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Analysis of Last Mile Delivery Performance Barriers by the DEMATEL Approach

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Abstract: E-commerce industry depends upon the last mile delivery performance. There are some variables acting as enablers help to improve the last mile delivery performance whereas variables acting as barriers restrict the growth in last mile delivery performance. After studying several literatures of supply chain, some variables are identified on which last mile delivery performance depends. Among these variables, barriers have been identified. This paper analyses the impact of barriers on last mile delivery performance. on the basis of literature review, expert talk and brainstorming, twenty variables as barriers to last mile delivery are identified. An integrated decision-making trail and evaluation laboratory (DEMATEL) approach is used to inter-relate barriers and cause/effect relationship among the barriers. Eleven barriers are selected to be considered in cause group and further are in Effect group. Routing simulation, Alternative vehicles, Unawareness about upgraded technology are most important barriers according to study. A framework for barriers to last mile delivery is proposed which provides valuable insights to managers for better last mile delivery performance and improves customer satisfaction.

Keywords: Last mile delivery, supply chain, barriers/criteria, DEMATEL, cause-effect relationship

1. INTRODUCTION

For an effective e-commerce business, last-mile delivery (LMD) plays a significant role. Last mile delivery (LMD) is defined as "a collection of actions and processes required for the delivery procedure from the last transit point to the final drop point of the delivery chain". The global sharing economy Hamari et al.[1)], in which items or services are rented, exchanged, or traded through online platforms, is predicted to grow in the future. There is information flow, material flow and process flow occur[2)]. It can be seen from three viewpoints, each represented by a different stakeholder: demand, supply, and its physical environment, which is governed by local government[3)].

According to nature of the e-commerce industry the statistics about e-commerce businesses is as the estimated size of the Indian e-commerce market in 2020 is $38 billion. By 2020, around 4.2% of India's retail purchases will be made online. almost 80% of e-commerce traffic in India will come from mobile devices. Amazon and Flipkart (a Walmart-owned company) will own a combined 60–65% of the Indian e-commerce industry. over 23% of Indian internet customers will make purchases outside of their country. E-commerce in rural India will rise by about 57% annually. Approximately 80% of Indian customers view delivery time as a critical component. Employment in e-commerce: Over a million people are expected to be employed in India's e-commerce industry by 2020.

But a sizable portion of Indian e-commerce companies will be losing money: about 80% this is a challenging phase.

A study conducted by Anand et al.[4,47)] applied the DEMATEL method to identify the factors that impact last mile delivery performance in the Indian e-commerce industry. The study found that several factors, including delivery time, customer satisfaction, and delivery cost, have a significant impact on the performance of last mile delivery. Similarly, another study used the DEMATEL method to identify the factors that affect the efficiency of last mile delivery in the Iranian e-commerce industry. The study found that the key factors affecting last mile delivery efficiency were delivery cost, delivery time, transportation mode, and customer satisfaction.

Last mile delivery is a downstream part of supply chain management. As supply chain (SC) is divided into two parts, first part is concerned with upstream activity where

material/information flow from supplier to manufacturer and second part is connected with downstream activity, were material/information flow from manufacturer to customer through distributor, retailer[5].

Recent studies have also highlighted the impact of last mile delivery on the environment and sustainability. For example, a study conducted by Hu et al.[6] used the DEMATEL method to identify the key factors affecting the carbon emissions of LMD in the Chinese e-commerce industry. The study found that factors such as delivery distance, delivery frequency, and delivery mode were significant contributors to carbon emissions in last mile delivery.

In the Indian warehouse and industry sectors, last mile delivery plays a crucial role in ensuring the timely delivery of goods to customers[7]. Research has shown that the last mile delivery process can account for up to 50% of the total logistics cost, highlighting the importance of optimizing this stage of the delivery process. A study by Wang et al.[8] investigated the key factors affecting the LMD performance of e-commerce warehouses in China. The study found that factors such as delivery time, delivery cost, and transportation mode were significant in determining the efficiency of last mile delivery[9,22]. Additionally, the study suggested that the adoption of emerging technologies, such as e-vehicles and drones, could significantly improve LMD performance in the e-commerce industry.

In LMD there are several barriers which affects the supply channel. Here some of the barriers are recognize on the basis of literature survey like: Cost of delivery, Number of delivery locations, Time window and off-peak deliveries, Time window and off-peak deliveries, crowd sourcing, Stochastic demand, Market competition and uncertainty, inventory storage, Lack of information technology, Lack of new technology, social influence affect, Return policy, and Alternative vehicles[10]. However, various organisations may have different views regarding the implementation of last mile hurdles from an industry perspective. This study project involves a number of last-mile-related factors, which makes it a multi-criteria decision-making challenge. For the analyses of these criteria or barriers this article proposes an integrated DEMATEL approach.

In this sense, the objective of this article is:

1) To identify different barriers which affecting last mile delivery from the perspective of warehouses and industries.
2) To provide inter relationship in barriers and categorise them into cause-and-effect group.
3) To analyse managerial applications of the research.

Last mile delivery has a vast role to make industry revolution. It is upgraded day by day in abroad as well as in India. Drones are already come in the market to provide the delivery of necessary things. Information technology, RFID, Internet of things and big data has come in the market to enhance the facility and deliver things as soon as possible[11]. We know population of India is approximately 135 crores, and 70% of population is living in rural areas. So, making last mile delivery effective we have to work for urban as well as rural areas.

In this context a framework for last mile delivery is proposed which selected the barriers for making LMD effective. Successfully adoption of this framework enhance productivity, market growth and per capital income. Customers' satisfaction and last mile efficiency are being sought by service providers. Recent research and commercial advancements have centred on gathering and analysing data to enhance delivery success rates, often known as hit rates. Various techniques exist in e-commerce to manage LMD services to clients provide directions for improvement, such as shifting collection stations' locations. All these criteria are selected in this context and attempt to provide best analysis[12,43].

This research work aims to make the following several useful contributions:

1) Initially, from the viewpoint of a downstream supply chain, the current research work presents twenty barriers to Last Mile delivery implementation. The barriers noted can be used as a starting point to address potential problems with real acceptance and implementation of last mile delivery.
2) Next, in the context of adding to the theory, the DEMATEL-based model is made available to identify and analyze the barriers to the implementation of last mile delivery in the downstream supply chain. The methodological model's analysis of the barriers is logically valid because it recognizes that the problems are categorized into cause-and-effect groups and are more focused on performance and results.
3) Then, this study offers a framework, focusing on how to manage delivery-related problems most effectively.

The remainder of the article is divided into the following sections. The literature related to this work is included in segment 2. The research methodologies employed for this work are covered in segment 3. The suggested model for this research is shown in segment four. The findings and managerial suggestions of the study are covered in segment 5. Segment 6 concludes by presenting conclusions, limitations, and the direction of further research.

2. LITERATURE SURVEY

A review of various related articles is included in this study. A significant lot of research has been done recently on raising the importance of logistics services in the perspective of LMD. The majority of recent study on rating the importance of logistics facilities is done from the standpoint of customer preference. There are additional studies that look at the logistics service process as a whole and various approaches to manage LMD services to satisfy customers more effectively. Changes to delivery times, such as offering incentives or discounts for the best acceptable time windows, are among the

improvement paths. Ponce et al.[13] examine different strategies for making use of a third-party SC provider in order to confirm the LMD[14]. LMD is one of the most vulnerable phases of shipment transfer in terms of sustainability. Because of this, there are several initiatives to increase the effectiveness of delivery activity realization. The majority of delivery items are produced by e-commerce; hence this service is specifically examined[15]. The globalization of e-commerce has compelled the formation of business associations in a uniform system of product distribution.

It is necessary to identify the system's weak spot in order to make improvements that will result in the highest level of customer satisfaction and help to construct an evaluation framework. According to earlier literature, Lang et al.[16] created a framework that focuses on consumer expectations and economic performance criteria in order to evaluate the delivery system (DS) of an online retailer. Researcher assessed the DS of the online retailer using professional thoughts.

According to Bagri et al., Examining green practices and firm performances informs the green barriers for supply chain. This will identify to make performance better in downstream supply chain. Another researcher J. Kaur et al., A DEMATEL based approach for investigating barriers in green supply chain management in Canadian manufacturing firms involves consideration of environmental impacts of all the processes in a typical supply chain to minimize their negative consequences.

According to different researchers Analysis of the LMD service quality of e-commerce firms in India using DEMATEL method, considering factors such as crowd sourcing, traffic congestion and uncertain demand. Another study analyzes the last mile delivery performance of e-commerce firms in India using the DEMATEL method, considering factors such as warehouse location, delivery cost, and delivery speed etc.

Guo, X.,[8,17] study on the evaluation of LMD performance in the e-commerce industry based on DEMATEL method. This study uses the DEMATEL method to evaluate the performance of LMD in the e-commerce industry, considering factors such as warehouse location, delivery cost, and delivery speed.

Following is a list of concerns that need to be addressed based on a review of previous literature in the subject of evaluation frameworks or models:

(1) A design criterion, which were either based on knowledge systems, marketing, or a combination of the two, were considered by all previous frameworks. There is a requirement to evaluate operational factors.
(2) Most of the frameworks were used to rate e-commerce, with only a few covering performance evaluations. As a result, a framework for evaluating performance is required.
(3) According to literature reviews, the bulk of the frameworks were for educational platforms, banking, and tourist etc. by using one optimization method. There was very little evaluation framework for last mile logistics, which solely facilitate more numbers of items in a single frame; hence, a framework for last mile delivery is utilized by using DEMATEL multi criteria decision making technique.

This is a pilot-based survey study. Where around 55 responses occur for this survey. 12 industrial persons, 20 academicians and others are given their response for selecting the scales of barriers.

In this work, twenty important barriers are identified for effective implementation of last mile delivery in downstream supply chain through literature survey (see table 1) and brain storming with industrial persons and academicians.

Table 1 - Identification of Barriers

S.N.	Barriers	Sources	Influence on last mile delivery performance
1	High delivery cost (C1)	Kumar et al., 2019, Hosseini and Barker (2016)	Cost of delivery affects last mile delivery directly if it increases the aspect of last mile delivery increases.
2	Excessive maintenance and operations cost (C2)	Mangla et al., 2018; Khandelwal et al., (2020)	Cost of maintenance and operations affects the last mile delivery performance.
3	Large Number of delivery locations (C3)	Wang et al. (2017)	If number of delivery locations increases then it will provide ease of product availability.
4	Time window (C4)	Miriam Pirra, Angela Carboni, Francesco Deflorio (2021)	Time window directly affects the last mile delivery
5	Traffic congestion (C5)	Miriam Pirra, Angela Carboni, Francesco Deflorio (2021)	Traffic congestion will influence the last mile. Sometime it will create more time to reach the customer.

6	Lack of customer awareness (C6)	Davoudabadi et al. (2019)	Most of the time customers are not aware about last mile. They have the idea when the product delivered.
7	Limited facility of Loading and unloading (C7)	Wang et al. (2017)	It may affect the last mile delivery. Loading and unloading should be planned as per the time scheduled.
8	Crowd sourcing (C8)	Tho V.Le et al. (2019), Po-Lin Lai et al. (2021)	Most of the time crowd sourcing affected the last mile delivery. As it is not possible to determine the density of customers at the same time.
9	Stochastic demand (C9)	Tho V.Le et al. (2019)	Stochastic demand plays an important role to affect the last mile delivery.
10	Uncertainty in Market and demand (C10)	Jeremy Toner et al. (2020), and Jeremy Toner et al. (2021)	Healthy market competition should be there so that each and every player of the market gets benefit.
11	Inventory storage (C11)	Gan et al. (2019)	Inventory storage is part of last mile practice. It involves the material at a single stage.
12	Performance expectations (C12)	Seshadri Srinivasa Raghavan et al. (2022) and Po-Lin Lai et al. (2021)	Customer expected that purchase product should be performed well.
13	Lack of Environment awareness (C13)	Khandelwal and Barua, 2020, Lahane and Kant et al., 2021 b	Product delivery by any kind of mode affect environment so environment awareness should be there.
14	Limited information technology tools accessibility (C14)	Alimohammadlou and Bonyani (2018), Rajesh and Ravi (2015)	Most of the time modern information technology are not used which affect last mile delivery so lack of information technology plays an important role in last mile delivery.
15	Unawareness about upgraded technology (C15)	Urbinati et al., 2021, Wang et al. (2017)	Most of the time modern tools are not used which affect last mile delivery
16	Social influence affect (C16)	Devari A K et al. (2017), Maik Trott et al. (2021)	Social influence directly affects the last mile delivery.
17	Non-Transparent Return policy (C17)	Maik Trott et al. (2021)	Return policy is also the subsidiary part of last mile delivery.
18	Non availability of skilled workforce (C18)	Wang et al. (2017)	Employee should be trained on regular interval so that they can make last mile more effective.
19	Routing simulation (C19)	Wang et al. (2017), Felix M. Bergmann et al. (2019)	Routing simulation is a prime factor for last mile delivery.
20	Alternative vehicles (C20)	Felix M. Bergmann et al. (2019)	Alternative vehicles are the option to make last mile delivery green and more effective.

2.1 Gaps Identification

The following are the research gaps, as per the literature review:

1) By examining studies on downstream supply chain management, it was discovered that most of them were limited to broad surveys, conceptual understanding, and policy creation. In order to successfully execute last-mile delivery in the downstream supply chain in the context of India, it is therefore still necessary to perform a lot of study and analysis of the causal driving factors.
2) To increase the effectiveness of different corporate activities of the LMD implementation from a downstream situation, a collection of practical and typical barriers needs to be rigorously proposed.
3) DEMATEL approach has been assess in limited article to value the last mile delivery evaluation criteria in downstream supply chain.

3. RESEARCH METHODOLOGY

3.1 DEMATEL METHOD

DEMATEL is a method for modeling relationships between variables that is widely used. Cause and effect are two crucial components in DEMATEL, and they serve as the foundation for dividing the variables into two quadrants (cause and effect). Then between them, directional linkages are drawn Awasthi et al.[18,42] This technique is similar to mind mapping in that the expert responses for the barriers are organized in a visual impact-map that aids in determining the best course of action for addressing the problem in real-world scenarios. DEMATEL identifies the connections between the criteria and ranks them on the basis of connections and the intensity of their impact on one another[19,44]. Figure 1 shows the proposed framework for research study which helpful to recognize the barriers, method implementation and finding the final results.

The steps of DEMATEL Method (Figure 1) are:

Step 1: Identify the performance barriers through literature. Expert panel for pair-wise comparison is identified.

Step 2: Generation of direct Relation Matrix is prepared by comparing barriers in the scale from 0 to 4. which help experts to analyse the interlinked between criterion. Based on this scale, asked an expert to give their judgment to develop a pair-wise comparison matrix [A]nxn.

Step 3: "Normalised direct relation matrix (Y)" is prepared by using equation (I)

$$Y = [Yij]nxn = [\frac{A}{\max \sum_{j=1}^{n} |a_{ij}|}] \qquad (I)$$

Step 4: Total-Relation Matrix is obtained by using equation (II).

$$T = Y(I - Y)^{-1} \qquad (II)$$

Where I: Identity matrix; T: Total relation matrix =[t_{ij}]

Step 5: By using equation (II), to get the sum of rows (R) and columns (C)

$$R = \left\{\sum_{j=1}^{n} t_{ij}\right\}_{n\times 1} \qquad (III)$$

$$C = \left\{\sum_{i=1}^{n} t_{ij}\right\}_{1\times n} \qquad (IV)$$

Step 6: In this step mapping data set of $(R + C; R - C)$, to draw the cause-and-effect Diagram. Figure2. Shows the cause-and-effect diagram followed in the Research.

Proposed Framework

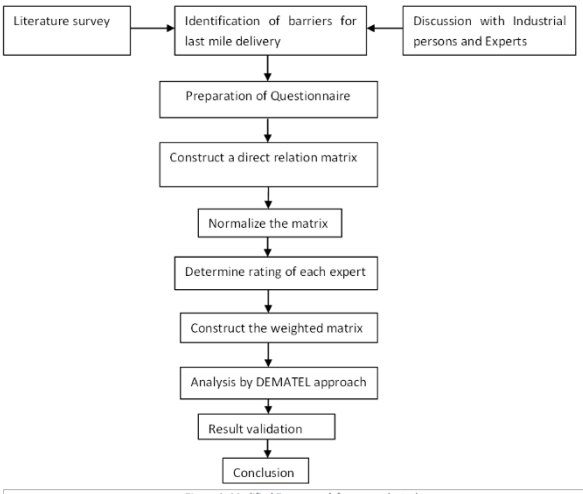

Figure 1. Modified Frame work for research study

3.2 DATA COLLECTION (DEMATEL Approach)

Assumption:

1) Every criteria is mutually dependent and influence to other criteria.

Comparison scale of DEMATEL Method

Definition	Scale
No influence	0
Low influence	1
Medium influence	2
High influence	3
Very high influence	4

Here putting the values of scale for influencing parameter based on literature survey and brain storming with industrial persons and academicians.

Twenty significant and frequently occurring impediments to the deployment of last mile delivery in the context of a downstream supply chain have been identified based on a survey of the literature and brainstorming. Using the DEMATEL technique, these barriers are further examined to determine their causal relationships. For the purpose of developing pair-wise comparisons of barriers in the form of scale as shown in Table 1, the same panel of experts has been convened for discussion[20,49]. For each group of experts, a direct relation matrix is created using the recorded language evaluations of the experts and the corresponding numbers. Only the pair-wise comparison matrix in linguistic terms is displayed as in Table 2 in order to avoid the repetitious type of activity.

Table 2. Generation of direct relation matrix

Barriers	Cost of delivery	cost of maintenance and operations	Number of delivery locations	Time window and off-peak deliveries	Traffic signal and congestion	Lack of customer awareness	Loading and unloading facility	crowd sourcing	Stochastic demand	Market competition and uncertainty	inventory storage	Performance expectations	Environment awareness	Lack of information technology	Lack of new technology	Social influence affect	Return policy	Employee service facility	routing simulation	Alternative vehicles	Sum
Cost of delivery	0	1	1	2	2	1	2	1	2	3	3	2	1	2	3	2	3	2	4	3	40
cost of maintenance and operations	2	0	1	1	1	1	2	1	2	2	3	2	1	2	3	2	3	2	4	3	38
Number of delivery locations	3	3	0	1	3	2	3	3	3	3	3	3	1	3	3	2	2	2	4	3	50
Time window and off-peak deliveries	2	3	2	0	1	2	2	2	2	2	2	1	1	2	2	1	2	1	3	2	35
Traffic signal and congestion	1	1	2	2	0	2	1	2	2	3	1	2	2	1	2	3	1	1	3	2	34
Lack of customer awareness	1	1	3	3	1	0	2	1	2	3	2	2	2	2	2	3	3	3	3	3	42
Loading and unloading facility	1	3	3	1	1	2	0	2	1	2	2	2	1	1	1	0	1	2	3	3	32
crowd sourcing	1	3	3	2	2	2	1	0	2	2	1	2	1	2	2	3	0	2	3	2	36
Stochastic demand	1	2	3	3	1	2	2	3	0	3	2	2	2	2	1	2	1	2	3	3	40
Market competition and uncertainty	1	2	2	1	1	3	1	2	3	0	2	2	1	3	3	1	2	3	2	3	38
inventory storage	1	3	3	2	1	3	3	1	3	3	0	2	1	2	2	1	2	2	2	2	39
Performance expectations	1	3	3	1	1	2	2	1	2	2	2	0	2	2	3	1	2	2	3	3	38
Environment awareness	1	1	1	1	2	2	1	1	1	1	1	1	0	2	2	3	1	1	1	3	27
Lack of information technology	3	2	3	3	2	3	3	2	2	3	2	3	2	0	4	1	2	3	3	3	49
Lack of new technology	3	3	3	3	2	3	3	2	2	2	2	3	2	4	0	2	2	4	3	3	51
Social influence affect	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	0	0	1	1	1	20
Return policy	1	1	1	1	2	1	1	1	1	2	3	2	1	1	2	1	0	1	2	1	26
Employee service facility	1	1	2	2	1	2	1	1	1	1	1	2	1	2	1	1	1	0	1	2	25
routing simulation	3	3	3	2	3	2	3	2	3	3	2	3	2	3	3	2	2	2	0	3	49
Alternative vehicles	4	3	3	2	3	2	2	2	2	2	2	2	3	3	3	2	2	2	4	0	48

Table 3. Normalize direct relation matrix

Barriers	Cost of delivery	cost of maintenance and operations	Number of delivery locations	Time window and off-peak deliveries	Traffic signal and congestion	Lack of customer awareness	Loading and unloading facility	crowd sourcing	Stochastic demand	Market competition and uncertainty	inventory storage	Performance expectations	Environment awareness	Lack of information technology	Lack of new technology	Social influence affect	Return policy	Employee service facility	routing simulation	Alternative vehicles
Cost of delivery	0	0.0196	0.0196	0.0392	0.039	0.0196	0.039	0.02	0.039	0.0588	0.06	0.039	0.02	0.0392	0.0588	0.03922	0.0588	0.039	0.08	0.059
cost of maintenance and operations	0.0392	0	0.0196	0.0196	0.02	0.0196	0.039	0.02	0.039	0.0392	0.06	0.039	0.02	0.0392	0.0588	0.03922	0.0588	0.039	0.08	0.059
Number of delivery locations	0.0588	0.0588	0	0.0196	0.059	0.0392	0.059	0.059	0.059	0.0588	0.06	0.059	0.02	0.0588	0.0588	0.03922	0.0392	0.039	0.08	0.059
Time window and off-peak deliveries	0.0392	0.0588	0.0392	0	0.02	0.0392	0.039	0.039	0.039	0.0392	0.04	0.02	0.02	0.0392	0.0392	0.01961	0.0392	0.02	0.06	0.039
Traffic signal and congestion	0.0196	0.0196	0.0392	0.0392	0	0.0392	0.02	0.039	0.039	0.0588	0.02	0.039	0.039	0.0196	0.0392	0.05882	0.0196	0.02	0.06	0.039
Lack of customer awareness	0.0196	0.0196	0.0588	0.0588	0.02	0	0.039	0.02	0.039	0.0588	0.04	0.039	0.039	0.0392	0.0392	0.05882	0.0588	0.059	0.06	0.059
Loading and unloading facility	0.0196	0.0588	0.0588	0.0196	0.02	0.0392	0	0.039	0.02	0.0392	0.04	0.039	0.02	0.0196	0.0196	0	0.0196	0.039	0.06	0.059
crowd sourcing	0.0196	0.0588	0.0588	0.0392	0.039	0.0392	0.02	0	0.039	0.0392	0.02	0.039	0.02	0.0392	0.0392	0.05882	0	0.039	0.06	0.039
Stochastic demand	0.0196	0.0392	0.0588	0.0588	0.02	0.0392	0.039	0.059	0	0.0588	0.04	0.039	0.039	0.0392	0.0196	0.03922	0.0196	0.039	0.06	0.059
Market competition and uncertainty	0.0196	0.0392	0.0392	0.0196	0.02	0.0588	0.02	0.039	0.059	0	0.04	0.039	0.02	0.0588	0.0588	0.01961	0.0392	0.059	0.04	0.059
inventory storage	0.0196	0.0588	0.0588	0.0392	0.02	0.0588	0.059	0.02	0.059	0.0588	0	0.039	0.02	0.0392	0.0392	0.01961	0.0392	0.039	0.04	0.039
Performance expectations	0.0196	0.0588	0.0588	0.0196	0.02	0.0392	0.039	0.02	0.039	0.0392	0.04	0	0.039	0.0392	0.0588	0.01961	0.0392	0.039	0.06	0.059
Environment awareness	0.0196	0.0196	0.0196	0.0196	0.039	0.0392	0.02	0.02	0.02	0.0196	0.02	0.02	0	0.0392	0.0392	0.05882	0.0196	0.02	0.02	0.059
Lack of information technology	0.0588	0.0392	0.0588	0.0588	0.039	0.0588	0.059	0.039	0.039	0.0588	0.04	0.059	0.039	0	0.0784	0.01961	0.0392	0.059	0.06	0.059
Lack of new technology	0.0588	0.0588	0.0588	0.0588	0.039	0.0588	0.059	0.039	0.039	0.0392	0.04	0.059	0.039	0.0784	0	0.03922	0.0392	0.078	0.06	0.059
Social influence affect	0.0196	0.0196	0.0196	0.0196	0.02	0.0196	0.02	0.039	0.02	0.0196	0.02	0.02	0.02	0.0196	0.0392	0	0	0.02	0.02	0.02
Return policy	0.0196	0.0196	0.0196	0.0196	0.039	0.0196	0.02	0.02	0.02	0.0392	0.06	0.039	0.02	0.0196	0.0392	0.01961	0	0.02	0.04	0.02
Employee service facility	0.0196	0.0196	0.0392	0.0392	0.02	0.0392	0.02	0.02	0.02	0.0196	0.02	0.039	0.02	0.0392	0.0196	0.01961	0.0196	0	0.02	0.039
routing simulation	0.0588	0.0588	0.0588	0.0392	0.059	0.0392	0.059	0.039	0.059	0.0588	0.04	0.059	0.039	0.0588	0.0588	0.03922	0.0392	0.039	0	0.059
Alternative vehicles	0.0784	0.0588	0.0588	0.0392	0.059	0.0392	0.039	0.039	0.039	0.0392	0.04	0.039	0.059	0.0588	0.0588	0.03922	0.0392	0.039	0.08	0

Table 4. Total relation matrix

Barriers	C 1	C 2	C 3	C 4	C 5	C 6	C 7	C 8	C 9	C 10	C 11	C 12	C 13	C 14	C 15	C 16	C 17	C 18	C 19	C 20
C 1	0.1106	0.1535	0.1623	0.1499	0.142	0.1453	0.159	0.125	0.161	0.1965	0.18	0.168	0.114	0.1722	0.2005	0.14221	0.1633	0.165	0.24	0.211
C 2	0.1439	0.1281	0.1558	0.1265	0.119	0.139	0.154	0.12	0.156	0.1719	0.17	0.162	0.11	0.1663	0.1942	0.13756	0.159	0.159	0.23	0.205
C 3	0.1939	0.2238	0.1793	0.1603	0.186	0.1946	0.208	0.189	0.211	0.233	0.21	0.219	0.137	0.2238	0.2375	0.17069	0.1721	0.198	0.29	0.252
C 4	0.1369	0.1758	0.1647	0.1001	0.112	0.149	0.147	0.132	0.149	0.1641	0.15	0.136	0.103	0.1578	0.1674	0.11417	0.1348	0.133	0.21	0.178
C 5	0.1122	0.1323	0.1579	0.132	0.088	0.1436	0.121	0.129	0.143	0.1741	0.12	0.147	0.118	0.1335	0.1602	0.14747	0.1087	0.126	0.2	0.17
C 6	0.1329	0.1566	0.2015	0.1701	0.126	0.1286	0.162	0.129	0.164	0.199	0.16	0.17	0.134	0.1757	0.186	0.16375	0.1656	0.185	0.23	0.216
C 7	0.1121	0.1684	0.1747	0.1113	0.106	0.1413	0.101	0.125	0.123	0.1547	0.14	0.146	0.097	0.1319	0.1403	0.0893	0.1099	0.143	0.2	0.187
C 8	0.1207	0.1777	0.1852	0.1395	0.132	0.1511	0.13	0.098	0.151	0.1653	0.13	0.156	0.105	0.1604	0.1701	0.15392	0.0983	0.153	0.21	0.18
C 9	0.1299	0.1727	0.1986	0.167	0.123	0.163	0.158	0.163	0.124	0.1958	0.16	0.167	0.131	0.1722	0.1645	0.14403	0.1259	0.164	0.22	0.212
C 10	0.1269	0.1668	0.1771	0.13	0.12	0.1779	0.137	0.14	0.175	0.1362	0.16	0.164	0.111	0.1869	0.1957	0.12248	0.1421	0.181	0.2	0.208
C 11	0.1273	0.1877	0.1964	0.1475	0.12	0.1791	0.175	0.124	0.178	0.1945	0.12	0.166	0.111	0.1697	0.1793	0.12241	0.1446	0.164	0.2	0.193
C 12	0.1282	0.1863	0.1942	0.1279	0.121	0.1593	0.156	0.122	0.158	0.174	0.16	0.127	0.129	0.1693	0.1968	0.12239	0.1431	0.162	0.22	0.209
C 13	0.0944	0.108	0.1149	0.0955	0.108	0.1218	0.1	0.091	0.101	0.1133	0.1	0.106	0.065	0.1276	0.1355	0.1292	0.0907	0.105	0.13	0.16
C 14	0.1918	0.2023	0.2311	0.1937	0.165	0.2099	0.205	0.168	0.189	0.2283	0.19	0.216	0.153	0.1659	0.2512	0.14942	0.1708	0.213	0.26	0.249
C 15	0.1951	0.2233	0.2347	0.1971	0.168	0.2129	0.208	0.171	0.192	0.2144	0.19	0.219	0.156	0.2421	0.1825	0.17046	0.1737	0.234	0.27	0.253
C 16	0.0757	0.0883	0.0928	0.0773	0.072	0.0838	0.081	0.092	0.082	0.0909	0.08	0.086	0.067	0.0886	0.1116	0.05538	0.0549	0.085	0.11	0.1
C 17	0.0907	0.1077	0.1135	0.0929	0.105	0.1027	0.099	0.089	0.101	0.1307	0.14	0.123	0.081	0.1077	0.1328	0.08882	0.0707	0.103	0.15	0.122
C 18	0.0904	0.1049	0.1291	0.1096	0.086	0.1178	0.097	0.087	0.098	0.1093	0.1	0.121	0.08	0.1234	0.1125	0.08713	0.0886	0.081	0.13	0.138
C 19	0.19	0.2182	0.2287	0.1739	0.182	0.19	0.203	0.167	0.206	0.2273	0.19	0.214	0.152	0.2189	0.2324	0.16699	0.1687	0.193	0.21	0.247
C 20	0.2067	0.2142	0.2243	0.1717	0.181	0.1865	0.183	0.164	0.185	0.2064	0.18	0.193	0.168	0.2163	0.23	0.16625	0.1669	0.189	0.28	0.188

Then, according to technique, the sums of the total relation matrix's rows (R) and columns (C) are determined. The datasets (Ri+Ci), also known as prominence, and (Ri-Ci), also known as relation, of the barriers under consideration are computed (see Table 4). The prominence of the barriers indicates their significance. The classification of the barriers into cause-and-effect groups is shown by Relation (Ri-Ci). Additionally, the barriers are classified based on the (Ri+Ci) dataset, and on the basis of the (Ri-Ci) dataset, the barriers are separated into cause-and-effect groups (see Table 5).

Table. 5- Calculation in row and column for making identity

Barriers	Ri	Ci	Ri+Ci	Ri-Ci	Identity
C1	3.260	2.71	5.970	0.550	Cause
C2	3.115	3.297	6.412	0.181	Effect
C3	4.085	3.516	7.601	0.569	Cause
C4	2.910	2.774	5.684	0.136	Cause
C5	2.761	2.57	5.331	0.191	Cause
C6	3.356	3.097	6.453	0.259	Cause
C7	2.700	2.98	5.680	-0.279	Effect
C8	2.967	2.63	5.597	0.337	Cause
C9	3.260	3.048	6.308	0.212	Cause
C10	3.156	3.48	6.636	-0.323	Effect
C11	3.205	3.02	6.225	0.185	Cause
C12	3.163	3.21	6.373	-0.046	Effect
C13	2.200	2.32	4.520	-0.119	Effect
C14	4.003	3.31	7.313	0.693	Cause
C15	4.107	3.58	7.687	0.527	Cause
C16	1.672	2.644	4.316	-0.971	Effect
C17	2.146	2.652	4.798	-0.505	Effect
C18	2.085	3.14	5.225	-1.054	Effect
C19	3.973	4.09	8.063	-0.116	Effect
C20	3.902	3.88	7.782	0.022	Cause

Here values of (Ri + Ci) Reveals the importance of criteria/barriers and it indicates degree of relation between each criteria with other criteria. If value of (Ri+Ci) has higher it means it has more relation with other criteria same time less value of (Ri+Ci) indicates less relationship with other criteria. In the table 4, alternative vehicle has higher value it means it has maximum relationship with other criteria. Now (Ri-Ci) values give information about kind of relationship with other criteria. If the values of (Ri-Ci) are positive it goes to cause group, known as dispatcher. In this analysis values of 11 criteria's are positive it means these criteria's influence to other criteria. Now if the values of (Ri-Ci) criteria are negative it falls under the effect group also known as receiver. Here 9 criteria's are considered in this group. Negative values of criteria shows that they are influence by other criteria.

3.3 Causal Effect Diagram

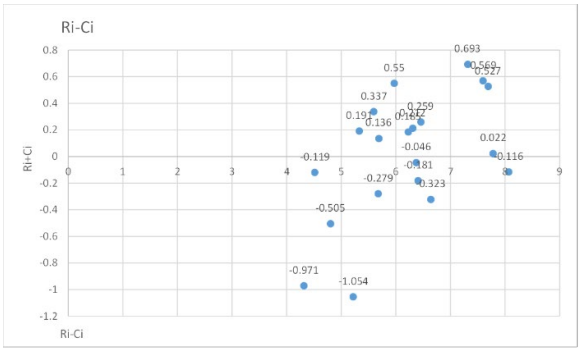

Figure 2. Causal Effect Diagram for criteria

Figure 2. Causal Effect Diagram for criteria

Figure 2 shows Causal effect diagram made in scattered plot in excel. In this diagram values of Ri+Ci is plotted in horizontal axis and values of Ri-Ci is plotted in vertical axis. This diagraph represents the direct and indirect effect of various criteria among each other. The threshold values to identify all the criteria which have negligible effect over other criteria are decided by Decision maker. In this article, 11 criteria are found in cause group like Cost of delivery (C1), Number of delivery locations(C3), Time window and off-peak deliveries(C4), Traffic signal and congestion(C5), Lack of customer awareness(C6), Crowd sourcing(C8), Stochastic demand(C9), Inventory storage(C11), Lack of information technology(C14), Lack of new technology(C15), Alternative vehicles(C20) and 9 criteria are considered in effect group like cost of maintenance and operations(C2), Loading and unloading facility(C7), Market competition and uncertainty(C10), Performance expectations(C12), Environment awareness(C13), Social influence affect(C16), Return policy(C17), Routing simulation(C19).

Figure 3. ratings of barriers to implement last mile

Figure 3. Importance ratings of barriers to implement last mile

The importance rating of the identified barriers based upon the (Ri+Ci) dataset (in table 5) is given as: C19-C20-C15-C3-C14-C10-C6-C2-C12-C9-C11-C1-C4-C7-C8-C5-C18-C17-C13-C16.

4. RESULT ANALYSIS AND DISCUSSION

In this research article, 20 criteria/ barriers are considered. Out of these criteria's, 11 criteria are found in cause group like Cost of delivery (C1), Number of delivery locations(C3), Time window and off-peak deliveries(C4), Traffic signal and congestion(C5), Lack of customer awareness(C6), Crowd sourcing(C8), Stochastic demand(C9), Inventory storage(C11), Lack of information technology(C14), Lack of new technology(C15), Alternative vehicles(C20) and 9 criteria are considered in effect group like cost of maintenance and operations(C2), Loading and unloading facility(C7), Market competition and uncertainty(C10), Performance expectations(C12), Environment awareness(C13), Social influence affect(C16), Return policy(C17), Routing simulation(C19) shows in figure 2. The importance of each criterion is revealed by the values of (Ri + Ci), which indicate the degree of relationship between each criterion and the others. If (Ri+Ci) value is higher, it suggests that it has a stronger association with other criteria. Conversely, if (Ri+Ci) value is lower, it shows that it has a weaker relationship with other criteria. As can be seen in Table 5, alternate vehicle (C20) has a greater value, indicating that it has the greatest link with the other criteria. Now, (Ri-Ci) values reveal the nature of the relationship with other criteria. If (Ri-Ci) is positive, it belongs to the cause group or dispatcher. When the values of eleven criteria's are positive in this study, it suggests that these criteria have an influence on other criteria and when the values of the criteria are negative, the effect group, also known as the receiver, is formed. In this group, nine characteristics are taken into account. Criteria with negative values indicate that they are influenced by other criteria.

5. MANAGERIAL IMPLICATIONS

This study proposes an outline to improve the LMD performance with the help of twenty (20) barriers. According to the findings, cause group barriers have an impact on the effect group barriers, it would be necessary to focus on them in advance. Based on the outcomes of the total relation matrix, this research provides evaluation criteria of causal relationships among last mile delivery parameters. The research helps to improve the development of industrial growth, educate public and customers for active last mile delivery idea. This will also help decision makers to understand market scenario and to identify barriers which greatly affects the performance of LMD in downstream supply chain.

6. LIMITATIONS AND FUTURE SCOPE

The constraint of this learning is the consideration of qualitative parameters of last mile delivery although performance evaluation requires quantitative parameters also. It will affect the efficiency of last mile chain and perception of customer approach. In this study application of DEMATEL approach is done and one can go for further mixed MCDM method like VIKOR, TOPSIS, ISM, ELECTRA AND PROMETHEE etc. This will set the benchmark for improving the performance of last mile delivery.

7. CONCLUSION

In this article, an investigation is made for the barriers in last mile delivery using a DEMATEL approach. Literature survey helps in getting the input barriers. With the help of DEMATEL approach identify barriers are categorized in cause-and-effect group. There are twenty (20) barriers are identified. Out of twenty (20) barriers, Elevens (11) are considered in cause group and Nines (9) are considered in effect group. The most important barriers according to this study are routing simulation, alternative vehicles, and unawareness about upgraded technology. In this analysis some of the industrial visits are managed for considering data so that last mile delivery performance can be improved. The strength of this article is the application of DEMATEL in LMD, by identification of barriers and analyzing the cause-and-effect group. Literature validates the results obtain by the DEMATEL method in last mile context.

The fact that the proposed work is among the first few to analyze last mile delivery barriers for the distribution of items in warehouses in the Indian environment is one of its strengths. Second, the obstacles are examined for causation and prominence, which can assist firms in focusing efforts, time, and resources on the most significant barriers to successful last-mile delivery in downstream supply chain practices.

The goal of this study was to improve e-fulfillment performance by implementing the DEMATEL-based technique to evaluate last mile performance for an e-tailer while taking into account the interdependencies among performance characteristics. This study's methodology makes it easier to determine the relative importance of each performance component. The goal of this article is to educate the manager on the critical e-fulfillment performance factors that require close attention. Routing simulation, alternate vehicles, and unawareness of new technological advancements are the most crucial factors in performance improvement. Industry may utilize these collected data and further improve their growth and strengthen the economy.

Reference

1) Juho Hamari, Mimmi S., Antti Ukkonen, The sharing economy: Why people participate in collaborative consumption, 02 June 2015,
2) A. Agarwal, and R. Shankar, "On-line trust building in e-enabled supply chain" *Supply Chain*

Management: An International Journal, Volume 8, Issue 4, Pages 324-334 (2003).

3) S. Jain, N.K. Jain, and B. Metri, "Strategic framework towards measuring a circular supply chain management", *Benchmarking: An International Journal*, Vol. 25 No. 8, pp. 3238-3252. (2018).
4) Santosh Anand, M.K. Barua, Modeling the key factors leading to post-harvest loss and waste of fruits and vegetables in the agri-fresh produce supply chain, Computers and Electronics in Agriculture, Volume 198, July 2022, 106936
5) A. Agarwal, R. Shankar, M.K. Tiwari, (2007), "Modeling agility of supply chain", *Industrial marketing management*, Volume 36, Issue 4, Pages 443-457 (2007).
6) Peng Jiang, Wenbao Wang, Yi-Chung Hu, Yu Jing Chiu, Shu-Ju Tsao Pattern classification using tolerance rough sets based on non-additive grey relational analysis and DEMATEL, Grey Systems: Theory and Application, ISSN: 2043-9377, 2021, Vol. 11 No. 1, pp. 166-182. https://doi.org/10.1108/GS-05-2020-0062
7) S. Ahmed, C. Karmaker, D. Doss, and A. Khan, "Modelling the barriers in managing closed loop supply chains of automotive industries in Bangladesh", *International Journal of Supply and Operations Management*, Vol. 7 No. 1, pp. 76-92 (2020).
8) X. Jiang, H. Wang, X. Guo, X. Gong, "Using the FAHP, ISM, and MICMAC Approaches to Study the Sustainability Influencing Factors of the Last Mile Delivery of Rural E-Commerce Logistics", *Sustainability*, 11, 3937 (2019).
9) Garg, and Chandra Prakash "Modeling the e-waste mitigation strategies using grey-theory and DEMATEL framework", *Journal of Cleaner Production*, Volume 281, 25 January 2021, 124035 (2020).
10) S.F.W.Z. Lim,., X. Jin, and J.S. Srai, "Consumer-driven e-commerce: A literature review, design framework, and research agenda on last-mile logistics models", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 3, pp. 308-332 (2018).
11) A. Mohammed, B. Naghshineh, V. Spiegler& H. Carvalho "Conceptualizing a supply and demand resilience methodology: A hybrid DEMATEL-TOPSIS-possibilistic multi-objective optimization approach". *Computers & Industrial Engineering*, 160, 107589. (2021).
12) E. Morganti, and S. Seidel "The impact of e-commerce on final deliveries: alternative parcel delivery services in France and Germany", Science Direct *Transportation Research Procedia,* 4, 178 – 190 (2014).
13) Diego Ponce, Ivan Contreras, Gilbert Laporte, E-commerce shipping through a third-party supply chain, Transportation Research Part E: Logistics and Transportation Review, Volume 140, August 2020, 101970
14) A. Ali, A. Mahfouz, and A. Arisha, "Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review", *Supply Chain Management: An International Journal*, Vol. 22 No. 1, pp. 16-39 (2017).
15) A. Halldorsson, and J. Wehner, "Last-mile logistics fulfilment: A framework for energy efficiency", *Research in Transportation Business and Management*, Volume 37, December (2020).
16) L.D. Lang, A. Behl, N.N.D. Phuong, J. Gaur, and N.T. Dzung, "Toward SME digital transformation in the supply chain context: the role of structural social and human capital", *International Journal of Physical Distribution & Logistics Management*, Procedia CIRP, Volume 98, 2021, Pages 436-441
17) Xuezhen Guo, "On integrating crowd sourced delivery in last-mile logistics: A simulation study to quantify its feasibility", *Journal of Cleaner Production*, 241, 118-365 (2019).
18) Awasthi, Anjali & Grzybowska, Katarzyna. (2014), Barriers of the Supply Chain Integration Process. 10.1007/978-3-319-07287-6_2.
19) Ashu Kedia "Locating collection and delivery points for goods' last-mile travel: A case study in New Zealand" Science Direct, *Transportation Research Procedia*, 46, 85–92 (2020).
20) S. Balsara, P.K. Jain, A. Ramesh, "An integrated approach using AHP and DEMATEL for evaluating climate change mitigation strategies of the Indian cement manufacturing industry", *Environmental Pollution*, 252, 863–878 (2019).
21) S. Chandak, and N. Kumar, "Development of a framework to improve supply chain performance through e-business and sustainability enablers: An emerging economy perspective", *Management of Environmental Quality*, Vol. 31 No. 5, pp. 1045-1070 (2020).
22) Janpriy Sharma, Mohit Tyagi, Arvind Bhardwaj, Ravinderjit Singh Walia, Factors Assessment for Encumbering the Implementation of Sustainability Based Lean Six Sigma Practices in Food Supply Chain, *EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy*, Vol.10(1) pp379-388, (2023). https://doi.org/10.5109/6781097
23) R. Dubey, and A. Gunasekaran, "Shortage of sustainable supply chain talent: an industrial training framework", *Industrial and Commercial Training*, Vol. 47 No. 2, pp. 86-94 (2015).
24) A. Halldorsson, & J. Wehner, "Last-mile logistics fulfilment: A framework for energy efficiency", *Research in Transportation Business and Management*, Volume 37, (December 2020).

25) H. H. Wu, and S. Y. Chang, "A case study of using DEMATEL method to identify critical factors in green supply chain management", *Applied Mathematics and Computation*, Volume 256, , Pages 394-403 (2015).
26) H. Sun, W. Mao, Y. Dang, Y. Xu, "Optimum path for overcoming barriers of green construction supply chain management: A grey possibility DEMATEL-NK approach", *Computers & Industrial Engineering*, Volume 164, February 2022, 107833 (2022).
27) H. Kuancheng, and M.N. Ardiansyah, "A Decision Model for Last-mile Delivery Planning with Crowd sourcing Integration", *Computers & Industrial Engineering*, Volume 135(1), (2019).
28) K. Huang, "A decision model for last-mile delivery planning with crowdsourcing Integration" *Computers & Industrial Engineering*, 135, 898–912 (2020).
29) V. Kumar, I. Sezersan, J.A. Garza-Reyes, E.D. Gonzalez, A.S. Moh'd Anwer, "Circular economy in the manufacturing sector: benefits, opportunities and barriers". *Manag. Decis*. 57, 1067–1086 (2019).
30) Kuo-Ping Lin, Ming-Lang Tseng, Ping-Feng Pai, , "Sustainable supply chain management using approximate fuzzy DEMATEL method", *Resources, Conservation and Recycling*, Volume 128, pp 134-142 (2018).
31) R. Mangiaracina, A. Perego, A. Seghezzi, and A. Tumino, "Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review", *International Journal of Physical Distribution & Logistics Management*, Vol. 49 No. 9, pp. 901-920 (2019).
32) S.K. Mangla, S. Luthra, N. Mishra, A. Singh, N.P. Rana, M. Dora, Y. Dwivedi, "Barriers to effective circular supply chain management in a developing country context", *Prod. Plann. Control,* 29 (6), 551–569 (2018).
33) S.K. Mangla, S. Luthra, S.K. Jakhar, M. Tyagi, and B.E. Narkhede, "Benchmarking the logistics management implementation using Delphi and fuzzy DEMATEL", *Benchmarking: An International Journal*, Vol. 25 No. 6, pp. 1795-1828 (2018).
34) Masoud Rabbani, Ali Reza Nazari-Estahbanati, Soroush Aghamohamadi-Bosjin, "Supplier selection and order allocation problem through option contracts under supply disruption risks", *International Journal of Business Performance and Supply Chain Modelling*, Vol.11, No.4. (2020).
35) R. Nagariya, D. Kumar, and I. Kumar, "Sustainable service supply chain management: from a systematic literature review to a conceptual framework for performance evaluation of service only supply chain", *Benchmarking: An International Journal*, Vol. 29 No. 4, pp. 1332-1361 (2022).
36) A. Prashar, and S. Aggarwal, "Modeling enablers of supply chain quality risk management: a grey-DEMATEL approach", *The TQM Journal*, Vol. 32 No. 5, pp. 1059-1076 (2020).
37) A. Raj, and B. Sah "Analyzing Critical Success Factors for Implementation of Drones in the Logistics Sector Using Grey- DEMATEL based approach", *Computers & Industrial Engineering*, 106118 (2019).
38) M. Saroha, D. Garg, and S. Luthra, "Identification and analysis of circular supply chain management practices for sustainability: a fuzzy-DEMATEL approach", *International Journal of Productivity and Performance Management*, Vol. 71 No. 3, pp. 722-747. (2022).
39) M.K. Tiwari, A. Agarwal, R. Shankar, "Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach", *European Journal of Operational Research*, Volume 173, Issue 2006, Pages 211–225 (2006).
40) Wei Qi, Lefei Li, Sheng Liu, Zuo-Jun Max Shen , "Shared Mobility for Last-Mile Delivery: Design, Operational Prescriptions, and Environmental Impact", *Manufacturing & Service Operations Management*, Vol. 20, No. 4. (2018).
41) Yuncheol Kanga, SeokgiLeeb, Byung Do Chungc, "Learning-based logistics planning and scheduling for crowd sourced parcel delivery", *Computers & Industrial Engineering,* 132, 271–279 (2019).
42) Muhammad Idham Sabtu, Hawa Hishamuddin, Nizaroyani Saibani, Mohd Nizam Ab Rahman, "A Review of Environmental Assessment and Carbon Management for Integrated Supply Chain Models", *EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy,* Vol.8(3), pp628-641, (2021). https://doi.org/10.5109/4491655
43) Masahito Tanaka. *EVERGREEN Joint Journal of Novel Carbon Resources Sciences & Green Asia Strategy*, Vol.4(4), pp.1-7, (2017). https://doi.org/10.5109/1929724
44) Yusei Masaki. *EVERGREEN Joint Journal of Novel Carbon Resources Sciences & Green Asia Strategy*, Vol.3(2), pp.59-67, (2016). https://doi.org/10.5109/1800873
45) Xiaer Xiahou, Yifan Wu, Tianle Duan, Peng Lin, Funing Li, Xiaojun Qu, , Qiming Li And Jiaxin Liu, "Analyzing Critical Factors for the Smart Construction Site Development: A DEMATEL-ISM Based Approach", *Buildings* 2022, *12*(2), 116 https://doi.org/10.1108/IJPDLM-12-2021-0525
46) A. Jindal , S. K. Sharma , K. S. Sangwan , G. Gupta, "Modelling Supply Chain Agility Antecedents Using Fuzzy DEMATEL", *Logistics Operations, Supply Chain Management and Sustainability*, (2014).
47) G. P. Bagri, D. Garg, A. Agarwal, "Examining green practices and firm performances", *Int. J. Business Performance and Supply Chain Modelling*, Vol. 12, No. 4, pp. 329-361, (2021).
48) G. P. Bagri, D. Garg, A. Agarwal, "To Analyze the Relationship Between Strength, Weakness,

Opportunities, and Threats of Indian Coal Mining Industries Towards Sustainable Development", *International Journal of Social Ecology and Sustainable Development*, Vol. 13, Issue 7, (2022).

49) J. Kaur, R. Sidhu, A. Awasthi, S. Chauhan & S. Goyal (2017), A DEMATEL based approach for investigating barriers in green supply chain management in Canadian manufacturing firms, *International Journal of Production Research*, DOI: 10.1080/00207543.2017.1395522