Analysis of barriers in Adoption of Shared Micromobility in India: An Interpretive Structural modelling approach

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ABSTRACT

Micromobility is emerging at a fast pace in India with many companies investing in this start-ups space. Many cities have introduced shared electric bikes and scooters with perceived benefits of less air and noise pollution, reduction in traffic congestion and as a faster independent alternate mode of transport. With benefits also come challenges in form of "lack of infrastructure", "government support", "public safety", and so on. By overcoming these challenges, this means of transport would gain popularity and people at large would accept and adopt it. This study aims at finding and evaluating the relationship between the barriers which affects the adoption of micromobility in Indian context. The barriers and their relationships were identified based on the literature review done and interviews conducted with operations heads (in the city), managers and associate level employees of a few shared electric mobility companies. There after Interpretive Structural Modelling and MICMAC analysis was conducted based on these inputs. Hence, this study provides an overview of the challenges in the adoption of micromobility and the relationship between of these challenges. This study shows the presence of linkages between the challenges. Hence addressing a few challenges could implicitly address other problems, which could save on resources. Results of this study provides important insights for regulation and policy related to micromobility. An understanding of the barriers would enable better infrastructure planning and policy making by government, practitioners and researchers.

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Introduction

Metros as well as tier 1 and 2 cities have been struggling with problems related to transportation system like increased level of air pollution, congested roads, non-availability of parking space, improper infrastructure for walking and cycling. The city planners are trying to mitigate the same. One such solution is shared micromobility adoption which tackles the above mentioned challenges (Eccarius & Lu, 2020). According to a survey conducted by Council on Energy, Environment and Water (CEEW) in 2019, 70 percent of the Urban Indian Population travels less than 10 KMs and average time taken to travel is up to 27 Minutes. For their weekly needs, more than half the population walks while around 51 percent use personal Motorbikes. Majority of people belonging to each group 18-34 years use modes such as public transport, Non-motorized and shared Vehicles as well as walking. Micromobility can be the answer to the travel requirements in India (Mobility & Preferences, 2019). Micromobility refers to the use of powered two wheeler vehicles for the purpose of shorter trips as personal transport. Its perceived benefits are reducing carbon footprints, reduction in congestion and affordable to all socio economic classes (Eccarius and Lu,2020). Tice (2019) mentions that micromobility promises the challenges of overcoming first and last mile travel but there is still challenges which the segment faces in form of parking, storage and operations.

A careful transition is needed to overcome the resistance to the adoption of the new innovation such that it does not disturb the existing power structures (Gössling & Cohen, 2014). With literature focused on individual barriers to adoption of micromobility and challenges faced, there is a need to form linkages and connections between the challenges in a structural form in order to understand them better. A technology will become preferable to a customer when it is convenient to use (Davis, 1993). For making a service convenient, various barrier to adoption must be addressed. This study focuses on listing the various barriers and establishing a structural relationship between them. By making use of Interpretive Structural Modelling (ISM), the relationship between various barriers will can analysed. A framework to tackle the barriers can be derived from the resulting model which can be used by city planners, shared micromobility providers and Government agencies to formulate a strategy for smooth adoption of micromobility in India.

Literature Review

A field study was conducted by Hardt and Bogenberger (2016) in Munich, Germany to gauge the attitude of users towards Electric Scooter in an Urban Environment. According to their study E-Scooter is sufficient for majority of daily trips while the problems faced was mainly related to safety, weather conditions and baggage capacity. Eccarius and Lu (2020) conducted a survey amongst university students in Taiwan to understand the factors which affect the adoption of micro mobility. This study was mostly concentrated on usage intentions for Electric Scooter sharing (ESS) of students aged 18-24 years which concluded that Awareness knowledge about ESS and its environmental values influence usage among students. Kim et al. (2015) conducted a research on exploring factors affecting Electric Vehicle Sharing Program (EVSP) which suggested that economic and social perspective has a significant impact on user attitude. El-Assi et al. (2017) analysed factors affecting shared bike ridership in Toronto, it is concluded that built environment and weather affects the bike ridership.

This section summarizes the challenges identified by various researchers.

2.1. Awareness among Masses - Eccarius & Lu (2020) studied the awareness among the university students on using micromobility for their daily trips. Ability of the students to recognise the benefits of using this mode was found to affect their usage intention. Awareness-knowledge was found to influence the behaviour and attitude towards using micromobility.

2.2. Lack of Infrastructure – Charging, Parking and Riding: It is mentioned that cycling infrastructure was broadly seen as an effective measure for micromobility adoption. From this survey it was also seen that developing bike sharing ecosystems and public ebike charging stations can be effective. Both the docked and dockless micromobility services have their own set of challenges when it comes to parking. Infrastructure has to be created for docked which can sometimes cause inconvenience to the pedestrians while dockless vehicles can be parked anywhere which again creates public inconvenience and there is chance of vehicle damaging (Aono & Bigazzi, 2019).

2.3. Regulation - Aono & Bigazzi (2019) carried out a survey amongst industry stakeholders in US, where regulation was one of the major factors impacting the adoption of micromobility. Three specific regulations essential emerged for ebikes and they were: regulation of speed, licensing, and age restrictions.

2.4. Government Support – Meng et al. (2020) state that for implementing a multimodal shared mobility a collaborative partnership between shared mobility providers and government is required to build a merit based business model to achieve infrastructure provision and smart technology. Government of India launched FAME II in 2019, a capital subsidy scheme for Electric Vehicles incentivising demand side and in Union Budget 2019 a GST of 12 percent was brought down to 5 percent for EV buyers (Mobility & Preferences, 2019).

2.5. Operations heavy – A BCG article by Schellong et al. (2019) states that shared micromobility providers face the biggest challenge in providing customer service because shared micromobility is an operation intensive field. The customer wants a vehicle fully charged at the right place, right time and also in good condition. All these tasks incur a lot of cost. Micromobility will be used in neighbourhoods within a range of 0 to 10 Km. Shared Micromobility being a new and rising business segment will see a lot of players providing best service at a low cost. Tackling operations becomes a critical need as it incurs cost on part of the company.

2.6. Asset heavy – After the operations, the biggest cost for shared micromobility are assets in form of different types of powered two wheelers which requires four months for a company to breakeven if we don't consider marketing and overhead expenses. The maintenance cost also adds on to it because these vehicles were not designed for shared use (Schellong et al., 2019). Fitting various tracking devices and locking systems also contribute to cost.

2.7. Weather/Road Conditions – Hardt & Bogenberger (2019) conducted a pilot project in Munich, Spain where it was found from the pre and post survey that weather conditions also affected the usage of escooter. Daniel Schellong et al. (2019) also state escooters are ill suited for hilly terrain as well as inclement weather. But the service providers are in talk with the manufactures about changes in next generation products which will address these issues.

2.8. Public Safety - Safety - The safety concerns related to using micromobility is specified related to helmets, speed limits, accidents and parking locations (Allem & Majmundar, 2019; Badeau et al., 2019). In India, vehicles below 250W and less than 25km/hr speed are not classified as motor vehicles and the rules are not applicable to them such as license, helmet etc. same as in case of bicycles. As per the Central Motor Vehicle (Eighteenth) Amendment Rules 2018 notified on December 20 in the gazette, teenagers between 16 and 18 years will be able to obtain a license for electric scooters with a maximum restricted speed of 70 km per hour (Baishali Adak, 2020).

2.9. Rapid Change in Technology - mentions that rapid change in technology is also changing the transportation landscape which might quickly replace an existing technology. It also mentions that vehicle automation is among the top ten technology disruptors (Bagloee et al., 2016). As technology changes, the cost to upgrade an asset heavy transportation segment can go up considering the many start-ups emerging to take advantage of the novice market.

2. 10. Misuse/theft of Asset – The misuse of shared vehicles due to irresponsible behaviour of the rider, vandalism and theft have been reported. This creates a negative impact while introducing a technology or a service (Stefan Gössling, 2020). Misuse of assets also increases cost to the company.

Table 1 represents a summary of the variables identified along with the depiction of these variables for ISM analysis.

Table 1: Summary of Variables Identified from Literature Review

Variables	**Depiction**	**Description**	**Reference**
Awareness among Masses	1	Knowledge based Awareness	Eccarius & Lu, (2020)
Lack of Infrastructure	2	Charging, parking and riding lanes	Aono & Bigazzi, (2019)
Regulation (Policies and legislation)	3	Licensing, Helmet protection, speed limits, parking rules etc.	Aono & Bigazzi, (2019)
Government Support	4	Various tax exemption, infrastructural planning policies	Meng et al, (2020)
Operations heavy	5	Frequent Charging, Making bikes accessible at right place, time etc.	Schellong et al, (2019)
Asset heavy	6	The fleet is owned by the company unlike shared Cab model where the company plays the role of aggregator.	Schellong et al, (2019)
Weather	7	Weather conditions like Rains, temperature affects usage intention	Hardt & Bogenberger, (2019)
Public Safety	8	Accident due to lack of separate lanes for low speed vehicles, Usage of pedestrian paths to ride two wheelers causing safety issues.	Allem & Majmundar, (2019) Badeau et al, (2019) Baishali Adak, (2020).

Rapid Change in Technology	9	Transport sector is booming with disruptive technology like Automated Vehicles, Self-driving cars etc. Alignment with technology becomes important	Bagloee et al., (2016)
Misuse/theft of Asset	10	Cases of Misuse of Shared Two wheelers incurs cost to the company as it owns the asset.	Gössling, (2020)

Methodology

This study is exploratory in nature, as not much research is conducted on the acceptance of micromobility in the Indian context. The literature was reviewed which led to the identification of 10 barriers (variables for the sake of this study) for the adoption of shared micromobility in India. Data was collected on the 10 barriers identified for this study.

Three Telephonic interviews were conducted with the city manager, operations manager and associate level employees of two shared micromobility start-ups in India. These units of analysis were experts in their field. Given the exploratory nature of the study, inputs generated from these experts through interviews were used for further analysis.

The experts gave their opinion on whether the identified barriers were applicable in Indian context. They briefly described the operations of a micromobility start-up and how these barriers affect these activities. The opinions which were mutual were taken into evaluation. A mental model of relationship between the variables was also discussed. For structural analysis, a questionnaire was filled by the experts. It consisted of questions which evaluated the relationship between the barriers. For example, experts were asked if "Awareness among Masses" and "Misuse/theft of Asset" were related to each other. If they are related to each other, does solving barrier "Awareness among Masses" solve the challenge of "Misuse/theft of Asset" and vice versa or do they mutually affect each other. Similarly, all the barriers were pairwise evaluated and this data was analysed using "Interpretive Structural Modelling (ISM)". Interpretive Structural Modelling tool was used to establish structured relationship between variables and formulate a model which can be used to further analyse the challenges and their effect on each other. Interpretive Structural Modelling was developed by (Warfield, 1974). ISM has been extensively used in researches related to social science. It helps in establishing relationships between variables when there is limited research related to it (Dubey & Ali, 2014). ISM imposes order in complex variables and its interconnections. ISM is a concept which uses practical experience of experts to develop a simple model of interconnections between the complex variables (Cherrafi et al., 2017). The tool Matlab was used for processing ISM.

Data Analysis:

Relationships between variables were established based on literature reviewed and expert opinions gathered through interviews. ISM followed by MICMAC was conducted for analysing and arriving at the proposed model.

4.1. ISM analysis

The ISM methodology includes the following steps:

1. To make a list of various variables related to the problem based on Literature review
2. Developing a questionnaire to establish relationship between all the variables on one to one basis.
3. Creating a conceptual Model
4. A "Structural Self-Interaction Matrix (SSIM)" (Table 2) is to be developed.
5. Formation of Initial Reachability Matrix (Table 3)
6. In ISM assumes transitivity between variables as its conceptual methodology. For example, if A and B variables are related and B and C are also related then there is a relationship between A and C also. So a transitivity check is done.
7. A "Final reachability matrix" is formed (Table 4).

8. Level Partitioning: Based on the relationship between the variables, a reachability set, antecedent set and intersection sets are formed. When the antecedent set and interaction set are similar a level is formed for a given variable. These levels are used to build the structural model (Table 5).
9. Matriced' Impact Croise's Multiplication Appliqee (MICMAC) Analysis is done to classify variables in different categories (Figure 1).

Based on the following criteria a "Structural Self-Interaction Matrix (SSIM)" matrix was developed:

1. V: If solving Barrier i solves barrier j.
2. A: If solving Barrier j solves barrier i.
3. X: Both the Barrier affect each other.
4. O: No relationship between Barriers

Table 2: "Structural Self-Interaction Matrix (SSIM)" for each pair of variables

Barriers (i,j)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Awareness among Masses	X	V	A	A	O	O	O	V	O	V
Lack of Infrastructure		X	X	A	X	O	O	V	A	V
Regulation (Policies and legislation)			X	X	V	V	O	X	V	V
Government Support				X	V	V	O	V	O	V
Operations heavy					X	O	O	V	A	X
Asset heavy						X	O	O	O	O
Weather							X	O	O	O
Public Safety								X	A	O
Rapid Change in Technology									X	V
Misuse/theft of Asset										X

Initial Reachability Matrix (Table3): It was generated by using the following steps:

1. If V is the entry in the matrix, then (i,j) entry will be 1; while the corresponding (j,i) becomes 0.
2. If A is the entry in the matrix, then (i,j) entry will be 0; while the corresponding (j,i) becomes 1.
3. If X is the entry in the matrix, then (i,j) entry will be 1; while the corresponding (j,i) becomes 1.
4. If O is the entry in the matrix, then (i,j) entry will be 0; while the corresponding (j,i) becomes 0.

Table 3: Generating reachability matrices by using the SSIM

Barriers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	1	1	0	0	0	0	0	1	0	1
2	0	1	1	0	1	0	0	1	0	1
3	1	1	1	1	1	1	0	1	1	1
4	1	1	1	1	1	1	0	1	0	0
5	0	1	0	0	1	0	0	1	0	1
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	1	0	0	0	0	1	0	0
9	0	1	0	0	1	0	0	1	1	1
10	0	0	0	0	1	1	0	0	0	1

The further process of generating to check the transitivity and level partitioning was done using Matlab in order to form the "Final reachability matrix".

Table 4: Final reachability Matrix

Barriers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Driver**
1	1	1	1	1	1	1	0	1	1	1	**9**
2	1	1	1	1	1	1	0	1	1	1	**9**
3	1	1	1	1	1	1	0	1	1	1	**9**
4	1	1	1	1	1	1	0	1	1	1	**9**
5	1	1	1	1	1	1	0	1	1	1	**9**
6	0	0	0	0	0	1	0	0	0	0	**1**
7	0	0	0	0	0	0	1	0	0	0	**1**
8	1	1	1	1	1	1	0	1	1	1	**9**
9	1	1	1	1	1	1	0	1	1	1	**9**
10	1	1	1	1	1	1	0	1	1	1	**9**
Dependence	**8**	**8**	**8**	**8**	**8**	**9**	**1**	**8**	**8**	**8**	

From the final reachability matrix, we calculate the driving and dependence power which depicts the function of the variable in the structure.

Table 5: Level Partitioning the "Final Reachability Matrix"

Barriers	**Driving Power**	**Level**
[6,7]	1	1
[1,2,3,4,5,8,9,10]	9	2

4.2 MICMAC Analysis

MICMAC is used to analyse the driving and dependence power of the barriers. The driving and dependence power are calculated from the final reachability matrix by adding summing the rows and columns respectively. The driving power of the variable depicts the impact it has on other variable while the dependence power depicts how much the variable is impacted by other variables (Kumar et al., 2016). Table 4 shows the driving and dependence power of the variables.

Based on the powers, the variables are divided into four clusters:

1. Autonomous: The cluster labelled as Autonomous variables have no relationship with other variables that is weak driving and dependence power. Weather Conditions (7) is an Autonomous factor, which does not drive to solve the barriers nor is it impacted by any other barrier.
2. Dependent: The cluster labelled as dependent variables have weak driving power but strong dependence power. Variable 6 which is Asset heavy depends on the other variables so it is categorized as dependent variable.
3. Driving: The cluster labelled as driving variables have strong driving power but weak dependence power. No barriers were classified as driving barriers.
4. Linkage: The cluster labelled as Linkage variables have strong driving as well as dependence power. When variables are directly or indirectly (through transitivity) dependent on each other they are called linkage variables. Barriers (1,2,3,4,5,8,9,10) are linkage variables.

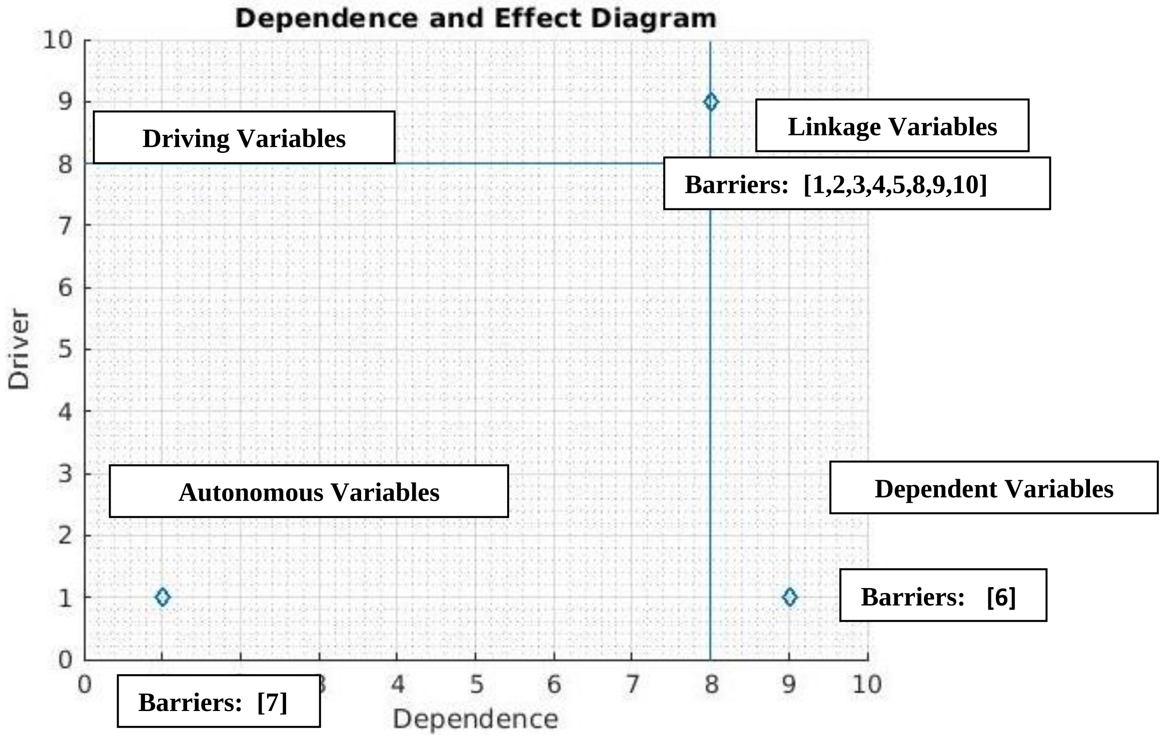

Figure 1: Dependence and Effect Graph using MICMAC Analysis

Discussion and Conclusion

Micromobility as a new transportation technology is just emerging that is why we see a strong linkage between variables (1,2,3,4,5,8,9,10). From the reachability matrix (Table3) we can see that Awareness among masses impacts the infrastructure, public safety and misuse of the vehicles. Usage intention is linked to Awareness as mentioned by (Eccarius & Lu, 2020). As the users get knowledge about the way this mobility works, it impacts other factors according to the final reachability matrix (Table 4). As users start using this mode of transport, there will be a need of Infrastructure for ease of use. If this problem gets solved it will enable policy makers to make proper regulations. In the same way if regulations or policies are in place public safety challenge will be mitigated.

From the above discussion we can conclude that addressing one barrier can affect the other barriers as well. For an emerging mobility option like micromobility a proper framework of policies and government support will enable a cascading effect on building of infrastructure, public awareness and safety etc. A lot of problems in operations of a shared mobility companies are caused due to the lack of infrastructure, policies, regulations and vehicle misuse. As one of these barriers are solved the operations will be optimized and cost efficient. When it comes to companies being asset heavy, ease of operations will take care of the efficient and optimal use of resources. A framework is required to be formed by the policy makers as to which barrier is easy to solve first in order to have that cascading effect. This study enabled us to categorize the barriers and how each barrier will impact the other. It provides the policy makers a start to look at the challenges in a more structured way so the adoption of micromobility can replace ICE vehicles for shorter trips.

Limitations & Scope for Future Research

The limitation of Interpretive Structural Modelling is that it is based on expert's personal opinion so it does not have a statistical significance as which variable has the most or least impact. To overcome this drawback multiple interviews were conducted. Further research can be undertaken to gauge the impact a variable will have on the other and which variable should be considered first. Individual barriers can be studied in-depth and possible solutions can be proposed in context of different geographic locations and cultures.

References

[1] Allem, J. P., & Majmundar, A. (2019). Are electric scooters promoted on social media with safety in mind? A case study on

Bird's Instagram. Preventive Medicine Reports, 13(November 2018), 62–63. https://doi.org/10.1016/j.pmedr.2018.11.013

[2] Aono, S., & Bigazzi, A. (2019). Industry Stakeholder Perspectives on the Adoption of Electric Bicycles in British Columbia. Transportation Research Record, 2673(5), 1–11. https://doi.org/10.1177/0361198119837158

[3] Badeau, A., Carman, C., Newman, M., Steenblik, J., Carlson, M., & Madsen, T. (2019). Emergency department visits for electric scooter-related injuries after introduction of an urban rental program. American Journal of Emergency Medicine, 37(8), 1531–1533. https://doi.org/10.1016/j.ajem.2019.05.003

[4] Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016). Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. Journal of Modern Transportation, 24(4), 284–303. https://doi.org/10.1007/s40534-016-0117-3

[5] Cherrafi, A., Elfezazi, S., Garza-Reyes, J. A., Benhida, K., & Mokhlis, A. (2017). Barriers in green lean implementation: A combined systematic literature review and interpretive structural modelling approach. Production Planning and Control, 28(10), 829–842. https://doi.org/10.1080/09537287.2017.1324184

[6] Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. In International Journal of Man-Machine Studies (Vol. 38, Issue 3, pp. 475–487). https://doi.org/10.1006/imms.1993.1022

[7] Dubey, R., & Ali, S. S. (2014). Identification of flexible manufacturing system dimensions and their interrelationship using total interpretive structural modelling and fuzzy MICMAC analysis. Global Journal of Flexible Systems Management, 15(2), 131–143. https://doi.org/10.1007/s40171-014-0058-9

[8] Eccarius, T., & Lu, C. C. (2020). Adoption intentions for micro-mobility – Insights from electric scooter sharing in Taiwan. Transportation Research Part D: Transport and Environment, 84, 102327. https://doi.org/10.1016/j.trd.2020.102327

[9] El-Assi, W., Salah Mahmoud, M., & Nurul Habib, K. (2017). Effects of built environment and weather on bike sharing demand: a station level analysis of commercial bike sharing in Toronto. Transportation, 44(3), 589–613. https://doi.org/10.1007/s11116-015-9669-z

[10] Gössling, S. (2020). Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change. Transportation Research Part D: Transport and Environment, 79, 102230. https://doi.org/10.1016/j.trd.2020.102230

[11] Gössling, S., & Cohen, S. (2014). Why sustainable transport policies will fail: EU climate policy in the light of transport taboos. Journal of Transport Geography, 39, 197–207. https://doi.org/10.1016/j.jtrangeo.2014.07.010

[12] Hardt, C., & Bogenberger, K. (2019). Usage of e-Scooters in Urban Environments. Transportation Research Procedia, 37(September 2018), 155–162. https://doi.org/10.1016/j.trpro.2018.12.178

[13] Kim, D., Ko, J., & Park, Y. (2015). Factors affecting electric vehicle sharing program participants' attitudes about car ownership and program participation. Transportation Research Part D: Transport and Environment, 36, 96–106. https://doi.org/10.1016/j.trd.2015.02.009

[14] Kumar, S., Luthra, S., Govindan, K., Kumar, N., & Haleem, A. (2016). Barriers in green lean six sigma product development process: An ISM approach. Production Planning and Control, 27(7–8), 604–620. https://doi.org/10.1080/09537287.2016.1165307

[15] Meng, L., Somenahalli, S., & Berry, S. (2020). Policy implementation of multi-modal (shared) mobility: review of a supply-demand value proposition canvas. Transport Reviews, 40(5), 670–684. https://doi.org/10.1080/01441647.2020.1758237

[16] Mobility, S., & Preferences, C. (2019). How Urban India Moves. October.

[17] Schellong, D., Sadek, P., Schaetzberger, C., & Barrack, T. (2019). The Promise and Pitfalls of E-Scooter Sharing. Boston Consulting Group, 1–14.

[18] Tice, P. C. (2019). Micromobility and the Built Environment. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 63(1), 929–932. https://doi.org/10.1177/1071181319631430

[19] Warfield, J. N. (1974). Developing Interconnection Matrices in Structural Modeling. IEEE Transactions on Systems, Man and Cybernetics, SMC-4(1), 81–87. https://doi.org/10.1109/TSMC.1974.5408524