265	0.099	0.165	0.095	0.058	0.042	
Importance Criteria Rank		1	2	4	3	5	6	7	
C1	Absence of Supply Chain flexibility	0.10	0.09	0.02	0.07	0.03	0.02	0.00	0.26
C2	Absence of government funding	0.02	0.05	0.02	0.06	0.02	0.02	0.01	0.53
C3	Absence of Confidence	0.06	0.07	0.04	0.06	0.01	0.02	0.00	0.49
C4	Communication problems	0.08	0.12	0.04	0.04	0.05	0.02	0.01	0.23
C5	Lack of security and safety	0.08	0.07	0.04	0.04	0.03	0.02	0.02	0.41
C6	Scarcity of work force	0.10	0.05	0.03	0.03	0.04	0.01	0.02	0.47
C7	Consumer attitude	0.10	0.09	0.02	0.07	0.02	0.01	0.01	0.28
C8	Maintenance of an appropriate balance among supply and demand	0.08	0.02	0.03	0.04	0.01	0.02	0.02	0.68
C9	Deficiency of surplus medical amenities	0.10	0.12	0.01	0.01	0.03	0.03	0.02	0.34
C10	Lack of Viability	0.10	0.05	0.04	0.01	0.01	0.01	0.00	0.60
C11	Lack of access	0.02	0.09	0.02	0.07	0.03	0.02	0.01	0.50

• **Absence of Confidence**

Belief is a critical element in combating COVID-19. Vital problems that undermine faith include a scarcity of distinctness and an abundance of information [55]. Another study [56] argued that using blockchain and framework interconnections in the SC would resolve trust problems and help the SC run more smoothly. Decay of goods may also be confirmed via e-commerce monitoring depending on coronavirus hotspot locations.

• **Communication problems**

Data discussion among group and government bodies, miscommunication amongst central and limited authorities COVID-19 spreads too fast through the current COVID-19 pandemic in any region of the globe owing to poor communication. Due to a breakdown in lockdown communication, transporting supplies became trapped amid locations, jeopardizing customers' necessities. In India, it was claimed that policemen and municipal authorities are ordering merchants to close their

shops due to the absence of knowledge exchange [57]. During epidemics, efficient communication regarding symptoms, the source of germs, lockdown times, and the availability of necessary commodities, among other things, is essential for containing the outbreak. According to A, adopting Industry 4.0 technology will facilitate the efficient sharing of knowledge amongst all individuals.

• **Lack of security and safety**

The bulk of these essential workers will start to collaborate in medical institutions, retail shops, water services, and other settings to guarantee that the rest of the community maintains a feeling of normalcy throughout this epidemic. As shop employees and medical personnel are on the front lines, they are always in danger of infection—the security and safety of employees and companies operating throughout an outbreak exhibit significant difficulties. For instance, a food distribution business in Germany converts a victim of a cyber-attack, while in the United States, a worker gets connected through phishing emails [51]. The government must ensure their safety while they fight for countries.

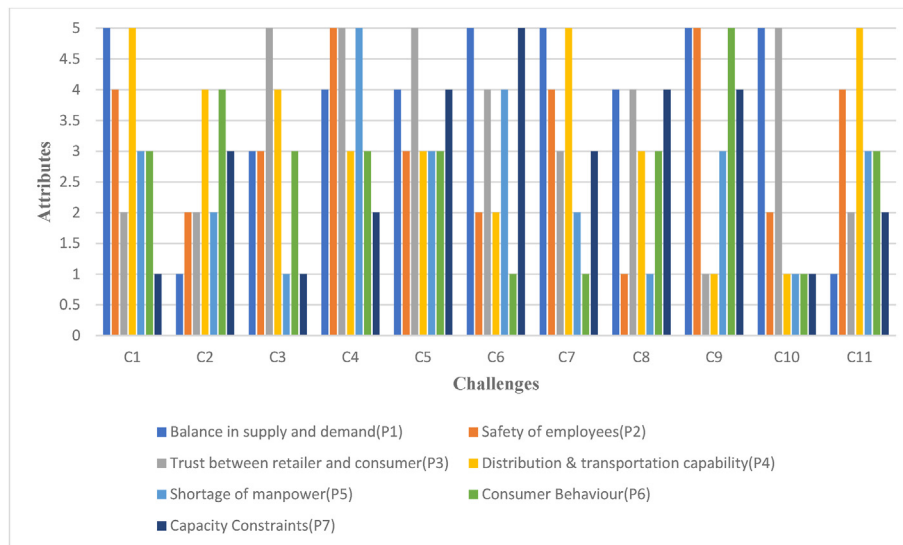


Fig. 3. Comparison of attributes of models in linguistic terms.

• Scarcity of work force

As a result of the COVID-19 epidemic, the globe is experiencing a severe labor shortage that threatens to destabilize the global SC. Following the declaration of the lockdown, India is experiencing a labor deficit, which is affecting the flow of goods [52]. Additionally, as reported by Ref. [50], the globe is experiencing a shortage of trained and qualified professionals capable of addressing these health problems.

• Consumer attitude

In the times of pandemic often involves an uncertainty in buying attitude of the buyer which might probably be due to the cash inflows. These buyers might have their own customized list of basic amenities and essentials. Abrupt variation in various items might catch the supplier off guard as he might be not ready to suffice such an immense demand. In a recent study [25] substantial stockpiling was associated in various countries which might be due to the outcry of the pandemic, overall disrupting the supply process of all essentials. The conditions among customers and suppliers becomes extremely sensitive in hoarding up of essentials which might require surplus security to stabilise such conditions [47].

• Maintenance of an appropriate balance among supply and demand

This might be interpreted to be the chief consequence faced by retailers since the pandemic. This probably happens as inadequate essentials are kept in inventory and upsurge in the demand creates hurdles for the supply team to fulfil any future orders. This can be clearly understood through an instance explained in a study [48] were lack of awareness and flexibility were identified as the primary causes for supply and demand interruptions.

• Deficiency of surplus medical amenities

Often retailers while visiting stores in a hurry forget basic medical facilities such as mask and sanitizers. Stores are lacking such basic supplies since the outbreak has spread rapidly which has created a huge gap in production of these supplies. This has enabled government to speed up the production process of these supplies as it is quite evident that coronavirus spreads through contact.

• Lack of Viability

Parallel to resilience another concept is studied in deep which brings another concept namely viability for the combined supply chain. Viability is an amalgamation of resilience, flexibility, and renewability that is able to accomplish and establish supplies of different things and amenities to the public in the pandemic.

• Lack of access

This particular task is closely associated with a country's policy making and safety. In order to restrain the spread of COVID-19 governments across the globe boldly imposed lockdowns which some where did stop the spread but was also responsible for various other essential activities to be stopped. For instance, people carrying essentials have served extreme difficulty in transporting these essentials from one place to another as transport was disrupted [58]. Furthermore, this created a ruckus among manufacturer who were left short in supply for production process.

The level of importance of the considered performance attributes for problems of supply chain with different criterions.

4.3. Validation of proposed model with previous literature

The intelligent model prepared in this study were compared to other researches which analysed and identifies prime problems in supply chain. The ranked problems are depicted in priority as shown above in Table 10. The results generated by AHP-TOPSIS were deemed quite close and parallel to other studies for similar frameworks analysed earlier. To validate and defend the selection of the applied model, previous supply chain related problems were recollected and compared as presented in Table 11. In accordance with earlier identified problems, the present model has shown the same pattern of higher accuracy in detecting problem as in case of AHP-TOPSIS model, thereby validating the proposed integrated framework. Earlier models with different problem set predicted similar efficiency levels [49].

5. Conclusions, limitations and future scope

5.1. Conclusions and policy implications

While the rest of the world is quarantined, merchandising shops and SC are offering numerous amenities and facilities to the public. Under the

Table 10
Ranking of challenges found in supply chain.

Challenges	P _i (Score)	Rank
Absence of Supply Chain flexibility	0.26	10
Absence of government funding	0.53	3
Absence of Confidence	0.49	5
Communication problems	0.23	11
Lack of security and safety	0.41	7
Scarcity of work force	0.47	6
Consumer attitude	0.28	9
Maintenance of an appropriate balance among supply and demand	0.68	1
Deficiency of surplus medical amenities	0.34	8
Lack of Viability	0.60	2
Lack of access	0.50	4

Table 11
Comparison of prediction capability of various models and developed ANFIS-HSA.

References	Model	Problem Identification
Thunberg & Fredriksson (2018) [59]	Supply chain planning	Lack of planning
Yeh et al. (2011) [60]	Genetic algorithm	Lack of sustainable approaches
Angarita-Zapata et al.(2021) [61]	Machine learning	Digitalization incompetency
Current study	AHP-TOPSIS	Appropriate balance among supply and demand

threat of infection, merchants (grocery stores and pharmaceuticals) are attempting to satisfy client needs. Retail businesses have several challenges in providing services to customers while also keeping employees safe. The contemporary research enumerates the multiple performance attributes of different popular problems dealt by retailer associated with supply chain. The purpose of this research is to determine the operational problems that the store experienced during the COVID-19 epidemic.

The ongoing COVID-19 pandemic is unquestionably one of the most devastating events in the last few decades or so. One of its major affected area is the suppliers of multiple products due to unavailability of multiple resources. On a global level, this study can contribute by using such hybrid models to identify and prioritize problems in supply chain, thereby devising its solution before it even happens and averting its consequences. Also, future researchers have a feasible model which can yield efficient valuable results for potential upcoming problems apart from supply chain management.

According to an investigation of a review, merchants confront 11 key obstacles, through this health catastrophe. Possible study scopes are briefly mentioned under each task. A path for implementing Industry-4.0 was suggested based on the research scope. The contemporary research enumerates the multiple performance attributes of different common problems for supply chain inventory managers.

In the end the research was capable of recognizing eleven prime problems that serve as an operational obstacle in the supply chain industry and proposed the use of Industry 4.0 technology and modern technologies to address them. The contemporary study is accomplished by employing integrated combination of two Multi Criteria Estimators methods- Analytical Hierarchical Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

- From a combined point of view maintenance of an appropriate balance among supply and demand comes out to be prominent problem faced by retailers during COVID-19 period.

- Weightage was assigned to multiple criterions which happened to be prominent factors during COVID-19 pandemic. The weightage was calculated by AHP method through which assignment is as follows: Balance in supply and demand(P1) = 27.5%, Safety of employees (P2) = 26.5%, Trust between retailer and consumer (P3) = 9.94%, Distribution & transportation capability (P4) = 16.41%, Shortage of manpower (P5) = 9.53%, Consumer Behavior (P6) = 5.85% & Capacity Constraints (P7) = 4.21%.
- Balance in supply chain and demand is the most significant attribute while selection of a problems for supply chain
- Among the possible supply chain problems, Maintenance of an appropriate balance among supply and demand > Lack of Viability > Absence of government funding > Lack of access > Absence of Confidence > Scarcity of work force > Lack of security and safety > Deficiency of surplus medical amenities > Consumer attitude > Absence of Supply Chain flexibility > Communication problems.

Similarly, communication problems scores lowest in ranking due to it being highly ineffective.

The suggested approach can assist policymakers in developing a COVID-19 action plan. Both the scientific and management communities will benefit from the outcomes of this study. This research is confined to the COVID-19 pandemic, which limits the applicability of the findings to other epidemic outbreaks.

Looking at the current scenario the pandemic might return with a deadly new variant and put the mankind in danger again. To avert this threat, prime policy makers such as researchers, scientist, environmentalist, supply chain managers need to come out with possible measures that might prevent the supply chain disruption by implementing proper management rules. The following are some guidelines which might be considered by future policy makers:

- Agricultural food products are the primary requirement of every human being. Special units or stores should be designed where such products quantity and quality can be regular checked.
- A specialized team needs to be created which can access pre-stage conditions of such pandemic, thereby warning the people to keep adequate quantity for long term use in case of sudden lockdown.
- An online mobile application needs to be developed which can converse between supply chain managers and retailers which will enable them to connect regularly.
- Lockdowns based information should be first discussed with suppliers, so that the economy and people may not suffer.

5.2. Limitations

Researches always lag in some respect. Numerous limitations are

related with every research due to which the research might remain incomplete and might be potentially explored by other examiners. Corresponding to other studies, subsequent are some prime limitations of the research:

- Limited number of experts review, which might be one directional probably due to geographical locations.
- Other possible problems in supply chain post pandemic might be interlinked with current research.
- Limited criterions were considered in the present study.
- Only one type of ranking method is used which might not provide comparative results with other hybrid ranking techniques.
- Country wise parameters were not considered in the research.

5.3. Scope for future work

The restrictions or constraints of the research gives proper ideas to future researchers for conducting forthcoming research. Previous researches have also suggested possible works for future works. Subsequent suggestions may be considered as scope for future research:

- Country wise parameters or constraints can be incorporated in next possible research.
- A new model on ranking techniques might also be explored in supply chain field as in other management applications the results were noteworthy.
- More input constraints or criterions might be considered to build a possible framework.
- More number of experts might be considered for future researches to incorporate multi-functionality of the research.

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Declaration of competing interest

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