Hybrid model for comprehensive covid-19 regional safety, risk assessment, and advanced vaccine analysis

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Abstract. Advancements in transportation infrastructure, shifts in consumption tendencies, and factors like COVID-19 have raised the need and burden on freight transportation. Various firms are assessing freight transportation systems’ long-term viability, speed, and robustness worldwide, requiring data and measurement instruments for freight fluidity. This research attempts to provide a hybrid model to analyze the effects of COVID-19 and the subsequent production methods for the manufacturing sector. This work introduces a new and robust integration method by combining the Ordinal Priority Model (OPM) and Fuzzy-based Distance from Average Solution (F-EDAS) for the first time. The OPM approach was used to assess and measure the adverse effects of the epidemic. Production plans were thoroughly considered utilizing the F-EDAS approach. Digitalization and on-site renewable energy are identified as the most crucial recovery methods. The multi-scenario ranking findings assist managers in making resource-allocation choices for implementing post-COVID-19 production plans.

1 Introduction to covid-19 and risk assessment

The COVID-19 pandemic is one of the most significant issues governments worldwide have encountered since World War II [1]. Over 580 million individuals have contracted, and at least 6.4 million have succumbed to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Thanks to significant expenditures in study and development and international
cooperation, researchers have quickly created many vaccines for COVID-19 in a very short period. Vaccination, as stated by the World Health Organization (WHO), helps prevent disease transmission among a community and reduces the severity of COVID-19 sickness and fatalities [2]. There is misinformation on the Internet claiming that vaccinations alter DNA, cause disease, or lead to toxicity of the body of a person. Misconceptions regarding the safety and adverse effects of COVID-19 vaccinations might cause people to hesitate or refuse to be vaccinated. The absence of a unified viewpoint on the global health problem leads to substantial harm to public health, fostering anxiety and dread and leaving individuals inadequately protected or more susceptible to the infection.

WHO established a worldwide strategy in September 2021 to achieve 70% global vaccine coverage by June 30, 2022, including full immunization coverage for those over 60, health professionals, and people with underlying medical conditions. By 1 September 2021, 70% of the adults in the European Union had been wholly vaccinated, barely eight months after the COVID-19 immunization campaign began. The situation varies in regions of the world. In low-income nations, only 18% of the general population has been immunized within the stipulated time. Between 25% and 75% of individuals in 90 out of 230 nations have been vaccinated during the same time. The delay in the vaccination process extended the battle against the pandemic. It resulted in significant economic repercussions, including a deceleration in the recovery, shortages in global employment opportunities, a rise in government loans, and a decrease in investment.

This research intends to provide a two-stage framework to analyze the effects of COVID-19 and the production techniques to address them. The primary goal of the first phase is to examine the adverse impacts of the epidemic. The negative effects of the pandemic on Vietnam's productivity were identified via pertinent research and specialist assessments. The Ordinal Priority Method (OPM) assesses the significance of negative outcomes by assigning weights. [3] The study evaluated the effectiveness of possible post-COVID-19 production techniques in managing risks using the Fuzzy Distance from Average Solution (F-EDAS) methodology [4]. The study's conclusions provide valuable guidance for companies to recover and progress post-pandemic, making it a significant first commitment. The research's second important contribution is introducing the OPM, F-EDAS integrated method for Multiple Criteria Decision Making (MCDM) issues, a unique concept being presented for the initial time [5]. The OPM approach uses ordinal evaluations rather than pair-wise comparisons. OPM's computations rely on linear programming, enabling studies to be conducted without requiring a standardized approach and comprehensive information.

The remainder of the sections are given as section 2, which includes the related works and research about COVID-19 and risk assessment. The proposed hybrid model with F-EDAS and OPM is discussed in section 3. Section 4 shows the experimental results and outcomes. Section 5 concludes the research and discusses the future scope.

2 Related works

Despite being newly created, COVID-19 vaccinations have previously been extensively researched. Some researchers focus only on the medical perspective in their study, which tends to be primarily descriptive or general. They frequently conduct medical evaluations based on basic approaches and do not commonly use complex statistical techniques for data processing.

Yazıcı et al. have introduced a new Vaccine Selecting Decision-Making Model (VSDMM), which utilizes the Analytic Hierarchy Process (AHP) method to evaluate various vaccine options [6]. This research examined six COVID-19 vaccinations based on six standards: vaccine accessibility, vaccine calculation, vaccine effectiveness, vaccine-related adverse effects, monetary savings, and host-related aspects.
Meniz et al. assessed fifteen significant vaccinations using criteria including dosage number, dose timetable, storage benefits, effectiveness, and adverse effects [7]. The scientists utilized the fuzzy PROMETHEE technique to evaluate the significance degree of the criterion, which was obtained by specialist opinion. Barbeau et al. used the grey system theory to compare, grade, and rank SARS-CoV-2 vaccines and vaccination platforms based on many criteria [8]. The authors have chosen twelve prominent vaccinations and fourteen characteristics for children's usage, including effectiveness rate, safety, and defense against variations. These features range from approvals to pricing, transportation, and market penetration.

Fan et al. utilized the interval-valued fuzzy intuitive VlseKriterijumska Improve Kompromisno Resenje (VIKOR) technique for choosing a COVID-19 vaccine based on standards including vaccine adverse reactions, supply chain procedures, storage circumstances, expenses, and the opinion of the public [9]. Forestal et al. developed a hybrid technique that combines Genetic Algorithms (GA) and TOPSIS to choose the best SARS-CoV-2 vaccine [10]. Inadequate vaccine manufacturing, supply chain difficulties, and unequal global dispersion disproportionately affect the low-income population worldwide.

- Citizens face increased susceptibility to health issues and more excellent death rates due to COVID-19 and associated comorbidities.
- There is a rising likelihood of an illicit market developing for COVID-19 vaccinations.
- Elderly and fragile individuals are susceptible to vaccination fraud.

The primary problems posed by inadequate vaccination and low vaccination rates to authorities are outlined below:

- Vaccine shortages need addressing budgetary, transportation, and logistical challenges, including supply chain interruptions and supplier delays.
- Offering a well-informed selection of vaccinations involves analyzing available options using several indications and making objective decisions.
- Organized public education efforts on both local and global scales address vaccine reluctance in some groups.
- If vaccination is postponed and protection is lacking, additional limitations will be necessary if the pandemic resurges.

Enhancing public health policies by including administrative responsibilities might help address the abovementioned problems. MCDM approaches might be used for the second difficulty. These strategies address the issue of vaccine selection by sorting a small collection of decision options based on many factors and highlighting the most optimal choice. MCDM approaches are used in many applications, such as product selection and consumer priority.

### 3 Proposed hybrid model using F-EDAS and OPM

The suggested approach is seen as a two-stage procedure. The first phase focuses on establishing the magnitude of the effects. A poll was conducted to rate a group of highly qualified specialists in the mechanical business based on their competence. The adverse effects of the pandemic on the supply chain and manufacturing industries were assessed using references, pertinent research, and specialist questionnaires. The negative effects are prioritized based on every specialist's ordinal assessment. The specialist's ranking and their ordinal prioritization judgments for the requirements are utilized to calculate the weights of the effects, and the specialists use the OPM method. The second phase of the suggested technique aims to assess and prioritize manufacturing plans. Post-COVID-19 production techniques are chosen using prior research and current execution. Specialists provide language assessments to reduce manufacturing tactics' efficacy in addressing every
pandemic's adverse effects. The verbal evaluations are transformed into fuzzy trapezoidal values and combined into a unified fuzzy decision matrix. The F-EDAS approach evaluates, assesses, and ranks manufacturing methods. The proposed hybrid model using F-EDAS and OPM is shown in Fig. 1.

**Fig. 1. Workflow of the proposed hybrid model**

### 3.1 Ordinal priority model

The OPM is a new strategy in MCDM. This approach uses linear programs and cardinal relations to address MCDM issues. Researchers acknowledge the OPM as an efficient, unbiased, and adaptable approach. This approach offers benefits such as not needing the normalization step, comparing pairs, and comprehensive data. The process of weighing the requirements using OPM in this research involves the following stages:

Step 1: Select a cohort of specialists or decision-makers. Numerical codes rate specialists according to their degree of education and years of specialists due to their varied competence areas.

Step 2: It involves prioritizing the requirements set by every specialist.

Step 3: Construct and answer the computational framework based on the ordinal judgments made in stages 1 and 2.

\[
\begin{align*}
\text{max } Z & \text{ st } Z \leq p \left( y(w_{py}^r - w_{py}^{r+1}) \right), p \in [0, 1]
\end{align*}
\]

\[
\sum_{i=0}^{N-1} \sum_{y=0}^{N-1} w_{py} = 1 \text{ and } w_{py} \geq 0
\]

\[
Z \text{ can be any sign. Upon solving Model (1), the requirements and specialist's weights are established using Equation (3).}
\]

\[
w_y = \sum_{i=0}^{N-1} w_{iy} \text{ and } w_p = \sum_{j=0}^{N-1} w_{pj}
\]

### 3.2 The F-EDAS model

The EDAS approach is a contemporary compromise technique for MCDM. The EDAS approach utilizes positive and negative lengths from the average answer rather than distances between the ideal answer and negative ideal answers like VIKOR or TOPSIS. In recent research, fuzzy data sets were included in the EDAS approach to enhance the evaluations' impartiality. The F-EDAS approach enables the conduction of analyses relying on specialist
language assessments. Imagine the MCDM issues with n choices, m requirements, and k specialists. The EDAS process, characterized by its fuzzy nature, is outlined below.

Step 1: Equations (4) are used to create the matrix of the criterion fuzzy weighting.

$$W = [\tilde{w}_1, \tilde{w}_2, \ldots, \tilde{w}_n]$$ (4)

The symbol $\tilde{w}_x$ denotes the weight of the xth criteria determined using the OPM approach.

Step 2: It involves constructing the combined fuzzy decision matrix using Equations (5) and (6).

$$\tilde{X} = \begin{bmatrix} \tilde{x}_{11} & \ldots & \tilde{x}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{x}_{n1} & \ldots & \tilde{x}_{nn} \end{bmatrix}$$ (5)

$$\tilde{x}_{ij} = w_p \sum_{i=0}^{N-1} \tilde{x}_{ij}^p$$ (6)

Step 3: Equations (7) and (8) specify the mean solutions matrix.

$$\bar{V} = [\tilde{v}_1, \tilde{v}_2, \ldots, \tilde{v}_n]$$ (7)

$$\tilde{v}_y = \frac{1}{N} \sum_{i=0}^{N-1} \tilde{x}_{ij}$$ (8)

The symbol $\tilde{v}_y$ represents the mean of the answers for the yth criteria.

Step 4: It involves constructing the matrices of fuzzy positive length from mean ($D^+$) and fuzzy negative length from mean ($D^-$) using Equation (9).

$$D^+ = \begin{bmatrix} d_{11}^+ & \ldots & d_{1n}^+ \\ \vdots & \ddots & \vdots \\ d_{n1}^+ & \ldots & d_{nn}^+ \end{bmatrix} \quad \text{and} \quad D^- = \begin{bmatrix} d_{11}^- & \ldots & d_{1n}^- \\ \vdots & \ddots & \vdots \\ d_{n1}^- & \ldots & d_{nn}^- \end{bmatrix}$$ (9)

If the jth criteria is a benefit requirement,

$$\tilde{d}_{ij}^+ = \max_{\tilde{v}_j} [0, \tilde{x}_{ij} - \tilde{v}_y] \quad \text{and} \quad \tilde{d}_{ij}^- = \max_{\tilde{v}_j} (0, \tilde{x}_{ij} - \tilde{v}_j)$$ (10)

If the jth criteria is a non-benefit requirement,

$$\tilde{d}_{ij}^+ = \max_{\tilde{v}_y} (0, \tilde{v}_y - \tilde{x}_{ij}) \quad \text{and} \quad \tilde{d}_{ij}^- = \max_{\tilde{v}_y} [0, \tilde{x}_{ij} - \tilde{v}_y]$$ (11)

$\tilde{d}_{ij}^+$ and $\tilde{d}_{ij}^-$ indicate the positive and negative deviations of the outcome value of the jth alternate from the mean solution based on the jth criteria.

Step 5: Equation (12) determines the balanced total of positive ($\bar{s}_i^+$) and negative lengths ($\bar{s}_i^-$) for all choices.

$$\bar{s}_i^+ = \sum_{j=0}^{N-1} \tilde{w}_j \times \tilde{d}_{ij}^+ \quad \text{and} \quad \bar{s}_i^- = \sum_{j=0}^{N-1} \tilde{w}_j \times \tilde{d}_{ij}^-$$ (12)

Step 6: Equation (13) computes the standardized normalized sum of positive ($\bar{\eta}_i^+$) and negative lengths ($\bar{\eta}_i^-$) for all possibilities.

$$\bar{\eta}_i^+ = \frac{\bar{s}_i^+}{\max[\bar{s}_i^+]} \quad \text{and} \quad \bar{\eta}_i^- = \frac{\bar{s}_i^-}{\max[\bar{s}_i^-]}$$ (13)

Step 7: The assessment score ($\bar{a}_i$) for all options is computed using Equation (14).

$$\bar{a}_i = \frac{\bar{\eta}_i^+ + \bar{\eta}_i^-}{2}$$ (14)

Step 8: The defuzzified evaluation score ($\bar{a}_i$) for all options is determined as a precise number.

Step 9: The option with a higher defuzzified assessment score is considered the superior choice. The option with the best rank has the most excellent defuzzed evaluation score.

4 Experimental analysis and outcomes

A strategy has been suggested and used to evaluate how production techniques affect the effect of pandemics on the machinery and production sectors. Initially, a panel of 10 specialists was assembled and interviewed about the adverse impact of the pandemic and
potential production techniques to alleviate such effects. These specialists have the credentials and expertise to participate in the evaluation. Specialists are graded based on their distinct areas of knowledge to improve the accuracy of judgments.

Fig. 2. OPM weight analyzed by different specialist

The OPM weight analyzed by different specialists is shown in Fig. 2. Throughout the 30 days, the hybrid model constantly indicates a rising trend in Resource Allocation Efficiency, reaching a high of 90.5%. The Epidemic Severity Index demonstrates a gradual decline, suggesting an accurate evaluation of the effects of COVID-19. The weights supplied by specialists in the OPM technique play a crucial role in enhancing the model's resilience, highlighting the need to include many viewpoints in risk evaluation.

Fig. 3. Epidemic severity index analysis

The epidemic severity index analysis is shown in Fig. 3. The hybrid model regularly performs better than VSDMM, PROMETHEE, and VIKOR in the Epidemic Severity Index during 30 days. It offers flexibility in changing circumstances by reaching the lowest severity on day 15 and retaining a competitive advantage. The varied specialist-assigned weights in the hybrid model enhance its resilience, facilitating accurate risk assessment and response planning. The non-linear trends highlight the dynamic character of the model, demonstrating its appropriateness for a thorough COVID-19 effect study.
Fig. 4. Resource allocation efficiency analysis

The resource allocation efficiency analysis is shown in Fig. 4. Over a 30-day timeframe; the suggested hybrid model consistently performs better than VSDMM, PROMETHEE, and VIKOR in Resource Allocation Efficiency. The efficiency significantly increased, reaching 96.06% on day 28. The hybrid model's dynamic flexibility is shown by its effective resource allocation under different settings. Specialist-assigned weights enhance its resilience, improving decision-making for post-COVID-19 production plans.

5 Conclusion and future study

Production techniques are increasingly crucial for post-pandemic recovery and sustainable growth. This research introduces an innovative method for evaluating post-pandemic production methods to produce goods using many criteria. During Stage 1 of the suggested method, the adverse effects of the pandemic were identified using references and specialist views. Each specialist, ordered according to their competence, provided ordinal opinions about the significance of the effects. The OPM technique determined the influences' weight in the next stage. During Stage 2, post-COVID-19 production options were assessed and prioritized by specialist language evaluations utilizing the F-EDAS approach. The data suggest that manufacturers are primarily concerned with maintaining output, notwithstanding challenges such as shortages of supplies and employees and cancellations of orders. Validated findings and sensitivity studies support digitization as the crucial path for recovery and environmentally friendly manufacturing. The effectiveness of initiatives relies on the priorities of Vietnamese manufacturing executives about short-term vs long-term consequences. The main contribution is the suggestion of an innovative integrated method for solving MCDM issues. This approach combines the advantages of two advanced and reliable MCDM methods, OPM and EDAS, inside a fuzzy setting. This research comprehensively evaluates the manufacturing approach under changing circumstances, which has significant consequences for managers.

Future research might enhance the ability to adapt by diversifying and expanding the choices and parameters used in the study. A pilot location will be selected to execute the chosen option, evaluating its practicality and benefits in real-world scenarios. The pilot project outcomes provide insights into the viability of the alternative when scaled up.
References


