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Evaluating Online Food Delivery Services: Cost Efficiency Through AHP and TOPSIS

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ABSTRACT

Through the integration of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP), this study investigates the evaluation of delivery efficiency in online food delivery platforms. Maintaining timely and effective deliveries has become essential for retaining client happiness and competitive advantage in the rapidly expanding online meal delivery market. The complex interplay of delivery efficiency—which takes into account variables including delivery time, cost, customer happiness, and environmental impact—means that traditional assessment techniques frequently fall short in this regard.

In order to improve delivery efficiency in online food delivery platforms, this research first uses AHP to determine the relative importance of various criteria influencing delivery efficiency. AHP helps to structure the problem into a hierarchical model, making it easier to assign weights to each criterion based on expert judgment. In order to rank different delivery options, the TOPSIS method is then used, which compares them to an ideal solution. This combination of AHP and TOPSIS provides a comprehensive, multi-criteria decision-making framework that facilitates a more nuanced assessment of delivery performance. The results indicate that combining AHP and TOPSIS methods can greatly improve the evaluation process.

Keywords: Online Food Delivery, Cost Efficiency, AHP (Analytic Hierarchy Process), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), Delivery Performance.

Introduction

Recent technological advancements, shifting customer preferences, and the ease of having food transported right to one's door have all contributed to the explosive expansion of the online food delivery market (Anbumathi, R., et. al., (2023). Enterprises are facing mounting pressure to streamline their processes, guarantee cost effectiveness, and uphold elevated customer satisfaction standards as the market keeps growing. Online meal delivery businesses have a number of difficulties, one of which is balancing cost effectiveness with other important considerations including customer service, food quality, and delivery timeliness (Annaraud, K., & Berezina, K. (2020). In order to achieve this balance, an extensive and strong assessment system that can support a variety of criteria and offer decision-makers useful information is needed. This makes the combination of the Technique for Order of

Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP) techniques a potent way for assessing cost-effectiveness in online meal delivery services. Mathematically and psychologically grounded, Analytic Hierarchy Process (AHP) is a systematic method for organizing and evaluating complicated choices. The methodical evaluation of different elements impacting cost efficiency is made possible by its assistance in decomposing the decision-making process into a hierarchy of criteria and sub-criteria. In contrast, TOPSIS is a multi-criteria approach to decision-making that assigns a ranking to options according to how near they are to the optimal answer (Ajjipura Shankar, et. al., (2022). This study combines these two approaches in an effort to offer a thorough evaluation framework that evaluates cost effectiveness in addition to taking into other vital aspects of Online food delivery. In the context of online meal delivery, this method makes it possible to comprehend cost effectiveness from a more comprehensive angle. Businesses are better equipped to make decisions that meet both consumer expectations and their strategic objectives when they take a broad variety of variables into account and apply an organized, multi-criteria framework (Ma, B., et. al., (2024). With this study, we hope to further the current conversation on online meal delivery service optimization by showcasing the usefulness of AHP and TOPSIS in assessing and improving overall cost effectiveness.

1. Literature Review

A growing interest in improving operational performance in this dynamic industry is reflected in the extensive literature on evaluating cost efficiency in online food delivery services through multi-criteria decision-making techniques like AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). A thorough examination of the expansion of the online meal delivery industry is given by Tsai, P. H., et al. (2023), who highlight how customer behavior and technology developments influence the quality of services. In their discussion of the ways in which the COVID-19 epidemic has changed customer expectations, Hong, C., et al. (2023) emphasize the growing significance of affordable, contactless delivery choices. According to Sureeyatanapas, P., and Damapong, K. (2024), market competitiveness and logistical difficulties are important variables affecting cost efficiency. They argue that using big data and sustainable practices can give a competitive edge. According to Arli, D., et al. (2024), sustainability practices—such as ethical sourcing and eco-friendly packaging—are becoming more and more important in cutting expenses and improving attractiveness to consumers. Lin, P. M., et al. (2024) draw attention to the ways that digitization—including artificial intelligence and machine learning—can optimize delivery routes and raise customer satisfaction. According to Hong, C., et al. (2023), upholding good service standards is essential for keeping clients and cutting expenses. They look at a variety of service quality models and their relation to cost efficiency. The impact of customer feedback on operational modifications and cost-management tactics is investigated by Pillai, S. G., et al. (2022). In their exploration of the logistical intricacies of delivery services, Dsouza, D., & Sharma, D. (2021) emphasize the necessity of effective route optimization in order to save expenses. According to Khan, M. F. (2020), technology advancements like drone deliveries can drastically cut down on delivery times and related expenses. In their analysis of factors impacting consumer loyalty, Nguyen, B., et al. (2021) conclude by highlighting the importance of cost efficiency as a crucial element in determining repeat business in a competitive market. All of these studies together highlight how complicated cost efficiency is for online food delivery businesses and how useful AHP and TOPSIS are for assessing and improving operational performance.

Numerous academic works have addressed the application of AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) techniques for assessing cost effectiveness in online meal delivery services. In their thorough analysis of AHP and TOPSIS, Abdullah, N. S. K., et al. (2024) show how well these tools work when evaluating a variety of factors in situations involving decision-making, such as the price-efficiency of the food delivery industry. Studying the implementation of these techniques in online food delivery services, where cost, delivery time, and customer happiness are important considerations, Ajjipura Shankar et al. (2022) draw comparisons with these techniques' usage in infrastructure project management. Nguyen, N. B. T., et al. (2021) investigate multi-criteria decision-making techniques for assessing the selection of green suppliers. They show how AHP and TOPSIS may be modified to evaluate cost-efficiency by taking into account a variety of environmental and economic variables. In their comparison of AHP and TOPSIS, Correa, J. C., et al. (2019) discuss how choosing a renewable energy project involves striking a balance between cost-effectiveness, sustainability, and service quality—akin to ordering meals online. The healthcare industry is the subject of Ajjipura Shankar et al.'s (2022) study, which demonstrates how these techniques may assess service quality and cost-effectiveness and offers insights into how they might be used to maximize operational efficiency in online meal delivery services. Collectively, these studies highlight how AHP and TOPSIS are flexible and useful for assessing cost-effectiveness in a variety of industries, including online meal delivery.

2. Proposed Model

These two methods, AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), are combined to see how cost-effective online food delivery services like Uber Eats, Swiggy, and Zomato are. Figure 1 shows the results. The primary objective is cost efficiency. The objective is to evaluate the cost-effectiveness of each online food delivery service by considering a variety of factors. Four criteria influence cost efficacy: minimum order amount, delivery fee, discount offers, and membership/subscription costs. Zomato, Swiggy, and Uber Eats are the three alternatives that are currently being assessed. These are the various online food delivery services that are currently being assessed. This model can be especially beneficial for businesses seeking to optimize their service offerings and for consumers seeking the most cost-effective online food delivery service.

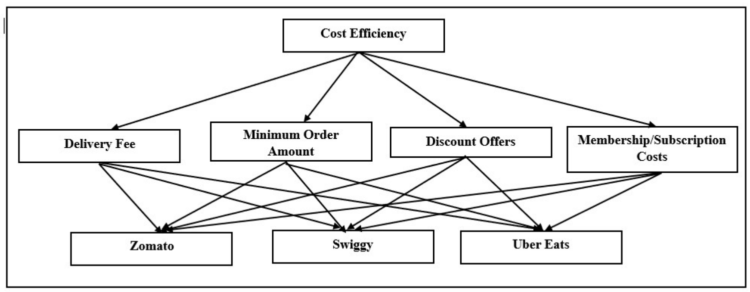

Figure 1: Proposed Model for the Study

3. AHP Method

The pairwise comparison matrix shows how important each of the five factors—Delivery Fee (DF), Minimum Order Amount (MOA), Discount Offers (DO), Membership/Subscription Costs (MSC), and Hidden Costs (HC)—is in figuring out how cost-effective a business is. The matrix demonstrates that the Delivery Fee (DF) is the most critical factor, as it has a higher value than the other attributes, suggesting that it has a greater impact on cost efficiency. Additionally, the Minimum Order Amount (MOA) is of considerable importance, particularly when contrasted with Discount Offers (DO) and Membership/Subscription Costs (MSC). Discount Offers (DO) are considered less significant than DF and MOA, but they are more influential than MSC and HC. MSC and HC are perceived to be the least significant, as their values are either equal or lower across comparisons, indicating that they have the least impact on overall cost efficiency. The values serve as a foundation for determining the weights of each attribute, which will be employed in succeeding decision-making processes, including the AHP and TOPSIS methods.

Table 1: Pair wise Comparison Matrix

Attributes	DF	MOA	DO	MSC	HC
DF	1.00	2.00	3.00	1.00	2.00
MOA	0.50	1.00	3.00	2.00	2.00
DO	0.33	0.33	1.00	2.00	2.00
MSC	1.00	0.50	0.50	1.00	1.00
HC	0.50	0.50	0.50	1.00	1.00

The relative significance of each attribute in determining cost efficiency is represented by the normalized pairwise comparison matrix, which normalizes each value to a sum of 1 across each column. The local weights that are derived from this matrix offer a distinct indication of the importance of each attribute. The predominant influence on cost efficiency is reaffirmed by the maximum local weight of 0.31, which is attributed to the Delivery Fee (DF). The Minimum Order Amount (MOA) is followed by a weight of 0.26, which also suggests its substantial impact. Discount Offers (DO), Membership/Subscription Costs (MSC), and Hidden Costs (HC) are assigned progressively lower weights of 0.17, 0.15, and 0.12, respectively, underscoring their relative minor significance in the overall evaluation. In order to ascertain the most cost-effective online food delivery service, these local weights will be essential in subsequent analyses, including those conducted in AHP and TOPSIS.

Table 2: Normalised Pair wise Comparison Matrix

Attributes	DF	MOA	DO	MSC	HC	Local weights
DF	0.30	0.46	0.38	0.14	0.25	**0.31**
MOA	0.15	0.23	0.38	0.29	0.25	**0.26**
DO	0.10	0.08	0.13	0.29	0.25	**0.17**
MSC	0.30	0.12	0.06	0.14	0.13	**0.15**
HC	0.15	0.12	0.06	0.14	0.13	**0.12**

The consistency ratio (CR) is an important part of the Analytic Hierarchy Process (AHP) and is used to check how accurate the decisions made in the pairwise comparison matrix are. In this instance, the consistency index (CI) is 0.107, and the maximal eigenvalue (lam_max) has been calculated to be 5.428. Subsequently, the consistency ratio (CR) is calculated to be 0.095, which is less than the generally acknowledged threshold of 0.1. This suggests that the comparisons of the attributes—Delivery Fee (DF), Minimum Order Amount (MOA), Discount Offers (DO), Membership/Subscription Costs (MSC), and Hidden Costs (HC)—are consistent and dependable. The pairwise comparison matrix's judgments are sufficiently consistent to warrant further analysis, such as identifying the most cost-effective online food delivery service, as indicated by a CR of 0.095.

Table 3: Consistency ratio

Attributes	DF	MOA	DO	MSC	HC	Weighted Sum Value	Criteria weights	Consistency Vector
DF	0.31	0.52	0.50	0.15	0.24	1.71	**0.31**	5.60
MOA	0.15	0.26	0.50	0.30	0.24	1.45	**0.26**	5.62
DO	0.10	0.09	0.17	0.30	0.24	0.89	**0.17**	5.33
MSC	0.31	0.13	0.08	0.15	0.12	0.79	**0.15**	5.28
HC	0.15	0.13	0.08	0.15	0.12	0.63	**0.12**	5.32
lam_max	5.428							
CI	0.107							
CR	0.095							

4. TOPSIS METHOD

In the TOPSIS method, the relative efficacy of each attribute is represented by the normalized decision matrix. To guarantee that the values in the matrix are comparable, they have been normalized. Each entry displays an attribute's proportionate value in relation to the sum of squares of all attribute values. For instance, delivery fee (DF) has the highest normalized values across the majority of criteria, suggesting a significant impact on the decision-making process. The Minimum Order Amount (MOA) and Discount Offers (DO) also exhibit significant influence, particularly in their respective columns. Conversely, Membership/Subscription Costs (MSC) and Hidden Costs (HC) exhibit lower values, indicating they are of diminished significance. This matrix ultimately determines the distance between each alternative and the ideal and negative-ideal solutions, which is a critical stage in the process of evaluating the alternatives in terms of cost efficiency.

Table 4:Normalized Decision Matrix

Attribute/Criteria	DF	MOA	DO	MSC	HC
DF	0.62	0.84	0.68	0.30	0.53
MOA	0.31	0.42	0.68	0.60	0.53
DO	0.21	0.14	0.23	0.60	0.53
MSC	0.62	0.21	0.11	0.30	0.27
HC	0.31	0.21	0.11	0.30	0.27

The weighted normalized matrix in the TOPSIS analysis is a more precise representation of the performance of each alternative, as it includes both the normalized decision matrix and the local weights of the criteria.. The matrix demonstrates that Zomato, Swiggy, and Uber Eats have varying scores across the various criteria—Delivery Fee (DF), Minimum Order Amount (MOA), Discount Offers (DO), Membership/Subscription Costs (MSC), and Hidden Costs (HC). For each alternative, Si+ (distance from the ideal solution) and Si- (distance from the negative-ideal solution) are calculated. A smaller Si+ and a larger Si- indicate superior performance. Zomato has achieved the greatest performance index (Pi) of 1.91, thereby securing the top position in terms of cost efficacy. Swiggy is the second-ranked service, with a Pi of 1.89, and Uber Eats is the third-ranked service, with a Pi of 1.87. The ideal solution (V+) and negative-ideal solution (V-) are also identified, functioning as benchmarks for the best and worst conceivable scenarios, respectively. In general, the analysis indicates that Zomato provides the most cost-effective service among the three alternatives, with Swiggy and Uber Eats following closely behind.

Table 5: Weighted Normalized Matrix

Attribute/Criteria	DF	MOA	DO	MSC	HC	Si+	Si-	Pi	Rank
Zomato	0.61	0.26	0.17	0.15	0.24	1.02	1.96	1.91	1
Swiggy	0.92	0.52	0.34	0.30	0.36	1.50	2.84	1.89	2
Uber Eats	0.92	0.52	0.50	0.45	0.48	1.73	3.23	1.87	3
V+	0.61	0.26	0.50	0.15	0.24				
V-	0.92	0.52	0.17	0.45	0.48				

Figure 2 displays the weighted scores and distances from the ideal and negative-ideal solutions (Si+ and Si-) for three online food delivery services: Zomato, Swiggy, and Uber Eats. Zomato is the most cost-efficient service, as it is closest to the ideal solution and farthest from the negative-ideal solution, as evidenced by its lesser Si^+ (1.02) and higher Si^- (1.96). Swiggy ranks second in terms of cost efficiency, with Si^+ at 1.50 and Si^- at 2.84, indicating a moderate performance. Uber Eats, despite having the same DF value as Swiggy, is the least cost-efficient of the three services due to its higher Si^+ (1.73) and Si^- (3.23) values. Figure 2 emphasizes that Zomato surpasses its competitors in nearly all categories, except for Delivery Fee, where Uber Eats and Swiggy have identical scores. Zomato's position as the premier choice in terms of cost efficacy is further solidified by its overall reduced Si+ and higher Si- values.

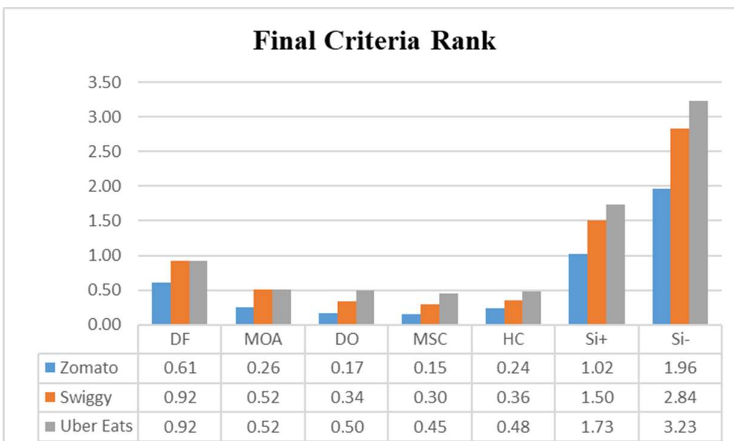

Figure 2: Final Criteria Rank

Figure 3 illustrates the significance of each criterion's distance from the ideal solution (V^+) and the negative-ideal solution (V^-) in the TOPSIS analysis. The values represent the degree to which each attribute is in close proximity to either the ideal or the worst-case scenario. There is a substantial disparity between V^+ (0.61) and V^- (0.92) in the Delivery Fee (DF), suggesting that it has a significant impact on the ranking of the alternatives. The high V- value indicates that a higher delivery fee significantly reduces cost efficiency. The Minimum Order Amount (MOA) has a moderate impact on the overall decision, as evidenced by the moderate difference between V^+ (0.26) and V^- (0.52). This suggests that higher minimal-order quantities are less preferable due to their closer proximity to the negative-ideal solution. The V^+ value of Discount Offers (DO) is 0.50, whereas the V^-value is significantly lower at 0.17. This indicates that greater discount offers are essential for achieving the ideal solution. These criteria significantly influence the perceived value of the service. V^+ (0.15) and V- (0.45) exhibit a significant difference in Membership/Subscription Costs (MSC), suggesting that reduced subscription costs are more favorable but less critical in comparison to other criteria. The considerable difference between V^+ (0.24) and V^- (0.48) in Hidden Costs (HC) is comparable to that of DF, suggesting that the reduction of hidden costs is crucial for the attainment of cost efficiency. The relative importance of each criterion in moving toward the ideal solution or away from the negative-ideal solution is emphasized in figure 3, with delivery fees and hidden costs being particularly influential in the decision-making process.

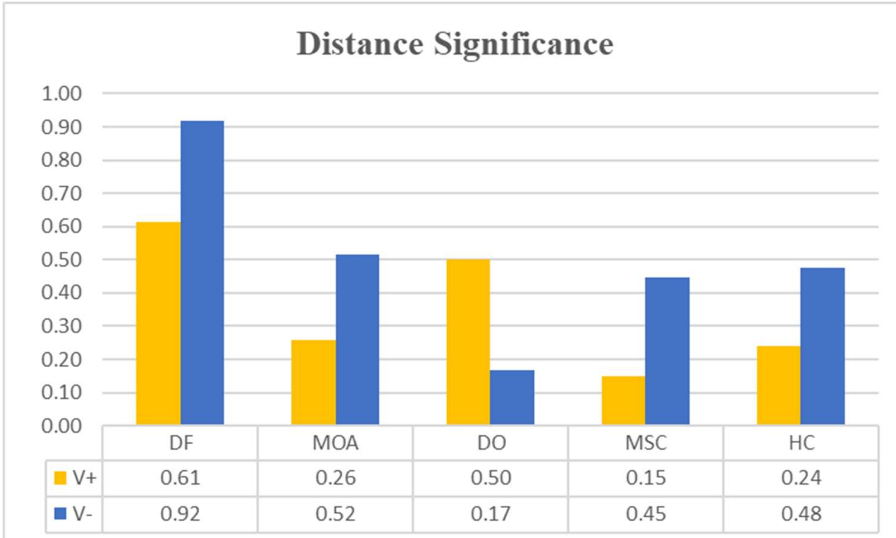

Figure 3: Distance Significance

5. Observation

The cost efficacy of online food delivery services—Zomato, Swiggy, and Uber Eats—is assessed by the proposed model, which incorporates the Analytic Hierarchy Process (AHP) and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods. The primary goal is to ascertain which service offers the most cost-effective solution by evaluating four critical factors: delivery fee (DF), minimum order amount (MOA), discount offers (DO), and membership/subscription costs (MSC). The AHP method assigns weights to each criterion, reflecting their relative importance in achieving cost efficiency, by structuring these criteria into a hierarchy and undertaking pairwise comparisons. The TOPSIS method then employs these weights to evaluate the alternatives according to their proximity to an optimal solution, thereby delivering a thorough assessment of cost efficiency.

The pairwise comparison matrix in the AHP analysis emphasizes the importance of the criteria in determining cost efficiency. In the comparison matrix, the delivery fee (DF) is the most critical factor, as evidenced by its significant impact on the overall cost efficiency, as indicated by its higher values. The minimum order amount (MOA) is also of significant importance, particularly in comparison to discount offers (DO) and membership/subscription costs (MSC), indicating that consumers prioritize lesser minimum order requirements. Discount Offers (DO) are still significant, but they are regarded as less critical than DF and MOA, but more influential than MSC and Hidden Costs (HC). The weights calculated and derived from this matrix are critical inputs for the subsequent TOPSIS analysis, which guides the assessment of each service's cost efficacy.

The consistency ratio (CR) is used to verify the consistency of the pairwise comparisons in AHP. In this instance, the reliability of the judgments in the comparison matrix is indicated by a CR of 0.095, which is below the threshold of 0.1. Being consistent is important to make sure that the weights that were calculated correctly show how important each criterion is, which sets a solid base for the next TOPSIS analysis. The credibility of the decision-making process is enhanced by the consistent and well-founded criteria that the final evaluation of the online food delivery services is based on, which is ensured by the reliable weights.

The TOPSIS method assesses the online food delivery services by determining the distance of each alternative from the ideal and negative-ideal solutions, utilizing the weights derived from AHP. The "Final Criteria Rank" chart visually displays the weighted scores for each criterion, demonstrating that Zomato is the most cost-efficient service, with the lowest distance to the ideal solution ($Si^+ = 1.02$) and the highest distance from the negative-ideal solution ($Si^- = 1.96$). Swiggy, which has slightly higher values ($Si^+=1.50$, $Si^-=2.8$), is in close second place, while Uber Eats, which has the highest values, is in third place. This analysis emphasizes the comparative performance of the services, with Zomato proving to be the most advantageous choice for cost-conscious consumers.

The "Distance Significance" graphic offers a comprehensive understanding of the extent to which each criterion influences the overall classification of the alternatives. The Delivery Fee (DF) exhibits a substantial disparity between its ideal ($V^+=0.61$) and negative-ideal ($V^-=0.92$) values, underscoring its substantial influence on the decision-making process. Discount Offers (DO) and Minimum Order Amounts (MOA) are also significant, albeit to a diminished extent. Discount offers are particularly important in finding the best solution. Membership/Subscription Costs (MSC) and Hidden Costs (HC) have smaller but still significant impacts, with HC being like DF in its contribution to cost efficiency. These observations emphasize the importance of minimizing costs across these criteria to achieve the best overall value, particularly for consumers who prioritize affordability in online food delivery services.

6. Conclusion

The incorporation of AHP and TOPSIS methods in the assessment of the cost efficacy of online food delivery services, including Uber Eats, Swiggy, and Zomato, offers a structured and dependable decision-making process. The analysis underscores the significant influence that Delivery Fee (DF) and Minimum Order Amount (MOA) have on the overall cost efficiency, as these factors are given significant weight in the AHP process. The evaluation is further refined by the subsequent implementation of TOPSIS, which ranks the services based on their proximity to an ideal solution. In this case, Zomato is the most cost-efficient option, followed by Uber Eats and Swiggy. The results emphasize the significance of meticulously evaluating a variety of factors when selecting a food delivery service, especially for consumers who are interested in optimizing their expenditures. This model not only assists consumers in making informed decisions but also provides valuable insights for businesses that are seeking to improve the cost efficacy of their service offerings to gain a competitive advantage.

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