Towards Achieving Customer Satisfaction in Last Mile Delivery for E-commerce Sector: A MCDM Approach

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Last mile delivery is the last leg in the delivery of finished goods from the manufacturer's facilities to the end customer, and in the case of e-commerce, last mile delivery of the product is the only physical touch point between businesses and customers, so it becomes even more important to achieve customer satisfaction in last mile delivery of the product to gain brand equity and brand loyalty so that the customers stay on your platform. To identify the most favorable mode of last-mile delivery that leads to customer satisfaction, a combination of multiple criteria decision-making methods, i.e., Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP), will be used. Essentially, this will be a fuzzy TOPSIS analysis of the different alternatives based on criteria identified to boost customer satisfaction, and the fuzzy criteria weights required for this calculation will be derived using the fuzzy AHP method. The results thus derived will guide to rank the different alternatives with respect to one another and to further derive our conclusion. Results of this survey suggest that the criteria for secure delivery of goods were the highest contributing mediators when it came to building customer satisfaction, and at the same time, the criteria for proximity to the delivery location were the least contributing criteria.

Keywords: Customer satisfaction, e-commerce, Sustainable logistics, Last-mile delivery, Multiple Criteria Decision Making, Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP), Triangular Fuzzy Numbers (TFN)

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1 Introduction

In India, as in other countries, e-commerce has altered how business is conducted. The Internet and mobile device adoption both played a role in the e-commerce sector's growth in India. By 2024, the Indian e-commerce industry is anticipated to reach a value of USD 99 billion, with a CAGR of 27% from 2019 to 2024. The grocery and fashion/apparel segments are anticipated to drive this market's expansion in India. There is a significant opportunity for growth because even at this rate, online retail in India will only represent 10.7% of total net retail sales, which includes both online and offline purchases. The top e-commerce players in India include Flipkart, Amazon, Shopclues, Paytm, and Snapdeal. Each of these businesses aims to connect with customers, so they will use their platforms and choose them as the winner.

To build brand equity and brand loyalty and keep customers on your platform, it is crucial to achieve customer satisfaction during the last-mile delivery of the product. Last-mile delivery is the final leg in the delivery of finished goods from the manufacturer's facilities to those of the end customer. In the case of e-commerce, the last-mile delivery of the product is the only physical touch point between businesses and customers. As a result, various businesses involved in this industry have needed a good last-mile delivery solution as the e-commerce sector has expanded over the past few years. Businesses can decide whether to handle this need in-house or by outsourcing it to a third party. The basic issue is the same in both scenarios: while the client wants a quicker and less expensive delivery, last-mile delivery is really the most time-consuming and expensive portion of the overall supply network, accounting for up to 53% of the total supply chain cost. Thus, achieving customer satisfaction in the case of last-mile product delivery becomes a challenging task.

2 Literature Review

In a big data analysis of 54250 customer reviews of Meituan China [1], it was suggested that maintaining high levels of service at the contact point in the distribution link is a major requirement towards achieving overall customer satisfaction. Out-of-home delivery enhances the customer experience by using an automated parcel locker or machine (APM) and pick-up and drop-off delivery (PUDO) to reduce the overall cost of delivery and inventory storage in the event of a missed delivery in the European context [2]. Another study adds the aspects of delivery time window and customer satisfaction to the travelling salesman problem in the case of deliveries by unmanned aerial vehicles. Maximize revenues by delivering products in the expected delivery window at a premium while balancing it with penalties or free deliveries when out of time to achieve customer satisfaction and loyalty [3]. The customer's opinion of the physical environment (be it home, office, or someplace else) when receiving the delivery can have a direct relation to their opinion about the delivery experience [4]. The horizontal collaboration of resources is used by businesses to benefit from both reduced cost and faster delivery, owing to better fleet and vehicle utilization resulting from the aggregation at the same tier, while reducing both traffic and carbon emissions [5]. Another reason for missed deliveries is that the schedules for delivery agents are generated based on the shortest tour distance and should rather factor in the availability of the customer to minimize the costs of missed deliveries [6]. The relative competitiveness of attended home delivery (AHD), reception boxes (RB), and collection and delivery points (CDPs) is explored. It suggests that while AHD is favorable in cases of sparsely populated areas with low order quantities, CDP is favorable in cases of densely populated areas with high order quantities, and RB is favorable for items to be delivered on a daily basis, while focusing on this situation as a vehicle routing problem [7]. Cost, tracing, and tracking are the key criteria behind the decision-making process using a fuzzy analytical hierarchy approach for getting to the solution [8].

The use of combined logistics (home delivery + self-pick-up) service modes is recommended for last-mile delivery and to decide the customer's utility based on the applicability and practicability of logistics services. The research method used for this analysis included the use of MCDM approaches such as AHP and TOPSIS [9]. Customer satisfaction is studied regarding parcel lockers to cut out

inefficiency in the last mile delivery by carrying out an exploratory study in Sweden, and it was found out that customer acceptance and satisfaction are heavily moderated by ease of use, perceived quality, and convenience perception [10]. Evaluation of the indexes that lead to improvement in the service quality level of rural last-mile delivery is carried out using fuzzy comprehensive evaluation (FCE) and the interpretative structural model (ISM). Results of their study suggested that accuracy of goods arrival and timely customer response were the two key favorable indexes [11]. The task of last-mile delivery providers is to optimize the movement of goods between the manufacturer and the end customer. They focused on how the parameters of selection for the consumer and the logistic system interact, as well as how the choice of the last mile delivery channel impacts the cost to the end customer and the profitability of the last mile service provider [12].

The customer acceptance for parcel lockers in Poland was studied through a survey, and it was found that the most important factor to improve the efficiency of such systems is to optimize the location of these lockers such that both the number of trips for the logistic companies and the travel distance for the end customer are minimized [13]. An engaged scholarship approach identified that for a customer to decide on unattended home delivery, it is a multi-dimensional construct that comprises cognitive, emotional, behavioral, sensorial, physical, and social responses [14]. Multidimensional research using the SERVQUAL instrument was carried out to measure service quality by collecting customer perception in five dimensions of service quality, which are tangibles, reliability, responsiveness, assurance, and empathy. It was found that the tangibles did not affect the customer's satisfaction level in the last mile delivery of the products [15].

3 Research Problem

Thus, as mentioned earlier in this report, the main aim would be to see how the performance of different alternatives for last-mile delivery interacts with the various performance and hygiene aspects in the Kano model, which mediate for customer satisfaction in the real-world scenario. Also, by doing this, we will try to identify the best choice of last-mile delivery mode to gain customer satisfaction.

Table 1. Different alternatives for last mile delivery

Mode of last mile delivery	Attended home delivery	→	Last Mile service provider performance in:	Cost of delivery	→	Customer satisfaction
				Proximity to delivery location		
	Reception box			Tracking and traceability		
				Secured delivery of goods		
	Collection-and-delivery points			Time of delivery		
				Speed of delivery		

4 Research Methodology

To identify the most favorable mode of last-mile delivery that leads to customer satisfaction, a combination of multiple criteria decision-making methods, i.e., Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP), is used. In compensatory approaches like TOPSIS, a poor result in one criterion might be offset by a good result in another criterion, allowing trade-offs between them. Compared to non-compensatory approaches, which include or exclude alternative solutions based on strict cut-offs, this offers a more realistic type of modelling.

Essentially, this will be a fuzzy TOPSIS analysis of the different alternatives based on criteria identified to boost customer satisfaction, and the fuzzy criteria weights required for this calculation will be derived using the fuzzy AHP method. Fuzzy AHP (Analytic Hierarchy Process) creates priority vectors, allows pairwise comparisons and decompositions, eliminates inconsistency, and gives a hierarchical structure. It integrates the quantitative and qualitative aspects of fuzzy decision-making and fuzzy reasoning.

The results thus derived will guide us to rank the different alternatives with respect to one another and to further derive our conclusion. The triangular fuzzy scale for relative importance [16] is shown below in Table 2:

Table 2. The triangular fuzzy scale

Numerical Values	Verbal Term	Fuzzy number
1	Equally important	(1,1,1)
3	Moderately more important	(2,3,4)
5	Strongly more important	(4,5,6)
7	Very strongly more important	(6,7,8)
9	Extremely more important	(9,9,9)
2	Important intermediate values	(1,2,3)
4		(3,4,5)
6		(5,6,7)
8		(7,8,9)

5 Data Collection and Results

To collect primary data on customer perception with respect to the various criteria associated with customer satisfaction and last-mile delivery of goods, interviews were conducted to collect the required data to create the pairwise comparison matrix to carry out the AHP calculations. The segment of population targeted for the same is mentioned as below:

Age bracket: ranging 25 to 54 yrs. (i.e. the most densely populated bracket)
Geography: Delhi NCR (to reflect the data of metro cities)
Employment type: Working individuals from diverse group

Over 15 interviews were conducted with different individuals in the targeted segment of the population, of which only 5 solutions whose consistency ratio was found to be below 10% were used for further calculation. The pairwise comparison matrix for the individuals whose consistency was found to be less than 10% is shown in Table 3.

Table 3. Commonized Pairwise comparison matrix based on Mode

Commonized Pairwise comparison matrix based on Mode	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery
Cost of delivery	1.00	1.00	1.00	0.14	1.00	0.20
Proximity to delivery location	1.00	1.00	0.33	0.11	1.00	0.20
Tracking and traceability	1.00	3.00	1.00	0.14	1.00	0.33
Secured delivery of goods	7.00	9.00	7.00	1.00	7.00	1.00
Time of delivery	1.00	1.00	1.00	0.14	1.00	0.33
Speed of delivery	5.00	5.00	3.00	1.00	3.00	1.00

The Commonized Pairwise comparison matrix was checked again for consistency and was found to be OK with a CR of .03

Table 4. Fuzzified Commonized Pairwise comparison matrix

Criteria	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery
Cost of delivery	(1,1,1)	(1,1,1)	(1,1,1)	(0.1,0.1,0.2)	(1,1,1)	(0.2,0.2,0.3)
Proximity to delivery location	(1,1,1)	(1,1,1)	(0.3,0.3,0.5)	(0.1,0.1,0.1)	(1,1,1)	(0.2,0.2,0.3)
Tracking and traceability	(1,1,1)	(2,3,4)	(1,1,1)	(0.1,0.1,0.2)	(1,1,1)	(0.3,0.3,0.5)
Secured delivery of goods	(6,7,8)	(8,9,10)	(6,7,8)	(1,1,1)	(6,7,8)	(1,1,1)
Time of delivery	(1,1,1)	(1,1,1)	(1,1,1)	(0.1,0.1,0.2)	(1,1,1)	(0.3,0.3,0.5)
Speed of delivery	(4,5,6)	(4,5,6)	(2,3,4)	(1,1,1)	(2,3,4)	(1,1,1)

Table 5. De-fuzzified criteria weight

Criteria	Fuzzy Geometric Mean value	Fuzzy criteria weight	De-fuzzified criteria weight
Cost of delivery	(0.52,0.55,0.59)	(0.05,0.06,0.08)	0.07
Proximity to delivery location	(0.40,0.44,0.50)	(0.04,0.05,0.07)	0.05
Tracking and traceability	(0.63,0.72,0.83)	(0.07,0.08,0.11)	0.09
Secured delivery of goods	(3.46,3.82,4.15)	(0.36,0.44,0.55)	0.45
Time of delivery	(0.56,0.60,0.66)	(0.06,0.07,0.09)	0.07
Speed of delivery	(2.00,2.47,2.88)	(0.21,0.29,0.38)	0.29

Based on F-AHP, the most valued factor for the customer was found to be the secured delivery of goods, and the least valued factor was again the proximity to the delivery location.

Thereafter, expert feedback on the impact of criteria with respect to different alternatives was taken, again in the form of a personal interview. To collect primary data for the preparation of the impact matrix, another interview or survey was floated to experts working in the domain of supply chain or logistics management, wherein inputs were taken for the impact of different alternatives under different criteria of customer satisfaction. The inputs were taken on a five-point scale [17], which was then fuzzified to minimize misunderstanding on the part of the expert using the below-shown scale in Table 6.

Table 6. Linguistic Variables for fuzzy numbers

Numerical Values	Verbal Term	Fuzzy number
1	Very low	(1,1,3)
3	Low	(1,3,5)
5	Average	(3,5,7)
7	High	(5,7,9)
9	Very High	(7,9,9)

The individual impact matrixes are then decoded and then fuzzified using the scale mentioned in Table 7.

Table 7. Individual fuzzified impact matrix

Individual fuzzified impact matrix	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery
Expert 1						
Attended home delivery	(1,1,3)	(7,9,9)	(7,9,9)	(7,9,9)	(1,1,3)	(3,5,7)
Reception box	(1,1,3)	(5,7,9)	(3,5,7)	(1,1,3)	(7,9,9)	(5,7,9)
Collection & delivery point	(7,9,9)	(1,1,3)	(5,7,9)	(5,7,9)	(5,7,9)	(7,9,9)
Expert 2						
Attended home delivery	(5,7,9)	(7,9,9)	(7,9,9)	(7,9,9)	(5,7,9)	(5,7,9)
Reception box	(5,7,9)	(7,9,9)	(5,7,9)	(5,7,9)	(7,9,9)	(5,7,9)
Collection & delivery point	(3,5,7)	(1,1,3)	(7,9,9)	(7,9,9)	(5,7,9)	(7,9,9)
Expert 3						
Attended home delivery	(3,5,7)	(7,9.9)	(5,7,9)	(7,9,9)	(5,7,9)	(3,5,7)
Reception box	(5,7,9)	(5,7,9)	(3,5,7)	(5,7,9)	(3,5,7)	(5,7,9)
Collection & delivery point	(5,7,9)	(1,1,3)	(3,5,7)	(7,9,9)	(1,1,3)	(7,9,9)

Thereafter, using the fuzzy criteria weights and the combined fuzzified impact matrix derived in Table 8 from the previous calculation, the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) are calculated for all criteria in Tables 9 and 10.

Table 8. Fuzzy Criteria weights and the Combined fuzzified impact matrix

Criteria	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery
Criteria weights	(0.05,0.06,0.08)	(0.04,0.05,0.07)	(0.07,0.08,0.11)	(0.36,0.44,0.55)	(0.06,0.07,0.09)	(0.21,0.29,0.38)
Criteria vs Alternatives	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery
Attended home delivery	(0.1,0.3,0.7)	(0.3,0.5,0.6)	(0.3,0.7,1.0)	(2.5,4.0,4.9)	(0.1,0.3,0.8)	(0.6,1.6,3.4)
Reception box	(0.1,0.4,0.7)	(0.2,0.4,0.6)	(0.2,0.5,1.0)	(0.4,2.5,4.9)	(0.2,0.5,0.8)	(1.0,2.0,3.4)
Collection & delivery point	(0.2,0.4,0.7)	(0.0,0.1,0.3)	(0.2,0.6,1.0)	(1.8,3.7,4.9)	(0.1,0.4,0.8)	(1.5,2.6,3.4)
VjB (FPIS)	(0.2,0.4,0.7)	(0.3,0.5,0.6)	(0.3,0.7,1.0)	(2.5,4.0,4.9)	(0.2,0.5,0.8)	(1.5,2.6,3.4)
VjW (FNIS)	(0.1,0.3,0.7)	(0.0,0.1,0.3)	(0.2,0.5,1.0)	(0.4,2.5,4.9)	(0.1,0.3,0.8)	(0.6,1.6,3.4)

Table 9. Fuzzy Positive Ideal Solution (FPIS)

Distance from FPIS	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery	DiB
Distance from FPIS	(0.01,0.03,0)	(0,0,0)	(0,0,0)	(0,0,0)	(0.01,0.03,0)	(0.69,0.91,0)	0.98
	0.12	0.00	0.00	0.00	0.13	0.73	
Distance from FPIS	(0.01,0.01,0)	(0.01,0,0)	(0.02,0.05,0)	(4.67,2.19,0)	(0,0,0)	(0.17,0.33,0)	2.21
	0.08	0.06	0.15	1.51	0.00	0.41	
Distance from FPIS	(0,0,0)	(0.06,0.12,0.07)	(0.02,0.01,0)	(0.52,0.09,0)	(0.01,0.02,0)	(0,0,0)	0.94
	0.00	0.29	0.10	0.45	0.11	0.00	

Table 10. Fuzzy Negative Ideal Solution (FNIS)

Distance from FNIS	Cost of delivery	Proximity to delivery location	Tracking and traceability	Secured delivery of goods	Time of delivery	Speed of delivery	DiW
Attended home delivery	(0,0,0)	(0.06,0.12,0.07)	(0.02,0.05,0)	(4.67,2.19,0)	(0,0,0)	(0,0,0)	1.95
	0.00	0.29	0.15	1.51	0.00	0.00	
Reception box	(0,0.01,0)	(0.03,0.07,0.07)	(0,0,0)	(0,0,0)	(0.01,0.03,0)	(0.17,0.15,0)	0.74
	0.05	0.24	0.00	0.00	0.13	0.33	
Collection & delivery point	(0.01,0.03,0)	(0,0,0	(0,0.01,0)	(2.08,1.4,0)	(0,0,0)	(0.69,0.91,0)	2.02
	0.12	0.00	0.06	1.08	0.03	0.73	

Based on the final calculations, the result of the ranking of different alternatives is as shown in Table 11 below:

Table 11. TOPSIS ranking of different alternatives

Alternative	DiB	DiW	Pi	Ranking
Attended home delivery	0.98	1.95	0.67	2
Reception box	2.21	0.74	0.25	3
Collection & delivery point	0.94	2.02	0.68	1

While collection and delivery point came out to be the most preferred mode of last mile delivery, it was closely followed by attended home delivery.

6 Conclusions and Limitations

The relative weightages for different criteria identified for customer satisfaction are shown below in Table 12:

Table 12. Relative weightages for different criteria identified for customer satisfaction

SN	Criteria	Criteria Weight	Ranking
1	Cost of delivery	0.065	5
2	Proximity to delivery location	0.053	6
3	Tracking and traceability	0.086	3
4	Secured delivery of goods	0.45	1
5	Time of delivery	0.072	4
6	Speed of delivery	0.292	2

The graphical representation of Relative weightages for different criteria in Fig. 1 is highlighting the secured delivery of goods as the most important criterion.

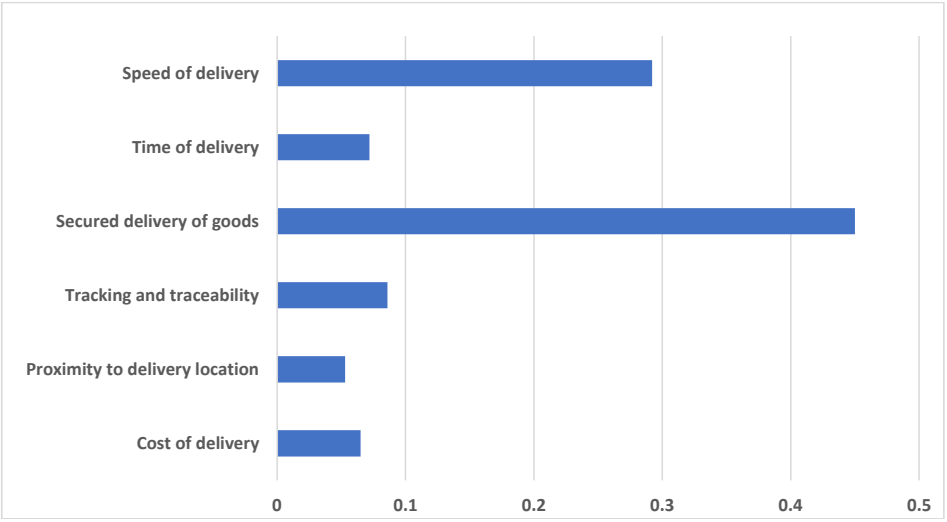

Figure 1. Relative weightages and ranking for different criteria.

From the results, the criteria for secured delivery of goods were the highest contributing mediators when it came to building customer satisfaction, and at the same time, the criteria for proximity to the delivery location were the least contributing criteria. Also, the customer prefers criteria such as time of delivery, speed of delivery, and tracking and traceability over the cost of delivery; thus, it can be said that the cost sensitivity of the customer is quite low regarding satisfaction with the mode of delivery. The relative ranking of different alternatives considered for last-mile delivery is shown in Table 13.

Table 13. Similarity to Ideal Solution for alternatives considered for last-mile delivery

SN	Alternatives	Similarity to Ideal Solution	Ranking
1	Attended home delivery	0.67	2
2	Reception box	0.25	3
3	Collection & delivery point	0.68	1

The graphical representation of Similarity to Ideal Solution for alternatives in Fig. 2 is highlighting the Collection & delivery point as the most preferred last-mile delivery mode.

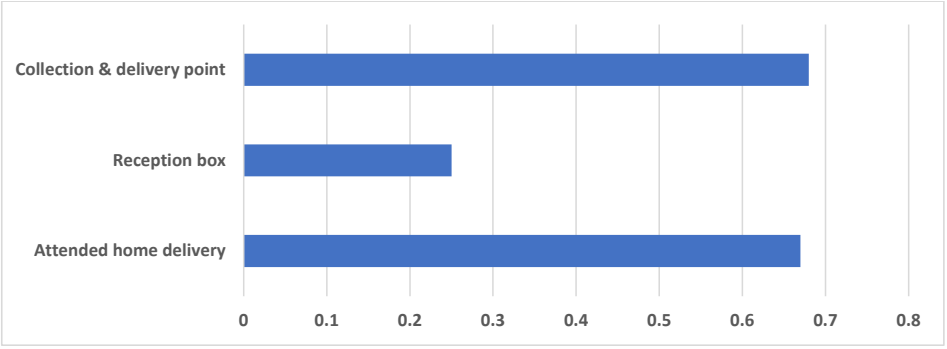

Figure 2. Similarity to Ideal Solution for alternatives

From the results, we can see that acceptance for collection and delivery points as a mode of delivery has outnumbered that for attended home delivery. While reception boxes were found to be the least accepted option for last-mile delivery,

7 Recommendations

Because it is the single biggest last-mile delivery difficulty organizations around the world are facing, last-mile delivery cost reduction is crucial. Delivering to clients directly is expensive, and frequently, the customer is not responsible for covering the charges. Driving further distances results in higher fuel expenses and emissions, as well as delays in deliveries.

From the results of this survey, we can derive that the primary reason for the general preference for at-home delivery is not proximity to the delivery location, but rather their preference for having secured delivery of goods that they have ordered. Considering the growing customer preference for secured delivery of goods, Last Mile delivery service providers should shift their focus towards improving the handling and management of goods so that the goods can be delivered to the end customer in a secured manner.

Since collection and delivery points have emerged as the most preferred delivery option among working individuals, companies should plan to benefit from this preference shift from tended home deliveries, which account for as much as 53% of the total logistics cost. By shifting towards collection and delivery points, a reduction of 20% to 30% in the last-mile delivery cost can be estimated, and such companies can emerge as cost leaders. Moreover, the collection and delivery point method of last-mile delivery also tends to be more sustainable and would help reduce carbon dioxide emissions.

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