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A Fuzzy AHP-Fuzzy TOPSIS Urged Baseline Aid for Execution Amendment of an Online Food Delivery Affability

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Abstract: The increased demand for this form of food delivery has been expected to drastically alter restaurant patrons' dining habits. As people have been forced to stay indoors to prevent the virus from spreading, food delivery services over the internet are in high demand. As established in this study, the planned ideal is a good executive implementation for online meal delivery services. Food delivery services are rapidly growing in India, opening up several opportunities for a wide range of online food delivery (OFD) platforms while also generating a competitive commercial sector. Following that, the fuzzy technique for order performance by similarity to ideal solution method (FTOPSIS) is used to rank online food delivery (OFD) enterprises based on the characteristics chosen. In this paper, we study the present multi-criteria decision-analysis (MCDA) paradigm based on the fuzzy analytic hierarchy process (FAHP) and the fuzzy technique for order performance by similarity to ideal solution (FTOPSIS) method to achieve the goal. After that, a hierarchy multiple criteria decision-analysis (MCDA) model based on fuzzy sets theory is introduced to deal with the online food delivery Service in the chain system. The fuzzy analytic hierarchy process (FAHP) is a fuzzy set theory technique for generating criteria weights, which are then used to interpret expert phonological evaluation statements.

Keywords: online food delivery; multi-criteria decision-analysis; fuzzy analytic hierarchy process; fuzzy technique for order performance by similarity to ideal solution method

MSC: 90C29; 90C31; 91A35; 91B06

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1. Introduction

With the advancement of internet technology, the general trend toward e-commerce, rising urbanisation, and shifting social norms since the middle of the 2000s, the online food delivery (OFD) market has been booming and is predicted to reach USD 200 billion in worldwide output value by 2025. Prior to the alarming COVID-19 becoming widely publicised, online food delivery was already benefiting from increased digitalisation and a plethora of delivery apps. While millions of companies, particularly those in the aviation, tourism, and hospitality sectors, were severely impacted by the COVID-19 crisis and faced the real possibility of significant revenue declines, the global turnover of the online food delivery (OFD) industry increased by about 140 percent as a result of the pandemic. Since the start of the pandemic, contactless delivery has been widespread. Food delivery services are now more swift and quick to acquire momentum among customers thanks to technological advancements.

In India, online food delivery (OFD) has been a popular choice due to a rise in demand for a significant period of time. The COVID-19 pandemic was one of several causes that contributed to the market's expansion, but it also served as an important catalyst for the explosive development of online food delivery (OFD) use during the previous year throughout the nation. These businesses are making significant investments in order to attract retailers and customers. However, as more customers choose to order food online, the expanding business is quickly becoming extremely competitive and difficult for the landscape's current competitors. The four pillars of sustainability-financial, facility value, expertise, societal impact, and environmental friendliness have significant consequences for this.

Analytic hierarchy process is a strategy that may be easily understood and simplifies even complex circumstances, weighting utilising pairwise comparisons that are simple to understand. Analytic hierarchy process also gives the decision-maker the ability to evaluate the consistency of their choices. Analytic hierarchy process is more applicable than other methods in a range of circumstances because of all these advantages. The Analytic hierarchy process also uses fuzzy set theory to address the numerous uncertainties and ambiguities in expert judgement, which are described by linguistic variables.

Fuzzy technique for order performance by similarity to ideal solution method (FTOPSIS) is a novel method that was recently introduced and has enhanced consistency and accuracy for prioritising the options. Additionally, the fuzzy technique for order performance by similarity to ideal solution method (FTOPSIS) turns into a suitable multi-criteria decision-making method for assessing options.

In this paper, we study a methodology based on multi-criteria decision-making (MCDM) to evaluate the long-term growth of the online food delivery (OFD) market in India. First, through a review of the literature and the opinions of experts, evaluation of financial norms (supply rate, operating skill, and risk managing), expertise criteria (network strategy, instantaneous, and e-commerce), societal and environmental criteria (health and living conditions, communication safety, and ecological influence), and facility value (order satisfaction, supply speed, handiness of expense, virtual/offline facility level, and customer response) have been identified. Four significant firms in the OFD market in India-Zomato, Swiggy, Domino's, and Uber Eats are taken into consideration in the assessment to show the applicability of the suggested approach. Here we used the multi-criteria decision-making technique that includes the fuzzy technique for order performance by similarity to ideal solution method (FTOPSIS) and analytic hierarchy process (AHP) employing triangular fuzzy sets. Also, we discussed the analytic hierarchy process method, which is frequently used to calculate the weights of the criterion. In order to produce more accurate findings and weights, the expert opinions were transformed into triangular fuzzy numbers. These triangular fuzzy numbers were then normalised, weighted, and finished in the weighted normalised fuzzy decision matrix. We used a technique that combines the fuzzy analytic hierarchy process (FAHP) with the fuzzy technique for order performance by similarity to ideal solution method (FTOPSIS), as suggested and employed in this paper. The results of this study could serve as a guide for stakeholders and decision-makers in the online food delivery (OFD) and other sectors.

To the best of the authors' knowledge, the online food delivery (OFD) market in India has not been thoroughly evaluated utilising the suggested methodology as previously described. The following goals are set for the case study that is presented in order to close the research gaps. First, the evaluation standards for online food delivery (OFD) are examined, focusing in particular on the Indian market. The weights assigned to the online food delivery (OFD) evaluation criteria are then determined. Third, the online food delivery (OFD) enterprises performing the best in terms of sustainable development are indicated using the deduced weights of the criterion. Finally, a discussion of the suggested work's managerial ramifications follows. The originality of this study may lie in the aims it addressed. The thorough construction of the online food delivery (OFD) market evaluation criteria from the literature and consulting with industry professionals is a significant benefit of this research. Additionally, this is the first study to examine the online food delivery (OFD) market using the advantages of the fuzzy analytic hierarchy process (FAHP) and fuzzy technique for order performance by similarity to ideal solution method (FTOPSIS) approaches. The validity of the suggested integrated framework is demonstrated through a case study from India. Last but not least, the management implications of the employed approach and its analysis would enlighten those in charge of making decisions in the online food delivery (OFD) market, not just in India but also on the international stage.

2. Literature Survey

The COVID-19 epidemic induced by SAR-CoV-2 had a massive worldwide impact. Civic isolates or lockdowns were implemented to limit citizens' drive and also avoid the disease after scattering due to a lack of standardised methodologies and licenced therapies to treat the illness. Whereas the isolation stood vital in halting the increase of COVID-19, it had a substantial effect on the universal wealth and source chains, with a significance that was predicted to go beyond nationwide limits [1]. The restaurant business is one of the pandemic's hardest devastated industries. Lockdowns have seen a significant decline in restaurant patronage, possibly contributing to the closure of a number of eateries [2]. Food delivery has become a standard feature of city life. Since the mid-2000s, the food delivery over the internet, online food delivery (OFD), business has been booming, thanks to the advancement in internet skills and total tendency towards e-marketing, more metropolitan existence, in addition to fluctuating societal behaviours [3]. Since the financial crisis, the endemic has had further effects on the restaurant industry, including changes in food preferences [4]; eating behaviour, and a preference for using digital platforms. Customers can buy meals from a number of restaurants and have them delivered to their door with just a single tap of their phone on online meal delivery services that provide a variety of options and convenience, as well as cashback benefits, rewards, great deals, and savings [5]. Demand for Online food delivery services rose with each fixed fresh case of COVID-19 in Taiwan, for example, with trades and buyers growing by 5.7% and 4.9%, respectively, during the outbreak [6]. Restaurants now have an additional delivery method thanks to the internet food delivery business and a new revenue source has emerged in the form of online food delivery (OFD). In this business model, restaurants sign up for a digital platform that allows clients to order food through an app. The meal will be taken from the restaurant and delivered to the customer by delivery riders. The analogue policy takes into account the number of diner's deals used for each positive transaction. Diners gain from this industry replica, which then allows them to carry on with work in spite of lockdowns, bringing down accumulation and eliminating the necessity of spending on extra labour or bikes/saloons for carters. Global revenues for online food delivery (OFD) were predicted to reach 91 million dollars in 2018 and 107 million dollars in 2019 according to Statista's Analogue Emporium View for virtual carter [7]. The lockdowns might have accelerated buyer and diner approval for this new means of payment as seen by an estimated 11% increase in virtual food delivery revenue in 2020. When restaurant operations transition to a larger focus on meal delivery, more takeout containers and packing are necessary. Unfortunately, this also means more of an ecological problem [8]. As a result of the quick rise of info-communication tools (ICT) and mobiles, wise technologies and software have become widespread in a significant part of routine life [9]. Apps for smartphones and other mobile platforms are developed and designed with the intention of being downloaded and used (e.g., for iPads and tablets). In the first quarter of 2017, there were roughly 178.1 billion apps available for download on mobile devices, with that number is expected to rise to 258.2 billion by 2022 [10,11]. Patron demand for online food delivery (OFD) services has risen dramatically in recent years and is expected to continue to climb steadily in the future. The whole income of the global online food delivery (OFD) service industry is estimated to reach $107.4 billion in 2019 and $182.3 billion by 2024 [12]. Furthermore, due to its contactless ordering and delivery mechanism, the online food delivery (OFD) market has gained even more global interest since the COVID-19 outbreak, and it is expected to continue to attract new customers [13]. Researchers developed a model based on the contingency framework and extended model of IT continuance to find the primary reasons for customers' continuous desire to use online food ordering systems [14]. Customers see such online food ordering systems as making their lives easier as long as they also perceive them to be interesting and engaging, according to researchers, and are thus further expected to obtain additional progressive approaches and inclined to continue. The epidemic has a significant influence on the use of plastic in restaurants. Because of concerns regarding COVID-19 transmission, restaurant guests choose single-use plastic silverware and food containers [15]. The study's objective is to discuss an integrated model based on the fuzzy analytic hierarchy process (FAHP) for evaluating and prioritising selection criteria and the fuzzy technique for order performance by similarity to ideal solution (FTOPSIS) for choosing and developing a reverse logistics partner. With an integrated approach to show how the proposed framework is applied, this study aims to showcase a real problem in the Indian electronics sector. While achieving efficiency and effectiveness in reverse logistics practises, this study seeks to significantly assist electronics businesses in the evaluation and selection of third-party reverse logistics partners [16]. In order to understand the relationships and significance of risks in the development of new products, we developed a research framework for this study based on pertinent literature and expert interviews. We then used the decision-making trial and evaluation laboratory (DEMATEL) and the analytic network process (ANP). The outcomes of a case study demonstrate that the six main risks of product development projects are the following: project completion time, mastery of key technical capabilities, controlling the project's progress, uniqueness and complexity, ability to control the market, and functional integrity of the product [17]. To cope with this assessment process in the fuzzy environment, a novel hybrid multi-criteria decision-making (MCDM) approach is put forth in this paper. For establishing the subjective and objective weights of criteria, we offer fuzzy versions of the SWARA (step-wise weight assessment ratio analysis) and CRITIC (criteria importance through inter criteria correlation) approaches. A new hybrid strategy is suggested based on these extended methodologies and the fuzzy EDAS (evaluation based on distance from average solution) method. In this method, the weights of the subjective and objective criteria are blended to produce more logical weights for the criterion. An evaluation of construction equipment with a focus on sustainability is used to test the proposed methodology [18]. App design has an impact on consumer preference in online food delivery (OFD) prior to customer involvement, individual outlooks, and third-party way, according to previously published studies [19]. The suggested model uses a robust goal programming (RGP) method based on Shannon entropy to address the uncertain multi-objectiveness. With an analysis carried out on various levels of uncertainty, the proposed technique has been applied to a genuine case study from an Iranian green service food production company in order to confirm its applicability [20]. As a result, it was clear that the increasing amount of online food delivery (OFD) users will result in augmented plastic practice. The concern of easily spreading COVID-19 is another issue surrounding the use of online food delivery (OFD), as a result, disposable utensils and food containers are becoming increasingly popular. According to experiments, SARS-CoV-2 may persist on a variety of surfaces for days, including plastic [21]. The odds of getting COVID-19 throughout this pathway are really quite remote [22]. The influence of online food delivery (OFD) product and service developments aimed at improving the consumer's propensity to order food online during the COVID-19 endemic. COVID-19 users' concern is measured and used as a mediator variable [23]. With the use of eight criteria, a model of five cleaner production techniques for the Libyan manufacturing sector has been developed in a study. A novel interval rough the SWARA (step-wise weight assessment ratio analysis) method that applies interval rough numbers to the criteria has been created to assess the significance of the criteria while taking decision-makers' preferences into account [24]. The goal of this study is to present a new, integrated model for creating intellectual capital performance indicators in order to enhance the current IC process model. The suggested model will be used by a company that provides financial shared services. The goal of the study is to create an IC measurement system using IC management and the multi-criteria decision-making approach and to utilise the best-worst method to determine the values of IC performance measures to prioritise Key Performance Indicators [25]. The goal of the paper is to suggest a multi-criteria decision-making approach for analysing the sustainable third-party reverse logistics providers assessment problem using data from hesitant fuzzy numbers. In order to do this, a novel hesitant fuzzy-combined compromise solution strategy is first introduced by fusing the conventional combined compromise solution method with the hesitant fuzzy set operators and discrimination measures in hesitant fuzzy set circumstances. Integrating a proposed discrimination measure-based objective weighting method with a subjective method suggested by experts, the weights of the criteria have been evaluated [26]. This study aims to prioritise the knowledge that students enrolled in cooperative education (co-op) programmes must have, and the findings are used to enhance a study strategy that is directly responsive to the needs of businesses and to improve the human capital of those businesses while working within the constraints of academic institutions. In this study, a rating of the taken-in knowledge is produced using the analytical hierarchy process (AHP). An easy-to-understand map that takes knowledge importance and study effort into account shows the determined priorities and improved opportunities [27].

3. Materials and Methods

As shown in Figure 1, the research approach is divided into two phases. First, based on relevant research and expert interviews, maintainable online food delivery (OFD) estimation norms and descriptions were created (Table 1). Financial, facility value, expertise, societal and eco-friendly factors were all taken into account. fuzzy analytic hierarchy process (FAHP) is a tool that assigns preference weights to criteria using the pairwise comparison concept. Preference weights and alternative ratings for each criterion were expressed as phonological phrases in the shape of triangular fuzzy numbers. To rank all of the alternatives, the fuzzy technique for order performance by similarity to ideal solution (FTOPSIS) was employed. The toughness and comprehensiveness image for computation, use of fuzzified judgement approach, and collection of sustainable online food delivery (OFD) were evaluated through a sensitivity study.

Table 1. Criteria for evaluating and describing sustainable online food delivery.

Main Criteria	Sub-Criteria	Goal	Descriptions
Financial Norms ($f1$)	$f11$: Supply Rate	Minimal	Transportation, labour, and administration costs all add up to a significant amount of money
	$f12$: Operating Skill	Maximal	Value propositions offered by the company, as well as the extension of its operational capabilities
	$f13$: Hazard Managing	Minimal	Investor risk management, cash flow statement, and shareholders' equity
Facility Value ($f2$)	$f21$: Order Satisfaction	Maximal	Order processing time is reduced, order pick-up time is reduced, and packaged food is kept clean.
	$f22$: Supply Speed	Minimal	Arrival of orders in a timely manner
	$f23$: Handiness of Expense	Maximal	Payment options are varied.
	$f24$: Virtual Facility Level	Maximal	SMS response time and customer service employee response time
	$f25$: Offline Facility Level	Maximal	Delivery personnel's attitudes, as well as dealers' responses to consumer concerns
	$f26$: Patron Response	Maximal	Customer behaviour intents, online reviews, and online rating
Expertise ($f3$)	$f31$: Network Strategy	Maximal	Platform that is up to date, has visual impacts on the pages, and is user-friendly
	$f32$: Instantaneous tracking systems	Maximal	Tracking and tracing over the internet, using cutting-edge technologies
	$f33$: Marketing Techniques	Maximal	Digital marketing, as well as digital technologies, are being used to promote products.

Table 1. *Cont.*

Main Criteria	Sub-Criteria	Goal	Descriptions
Societal and Eco-friendly ($f4$)	$f41$: Health and Living quarters	Maximal	Health and safety regulations, food cleanliness, and contactless delivery
	$f42$: Communication Safekeeping	Maximal	Data security for customers, as well as online payment security
	$f43$: Ecological Influence	Minimal	CO_2 emissions from automobiles, solid waste, and traffic noise are all examples of environmental issues

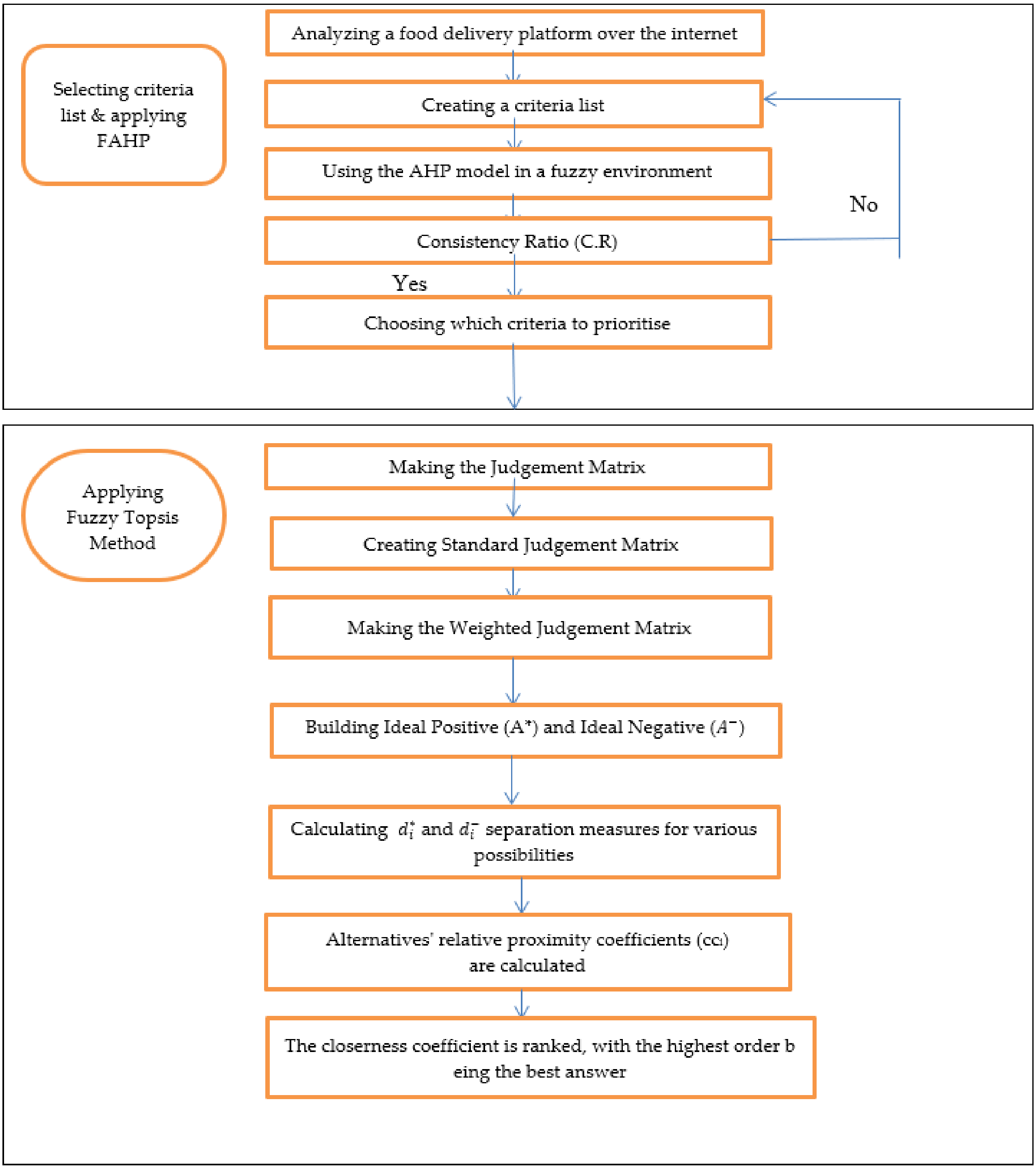

Figure 1. Evaluation process and Selection of online food delivery.

3.1. The Analytic Hierarchy Process Method

The analytic hierarchy process (AHP) is a pairwise comparison measuring technique that creates priority scales based on the opinions of experts. In a multi-criteria decision issue, the analytic hierarchy process discusses how to assess the comparative prominence of a group of actions [28]. The method combines qualitative assessments with quantitative criteria that may be measured [29]. Three principles govern the analytic hierarchy process technique: model construction, option and criteria comparison, and priority synthesis. Analytic hierarchy process has been utilised to tackle a wide range of challenging decision-making situations in the literature [30]. A hierarchy is used to organise a multidimensional outcome problem. Initially, analytic hierarchy process appears to be a complex multi-criteria decision-making problem that may be broken down into a hierarchy of interconnected choice measures and judgement substitutes. The Analytic hierarchy process organises the ideas, principles, and options into a family-tree-like ordered arrangement. There is an order in place at least three stages: top-level goal line of the delinquent, various tiers of criteria in the middle that identify options, and choice substitutes at the end [31]. The comparison of the substitutes and gages is the next phase. After the issue has already been dissected and the hierarchies have indeed been built, the prioritising approach continues by evaluating the significance of the criterion at each level. The paired judgement begins at the second level and continues until the lowest level, which is an alternative. The parameters were evaluated separately at each level based on the upper-level criteria and their influence levels [31]. In the analytic hierarchy process, a nine-level standardised comparison scale is used to make many pairwise comparisons (Table 2).

Table 2. Important scale of nine points of intensity.

Scale Rating	Meaning
1	Equally vital
3	Moderately Crucial
5	Crucial
7	Imperative
9	Very Important
2, 4, 6, 8	Between binary neighbouring decisions, there are values in the middle

The set of criteria is $C = C_j$, $j = 1, 2, \ldots, n$. A (n,n) assessment matrix A can be used to express the results of pairwise comparisons on n criteria, where each member a_{ij} ($i,j = 1, 2, \ldots, n$) is the quotient of the criteria's weights, as shown:

$$A = [a_{11}\ a_{12}\ \ldots\ a_{1n}\ a_{21}\ a_{22}\ \ldots\ a_{2n}\ \ldots\ \ldots\ \ldots\ \ldots\ a_{n1}\ a_{n2}\ \ldots\ a_{nn}\ ]; a_{ii} = 1,\ a_{ji} = \frac{1}{a_{ij}}; a_{ij} \neq 0 \tag{1}$$

In the final phase, the mathematical procedure begins to normalise each matrix and identify the relative weights. The eigenvector (w) corresponding to the greatest eigen value (λ_{max}) determines the relative weights.

$$(\lambda_{max})w = A_w \tag{2}$$

The matrices A have ranking 1 whereas if assessments are entirely consistent and $\lambda_{max} = n$ if they are not. Weights are obtained by normalising any of A's columns or rows [32]. It is important to note that the reliability of the pair-wise comparison assessments is strongly tied to the accuracy of the analytic hierarchy process output. An association of the entries of A: $a_{ij} \times a_{jk} = a_{ik}$ defines the consistency. The CI (consistency index) is designed as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{3}$$

As shown, the total reliability of a measure (CR) is measured as the proportion of the rate constant (CI) to the randomised indices (RI).

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{4}$$

The highest value of CR is 0.1. If the final consistency ratio is higher than the target, the review procedure must be used again to increase consistency. Consistency measurement can be used to assess decision-makers' consistency as well as the overall hierarchy [32].

3.2. The Fuzzy Analytic Hierarchy Process Method

The fuzzy analytic hierarchy process is frequently recommended in conjunction with other multi-criteria decision-making approaches. When addressing ambiguity and vagueness in the given weights to evaluate options, the fuzzy analytic hierarchy process is utilised in conjunction with the multi-criteria decision-making approach. The modelling of decision-making processes based on imprecise and hazy information, such as decision-makers' judgement, has been carried out using fuzzy set theory [33]. Qualitative qualities are represented by linguistic variables, which are qualitatively conveyed by linguistic phrases and quantitatively expressed by a fuzzy set and corresponding membership function in the universe of conversation.

- *Establishing fuzzy number*

The concepts that follow are involved in operations between linguistic variables. Sets with degrees of membership are called fuzzy sets. As an extension of the traditional concept of set, fuzzy sets have been proposed. In traditional set theory, a recombinant criterion determines the inclusion of elements in a collection [33]. A member will either be a member of the set or not a member of the set.

If the membership functions of a fuzzy number A on R is a triangular fuzzy number, then $\mu_{\mathrm{A}}^{\sim(\mathrm{x})} : \mathrm{R} \to [0,\ 1]$ is equal to the following Equation (5). (l, m, u) is a triangular fuzzy number (TFN), where (l, m, u) are the lowest, mean, and higher values, respectively, as shown in Figure 2.

$$\mu_{\mathrm{A}}^{\sim(\mathrm{x})} = \begin{cases} \frac{\mathrm{x}-\mathrm{l}}{\mathrm{m}-\mathrm{l}}, & \mathrm{l} \le \mathrm{x} \le \mathrm{m} \\ \frac{\mathrm{u}-\mathrm{x}}{\mathrm{u}-\mathrm{m}}, & \mathrm{m} \le \mathrm{x} \le \mathrm{u} \\ 0, & \text{Otherwise} \end{cases} \tag{5}$$

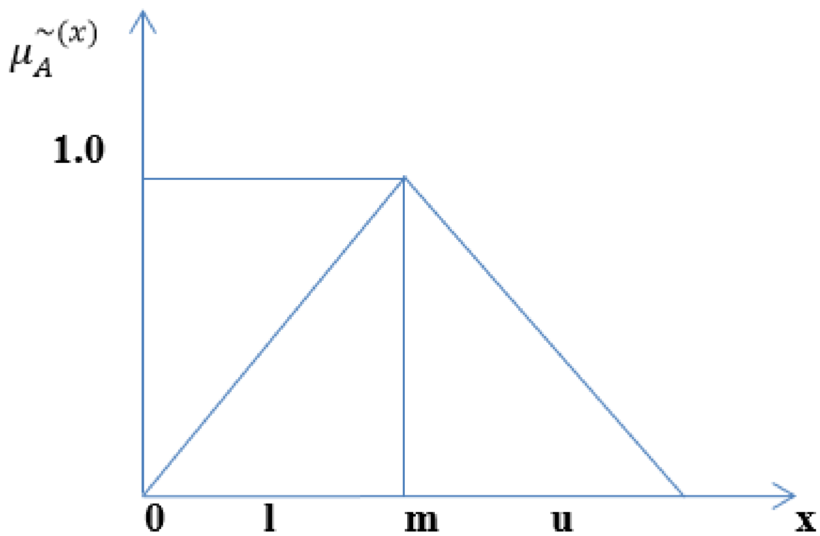

Figure 2. The triangular fuzzy number's Function of Membership.

In Equation (5), The lower and upper boundaries of the fuzzy number A are denoted by the letters l and u, respectively, and m denotes $\widetilde{A}$'s modal value (as Figure 2). $\widetilde{A} = (l, m, u)$ is used to represent the triangular fuzzy number. Triangular Fuzzy Number $\widetilde{A_1} = (l_1, m_1, u_1)$ and $\widetilde{A_2} = (l_2, m_2, u_2)$ possess the following operating laws: Equations (6)–(9).

Addition of the fuzzy number $\oplus$

$$\widetilde{A_1} \oplus \widetilde{A_2} = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = l_1 + l_2,\ m_1 + m_2, u_1 + u_2 \tag{6}$$

Multiplication of the fuzzy number $\otimes$

$$\widetilde{A_1} \otimes \widetilde{A_2} = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = l_1 l_2,\ m_1 m_2, u_1 u_2$$

for $l_1, l_2 > 0;\ m_1, m_2 > 0; u_1, u_2 > 0$ Equations (2)–(6)

Subtraction of the fuzzy number

$$\widetilde{A_1} \ominus \widetilde{A_2} = (l_1, m_1, u_1) \ominus (l_2, m_2, u_2) = l_1 - u_2,\ m_1 - m_2, u_1 - l_2 \tag{7}$$

Division of a fuzzy number $\varnothing$

$$\widetilde{A_1} \varnothing \widetilde{A_2} = (l_1, m_1, u_1) \varnothing (l_2, m_2, u_2) = l_1/u_2,\ m_1/m_2, u_1/l_2 \tag{8}$$

for $l_1, l_2 > 0;\ m_1, m_2 > 0;\ u_1, u_2 > 0$.

Reciprocal of the fuzzy number

$$\widetilde{A}^{-1} = (l_1, m_1, u_1)^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \text{ for } l_1, l_2 > 0;\ m_1, m_2 > 0;\ u_1, u_2 > 0 \tag{9}$$

- *Identifying phonological variables*

Phonological variables yield the values well-defined by their term set, which is a collection of phonological relations. Language words are phonological variables' personal categorisation. A phonological variable is one whose values are words or phrases in natural or artificial languages. This type of statement is used to compare nine basic phonological concepts, such as "Flawless", "Complete", "Brilliant", "Decent Enough", "Decent", "Better", "Average", "Less benefit", and "Equivalent" with respect to nine equal gauges. The fuzzy numbers mentioned in Table 3 were used to compute the results in this paper by [34]. Each membership function has three symmetric triangular fuzzy number parameters that specify the left, middle, and right points of the range within which the function is defined (scale of fuzzy number).

Table 3. Membership role of phonological gauge.

Fuzzy Numeral	Phonological Variables	Gage of Fuzzy Numeral
9	Flawless	(9, 9, 9)
8	Complete	(7, 8, 9)
7	Brilliant	(6, 7, 8)
6	Decent Enough	(5, 6, 7)
5	Decent	(4, 5, 6)
4	Better	(3, 4, 5)
3	Average	(2, 3, 4)
2	Less Benefit	(1, 2, 3)
1	Equivalent	(1, 1, 1)

- *Fuzzy analytic hierarchy process*

Then, in the following parts, we go over how to perform the fuzzy analytic hierarchy process.

Step 1: Make pairwise comparison matrices for all elements/criteria in the hierarchy system's dimensions. Assign linguistic labels to pairwise comparisons by deciding which of the two dimensions is more important, as shown in matrix $\widetilde{\mathrm{A}}$ below.

$$\widetilde{\mathrm{A}} = \begin{bmatrix} 1 & \widetilde{a}_{12} & \cdots & \widetilde{a}_{1n} \\ \widetilde{a}_{21} & 1 & \cdots & \widetilde{a}_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \widetilde{a}_{n1} & \widetilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \widetilde{a}_{12} & \cdots & \widetilde{a}_{1n} \\ \frac{1}{\widetilde{a}_{21}} & 1 & \cdots & \widetilde{a}_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{1}{\widetilde{a}_{n1}} & \frac{1}{\widetilde{a}_{n2}} & \cdots & 1 \end{bmatrix} \tag{10}$$

where $\widetilde{\mathrm{a}}_{\mathrm{ij}} = \begin{cases} \widetilde{9}^{-1}, \widetilde{8}^{-1}, \widetilde{7}^{-1}, \widetilde{6}^{-1}, \widetilde{5}^{-1}, \widetilde{4}^{-1}, \widetilde{3}^{-1}, \widetilde{2}^{-1}, \widetilde{1}^{-1}, \widetilde{9}, \widetilde{8}, \widetilde{7}, \widetilde{6}, \widetilde{5}, \widetilde{4}, \widetilde{3}, \widetilde{2}, \widetilde{1}, & \mathrm{i} \neq \mathrm{j} \\ 1, & \mathrm{i} = \mathrm{j} \end{cases}$.

Step 2: The fuzzified geometrical means and fuzzified weight with each parameter were calculated using the geometric mean approach.

$$\widetilde{\mathrm{r}}_{\mathrm{i}} = \left(\widetilde{\mathrm{a}}_{\mathrm{i}1} \otimes \ldots \otimes \widetilde{\mathrm{a}}_{\mathrm{ij}} \otimes \ldots \otimes \widetilde{\mathrm{a}}_{\mathrm{in}}\right)^{\frac{1}{\mathrm{n}}}$$

$$\widetilde{\mathrm{w}}_{\mathrm{i}} = \widetilde{\mathrm{r}}_{\mathrm{i}} \otimes [\widetilde{\mathrm{r}}_1 \oplus \ldots \oplus \widetilde{\mathrm{r}}_{\mathrm{i}} \oplus \ldots \oplus \widetilde{\mathrm{r}}_{\mathrm{n}}]^{-1}$$

where $\widetilde{\mathrm{a}}_{\mathrm{ij}}$: the dimension i to criteria j has a fuzzy comparison value, r_{i}: the geometric mean of each criterion's fuzzy comparison value and w_{i}: the ambiguous importance of the ith criterion, which is represented by the triangular fuzzy number, $\widetilde{\mathrm{w}}_{\mathrm{i}} = (\mathrm{lw}_{\mathrm{i}}, \mathrm{mw}_{\mathrm{i}}, \mathrm{nw}_{\mathrm{i}})$. The inferior, medium, and superior ideals of the indistinct encumbrance of the ith element are denoted by the letters $\mathrm{lw}_{\mathrm{i}}, \mathrm{mw}_{\mathrm{i}}$ and nw_{i}.

Several research studies have used the fuzzy analytic hierarchy process method to handle a variety of managerial issues. To analyse subjective expert judgments made through perception, use an analytical structure with the fuzziness procedure and then a crispy judgement matrix [35]. According to the analytical hierarchical procedure with fuzziness, present an inventory arrangement structure [36]. To create a pairwise comparison matrix that has an additive reciprocal attribute and is consistent, use fuzzy language preference relations [37]. Then calculate the micro and essential factors for an ISO 14001-based environmental management system's successful implementation, as well as the advantages [38]. In this paper, the analytic hierarchy process method is used to optimise delivery network design selection and then make appropriate decisions for home plus distribution centre decision-making [39]. Here, the authors debated over a consequence in the primacy variable derived from the analytic hierarchy process major eigenvalue technique [40]. To provide a judgement-making aid with an intentional collection of choices that combined the analytic hierarchy process and to tackle the issues, use a zero-one optimisation model assortment problematic derived with perspective from a single investor [41]. Here, it is explained how the analytic hierarchy process technique determines priority vectors [42]. In a fuzzy environment, suggested cluster management is founded on a technique for order performance by similarity to ideal solution approach models for the locality sector [43]. Fuzzy analytic hierarchy process and the technique for order performance by similarity to ideal solution are used to evaluate hazardous waste transportation companies [34]. Researchers have created an analogue apparatus for prototyping and small-batch manufacturing processes of industrial goods [44]. The decision-making framework based on an analytic hierarchy process has also been provided with a fuzzy analytic hierarchy process method to estimate the level of risk of mistaken behaviour in work systems [45]. In a multi-criteria judgement setting with fuzziness employed, the fuzzy analytic hierarchy approach was used to establish the weight of the particular/perceptual assessments for each criterion, as well as the generation of fuzzy synthetic utility values for alternatives [46]. To aid designers in identifying customer needs/requirements and design characteristics, as well as achieving an effective evaluation of the final design solution for achieving the desired levels, an outline that combines the analytical hierarchy process and the method for directive inclination by correspondence to perfect elucidation was proposed [47].

3.3. The Fuzzy Technique for Order Performance by Similarity to Ideal Solution Method

The technique for order performance by similarity to ideal solution is commonly utilised in real-world scenarios to solve ranking challenges. This strategy is frequently chastised for failing to account for the inherent ambiguity and imprecision that comes with mapping a decision-perspective maker to precise numbers. Crisp values are used to reflect personal judgments in the conventional technique for order performance by similarity to ideal solution formulation. However, the human preference model is unreliable in many situations, and decision-makers may be hesitant or unwilling to assign precise values to comparison judgements [30]. One of the most difficult aspects of the crisp evaluation process is to employ crisp values. One reason is that decision-makers are more comfortable giving interval assessments than single number values. Because some factors are difficult to quantify with precise numbers, they are frequently overlooked throughout the review. Another factor is the usage of mathematical models that are based on precise values. These approaches are incapable of dealing with the ambiguities, uncertainties, and vagueness that decision-makers face that also cannot be accompanied by a number of explicit values. Judgment can incorporate undefinable information, incompleteness, semi-information, and partly uninformed data in the judgement systems using fuzzy numbers [33,48]. As an outcome, the fuzzified technique for order performance by similarity to ideal solution and its expansions have been created to handle ranking and justification difficulties [49–54]. For the fuzzy technique for order performance by similarity to ideal solution, this paper uses triangular fuzzy numbers. The justification for choosing a Triangular Fuzzy Number is that it is intuitively simple to use and calculate for decision-makers. Furthermore, modelling with triangular fuzzy numbers has proven to be an excellent technique for expressing decision issues where the given knowledge is subjective and inaccurate [55–58]. The triangular form of the membership function is most commonly used in practice to represent fuzzy numbers [59].

Some key fuzzy set definitions are given below.

Definition 1. *A membership function $\mu_{\tilde{A}}^{(x)}$ assigns a real number in the interval [0, 1] to each element x in X in a fuzzy set $\tilde{A}$ in a universe of discourse X. The grade of membership of x in $\tilde{A}$ is denoted by the function value $\mu_{\tilde{A}}^{(x)}$.*

Definition 2. *A linguistic variable is a variable with linguistic terms as values. The concept of a linguistic variable comes in handy when dealing with situations that are too complicated or ill-defined to be adequately expressed using traditional quantitative phrases. "Weight" is a phonological variable with values of little, small, average, huge, elevated, and so on. Fuzzy numbers can be expressed using these phonological values.*

Definition 3. *The vertices approach is used to calculate the route between two triangular fuzzy numbers, $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$.*

$$d\left(\tilde{a}, \tilde{b}\right) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \tag{11}$$

Definition 4. *The weighted normalised fuzzy-decision matrix is generated as follows, taking into account the varied relevance levels of each criterion.*

$$\tilde{V} = [\widetilde{V_{ij}}]_{n \times j}, \; i = 1, 2, \ldots, n, \; j = 1, 2, \ldots, J \tag{12}$$

where, $\tilde{V}_{ij} = \tilde{x}_{ij} \times W_i$.

A set of $A_j = (j = 1, 2, \ldots, j)$ performance ratings in terms of criterion $C_i = (i = 1, 2, \ldots, n)$ called $\widetilde{x} = \widetilde{x}_{ij}, i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, J$.

A list of each criterion's importance weights $W_i = i = 1, 2, \ldots, n$.

A fuzzy technique for order performance by similarity to ideal solution phase is outlined as follows based on the preceding quickly explained fuzzy theory [53]:

Step 1: For criteria alternatives, choose the phonological values $\widetilde{x}_{ij}$, $i = 1, 2, \ldots, n$, $j = 1, 2, \ldots, J$. The property of normalised triangular fuzzy integers belonging to [0, 1] is preserved by the fuzzy linguistic rating $\widetilde{x}_{ij}$; consequently, no normalisation is required.

Step 2: Determine the fuzzy-decision matrix's weighted normalised weights. Equation (12). Calculates the weighted normalised value $\widetilde{V}_{ij}$.

Step 3: Determine if the solution is beneficial-perfect (A*) or deleterious-perfect (A^-). The fuzzy beneficial-perfect solution (FBPS, A*) and the fuzzy deleterious-perfect solution (FDPS, A^-) is depicted.

The formulas are as follows:

$$A^* = \{\widetilde{v}^*{}_1, \widetilde{v}^*{}_2, \ldots, \widetilde{v}^*{}_i\} = \left\{ \left(\max_j v_{ij} \mid i \in I' \right), \left(\min_j v_{ij} \mid i \in I'' \right) \right\}, \quad i = 1, 2, \ldots, n, \ j = 1, 2, \ldots, J \tag{13}$$

$$A^- = \{\widetilde{v}^-{}_1, \widetilde{v}^-{}_2, \ldots, \widetilde{v}^-{}_i\} = \left\{ \left(\min_j v_{ij} \mid i \in I' \right), \left(\max_j v_{ij} \mid i \in I'' \right) \right\}, \quad i = 1, 2, \ldots, n, \ j = 1, 2, \ldots, J \tag{14}$$

where I' denotes benefit criteria and I'' denotes cost criteria.

Step 4: Using the equations below, calculate the distance between A* and A for each alternative:

$$D^*{}_j = \sum_{j=1}^{n} d\left(\widetilde{v}_{ij}, \widetilde{v}^*{}_i\right), \ j = 1, 2, \ldots, J \tag{15}$$

$$D^-{}_j = \sum_{j=1}^{n} d\left(\widetilde{v}_{ij}, \widetilde{v}^-{}_i\right), \ j = 1, 2, \ldots, J \tag{16}$$

Step 5: Compare your results to the optimum solution.

$$CC_j = \frac{D^-{}_j}{D^-{}_j + D^*{}_j} = 1 - \frac{D^*{}_j}{D^-{}_j + D^*{}_j}, j = 1, 2, \ldots, J \tag{17}$$

where $\frac{D^-{}_j}{D^-{}_j + D^*{}_j} = CC_j^-$ is a hazy level of satisfaction and $\frac{D^*{}_j}{D^-{}_j + D^*{}_j} = CC_j^*$ is an indistinct break step that demonstrates how indistinct openings are corrected to meet decision-makers' target levels.

Figure 3 depicts the membership functions of these linguistic values, as well as the triangular fuzzy numbers associated with these variables (Table 4).

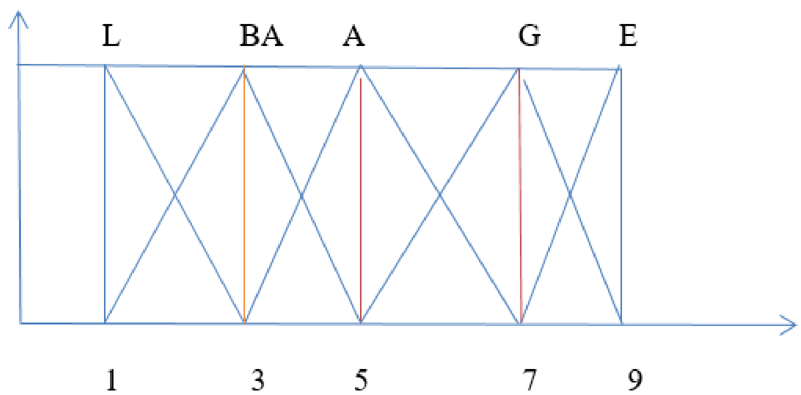

Figure 3. Linguistic values for criteria rating.

Table 4. Phonology grade level substitutes.

Linguistics Rating Level	Allocated Triangular Fuzzy Number
Low	(1, 1, 3)
Below Average	(1, 3, 5)
Average	(3, 5, 7)
Good	(5, 7, 9)
Excellent	(7, 9, 9)

4. Case Study

The efficacy of the suggested approach is examined in this paper using a case study of online food delivery (OFD) platform companies in India. Three specialists worked together to select the top four online food delivery services (OFDs) after conducting preliminary analysis. These firms are Uber Eats, Domino's, Zomato, and Swiggy. The Fuzzy analytic hierarchy process was employed to ascertain the relative preference weight of each criterion. The decision hierarchy for the evaluation and selection of online food delivery (OFD) is shown in Figure 4. It consists of 15 criteria in total, with four main ones being financial norms (supply rate, operating skill, and hazard managing), expertise criteria (network strategy, instantaneous, and e-commerce), societal and eco-friendly criteria (health and living quarters, communication safekeeping, and ecological influence), and facility value (order satisfaction, supply speed, handiness of expense, virtual/offline facility level, and patron response). After ranking all possibilities, a score line of the fuzzy technique for order performance by similarity to ideal solution model is prepared to demonstrate the model's resilience and comprehensiveness.

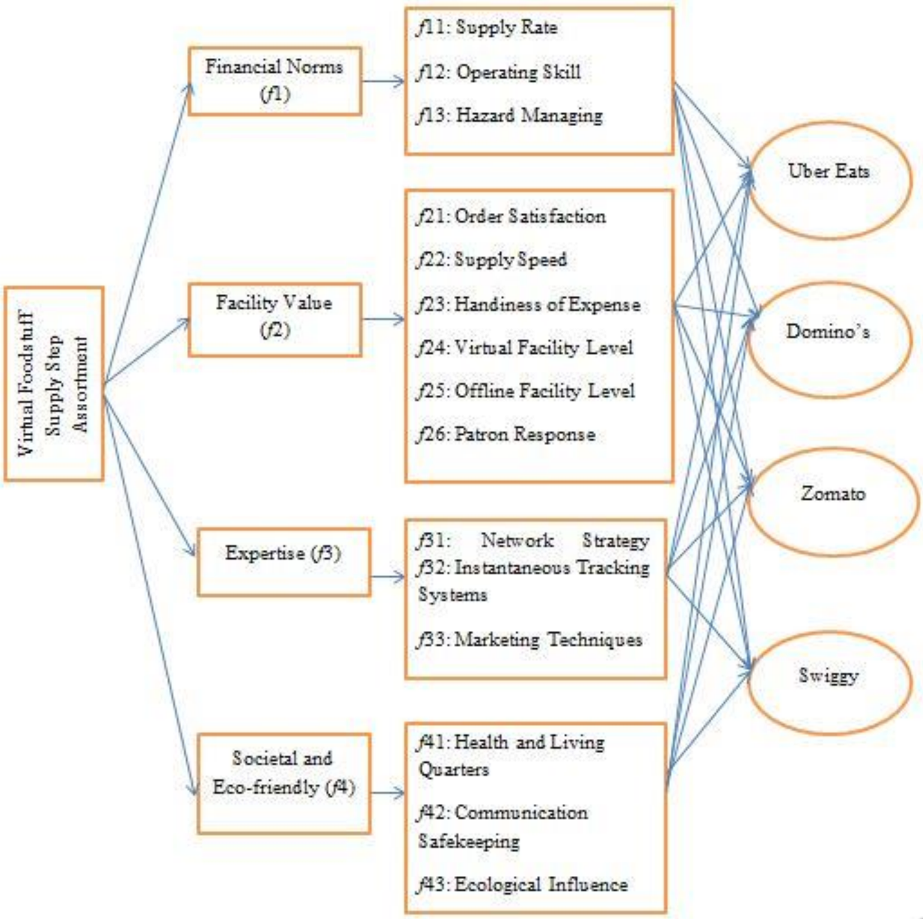

Figure 4. Evaluation and Selection of online food delivery using a decision hierarchy.

5. Results Analysis

With the analytic hierarchy process, a pairwise comparison matrix is created to compare the properties of several food delivery services. Analytic hierarchy process is used to estimate the weights of the main criteria and sub-criteria that take into account the decision-makers' subjective judgements. Four specialists in the field of online food services were recruited to construct the decision matrix.

Normalisation was accomplished using Equation (1) after constructing the evaluation matrix of the primary standards. The primacy vector was worked out. The eigenvalue was calculated with Equations (2) and (3). Equation (4) was used to calculate the consistency indicator and ratio.

The following primary categories are ordered based on estimated weighted values: Financial Norms, Facility Value, Expertise, and Societal and Eco-friendly factors (Table 5). When the same procedure was used to calculate the sub-criterion—Supply Rate, Operating Skill, Hazard Managing, Order Satisfaction, Supply Speed, Handiness of Expense, Virtual/Offline Facility Level, Patron Response, Network Strategy, Instantaneous Tracking Systems, Marketing Techniques, Health and Living Quarters, Communication Safekeeping, and Ecological Influence from the highest to lowest values—the results were as follows. The sub-criteria performance of online food services, on the other hand, was prioritised in the following order. The ranking of online food services ranged from excellent to poor. Table 6 displays the total findings.

Table 5. AHP ranked the main criteria.

Criteria	Weight
Financial Norms ($f1$)	0.4649
Facility Value ($f2$)	0.2086
Expertise ($f3$)	0.2341
Societal and Eco-friendly ($f4$)	0.0924

Table 6. AHP ranked the sub-criteria.

Sub Criteria	Weight	Sub Criteria	Weight
$f11$	0.0728	$f26$	0.0684
$f12$	0.0659	$f31$	0.0842
$f13$	0.0559	$f32$	0.0776
$f21$	0.0789	$f33$	0.0590
$f22$	0.0775	$f41$	0.0581
$f23$	0.0678	$f42$	0.0499
$f24$	0.0726	$f43$	0.0469
$f25$	0.0645		

$f11$: Supply Rate; $f12$: Operating Skill; $f13$: Hazard Managing; $f21$: Order Satisfaction; $f22$: Supply Speed; $f23$: Handiness of Expense; $f24$: Virtual Facility Level; $f25$: Offline Facility; $f26$: Patron Response; $f31$: Network Strategy; $f32$: Instantaneous Tracking Systems; $f33$: Marketing Techniques; $f41$: Health and Living Quarters; $f42$: Communication Safekeeping; $f43$: Ecological Influence.

In the fuzzy analytic hierarchy process, the outcome is significantly influenced by checking the consistency ratio; the following fuzzy analytic hierarchy process technique shows an example of how to calculate the four main criteria. Initial assessments were conducted by a group of specialists to rate the execution of these norms, which include Financial Norms ($f1$), Facility Value ($f2$), Expertise ($f3$), and Societal and Eco-friendly ($f4$). Tables 7 and 8 show the fuzzy analytic hierarchy process model's initial comparison matrix as well as the aggregated fuzzy comparison matrix.

Table 7. The initial comparison matrix.

Main Criteria	(7,8,9)	(6,7,8)	(5,6,7)	(4,5,6)	(3,4,5)	(2,3,4)	(1,2,3)	(1,1,1)	(1,2,3)	(2,3,4)	(3,4,5)	(4,5,6)	(5,6,7)	(6,7,8)	(7,8,9)	Main Criteria
$f1$							*									$f2$
$f1$						*										$f3$
$f1$					*											$f4$
$f2$							*									$f3$
$f2$								*								$f3$
$f2$							*									$f4$
$f3$					*											$f4$

Where * represents the values of combined fuzzy judgment matrix.

Table 8. Combined fuzzy judgment matrix.

Criteria	Financial Norms ($f1$)	Facility Value ($f2$)	Expertise ($f3$)	Societal and Eco-Friendly ($f4$)
Financial Norms ($f1$)	(1,1,1)	(1,2,3)	(2,3,4)	(3,4,5)
Facility Value ($f2$)	(1/3,1/2,1/1)	(1,1,1)	(1,1,1)	(1,2,3)
Expertise ($f3$)	(1/4,1/3,1/2)	(1,1,1)	(1,1,1)	(3,4,5)
Societal and Eco-friendly ($f4$)	(1/5,1/4,1/3)	(1/3,1/2,1/1)	(1/5,1/4,1/3)	(1,1,1)

To transform the phonological terms, the indistinct judgement matrix's sceptical (inferior bound) and expectant (superior bound) assessments were applied. To determine the quality evaluation score's reliability coefficient (CR), convert (i.e., triangle fuzzy number) to crisp values. Table 9 displays the primary criteria's non-fuzzy comparison matrix.

Table 9. Non-fuzzy comparison matrix.

Criteria	Financial Norms ($f1$)	Facility Value ($f2$)	Expertise ($f3$)	Societal and Eco-Friendly ($f4$)
Financial Norms ($f1$)	1	1.7321	2.8284	3.8730
Facility Value ($f2$)	0.5774	1	1	1.7321
Expertise ($f3$)	0.3536	1	1	3.8730
Societal and Eco-friendly ($f4$)	0.2582	0.5774	0.2582	1
Sum	2.1892	4.3095	5.0866	10.4781

Divide each unique value in a cell of the matrices by the column's average to create the normalised pairwise comparisons. This yields the prominence vectors of the fuzzy analytic hierarchy process model's four fundamental standards. As shown in Table 10, the prominence vectors were calculated from the average of the standardised matrix's row members.

Table 10. Normalised judgment matrix.

Criteria	Financial Norms ($f1$)	Facility Value ($f2$)	Expertise ($f3$)	Societal and Eco-Friendly ($f4$)	Priority Vector
Financial Norms ($f1$)	0.4568	0.4019	0.5561	0.3701	0.4462
Facility Value ($f2$)	0.2638	0.2321	0.1966	0.1652	0.2144
Expertise ($f3$)	0.1615	0.2321	0.1966	0.3701	0.2400
Societal and Eco-friendly ($f4$)	0.1179	0.1339	0.0507	0.0954	0.0994
Sum	1.0000	1.0000	1.0000	1.0000	1.0000

The gauge of integrity (CI), the indices at selection (RI), and the measure of dependability (CR) were calculated in this phase by calculating the greatest eigenvector (λ_{max}).

$$[1.8813\ 0.8842\ 0.9971\ 0.4003\ ]\,/\,[0.4462\ 0.2144\ 0.2400\ 0.0994\ ] = [4.2163\ 4.1240\ 4.1548\ 4.0278\ ]$$

Four important factors were considered in this research. As a result, we get n = 4. The following formulas were used to calculate λ_{max} and CI.

$$\lambda_{max} = 4.1307$$
$$\mathrm{CI} = 0.04357$$

RI = 0.9 was obtained when n = 4 and the consistency ratio (CR) is determined as follows:

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}} = 0.0484$$

CR = 0.0484 < 0.1, according to the findings. As a result, the fuzzy analytic hierarchy process model's results are satisfactory, and the pair-wise comparison matrices are totally consistent. The same approach was then used to calculate the remaining criteria. Table A1 displays the combined fuzzy comparison matrix with all criteria (Appendix A).

Table 11 illustrates the results of the fuzzy weights computed using the fuzzy geometric mean approach for all criteria in the fuzzy analytic hierarchy process model. Suspicious (lowermost weight), most likely (central weight), and expectant (uppermost weight) are three values in each fuzzy weight (the highest weight). In the fuzzy weight of norms superiority, the suspicious value is 0.0556, the most likely value is 0.0720 and the most expectant value is 0.0928. The remaining conditions are demonstrated in the same way. The subsequent step is the fuzzy technique for order performance by similarity to ideal solution model; these fuzzy preference weights were then applied.

Figure 5 depicts the levels of criterion influence. With 8.3433 percent, 7.9733 percent, 7.81 percent, 7.5466 percent, and 7.4066 percent, respectively, the categories "Network Strategy", "Instantaneous tracking systems", "Order Satisfaction", "Supply Speed", and "Virtual Facility Level" have the biggest influence percentages. The findings reveal that "Network Strategy" is more essential to experts than other cost and quality concerns when it comes to influencing the selection of online food services in the e-commerce industry. Network Strategy is a significant predictor of when managers should replenish stocks in e-commerce businesses, thus it is crucial to consider it while developing an inventory management strategy. It is also important to think about when you are adding new product lines to your online store. In order to survive and grow in India's burgeoning e-commerce sector, e-commerce businesses are focusing more on economic aspects. On the other side, green and resilient development methods have gained popularity. In order to strengthen Indian enterprises' competitiveness, the management inspires them to join successfully in the universal assessment sequence by adopting and assimilating defensible corporate schemes. Thus, financial criteria were highly valued, and other criteria from the three pillars of defensible growth (Societal and Eco-friendly challenges) are also relevant. Among 15 eco-friendly variables, "Supply Rate" and "Patron Response" are placed sixth (7.3466 percent) and seventh (7.2366 percent), respectively. These graphs show how social and environmental elements, in addition to economic considerations, play a considerable effect.

We define CC_j^- as the degree of satisfaction in the jth alternative and CC_j^* as the degree of gap in the jth alternative. We can figure out which gaps should be closed and how they should be closed in order to meet aspirational goals and choose the greatest win-win approach from a hazy collection of viable options. In the fuzzy technique for order performance by similarity to ideal solution model, the intuitionistic fuzzy ratings of criterion are generated using the fuzzy analytic hierarchy process model. According to the fuzzy technique for order performance by similarity to ideal solution process, the hazy normalisation decision problem and hazy weight normalisation decision table are reported in Tables 12 and 13. The satisfaction degrees of each organisation can be determined using the data in Table 14. Uber eats, Domino's, Zomato, and Swiggy's satisfaction degree values are 0.2844, 0.5202, 0.8474, and 0.6196, respectively. Figure 6 shows the online food services, which are, Zomato, Swiggy, Domino's, and Uber Eats, ranked first, second, third, and fourth with scores of 0.8474, 0.6196, 0.5202, and 0.2844, respectively.

Table 11. Fuzzy weights for each criterion.

Major Indicators	Parameters	Goal	Uncertain Parametric Means	Fuzzy Weights
Financial Norms ($f1$)	$f11$: Supply Rate	Minimal	(0.9548, 1.0968, 1.2545)	(0.0556, 0.0720, 0.0928)
	$f12$: Operating Skill	Maximal	(0.9117, 1.0193, 1.1437)	(0.0531, 0.0669, 0.0846)
	$f13$:Hazard Managing	Minimal	(0.8473, 0.9293, 1.0273)	(0.0493, 0.0610, 0.0760)
Facility Value ($f2$)	$f21$:Order Satisfaction	Maximal	(0.9733, 1.1659, 1.3663)	(0.0567, 0.0765, 0.1011)
	$f22$: Supply Speed	Minimal	(0.9293, 1.1268, 1.3299)	(0.0541, 0.0739, 0.0984)
	$f23$: Handiness of Expense	Maximal	(0.8874, 1, 1.1268)	(0.0517, 0.0656, 0.0834)
	$f24$: Virtual Facility Level	Maximal	(1.0472, 1.1268, 1.1801)	(0.0610, 0.0739, 0.0873)
	$f25$:Offline Facility Level	Maximal	(0.9548, 1, 1.0472)	(0.0556, 0.0656, 0.0775)
	$f26$:Patron Response	Maximal	(1.0759, 1.0968, 1.1132)	(0.0627, 0.0720, 0.0824)
Expertise ($f3$)	$f31$:Network Strategy	Maximal	(1.0968, 1.2698, 1.3928)	(0.0639, 0.0833, 0.1031)
	$f32$: Instantaneous tracking systems	Maximal	(1.0675, 1.1978, 1.3299)	(0.0622, 0.0786, 0.0984)
	$f33$:Marketing Techniques	Maximal	(0.7664, 0.9117, 1.1268)	(0.0446, 0.0598, 0.0834)
Societal and Eco-friendly ($f4$)	$f41$: Health and Living quarters	Maximal	(0.7519, 0.8874, 1.0759)	(0.0438, 0.0582, 0.0796)
	$f42$:Communication Safekeeping	Maximal	(0.6277, 0.7267, 0.8705)	(0.0365, 0.0477, 0.0644)
	$f43$:Ecological Influence	Minimal	(0.6158, 0.6754, 0.7725)	(0.0358, 0.0443, 0.0571)

$f11$: 7.3466%; $f12$: 6.82%; $f13$: 6.21%; $f21$: 7.81%; $f22$: 7.5466%; $f23$: 6.69%; $f24$: 7.4066%; $f25$: 6.6233%; $f26$: 7.2366%; $f31$: 8.3433%; $f32$: 7.9733%; $f33$: 6.26%; $f41$: 6.0533%; $f42$: 4.9533%; $f43$: 4.5733%.

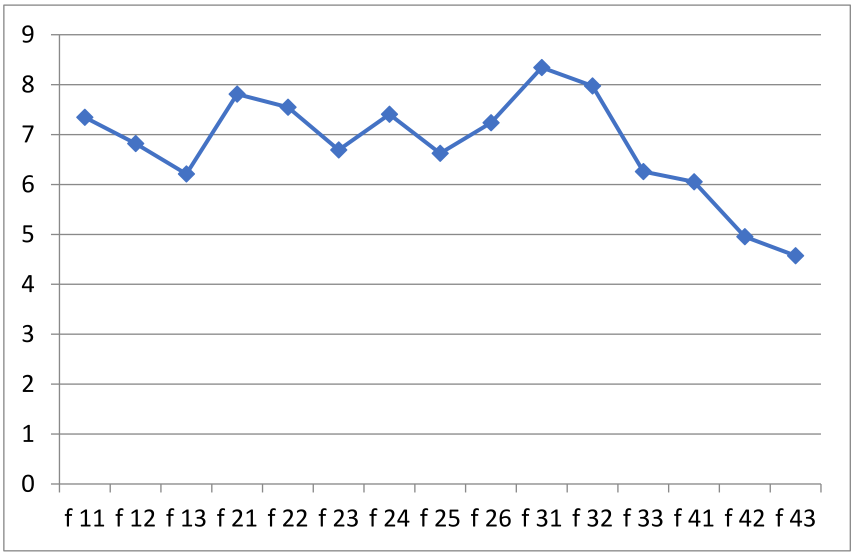

Figure 5. Influence level of FAHP model criterion.

Table 12. Fuzzy normalised decision matrix.

	Financial Norms ($f1$)	Facility Value ($f2$)	Expertise ($f3$)	Societal and Eco-Friendly ($f4$)
Uber Eats	0.1111, 0.3333, 0.7777	0.1111, 0.6296, 1	0.3333, 0.6296, 1	0.3333, 0.5294, 1
Domino's	0.3333, 0.7777, 1	0.5555, 0.8518, 1	0.3333, 0.7037, 1	0.3333, 0.3600, 0.6
Zomato	0.5555, 0.8518, 1	0.3333, 0.7777, 1	0.5555, 0.8518, 1	0.3333, 0.4736, 1
Swiggy	0.3333, 0.6296, 1	0.3333, 0.7777, 1	0.3333, 0.6296, 1	0.3333, 0.4736, 1

Table 13. Fuzzy weighted normalised decision matrix.

	Financial Norms ($f1$)	Facility Value ($f2$)	Expertise ($f3$)	Societal and Eco-Friendly ($f4$)
Uber Eats	0.3333, 1.6665, 5.4439	0.7777, 5.6664, 9	2.3331, 5.6664, 9	1.6665, 3.7058, 9
Domino's	0.9999, 3.8885, 7	3.8885, 7.6662, 9	2.3331, 6.3333, 9	1.6665, 2.52, 5.4
Zomato	1.6665, 4.259, 7	2.3331, 6.9993, 9	3.8885, 7.6662, 9	1.6665, 3.3152, 9
Swiggy	0.9999, 3.148, 7	2.3331, 6.9993, 9	2.3331, 5.6664, 9	1.6665, 3.3152, 9

Table 14. Closeness coefficient of each alternative.

Alternatives	$D^{-}{}_{j}$	$D^{*}{}_{j}$	Level of Satisfaction	Rank
Uber Eats	2.1883	5.5055	0.2844	4
Domino's	4.1327	3.8111	0.5202	3
Zomato	6.6815	1.2023	0.8474	1
Swiggy	5.5606	3.4128	0.6196	2

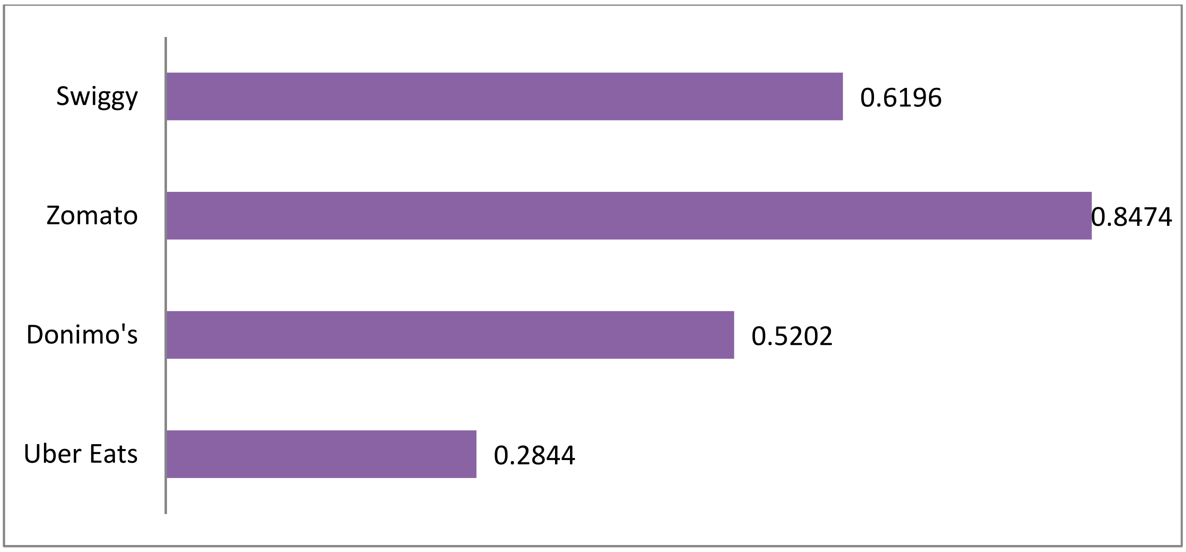

Figure 6. Score line of the FTOPSIS model.

6. Discussion

In the research work that is presented, a hybrid multi-criteria decision-making framework for the evaluation of the online food delivery market in India is established in consideration of a wide range of criteria, including financial norms (supply rate, operating skill, and hazard managing), expertise criteria (network strategy, instantaneous and e-commerce), societal and eco-friendly criteria (health and living quarters, communication safekeeping, and ecological influence), and facility value (order satisfaction, supply speed, handiness of expense, virtual/offline facility level, and patron response). The combination of the fuzzy analytic hierarchy process and fuzzy technique for order performance by similarity to ideal solution method has been initially proposed in the current research to tackle the problem in light of the discussion by thoroughly reviewing the literature. Triangular fuzzy sets in the analytic hierarchy process can translate expert opinions into language terms to get more precise and scientific attribute weights for the criterion. The reliability of the suggested integrated framework is shown by the fact that the offered case study is successfully addressed. The outcomes show that the model in use is able to rank common green online food delivery companies. According to the fuzzy analytic hierarchy process results, the top five online food delivery evaluation factors are Order Satisfaction, Supply Speed, Network Strategy, and Virtual Facility Level.

To meet the customer's needs in the first place, it is crucial in India that online shopping be convenient for payment. The vast majority of Indians still favour cash-on-delivery payment over online transactions, despite the advantages of cashless payment methods like credit or internet banking being established, which include cost savings and numerous conveniences for customers and businesses. Other than that, developing cutting-edge technology solutions that guarantee more efficient order fulfilment while keeping costs down is a competitive edge for online food delivery companies. One way for online food delivery firms to stay alive and attract clients is by merging orders, offering many delivery choices using robotics and drones, and utilising cloud kitchens. Figure 6 shows that Zomato (0.8474), Swiggy (0.6196), Domino's (0.5202), and Uber Eats (0.2844) are in order of top performing online food delivery companies in the current online food delivery market in India according to the chosen evaluation criteria. The outcomes can be used as a benchmark for online food delivery executives and decision-makers as they evaluate their companies' performance while taking into account a wider range of factors and identifying key industry determinants. The current study's chosen evaluation criteria will all aid online food delivery enterprises in overcoming a variety of obstacles and motivate them to consider sustainable development initiatives. The assessment of the online food delivery market in India and other markets has concentrated on a number of variables, including service quality, economic factors, and technology, but it is still difficult to keep in mind social and environmental issues.

7. Conclusions

There are limitations and possible extensions to this study. The author offered a brand-new methodology to offer a quick strategy for evaluating several online food delivery companies and assisting the decision-maker in choosing the finest one. The pairwise comparison procedure is made intuitively by combining enhanced analytic hierarchy process (AHP) with fuzzy set theory, which also helps to lessen or completely eliminate evaluation bias. In order to assist online food delivery services, this paper also introduces a strategy that combines improved analytic hierarchy process (AHP) with technique for order performance by similarity to ideal solution (TOPSIS). To ensure sustained development in this cutthroat industry, it is crucial for online food delivery enterprises to adopt a number of actions and take pertinent factors into account. The managerial implications of the used approach and its analysis would enlighten decision-makers in the online food delivery industry not only in India but also in the international market. The approach put out in this research can be connected to further cutting-edge market influences in subsequent investigations. Multi-criteria decision-making approaches like VIseKriterijumska Optimizacija I Kompromisno Resenje, Preference Ranking for Organisation Method for Enrichment Evaluation, Data Envelopment Analysis, and combinations of these, among others, can be used methodologically. To test the overall validity of the conclusions, additional studies might apply the suggested strategy or relevant approaches to particular situations of industries, particularly those connected to e-commerce.

In this paper, we discussed the fuzzy analytic hierarchy process and fuzzy technique for order performance by similarity to ideal solution methods together and summarised the results as follows. In the first part, we discussed the construction of the online food delivery market evaluation criteria using replies from industry experts that are explained in Figure 4 and Table 1. Next, we discussed a case study to evaluate the online food delivery enterprises in India by using the fuzzy analytic hierarchy process, which is explained with the help of Tables 5–10 and finally executed in Table 11. Also, we discussed the influence level of fuzzy analytic hierarchy process model criteria, which is shown in Figure 5 and the fuzzy technique for order performance by similarity to ideal solution method, which is explained with the help of Tables 12 and 13 and finally executed in Table 14. The final ranking order of online food delivery services from the fuzzy technique for order performance by similarity to ideal solution method is visualised in Figure 6.

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Appendix A

Table A1. Fuzzy logic combined judgement matrix of 15 criteria.

Parameters		$f11$			$f12$			$f13$	
$f11$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f12$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f13$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f21$	1.00	1.00	1.00	1.00	1.05	1.08	1.00	1.05	1.08
$f22$	1.00	1.00	1.00	1.05	1.08	1.10	1.05	1.08	1.10
$f23$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f24$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f25$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f26$	1.08	1.10	1.11	1.00	1.00	1.00	1.00	1.00	1.00
$f31$	1.00	1.05	1.08	1.00	1.00	1.00	1.00	1.00	1.00
$f32$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f33$	0.93	0.95	1.00	1.00	1.00	1.00	0.93	0.95	1.00
$f41$	0.91	0.93	0.95	0.93	0.95	1.00	1.00	1.00	1.00
$f42$	0.90	0.91	0.93	1.00	1.00	1.00	1.00	1.00	1.00
$f43$	1.00	1.00	1.00	0.90	0.91	0.93	1.00	1.00	1.00

Table A1. *Cont.*

Parameters		$f21$			$f22$			$f23$	
$f11$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f12$	0.93	0.95	1.00	0.91	0.93	0.95	1.00	1.00	1.00
$f13$	0.93	0.95	1.00	0.91	0.93	0.95	1.00	1.00	1.00
$f21$	1.00	1.00	1.00	0.93	0.95	1.00	0.91	0.93	0.95
$f22$	1.00	1.05	1.08	1.00	1.00	1.00	0.93	0.95	1.00
$f23$	1.05	1.08	1.10	1.00	1.05	1.08	1.00	1.00	1.00
$f24$	1.00	1.00	1.00	1.05	1.08	1.10	1.00	1.05	1.08
$f25$	1.00	1.00	1.00	1.00	1.00	1.00	1.05	1.08	1.10
$f26$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f31$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f32$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f33$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f41$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f42$	0.89	0.90	0.91	0.93	0.95	1.00	1.00	1.00	1.00
$f43$	0.91	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.00
Parameters		$f24$			$f25$			$f26$	
$f11$	1.00	1.00	1.00	1.00	1.00	1.00	0.91	0.93	0.95
$f12$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f13$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f21$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f22$	0.91	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.00
$f23$	0.93	0.95	1.00	0.91	0.93	0.95	1.00	1.00	1.00
$f24$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f25$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f26$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f31$	1.00	1.00	1.00	1.05	1.08	1.10	1.00	1.00	1.00
$f32$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f33$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f41$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f42$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f43$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Parameters		$f31$			$f32$			$f33$	
$f11$	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.05	1.10
$f12$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f13$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.05	1.10
$f21$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f22$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f23$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f24$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A1. *Cont.*

$f25$	0.91	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.00
$f26$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f31$	1.00	1.00	1.00	1.00	1.05	1.10	1.05	1.08	1.10
$f32$	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.05	1.10
$f33$	0.91	0.93	0.95	0.93	0.95	1.00	1.00	1.00	1.00
$f41$	1.00	1.00	1.00	0.91	0.93	0.95	0.93	0.95	1.00
$f42$	1.00	1.00	1.00	1.00	1.00	1.00	0.91	0.93	0.95
$f43$	1.00	1.00	1.00	0.89	0.90	0.91	1.00	1.00	1.00
Parameters		$f41$			$f42$			$f43$	
$f11$	1.05	1.08	1.10	1.08	1.10	1.11	1.00	1.00	1.00
$f12$	1.00	1.05	1.10	1.00	1.00	1.00	1.08	1.10	1.11
$f13$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f21$	1.00	1.00	1.00	1.10	1.11	1.13	1.05	1.08	1.10
$f22$	1.00	1.00	1.00	1.00	1.05	1.10	1.00	1.00	1.00
$f23$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f24$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f25$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f26$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f31$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$f32$	1.05	1.08	1.10	1.00	1.00	1.00	1.10	1.11	1.13
$f33$	1.00	1.05	1.10	1.05	1.08	1.10	1.00	1.00	1.00
$f41$	1.00	1.00	1.00	1.00	1.05	1.10	1.05	1.08	1.10
$f42$	0.93	0.95	1.00	1.00	1.00	1.00	1.00	1.05	1.10
$f43$	0.91	0.93	0.95	0.93	0.95	1.00	1.00	1.00	1.00

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