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A study on the influential factors of the last mile delivery projects during Covid-19 era

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Abstract
The Covid-19 has shifted the face of many markets including e-commerce and online business with many bottlenecks to be cleared. The last-mile delivery project has the greatest effect on all types of e-commerce companies because it has many consumer touchpoints as well as the Covid-19 pain points. Due to these interconnected issues, the delivery projects itself requires modern solutions. The purpose of this paper is to identify, analyse and categorize the major factors that affect the last mile delivery projects in e-commerce, food sector, retail sector and so on using total ınterpretive structural modelling approach during the Covid-19. Ten major factors are identified from literature review, and expert opinions are collected from multiple organizations that are involved in the last mile delivery projects. The results indicate that types of goods, achieving routing efficiency and meeting fulfilment timeline are the key factors for last mile delivery projects during the time of Covid-19. This study helps the managers to identify the key factors and to focus on these factors for the successful implementation of last mile delivery project.

Keywords Delivery projects · Last mile delivery · Project success factors · Logistics · Covid-19 influence · Distribution projects · Total interpretive structural modelling (TISM)

1 Introduction

Mankind faces the greatest challenge in human history because Covid-19 is severely affected on people all over the world. The current Covid-19 cases are exacerbated by the emergence of mutated forms of the corona virus, which may escape from immune surveillance or the immune response obtained against newly developed vaccines (Suresh et al. 2021a). Due to the first and second wave of Covid-19, lockdowns has been imposed in many countries. The Covid-19 pandemic has actually changed the buying behaviour of people all over the world even in e-commerce platform. Many people who were not a fan of online shopping have actually shifted to online platform during this Covid-19 period (Chaudhary 2020). The structure of e-commerce markets are transformed over the period of Covid-19 era and online sales gradually increased (Kim 2020). The resultant, last mile delivery projects managers are facing many challenges to deliver huge quantities of products to their customers door step and adhering the Covid-19 precautionary and contactless delivery (Viu-Roig and Alvarez-Palau 2020).

The process of the last-mile delivery projects are the most impactful one in online businesses as this has multiple touchpoints with the customers as well as the Covid-19 pain points. Due to these connective issues, the process itself needs to be addressed with modern solutions. Last mile shipping is the next stage of the delivery project, where a package is sent from a shipping hub to its actual destination, which is either a person's home or a grocery store (Gevaers et al. 2011). This is the most important step in the distribution process, and companies want to make sure

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that it goes as smoothly as possible (Vakulenko et al. 2019). This project is to meet the demand for fast shipping among consumers, especially in the e-commerce, food and retail industries. It is probably the most expensive part of the trip that the items take to get to their final destination (Ranieri et al. 2018). Although the significance of the last mile in achieving progress cannot be overstated, the difficulties in making it as effective as possible are numerous (Macioszek 2017). Further this was complicated during the Covid-19 era (Srinivas and Marathe 2021). It is the least effective leg of the chain, despite being the most essential one. The barriers to optimum last-mile delivery must be removed in order to ensure the quality of transportation operations and a pleasant customer experience (Weber and Badenhorst-Weiss 2018).

Many researchers have studied last mile delivery projects in the contexts of consumer driven logistics (Galkin et al. 2019), cost reduction (Ranieri et al. 2018), containerization of products (Dell'Amico and Hadjidimitriou 2012); analysis of transport operators' needs (Pronello et al. 2017), micro-hubs and crowd shipping (Ballare and Lin 2020), efficiency and sustainability (Tiwapat et al. 2018). Although, the identification of last mile delivery projects during Covid-19 era factors has not been investigated. The purpose of this paper is to identify, analyze, and categorize the last mile delivery projects during Covid-19 era. The analysis of factors related to the last mile delivery projects fills this research gap. This gap serves as inspiration for the current research, which uses the total ınterpretive structural modelling (TISM) approach to identify influencing major factors and analyze hierarchical interrelationships among major factors. The fact that the data, which are used in constructing this model obtained from experts participating in various forms of last-mile distribution, make the theoritical model more dependable and accurate. It is the first attempt to analyze the interrelationship among the last mile delivery projects factors during Covid-19 era.

The principal aim of this paper are as follows:

- To identify the influencing factors of last mile delivery projects during Covid-19 era.
- To analyze inter-relationships among these factors using TISM.
- To classify and rank the factors based on their dependence and driving power by using MICMAC analysis.

This study applies the TISM technique in the context of last mile delivery projects during Covid-19 era influencing factors, as indicated by the extensive extant literature for successfully implementing it to analyze the interrelationship between factors and create a hierarchical structure. The TISM is developed by Sushil (2012). TISM is used to model and organize the variables to understand their interrelationships better. This is a well-defined model that can be used to realize all factor intersections and relationships. Many researchers have used these methods to solve complex problems (Jena et al. 2017). The MICMAC study includes the development of a graph that categorizes factors based on driving power and dependence. The factors are divided into four categories by MICMAC: driving, autonomous, dependent, and linkage enablers (Patri and Suresh 2017).

2 Literature review

The implementation of last mile delivery projects are challenging during Covid-19 period. Sarma (2020) has briefed the last mile delivery project. Covid-19 has changed the day-to-day lives of people and increased the burden of supply chain businesses to provide consumers with smarter, quicker and more reliable last-mile deliveries. Businesses also accept the fact that having an Omni channel presence is a must to thrive in the future during the pandemic. At-home services also have been popular. At the same time, people's demand for clean, hygienic and white-glove home facilities has risen dramatically. Home service providers must not only increase the pace of their last-mile operations but also ensure that each job is completed professionally and to the highest possible quality standards. The use of artificial ıntelligence (AI) to optimize routes eliminates the need for human interference in despatch planning. This increases precision, lowers fuel costs and reduces preparation and delivery time. The AI-driven technology, especially SaaSbased logistic solutions, would be instrumental in optimizing the last-mile distribution operations across industries and geographies.

Market Study Report (2021) has studied with global autonomous last mile delivery market. People in remote areas also have difficulty obtaining everyday essential items due to widespread geography and severe weather conditions, making the process more complicated and expensive. The Covid-19 outbreak has created a number of new possibilities for drone delivery technology to flourish. To avoid human touch, drones have been used to carry facemasks to hospitals around the country. As a result, such factors are expected to support autonomous technology deployment in the last mile distribution phase. Yu and Rehman Khan (2021a) studied green agricultural product supply chain operations during Covid-19 era. Khan et al. (2021) studied the social sustainability implications in multi-tier supply chains. Yu and Khan, (2021b) studied green supply chain optimization process in uncertain situations.

Similarly, Unnikrishnan and Figliozzi (2020) have conducted a study on the impact of Covid-19 upon home delivery. For many customers, home delivery has provided a solution to some of the challenges of Covid -19. During Covid-19 lockout, people who are worried about their health are more likely to invest more money and make more home

deliveries. Household income is an important factor to be considered when analyzing adjustments during the lockdown. The households which ordered more home deliveries prior to Covid-19 have a better chance of ordering more during the lockdown.

Viu-Roig and Alvarez-Palau (2020) have dealt with e-commerce which is related to last mile logistics. In recent years, e-commerce has experienced rapid growth, a development that would be compounded by the impact of Covid-19, which has resulted in an increase in the purchase of internet pack. Last-mile logistics can only grow in importance, resulting in an unavoidable shift in how today's urban operate. The aim of urban freight distribution is to deliver unique goods on time and in the correct manner while keeping costs down and providing excellent customer service. It also helps to reduce the expense of urban freight transportation by combining deliveries, eliminating stops and shortening distances.

The insights from the Bangalore Urban Mobility Transition (RMI India, 2020) for final-mile distribution include improving charging and swapping networks. Small and Medium Enterprise (SMEs) would serve as micro-hubs for storing electric vehicles and products, allowing them to be used for final-mile delivery. Connectivity at the first and last mile in high-density areas of the city promotes first-and last-mile connectivity. It is necessary to create and update policies and regulations to encourage the adoption of new first- and last-mile connectivity options. In Bangalore, the construction of first- and last-mile connectivity options is becoming increasingly necessary in order to sustain high levels of public transportation use.

Susan Meyer (2020) has studies the optimization of the last-mile delivery. Consumers' immediate reaction to the Covid-19 pandemic is panic purchasing and stockpiling necessary goods. The market for online retailing is expected to last well beyond Covid-19, and may even increase in comparison with the conventional retail model, with long-term implications for the overall retail supply chain. Instead of relying on humans, which takes a lot of time, effort, and results in costly errors for the brand, automated route planning tools allow the optimization of delivery scheduling by optimizing the service level and cost. The comprehensive route optimization software must provide a number of features in last mile delivery.

Gupta et al. (2020) have pointed out that the national lockdown has brought the challenges of reaching welfare recipients to the frontline. Agents' lack of sufficient remuneration and rewards have led to a great deal of inefficiency in the last-mile distribution of scheme benefits, including high business correspondent (BCs) turnover rates and instances where consumers are overcharged. It is suggested that the requirements for enrolling in welfare programs need to be relaxed. The government relax requiremnets for documentation standards are proposed for enrollment at the federal level and harmony programs through welfare programs.

Bauer et al. (2020) also have studied the last mile delivery. Covid-19 has changed a lot of things in the lives of human beigs. Moving goods from one location to another has proved to be a more difficult logistical task than moving goods from one factory to another. The last mile accounts for about 40% of total logistic costs globally. This dynamic is a primary driver of migration to autonomous forms of transportation. The expected rise in delivery vehicles on the road would emit an additional six million tons of CO2, placing additional pressure on the current carbon reduction goals. The level to which last-mile players would shift to more environmentally sustainable modes of transportation, like the use of micro mobility solutions in dense urban areas and the use of autonomous EVs in general, would be critical in mitigating this danger.

Rozycki and Kerr (2020) have examined the last mile delivery before and after the Covid-19. Autonomous Ground Vehicles (AGVs) are used only in a limited number of markets, often in closed environments and on public roads. Drone transport allows for on-demand and same-day delivery, as well as the ability to escape traffic jams, enhances medical delivery performance, reduces costs and improves the patient experience, all of which may save the lives of human beings. WakeMed's flagship hospital and campus in Raleigh has been hosting United Parcel Service's drone network. FedEx also has introduced the Same Day Bot, a robotic delivery vehicle. 'Scout,' Amazon's own AGV, also has been released. Customers would put more pressure on courier and postal systems as environmental awareness grows. In city centers, where millions of people live and work, Evs outperform the conventionally driven vehicles in terms of noise and air quality. Since they are easy to start, virtually silent, and smooth to drive, EVs can be more convenient for short-distance drivers.

Twinn et al. (2020) have noted that the Covid-19 pandemic has had a direct impact upon logistic companies that deal with the movement, storage and flow of goods. The pandemic has spread across the world, resulting in lockdowns and border closures that stifle trade. Additional procedures like social distancing at warehouses implemented to ensure workers' safety have led to freight bottlenecks. Some businesses have implemented new social distancing protocols in warehouses, disinfected work environments or provided protective gear to protect their employees' wellbeing. Since the demand for critical goods is strong, warehouses and retailers are concentrating on grocery deliveries while companies in the last-mile segment are providing no-contact delivery options which include robots. The logistics industry has been undergoing a technological transformation. In the long run, robots,

drones and autonomous vehicles can reduce the risk of labour shortages for logistic service providers.

Narashimman (2020) has pointed out that the last-mile delivery has been taken to new heights, thanks to the same-day delivery. Despite the fact that the same-day delivery is a rapidly expanding market, it mostly appeals to urban millennials. Due to the Covid-19 outbreak, the speed of distribution is now critical in almost every vertical. It is, in reality, one of the most important aspects of customer satisfaction. Due to the pandamic outbreak, the same-day delivery has become more of a requirement than a luxury. Customer preferences are changing, e-commerce adoption is accelerating, and urbanization is rising, both of which are driving the same-day delivery. In many ways, the same-day delivery has changed the way people think of last-mile delivery. Customer satisfaction is increased by faster delivery options like the same-day delivery. Developing quicker delivery solutions allows a company to fulfil customer needs while still distinguishing it from rivals.

Similarly, Hinzmann and Bogatzki (2020) have conducted a study on last mile delivery vehicles. To meet the demands of last-mile delivery and increasing customer standards, the last-mile needs an alternative mode of transportation. ADVs seem to be a good choice for last mile delivery to overcome the existing problems of the last mile and reduce customer frustration with parcel delivery. As a result, for the first time, the acceptance of autonomous delivery drones and autonomous delivery robots would be examined in the form of a technology acceptance model. The last mile is a consumer-focused industry with a strong behavioral dimension.

Patel and Parmar (2020) have studied amazon logistics during Covid-19 era. Customers are informed about the delivery within a day with last-mile delivery. Amazon has been unable to come up with a solution for the last-mile delivery which is both cost-effective and timely. The cost of providing last-mile services accounts for 41% of total supply chain costs, which is more than any other segment, including warehousing and parceling. Amazon, however, would have to spend billions in its distribution services. Electric-powered delivery trucks, drones, sidewalk robots and collaborations with third parties are among the investments that have seen varying degrees of success.

In the same way, Deloison et al. (2020) have analysed the future of last mile eco system. However, the labour costs in developing countries are likely to remain low enough to avoid any significant technological changes affecting the last mile in the next five to ten years. Many e-commerce companies and startups are now providing quicker delivery options, like the same-day delivery, due to improved fulfilment processes. Traditional online categories like books, apparel and appliances have fueled the growth of incumbent online retailers like Amazon, Walmart and Alibaba. Groceries and health items are still mostly purchased in stores, but online penetration has significantly increased. However, the same-day and the instant delivery are the fastest-growing segments in the last-mile environment, with annual growth rates of 36% and 17% respectively. With the help of camera based object tracking and machine-learning tools, automated vehicle loading systems, and advanced analytic based driver applications, several automotive original equipment manufacturer (OEM)s have been working on concepts that actively support the work of parcel drivers.

Bopage et al. (2019) have proposed a strategic model to improve the performance of last mile delivery in e-commerce parcel delivery. The cost per parcel in rural areas is extremely high. Retailers, LM service providers and customers are the main players in the last-mile logistics. The current growth and popularity of e-commerce also have an effect on many consumers' daily lives by offering a broader variety of options, more easily available information and ease of purchase. Retailers are under pressure to manage their stock and provide efficient distribution in terms of speed, price, service and quality as the online shopping and delivery markets expand as well as the rapid rise in the number of orders. The speed at which customers obtain their orders is a major factor in the sucsess of e-commerce. The customers of e-commerce expect the same-day deliveries; thus, shorter delivery times must be given to ensure greater customer satisfaction.

Mishra and Balsara (2020) have pointed out that the Covid-19 related lockout has brought everyday life to a halt and disrupted all the economic activities. The lockdown has slowed down people's movement, caused labour shortages, disrupted factory operations, forced non-essential commodity and food service providers to close their doors, sparked panic buying among customers for staples, and left retailers with stock-outs in a few categories. The Indian consumer goods industry is in a state of flux. Due to the slow down in agriculture, liquidity crunch and employment challenges, the industry has been facing demand pressure, especially from rural consumers. The onset of the Covid-19 pandemic has intensified an increasingly difficult market climate. Consumers' shopping patterns would presume a much greater prevalence of e-commerce and home delivery. The future of consumer's digitalization would be years ahead of schedule. As a result, businesses that digitally transform their route to market and develop robust positive capabilities, including e-commerce, would win in the long run.

Jacobs et al. (2019) have pointed out that in the food and grocery industries, the last-mile delivery has become a primary customer expectation. Since grocery stores are as busy as public transportation during rush hour, 63% of customers shop online. As the popularity of online shopping grows, delivery would become increasingly necessary. Early adoption of new autonomous-delivery models in developed markets, as well as a compelling business case based on urban

demand. Customers would be attracted to and retained by a great last-mile delivery service that delights them. As a value-added service, satisfied customers are willing to pay more for faster delivery. This provides a way for businesses to cover distribution costs.

Mangiaracina et al. (2019) have dealt with the efficiency of last mile delivery. e-commerce is a fast-growing phenomenon, with the global retail industry valued at more than € 2500 billion in 2018. Due to the difficult target service levels, small order dimensions, and high level of dispersion of destinations, the last-mile delivery is the least effective and most costly component of the delivery process. The cost can equate half of the overall logistic costs. Identifying the most creative ideas and comprehending how they can reduce the expense of last-mile distribution is important.

Lim and Srai (2018) have studied the last-mile distribution in e-commerce omni channel retailing. It requires difficult trade-offs among delivery responsiveness, product range, and convenience, as well as enterprise-wide data visibility. The construction of a logistic supply chain's last-mile is often the most costly section. Due to the continued growth of internet based transactions, the study is directly relevant to managerial practice.

Joerss et al. (2016) have pointed out that the parcel delivery is the future of last mile. Global parcel delivery costs, excluding pickup, line-haul and sorting, are estimated to be around € 70 billion. This means that in mature markets, volumes would double in ten years, hitting 5 billion and 25 billion parcels per year in Germany and the United States respectively. However, labour costs in developing countries are likely to remain low enough to avoid any significant technological change affecting the last mile in the next five to ten years. Many e-commerce companies and startups are now providing quicker delivery options like the same-day and instant deliveries due to improved fulfilment processes.

The development of project charter is the most important process in pursuing a delivery project (Ayers, 2003). The knowledge of advanced logistic and distribution is required because this area of knowledge assigns all the tasks in the project process. The performance of delivery project is measured based on on-time delivery, distribution cost minimization, and without damage to the product. Delivery projects are judged against one or more of these measures (Hughes et al., 2020). In addition to the wellbeing of the staff is a concern with the management as it is challenging to maintain the Covid-19 protocol of social distancing while at work. There is a delay in transportation due to the government regulations during Covid-19. Further, there is uncertainty of demand and period (Bushuyev et al. 2020). All these directly increase the cost of delivery projects (Muller and Klein 2020).

3 Research methodology

Interpretive structural modelling (ISM) was developed by Warfield 1976. It is useful to analyse the interrelationships between the factors. The ISM approach has been extensively used in project managemnet field (Hughes et al. 2016; Shrivas and Singla 2020; Samantra et al. 2016). The ISM has been updated by Sushil (2012) as Total Interpretive Structural Modelling (TISM). The TISM provides the interpretations of the links, i.e., how factor-*L* is influencing factor-*M*. TISM is a theory building approach and it interprets both the nodes and the links. TISM approach is used by many researchers to solve complex problems in manufacturing and services sectors (Menon and Suresh 2019). The TISM approach has been extemsively applied in project management field (Sandbhor and Botre 2014; Wuni and Shen 2019). The TISM has been used in analysing the supply chain operational performance and challenges (Bag 2016; Agarwal and Seth 2021; Mathivathanan et al. 2021). Also, the TISM has been used to analyzing Covid-19 challenges and impacts (Lakshmi Priyadarsini and Suresh 2020; Lakshmi Priyadarsini et al. 2020; Sreenivasan and Suresh 2021). In this Study, TISM methodology is adopted to understand the interrelationship between the factors that influence the last mile delivery projects during Covid-19 era.

The list of factors that influence the last mile delivery projects during Covid-19 era have been ıdentıfıed from literature review and experts openion. Initially, selected experts from the last mile delivery organizations are consulted to identify the majaor factors. The closed-ended questionnaire has been developed based on pairwise comparisons of the identified major factors. Then the scheduled interviews are conducted with managers, supervisors, and delivery executives in the last mile logistics organizations. Face-to-face meeting invitations are sent to 31 respondents in India. Finally, 20 respondents are interviewed based on their willingness and available time to participate in this study. Each interview has been scheduled for 50 min duration in which 10 min are spent for clarification of study and factors definitions and the rest 40 min are utilized to gathering information from the respondents.

The Fig. 1 shows the flow of detailed steps related to modelling for last mile delivery projects during the Covid-19 era using the TISM approach. The following steps are adopted (Vaishnavi et al. 2019b; Vaishnavi and Suresh 2020; Menon and Suresh 2021a) for the successful application of the TISM model:

1. **Identification of the factors:** the major factors that influence the last mile delivery projects during Covid-19 era have been identified through expert opinion and literature review and depicted in Table 1.

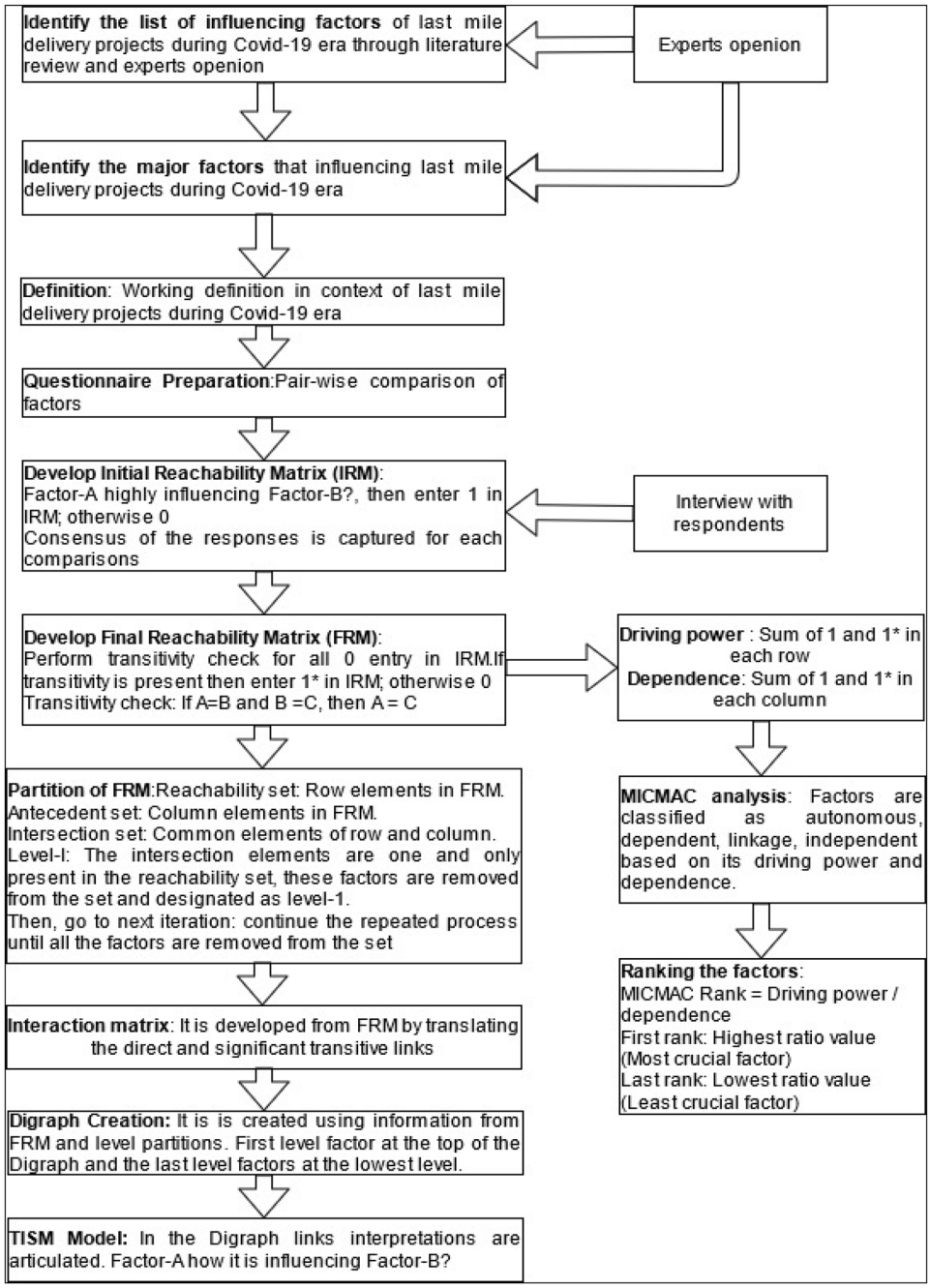

Fig. 1 Flow of TISM for last mile delivery projects during Covid-19 era

2. **Initial Reachability Matrix (IRM):** the contextual relationships between the pair of factors have been established in IRM (Sreelekshmi and Suresh 2021) and shown in Table 2. In this study, 20 responses have been collected and the respondents are managers, supervisors, and delivery executives in the last mile logistics organizations in India.
3. **Interpretation of relationship between factors:** how factor-A influences factor-B (Patil and Suresh 2019).
4. **Developing the final reachability matrix (FRM):** the FRM has been derived through transitivity check (Menon and Suresh 2021b) as shown in Table 3.
5. **Partition of the factors from FRM into levels** (Suresh and Arun Ram Nathan 2020)

Table 1 Major factors influencing the last mile delivery during Covid-19

Factor	Working definition
Customers' expectations (F1)	During this time of Covid, people are staying indoors and customers demand not only quick deliveries but also the same-day deliveries. This level of expectation affects the efficiency of the last-mile delivery services
Health (F2)	The most considerable aspect of people during this Covid is health which is the reason for a sudden boom in e-commerce. The most vulnerable identifiers in the process of e-commerce are the people involved in the last mile delivery
Delivery density (F3)	The products ordered have been significantly higher in the past months due to lockdown and the limited accessibility/restrictions make it harder for the last mile delivery person to carry out higher density orders
Cost of last mile delivery (F4)	The increased cost of the fuel and safety equipment due to Covid-19 is still a challenge for most of the enterprises to execute their last mile delivery
Types of goods (F5)	At times even the type of goods becomes a challenge to cargo bike courier services when transporting them through different places. All the types of goods cannot be sanitized
Achieving routing efficiency (F6)	Multiple routes under locked zone due to Covid-19 and the high volume of orders make it harder for the last mile delivery to happen effectively
Infrastructure (F7)	Delivering at the final destination inevitably involves long journeys through inefficient routes which might fail in making journeys go as planned. It also adds to the fuel cost
Issues from customers' side (F8)	Due to Covid-19, customers also face issues in receiving the ordered products as they are asked to collect the products from a local hub in some places. The inadequate information from the customer also makes the last mile delivery harder
Unpredictability in transit (F9)	This issue is even more aggregated after the blew out of corona virus, as it becomes unpredictable when the deliverable area would be locked down. Once the order is placed and the area goes under lockdown, it affects the delivery process
Meeting fulfilment timeline (F10)	If the timeline is missed, it could then prove very expensive for brands in both the short and long-terms. Due to Covid, the aspect of meeting the timeline is even harder with the limited resources and high demands, and more constraints are being faced which affects the last mile delivery

6. **Designing the interaction matrix:** the significat transitive links are identified through expert opinions and direct links are depicted in Table 4.
7. **Creating the digraph and the TISM model:** it is created by using level partitions and interaction matrix (Suresh and Abhishek 2021). The TISM model is shown in Fig. 2. In addition, the reasons behind the direct and the significant transitive links are presented.

4 Results and discussion

4.1 Interpretation of TISM Di-graph

Figure 2 graphically represents the TISM analysis of the factors having an influence on the last mile delivery during Covid-19.

Level III: level three has four factors, which are factor 5, 6, 9 and 10.

Table 2 IRM for factors influencing the last mile delivery during Covid-19 era

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	1	1	0	0	0	0	0	1	0	0
F2	1	1	1	0	0	0	0	0	0	0
F3	0	0	1	0	0	0	1	0	0	0
F4	0	0	1	1	0	0	0	0	0	0
F5	0	1	0	0	1	0	0	0	0	0
F6	0	1	1	0	0	1	0	0	0	0
F7	0	0	1	0	0	0	1	0	0	0
F8	0	0	0	0	0	0	0	1	0	0
F9	0	0	0	1	0	0	0	0	1	0
F10	1	0	0	1	0	0	0	0	0	1

Table 3 FRM for factors influencing the last mile delivery during Covid-19 era

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Driving power
F1	1	1	1*	0	0	0	1**	1	0	0	5
F2	1	1	1	0	0	0	1*	1*	0	0	5
F3	0	0	1	0	0	0	1	0	0	0	2
F4	0	0	1	1	0	0	1*	0	0	0	3
F5	1*	1	1*	0	1	0	1**	1**	0	0	6
F6	1*	1	1	0	0	1	1*	1**	0	0	6
F7	0	0	1	0	0	0	1	0	0	0	2
F8	0	0	0	0	0	0	0	1	0	0	1
F9	0	0	1*	1	0	0	1**	0	1	0	4
F10	1	1*	1*	1	0	0	1**	1*	0	1	7
Dependence	5	5	9	3	1	1	9	6	1	1	

*, **represents transitive links

Factor 5 influencing F1: types of goods influence the customer's expectation to a high level depending on certain criteria like the time taken to deliver the product and the fragility of the product. It often happens that the expectation increases as the products/goods get more premium.

Factor 5 influencing F2: types of goods influence health which is a more critical note as to the fear of customers in making contact with the goods after it is delivered. The main reason behind this provocative thought is because not all goods/products can be sanitized while or before last-mile delivery.

Factor 5 influencing F7: during the period of Covid-19, the last-mile delivery has become harder due to the quarantining of infectious areas and rerouting of transport. The goods, based on the types, cannot be carried at a single delivery enroute and with the lockdown, the cost of transport increases.

Factor 5 influencing F8: once the customer purchases the item/product and the last mile process is initiated, there are certain aspects that restrain the delivery to be successful. The customer becomes unreachable due to the lockdown or if the customer is quarantined due to Covid infection, the cost of product return increases based on the type of goods.

Factor 6 influencing F1: the inefficiency in attaining the best delivery route possible due to the Covid-19 lockdown makes the customers frustrated. The Covid-19 lockdowns have made everyone stay indoors which has increased the customer expectation in quick delivery of goods.

Factor 6 influencing F2: the rerouting and long travels for the delivery person make them even more exposed to the chances of getting infected with the corona virus.

Factor 6 influencing F3: the inefficiency in the delivery process increases the number of trips to be made by the delivery person. This, in turn, reduces the volume/density of the products to be delivered under normal conditions vs the new conditions due to Covid-19.

Factor 9 influencing F4: the unpredictability in transit increases the cost of last-mile delivery because once the process is initiated and the customer's area goes under lockdown, the product has to be returned which involves certain cost.

Factor 10 influencing F1: meeting the delivery timeline affects the customer's expectation because the expected

Table 4 Interaction matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	1	1	1*	0	0	0	0	1	0	0
F2	1	1	1	0	0	0	0	0	0	0
F3	0	0	1	0	0	0	1	0	0	0
F4	0	0	1	1	0	0	1*	0	0	0
F5	1*	1	0	0	1	0	1**	1**	0	0
F6	1*	1	1	0	0	1	0	0	0	0
F7	0	0	1	0	0	0	1	0	0	0
F8	0	0	0	0	0	0	0	1	0	0
F9	0	0	0	1	0	0	0	0	1	0
F10	1	1*	1*	1	0	0	1**	0	0	1

*, **represents significant transitive links

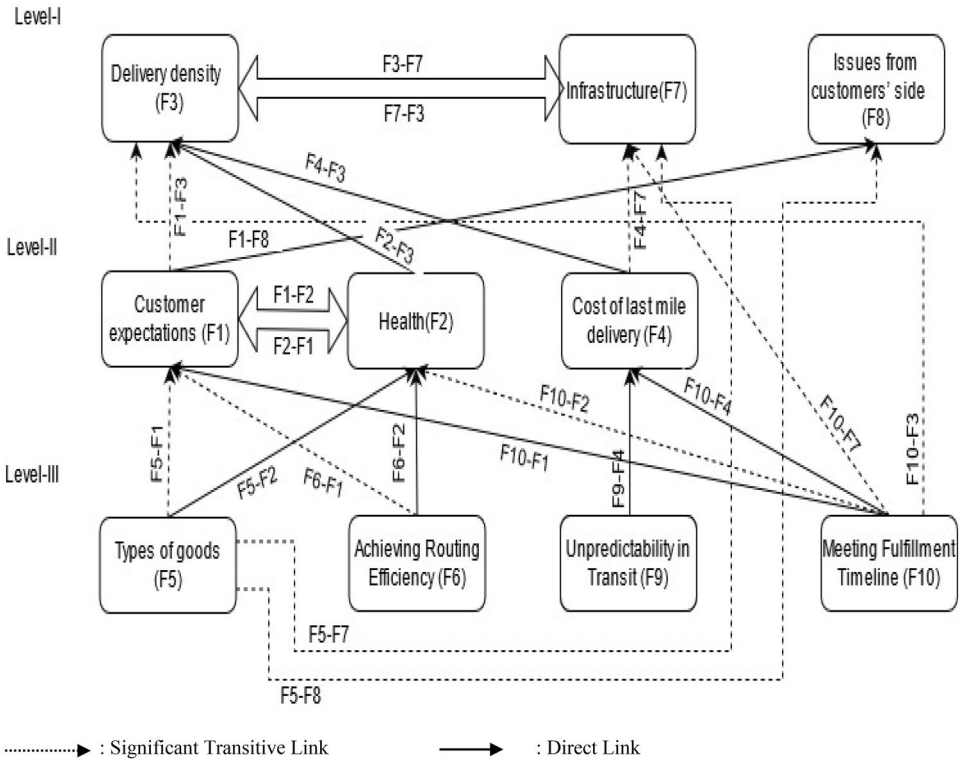

Fig. 2 TISM model for factors influencing the last mile delivery during Covid-19 era

delivery date has already been shared with the customer and the customer expects the need to be met at the stipulated time, but due to Covid, the timeline is hard to be met.

Factor 10 influencing F2: the longer the product is not delivered to the customer, it stays exposed to the risk of getting contaminated with the coronavirus, which results in a health crisis.

Factor 10 influencing F3: meeting the timeline affects the delivery density at a multifold level as the Covid may be critical in certain places and not in others, so the meeting of the timeline is not constant which might increase or decrease the delivery density.

Factor 10 influencing F4: meeting the timeline affects the cost of last-mile delivery as the delay with the product not delivered increases the inventory cost in addition to the transport cost.

Factor 10 influencing F7: meeting the timeline affects the infrastructure as the product's shelf time in the inventory might increase which leads to an additional cost.

Level II: level two have three factors, which are factor 1, 2 and 4.

Factor 1 influencing F2: the customer expectation certainly influences the health factor. There are common necessities that the customers seek before receiving their orders as to better sanitized delivery, the delivery person with a mask on and so on.

Factor 1 influencing F3: as people are staying indoors and spending less money on transports because of the nationwide lockdown, their expectancy of quick delivery has increased multifold, and as a result of this deemed increase in expectancy, the delivery density is piling up day by day.

Factor 1 influencing F8: ın certain cases, the customer expectancy influences the issues from the customer side like the customers expecting quick delivery and not being able to make it to the temporary delivery hub in Covid affected areas.

Factor 2 influencing F1: health influences the customer expectation, and the Covid-19 has led customers to subconsciously make the delivery process standard in sanitizing, following proper safety measures and quick delivery with the product being less exposed to the world.

Factor 2 influencing F3: health majorly influences the delivery density; as the orders are piling up due to the lockdown and restricted mobility of people, the health of a delivery person is critical and exposed to the infection at times. This reason shifts the delivery density up or down.

Factor 4 influencing F3: the cost of the last-mile delivery is increasing due to the additional costs like sanitizers, face masks for the delivery person and rerouting. Due to these relevancies, the volume of the order is getting unstable in delivery.

Factor 4 influencing F7: the increase in the cost of last-mile delivery has created a need to rethink the infrastructure of the inventory and the process of the last-mile delivery as a whole.

Table 5 Classification of factors using MICMAC

Class	Factor classification	Driving power	Dependence	Factors
Class-I	Autonomous	Weak	Weak	•Cost of last mile delivery •Unpredictability in transit
Class-II	Dependent	Weak	Strong	•Customers' side •Delivery density Infrastructure
Class-III	Linkage	Strong	Strong	•Customer expectations •Health
Class-IV	Driving	Strong	Weak	•Meeting fulfilment timeline •Types of goods Achieving routing efficiency

Level I: level one has three factors, which are factor 3, 7 and factor 8.

All the other factors (except F8) influence first level factor 3 and 7. Further, the other factors (except F3, F4, F7 and F9) influence the first level factor F8.

4.2 MICMAC analysis

MICMAC involves the categorization of the factors identified into four classes (Suresh et al. 2019a, b, 2021b, c) as shown in Table 5.

As per the MICMAC analysis, the factors influencing the last mile delivery are ranked (Suresh and Yogesh 2021) in Table 6.

Figure 3 depicts the MICMAC graph. Table 6 shows the ranking of the factors influencing the last mile delivery during Covid-19. According to the ranking, meeting fulfilment timeline is the triggering factor, that is ranked one and the issues from customers' side is the factor that is ranked sixth in the MICMAC analysis (Fig. 3).

5 TISM validation

To further validate the links between enablers, identified using the TISM method, the response of twelve respondents with more than 3 years of experience was selected, and quantitative analysis was carried out. A total of 22 links were considered for validation, and these links were taken from the interaction matrix. The responses were collected using a five-point Likert scale ranging from 1 to 5, (based on the strength of influences between the factors) i.e., "no influence",'low influence', 'moderate influence', 'high influence', 'very high influence' respectively.

Research hypotheses are as follows:

H0 There is no significant difference between the observed mean and specified mean in relation to opinion of current experts.

HA There is a positive significant difference between the observed mean and specified mean in relation to opinion of current experts.

Table 6 Ranking of factors for the last mile delivery during Covid-19 era

Factor	Driving power	Dependence	Driving power/ dependence	MICMAC rank
F1	5	5	1.000	4
F2	5	5	1.000	4
F3	2	9	0.222	5
F4	3	3	1.000	4
F5	6	1	6.000	2
F6	6	1	6.000	2
F7	2	9	0.222	5
F8	1	6	0.167	6
F9	4	1	4.000	3
F10	7	1	7.000	1

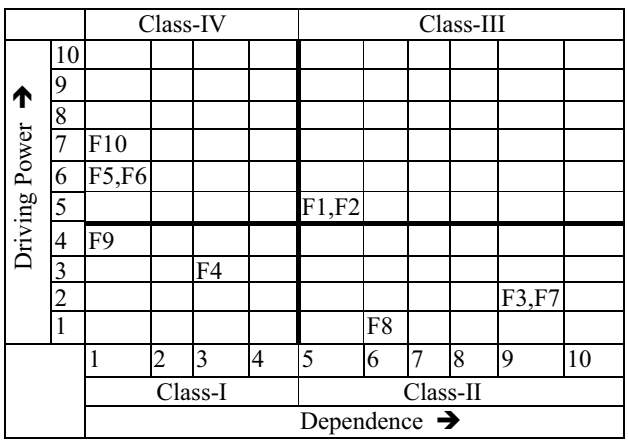

Fig. 3 MICMAC graph

i.e. H0: mean (observed)—mean (specified) = 0.
HA: mean (observed)—mean (specified) > 0.
Here, degree of freedom = 12–1 = 11.

A one-tailed one-sample t-test was found appropriate to test the hypotheses. The "hypothetical mean value" was set as 3.5. To run the t-test, Microsoft Excel was used. On the basis of the sample statistics and t-values, the results of hypotheses testing are shown in Table 7. At a 5 percent significance level, all those links that had a value less than 0.025 (significance value for a one-tailed test) were accepted, and other links were rejected (Menon and Suresh 2021c). Out of 22 links, the majority of the links were accepted and only four transitive links got rejected.

6 Theoretical and practical implications

In this study, develops conceptual framework using theory building apparoch like TISM. It has been used to develop a theoretical framework, through the principles established in the current literature and experts opinion (Corbin and Strauss 1990). TISM anwer the following key questions of what', 'how', and 'why' (Vaishnavi et al. 2019a). The identified major factors related to last mile delivery projects during Covid-19 era answers answer 'what'. The interrelationship between the pair of factors aswers 'how'. The interpretation of pair of factors provides the causality to answer 'why'(Sushil 2012). Dubey et al. (2015) and Dubey et al. (2017) have developed theoritical frameworks for sustainable manufacturing and green supply chain networks respectively by using TISM to answer the of 'what', 'how' and 'why'questions.

The key factors influencing the last mile delivery projects during Covid-19 era are meeting fulfilment timeline, types of goods, achieving routing efficiency. Using the findings of TISM model often makes better the possibility of more effective use of capital to balance key factors, rather than attempting to do the same through simplistic reasoning. The results would help the management to prioritize its activity so as to streamline its project execution during Covid-19 era. The present research has delved deep into the repercussions of the last mile delivey projects during pandemic on the cash flow, availability of delivery staff, movement of products, contractual obligations being infringed, transportation bottlenecks and degradation of perishible products. This gives a clear picture to the management as to which areas need to be addressed as to maximize the performance of delivery projects. This model would help the management to decide areas where immediate resumption of work is viable in terms of minimum disruption due to the various factors that can slow down delivery. It gives a clear picture to the management about the important precautions that they need to look into like establishing a steady flow of staff reserves to keep the projects up and going.

Table 7 Results of hypothesis testing

Sl. No	Factors linked	Mean	SD	t-value	Sig. (1-tailed)	Accept/reject
F1-F2	Customer expectations has an influence on health	3.833	0.389	2.966	0.00641	Accept
F1-F3	Customer expectations has an influence on delivery density	3.833	0.937	1.231	0.12186	Reject
F1-F8	Customer expectations has an influence on Issues from customers' side	4	0.426	4.062	0.00093	Accept
F2-F1	Health has an influence on customer expectations	3.833	0.389	2.966	0.00641	Accept
F2-F3	Health has an influence on delivery density	3.916	0.514	2.803	0.00859	Accept
F3-F7	Delivery density has an influence on Infrastructure	3.916	0.514	2.803	0.00859	Accept
F4-F3	Cost of last mile delivery has an influence on delivery density	4	0.603	2.872	0.00758	Accept
F4-F7	Cost of last mile delivery has an influence on Infrastructure	3.916	0.514	2.803	0.00859	Accept
F5-F1	Types of goods has an influence on customer expectations	4	0.603	2.872	0.00758	Accept
F5-F2	Types of goods has an influence on health	4	0.426	4.062	0.00093	Accept
F5-F7	Types of goods has an influence on infrastructure	3.833	0.389	2.966	0.00641	Accept
F5-F8	Types of goods has an influence on issues from customers' side	3.583	0.514	0.560	0.29314	Reject
F6-F1	Achieving routing efficiency has an influence on customer expectations	3.833	0.389	2.966	0.00641	Accept
F6-F2	Achieving routing efficiency has an influence on health	4.083	0.668	3.022	0.00580	Accept
F6-F3	Achieving routing efficiency has an influence on delivery density	3.833	0.389	2.966	0.00641	Accept
F7-F3	Infrastructure has an influence on delivery density	3.916	0.288	5	0.00020	Accept
F9-F4	Unpredictability in transit has an influence on cost of last mile delivery	3.833	0.389	2.966	0.00641	Accept
F10-F1	Meeting fulfilment timeline has an influence on customer expectations	4	0.603	2.872	0.00758	Accept
F10-F2	Meeting fulfilment timeline has an influence on health	3.666	0.492	1.172	0.13286	Reject
F10-F3	Meeting fulfilment timeline has an influence on delivery density	3.666	0.492	1.172	0.13286	Reject
F10-F4	Meeting fulfilment timeline has an influence on cost of last mile delivery	3.916	0.514	2.803	0.00859	Accept
F10-F7	Meeting fulfilment timeline has an influence on infrastructure	4	0.603	2.872	0.00753	Accept

7 Conclusion

The current study has identified the major factors that would help the management understand the implications of the last-mile delivery projects during Covid-19 era. The factors such as meeting the fulfilment timeline, types of goods and achieving routing efficiency have higher driving potential than the other factors. This paper has used the TISM approach to identify the factors and developed a model that leads to the successful understanding of the factors influencing the last mile delivery projects during the Covid-19 era. The propsed model would definitely improve the performance of the last mile delivery projects and would also help in attaining the goals of both delivery team and logistic organisations. The key factors identified are to support e-commerce and online businesses for the successful implementation of change. The pandemic has resulted in an increase in online purchase and products are delivered at customers' location/home. To cater to the changing delivery needs and delivery mode due to the Covid-19 pandemic disruptions, last mile logistic organizations need to formulate clear and well-defined cloud based planning and optimising processes that would serve as a roadmap for their organizations. The post-Covid-19 e-commerce projects may see integrated growth in new technological tools and applications and a parallel increase in the demand for last mile delivery capabilities. This helps in enriching the process along with solving many pain points faced by the last mile delivery person and the customer based on the factors presented.

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