Advances and Applications in Mathematical Sciences
Volume 21, Issue 12, October 2022, Pages 7125-7134

DEVELOPMENT OF CONCEPTUAL FRAMEWORK FOR LAST MILE DELIVERY

RISHABH MISHRA and VIVEK KUMAR PATHAK

Department of Mechanical Engineering
Krishna Institute of Engineering and Technology
Uttar Pradesh, India
E-mail: mishrarishabh556@gmail.com

Abstract

The main goal of this paper is to develop a sustainable as well as conceptual framework for last mile delivery. Last mile delivery is the downstream of supply chain management. Plan is to go through the concept of last mile delivery and understand the logic behind it. Then after understanding all the scenarios, the part of literature review comes and with the help of literature review, various factors affecting the last mile delivery pops up and these factors play a vital role in last mile delivery. So to increase the efficiency of last mile delivery, the minimization of these factors are necessary.

1. Introduction

Supply Chain management is actually handles entire production flow of goods which starts from the raw materials to all the way down to delivery of the final product. Basic supply chain management consists of five steps which is planning, sourcing, manufacturing, delivery and logistics and last returning. Effective supply chain management system minimizes the cost, waste and time in the production cycle. Last mile delivery refers to the downstream of the supply chain management. A product's journey from a warehouse to doorstep of the end-customer is termed as the last mile delivery. The focus of last mile delivery is to deliver the product or services to end user with efficient and sustainable approach. We researched literature survey and according to that we considered some factors and with the help of AHP method we optimize the solution. AHP process is the most refined

2020 Mathematics Subject Classification: 90B06.

Keywords: SCM, AHP, Multi-criteria decision analysis, Consistency Ratio.

Received August 21, 2021; Accepted September 27, 2021

process as it gives best solution for the problem. It gives ranks according to the defined attributes.

2. Literature Review

A review of several literature written on the recent development of last mile delivery and supply chain management. The literature also discuss the sustainable approach to increase the efficiency of the last mile delivery which hence increase the per capita income.

Last-mile logistics fulfilment: A framework for energy efficiency, (2020), Árni Halldórsson, Jessica Wehner, Research in Transportation Business and Management, Volume 37, December 2020. We studied that they focused on the energy efficiency in the supply chain.

Due to increasing demand of transportation, they study that the development of environmentally sustainable approach in which energy consumption is reduced in the last.

A Systematic Review of the Literature, (2019), John Olsson *, Daniel Hellström and Henrik Pålsson, Framework of Last Mile Logistics Research, Volume 11, 2019. In this research paper, the last mile logistics is represented as diversified, fragmented, and complex. Therefore, this paper provides an integrated view of the research area of last mile logistics by providing an overview of themes addressed in the literature and proposing a framework of last mile logistics literature.

Efficiency of UAV-based last-mile delivery under congestion in low-altitude air, (2021), Ruifeng She, Yanfeng Ouyang, Transportation Research Part C, Volume 122, January 2021. In this research paper, the author developed a steady state continuum traffic equilibrium model to describe last-mile delivery operations of a large fleet of drones in low-altitude air. Each drone takes a route which is very cost effective and minimizes the travel cost. In the future research they include hybrid systems utilizing. A decision model for last-mile delivery planning with crowdsourcing integration, (2019), Kuancheng Huang∗, Muhammad Nashir Ardiansyah, Computers and Industrial Engineering, Volume 135, September 2019. In this study, they focused on the decision whether to crowdsource the challenging last-mile

delivery through the relays at the transfer points. The operator has two options when performing the delivery, one being to rely on an in-house delivery truck or to use crowdsources. Different types of search methods are developed considering the unique problem features in this study to manage the neighborhood. In general, significant cost savings can be achieved by carefully planning the crowdsourcing integration as opposed to opting merely for the traditional pure truck delivery.

3. Challenges in Last Mile Delivery

There are various challenges in the last mile delivery which affects the efficiency of last mile delivery. To achieve greater profit one should minimize these factors.

Some of the factors are

(3.1) Cost is the major challenge in the last mile delivery. Cost includes delivery cost, operational cost, service cost, maintenance cost etc.

(3.2) Transparency has become an important element for any business. The consumers want to know where exactly their package is and when will it reach them. In response to this, many businesses especially the 3PLs began generating the tracking codes.

(3.3) Customers have always been the main driving force for pushing increased efficiency in e-commerce logistics. Many other challenges accompanied by the need for higher efficiency mean one thing, faster deliveries.

(3.4) At the time of delivery un-availability of the customer is a big hindrance in the efficient last mile delivery.

4. Research Method

In this paper Analytic hierarchy method is used for research process. The AHP method has been created after understanding the structure of a problem and the real hindrance that managers face while solving it. AHP consisted in hierarchy structuring, relative measurement (pairwise comparisons between criteria and between alternatives), and distributive synthesis (priorities are normalized, i.e., they sum equal to one).

There are four steps in AHP method

(4.1) Define Problem – AHP method depends upon the breaking the problem into a hierarchy of smaller problems.

(4.2) Define Criteria – In the process of breaking down the sub-problem, criteria to evaluate the solution emerge. There are various criteria which affects the problems or sub-problem. We identify them and jump to step 3.

(4.3) Establish Priority amongst Criteria Using Pairwise Comparison - In AHP method we uses pairwise comparison to create a matrix. We gave them priority by using surveys or by reading literature. By giving them priority on a numerical scale which comes out to be matrix and then we normalize it and jumps to step 4.

(4.4) Check Consistency – After normalizing we have to check the consistency of the matrix so that we can ensure that our distribution is correct and consistent and we can take further actions. For that we have to find out the consistency ratio and check whether the consistency ratio is less than or greater than equal to 0.1. If it is less than 0.1 then we can say that we get the consistent answer and we can move ahead.

5. Data Collection and AHP Analysis

This data collection is based on the literature survey, questionnaire and brain storming with academicians and industrial persons.

(5.1) Establish each factor of the pair-wise comparison matrix:

Criteria	Cost	Technology	Quality and Safety	Criteria Weights
Cost	1	4	3	0.465
Technology	0.25	1	2	0.168
Quality and Safety	0.33	0.5	1	0.116
Sum	1.58	5.5	6	

λ max	3.1047
RI (n=3)	0.58
CI = (λ max-n)/n-1	0.0523
CR= CI/RI	0.0902

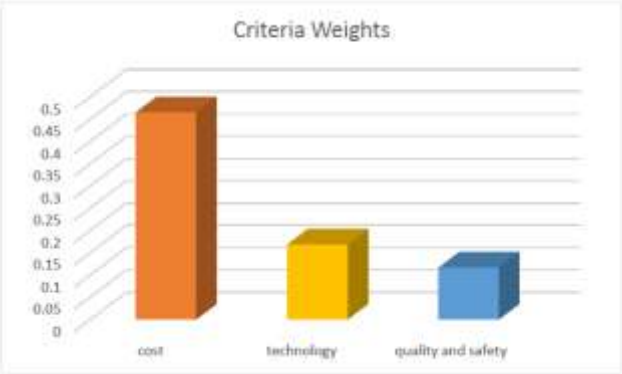

Figure 1. Weightage criteria of pair-wise comparison matrix.

(5.2) Subgroups: Matrix for sub criteria (Cost factor)

Criteria	Delivery cost	Cost of maintenance and operations	Running cost	Inventory cost	Criteria Weights
Delivery cost	1	4	3	4	0.5192
Cost of maintenance and operations	0.25	1	3	2	0.2325
Running cost	0.33	0.33	1	2	0.1481
Inventory cost	0.25	0.5	0.5	1	0.10003

Sum	1.83	5.83	7.5	9

λ max	4.2433
RI (n=4)	0.9
CI = (λ max-n)/n-1	0.0811
CR= CI/RI	0.0901

(5.3) Matrix for sub criteria (Technology factor)

Criteria	Real time visibility	Outdated Technology	Social media influence	Performance Expectations	Criteria Weights
Real time visibility	1	3	4	3	0.4928
Outdated Technology	0.33	1	3	3	0.2684
Social media influence	0.25	0.33	1	2	0.1353
Performance Expectations	0.33	0.33	0.5	1	0.1033
Sum	1.91	4.66	8.5	9	

λ max	4.2032
RI (n=4)	0.9
CI = (λ max-n)/n-1	0.0677
CR= CI/RI	0.0752

(5.4) Matrix for sub criteria (Quality and Safety Factor)

Criteria	Sustainable approach	Customer awareness	Environment awareness	Criteria Weights

Sustainable approach	1	3	4	0.4677
Customer awareness	0.33	1	2	0.1791
Environment awareness	0.25	0.5	1	0.1030
Sum	1.58	4.5	7	

λ max	3.0154
RI (n=3)	0.58
CI = (λ max-n)/n-1	0.0077
CR= CI/RI	0.0133

(5.5) Overall Rating For Criteria Framework

Factors	Weight	Sub-factors	Weight	Weighted Sum	Priority Ranking
Cost	0.4650	Delivery cost	0.5192	2.2941	1
		Cost of maintenance and operations	0.2325	1.0068	7
		Running cost	0.1481	0.5963	2
		Inventory cost	0.1000	0.4202	3
Technology	0.1683	Real time visibility	0.4928	2.1497	4
		Outdated Technology	0.2684	1.1473	8
		Social media	0.1353	0.5539	10

		influence			
		Performance Expectations	0.1033	0.4222	11
		Sustainable approach	0.4677	1.4175	5
Quality and Safety	0.1166	Customer awareness	0.1791	0.5396	6
		Environment awareness	0.1030	0.3095	9

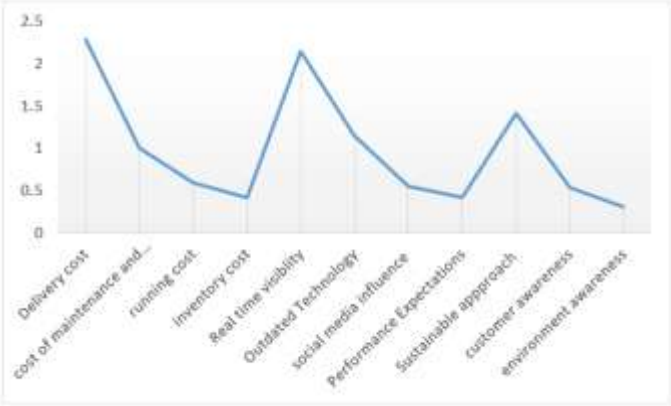

Figure 2. Overall ratings for criteria framework.

As we can see from the above calculations, we conclude that delivery cost affects the last mile delivery the most and hence to make the last mile delivery efficient we first minimize the delivery cost and after that running cost then inventory cost and so on. These data were collected by literature survey, questionnaire and brain storming with academicians and industrial persons. The method we used do not tell the exact answer to the organization but gives a clear understanding to the problem. Hence increase the efficiency of the organization.

6. Result Discussion

As we can see in the above table priority ranking, delivery cost ranked 1

that means delivery cost is the most affecting factor among the other factors which affects the last mile delivery. So in most of the scenarios we have to minimize the delivery cost to increase the efficiency of the last mile delivery. And we rated Performance expectations the lowest but that doesn't means it does not affect the last mile delivery, it does but with respect to others it affects less. But to increase the efficiency we have to increase the performance as well.

7. Conclusion

In this paper we learned about supply chain management and the last mile delivery is the downstream of supply chain management. With the help of AHP method we can prioritize the factors of last mile delivery. These factors directly influence the last mile delivery's efficiency. With the help of this method we can improve the efficiency of last mile delivery. Growth of e-commerce also plays an important role in this. The increase in the efficiency of last mile delivery will directly results in the improvement in the per capita income. To conclude a supply chain is a key of success in every company and methods like MCDA helps in quantitating the problems and gain a permanent and practical solution.

References

[1] Giulio Mangano and Giovanni Zenezini, The Value Proposition of innovative Last-Mile delivery services from the perspective of local retailers, IFAC-PapersOnLine 52(13) (2019).

[2] John Olsson, Daniel Hellström and Henrik Pålsson, Framework of Last Mile Logistics Research: A Systematic Review of the LIterature, 11 (2019).

[3] M. D. Simoni, E. Kutanoglu and C. G. Claudel, Optimization and analysis of a robot-assisted last mile delivery system, Transportation Research Part E: Logistics and Transportation Review 142 October 2020.

[4] A. Snoeck, D. Merchán and M. Winkenbach, Revenue management in last-mile delivery: state-of-the-art and future research directions, Transportation Research Procedia 46 (2020).

[5] Ruifeng She and Yanfeng Ouyang, Efficiency of UAV-based last-mile delivery under congestion in low-altitude air, Transportation Research Part C, 122 January, (2021).

[6] Yandong Hea, Mingyao Qi, Fuli Zhouc and Jiafu Su, An effective metaheuristic for the last mile delivery with roaming delivery locations and stochastic travel times, Computers and Industrial Engineering 145 July 2020.

[7] Yun Hui Lin, Yuan Wang, Dongdong He and Loo Hay Lee, Last-mile delivery: Optimal locker location under multinomial logit choice model, Transportation Research Part E, 142 October 2020.

[8] Kuancheng Huang and Muhammad Nashir Ardiansyah, A decision model for last-mile delivery planning with crowdsourcing integration, Computers and Industrial Engineering 135 September 2019.

[9] Mohamed Salamaa and Sharan Srinivas, Joint optimization of customer location clustering and drone-based routing for last-mile deliveries, Transportation Research Part C 114 May 2020.

[10] Giulio Mangano and Giovanni Zenezini, The Value Proposition of innovative Last-Mile delivery services from the perspective of local retailers, IFAC-PapersOnLine 52(13) (2019).

[11] Kum Fai Yuena, Xueqin Wangb, Fei Mac and Yiik Diew Wong, The determinants of customers' intention to use smart lockers for last-mile deliveries, Journal of Retailing and Consumer Services 49 July 2019.

[12] Patchara Kitjacharoenchaia, Seokcheon Lee, Vehicle Routing Problem with Drones for Last Mile Delivery, Procedia Manufacturing 39 (2019).

[13] Sudheer Ballarea and Jane Lin, Investigating the use of micro hubs and crowd shipping for last mile delivery, Transportation Research Procedia 46 (2020).

[14] Kum Fai Yuena, Xueqin Wangb, Li Ting Wendy Ngb and Yiik Diew Wong, An investigation of customers' intention to use self-collection services for last-mile delivery, Transport Policy 66 August (2018), 1-8.

[15] A. Agarwal and R. Shankar, On-line trust building in e-enabled supply chain Supply Chain Management: An International Journal 8(4) 324-334.

[16] A. Agarwal, R. Shankar and M. K. Tiwari, Modeling agility of supply chain Journal Industrial marketing management 36(4) (2007), 443-457.

[17] S. Luthra, D. Garg and A. Haleem, The impacts of critical success factors for implementing green supply chain management towards sustainability: an empirical investigation of Indian automobile industry, Journal of Cleaner Production 121(10) (2016), 142-158.

[18] A. Agarwal, R. Shankar and M. K. Tiwari, Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach, European Journal of Operational Research 173(1) (2006), 211-225.

[19] B. Tounsi et al., Mathematical Programming with Stochastic Equilibrium Constraints applied to Optimal Last-mile Delivery Services, Electronic Notes in Discrete Mathematics Science direct 52 (2016), 5-12.

[20] V. K. Pathak, D. Garg and A. Agarwal, Analysis of Performance Evaluation and Issues of Last Mile Delivery by AHP, IJSSCA, 2021.