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"Reforming Urban Commute with Shared E-Scooters: A Study on Bangalore Urban Market"

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Abstract

Urbanization is increasing in leaps and bounds as these promising places are turning to be hubs for commerce, opportunities, and innovation. Growing urban cities demand better planning and innovative methods to help people commute better. Shared e-scooters are considered as a viable solution in various countries as a solution to the traffic woes. In this context we tried to gain answers to the research questions:1. What are the various factors which influence the adoption of shared e-scooters in Bangalore urban market? 2. Which of these factors have a major influence on the adoption behaviour of the Bangalore urban people? 3.What are the key demographic traits of individuals using shared e-scooters in Bangalore? The study also identifies the various research gap identified by the authors, which can prompt further research. Jamovi 2.3.28 has been used for statistical analysis. Effort has been made to understand and list out the factors that can influence the diffusion of shared e-scooters in the Bangalore urban market.

Keywords: *e-scooters, micromobility, shared-scooters, adoption behaviour, urban mobility, shared micromobility*

Introduction

In recent times, urban transportation has seen notable changes due to technological advancements and a shift towards sustainable mobility options. One such development is the rise of shared electric scooters (e-scooters) as an attractive choice for urban travellers. These compact and eco-friendly vehicles offer a convenient and economical way to travel short distances in cities. We often notice the stylish scooters zoom passing us silently yet efficiently, carrying with them a host of promises from environmental benefits to reducing monthly expenditure. The increasing popularity of electric scooters can be attributed to their potential to address various urban challenges, including traffic congestion, air quality issues, and energy consumption. These micro-mobility solutions offer several advantages, such as reducing traffic congestion, emitting fewer pollutants, and consuming less energy compared to traditional vehicles.

Fossil fuel is non-renewable in nature and is posing a threat to the environment, with their usage contributing significantly to pollution and health hazards. Petrol and diesel vehicles emit harmful substances that have long-lasting negative effects on public well-being. In contrast, electric vehicles exhibit substantially lower emissions, making them a more sustainable choice. From an efficiency standpoint, electric scooters are superior, converting a higher percentage of electrical energy from the grid into usable power for propulsion compared to traditional fuel-powered vehicles. This efficiency gap highlights the inefficiency of fossil fuel vehicles, which waste a significant portion of energy stored in fuel. Moreover, electric vehicles produce zero tailpipe emissions, offering a cleaner alternative for transportation. Even when accounting for electricity generation, electric vehicles emit significantly less carbon dioxide than their petrol or diesel counterparts. India's ambitious goal to derive a substantial portion of its electricity from non-fossil fuel sources by 2030 further underscores the importance of transitioning to electric vehicles. Given these considerations, electric scooters represent the future of transportation in India, offering a sustainable solution to mitigate environmental impact and promote cleaner air and public health (India, Niti Ayog, 2024).

Bangalore, known for its bustling streets and increasing population, has been proactive in adopting new mobility solutions to tackle issues like traffic congestion, pollution, and accessibility. The introduction of shared e-scooters has generated interest and discussions among policymakers, transportation experts, businesses, and commuters about their potential to transform urban commuting in Bangalore (Alberica Domitilla Bozzi, 2021). Given this context, shared electric scooters have emerged as a practical choice for city travellers seeking efficient, cost-effective, and environmentally conscious transportation options. These electric-powered scooters, available without fixed docking stations, provide a convenient solution for covering short distances within urban areas, especially for the final leg of a journey. The incorporation of shared e-scooters into Bangalore's urban transportation system has attracted significant attention from various stakeholders, including government officials, city planners, transportation experts, businesses, and the general populace. This has prompted essential inquiries regarding the effects of shared e-scooters on urban travel dynamics, traffic flow, air quality, user habits, regulatory frameworks, and market conditions (India, 2024).

Literature review

This section has been divided into two sections. A) Bibliometric analysis B) systematic literature review. Bibliometric analysis was used to identify the research gap and systematic literature review was used to identify the factors affecting the adoption of shared e-scooters.

Bibliometric analysis to understand the research gap
Articles relevant for the study were sourced from Elsevier journal. Elsevier journal is a popular journal which covers vast aspects of transportation related studies. Keywords "India" and "e-scooters" and "Adoption behaviour" and "electric vehicles" were used. Total of 595 articles were studied using VOS Viewer. Keyword co-occurrences was studied on full counting basis. Minimum number of occurrences was fixed at 3 owing to the recentness of the technology. Following is the visual representation of the keyword density.

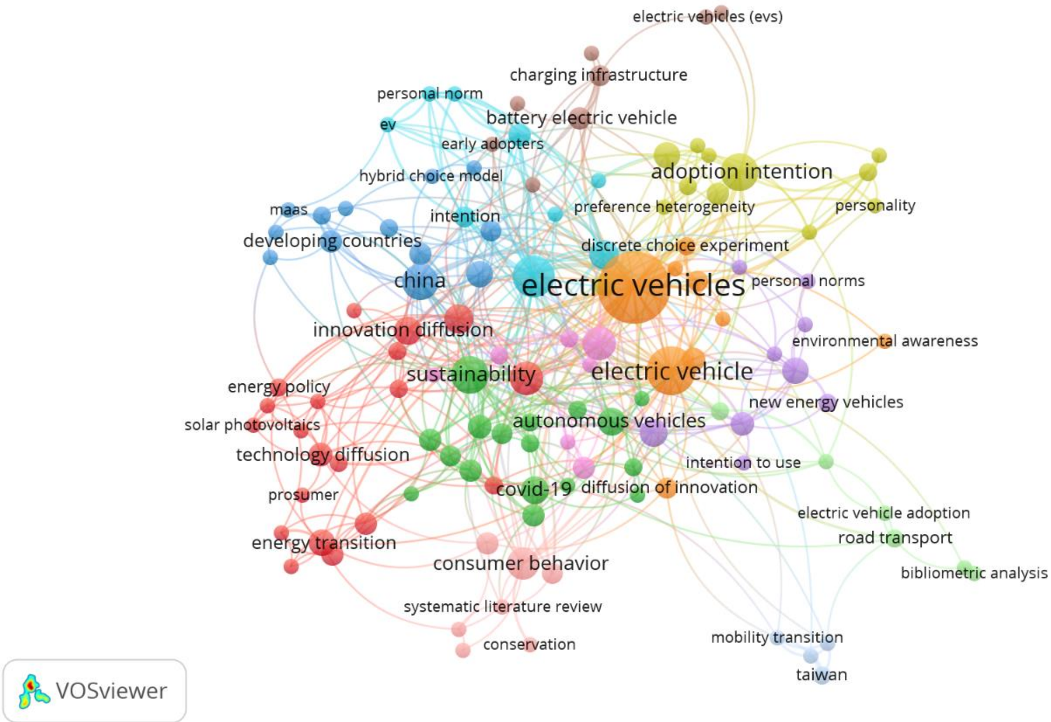

Figure 1: Bibliometric analysis of "India" and "e-scooters" and "Adoption behaviour" and "electric vehicles"
Source: https://tinyurl.com/2xtjbcuj

The keyword "shared mobility" which is of interest for the current study was picked up for analysis. This key word belongs to cluster 9 with a total link strength of 7 with occurrence of 3. This shows that of the total 595 articles, the keyword "shared mobility" has been used only thrice. This establishes the scope of study available for "shared mobility" or "shared e-scooter."

Systematic literature review
The documents for the study were extracted using "e-scooters," "shared mobility" and "urban mobility" as keywords. On various databases the combination of the mentioned keywords was searched. The search words were "Shared mobility" And "e-scooters" and "Shared micromobility specifically electric scooters" and "urban mobility." Articles were sourced from various databases like Scopus, Elsevier, and Springer. These databases were searched using the search engines like science direct, ebsco, Web of science and google scholar. In all, 954 articles were selected. The inclusion and exclusion criteria and the resulting number of articles are as follows. Articles published between 2019-2023 were selected for the study. This is because, the density of the did not reduce much by including one previous year. Which meant most of study relevant for out article were published after 2019. This resulted in 640 articles. Both research and review articles have been studied for the article. Further, Social sciences, business management and accounting domain were selected which meant excluding the other domains, specifically engineering domain as it is not relevant for this study. Some of the search engines had articles published in other languages as well. Hence articles in English language alone were selected. Also peer reviewed papers only were selected which resulted in 268 articles. Further we selected articles which offer full access. This resulted in a total of 115 articles. These articles were subjected to further scrutinization. 4 articles were duplicated. So they were eliminated resulting in 111 articles. Based on the relevance of the topic further it was trimmed to 70. The last criteria were, the key words must be used either in the topic or in the abstract. Finally based on this inclusion criteria we shortlisted 41 articles for the study.

Snapshot of Literature review

Sl	Authors	Title	Year	Publication	Type	Vehicle	Modality	Geography	Data collection Method	Sample Size	Target Population	Keywords
1	Farzana Mehzabin Tuli, Arna Nishita Nithila, Suman Mitra	Uncovering the spatio-temporal impact of the COVID-19 pandemic on shared e-scooter usage: A spatial panel model	2023	Transportation Research Interdisciplinary Perspectives	Research article	e-scooters	Shared	Austin, Texas	Secondary data	7403230 trip info	General population	Shared micromobility, COVID-19, Random effects, Spatial panel model, Spatio-temporal, Austin city
2	Stefano Carrese , Fabio ’Andreagiovanni , Tommaso Giacchetti , Antonella Nardin , Leonardo Zamberlan	A Beautiful Fleet: Optimal Repositioning in E-scooter Sharing Systems for Urban Decorum	2021	Transportation Research Procedia	Research article	e-scooters	Shared	Rome, Italy	Primary data,	37 time instances	General population	Sharing Mobility, Micromobility, Urban Decorum, Optimization, Matheuristics
3	Marialisa Nigro , Marisdea Castiglione , Fabio Maria Colasanti , Rosita De Vincentis , Carlo Liberto , Gaetano Valenti , Antonio Comi	Investigating Potential Electric Micromobility Demand in the city of Rome, Italy	2022	Transportation Research Procedia	Research article	e-scooters and e-bikes	Shared	Rome, Italy	Secondary data	243784 vehicles	General population	micromobility; probe vehicles; Floating Car Data; e-bikes; e-scooters.
4	Benjamin K. Sovacool , Chux Daniels, Abbas Abdul Rafiu	Transitioning to electrified, automated and shared mobility in an African context: A comparative review of Johannesburg, Kigali, Lagos and Nairobi	2022	Journal of Transport Geography	Review article	Automated vehicles, electric mobility,	Shared	Johannesburg (South Africa), Kigali (Rwanda), Lagos (Nigeria) and Nairobi (Kenya)	Secondary data	NA	General population	Low-carbon transitions, Low-carbon mobility, Electric vehicles, Ridesharing, Ride hailing, African transport pathways , Mobility as a service (MaaS), Global South
5	Draženko Glavi´, Marina Milenkovi´ , Aleksandar Trifunovi´ , Igor Jokanovi´and Jelica Komarica	Influence of Dockless Shared E-Scooters on Urban Mobility: WTP and Modal Shift	2023	Sustainability	Journal	Dockless Shared E-Scooters	Shared	Belgrade, Serbia	Primary data,	508	General population	e-scooter sharing; micro-mobility; willingness to use; mathematical model; rental price
6	PAWEŁ PISTELOK , DANIEL ŠTRAUB	It is time to get virtual: limitations of shared e-scooter mobility points, case study in Cracow (Poland)	2022	Institute of Urban and Regional Development	Case STudy	E-scooter	Shared	Cracow, Poland	Primary data,	146	Urban Population	Mobility points – shared e-scooters – shared mobility – public space –

												safety – Cracow
7	Kostas Mouratidis	Bike-sharing, car-sharing, e-scooters, and Uber: Who are the shared mobility users and where do they live?	2022	Sustainable Cities and Society	Journal	Escooter, Car & Bikes	Shared	Oslo, Norway	Primary data,	1796	Urban Population	Shared mobility, Shared electric scooter, Ridesourcing & ridehailing, On-demand transportation services, Sustainable urban mobility, Compact city
8	Camille Krier , Julie Chre´ tien, Marion Lagadic and Nicolas Louvet1	How do shared dockless e-scooter services affect mobility practices in paris? A survey-based estimation of modal shift	2021	Transportation research record	Journal	Dockless E-Scooter	Shared	Paris, France	Primary data,	3536	Urban Population	electric scooter; rental e-scooter; micromobility; micro personal mobility vehicles;
9	Gabriel Dias , Elisabete Arsenio and Paulo Ribeiro	The role of shared e-scooter systems in urban sustainability and resilience during the covid-19 mobility restrictions	2021	Sustainability	Journal	E-scooters	Shared	Braga, Portugal	Secondary data	SLR	Urban Population	micromobility; shared e-scooters; sustainable urban mobility; covid-19; first-mile-lastmile; urban resilience
10	Dibaj, Samira; Hosseinzadeh, Aryan; Mladenović, Miloš; Kluger, Robert	Where have shared e-scooters taken us so far? A review of mobility patterns, usage frequency, and personas	2021	Sustinability	Journal	E-scooters	Shared	Global	Secondary data	Scopus, Web of science, springer	Review Paper	electric scooter; rental e-scooter; micromobility; micro personal mobility vehicles; spatial analysis; temporal analysis; travel behavior; mobility pattern; personas; shared mobility
11	Alberica Domitilla Bozzi and Anne Aguilera *	Shared e-scooters: A review of uses, health and environmental impacts, and policy implications of a new micro-mobility service	2021	Sustinability	Journal	E-scooters	Shared	Global	Secondary data	Scopus, Web of science, springer - 47	Review Paper	shared e-scooters; micro-mobility services; users and uses; health impacts; environmental impacts; public policy
12	Cristopher Siegfried Kopplin , Benedikt Martin Brand ,	Consumer acceptance of shared e-scooters for urban and short-	2021	Transportation Research	Journal	e-scooters	Shared & Private	Germany	Primary data,	749	Urban Population	E-scooters, Technology acceptance,

	Yannick Reichenberger	distance mobility		Part D								Mobility Green consumers, Sustainability, Traffic safety
13	Gustav B¨osehans, Margaret Bell, Neil Thorpe, Dilum Dissanayake	Something for every one? - An investigation of people's intention to use different types of shared electric vehicle	2023	Travel Behaviour and Society	Journal	shared electric vehicle	Shared	Europe Cities	primary data,	2540	Urban Population	Consumer adoption; Electric mobility; Mobility hubs; Shared mobility; Regression
14	Anne Brown	Micromobility, Macro Goals: Aligning scooter parking policy with broader city objectives	2021	Transportation Research Interdisciplinary Perspectives	Journal	Escooter	Shared	US Cities	Secondary data	37	General population	E-scooter; Parking; Shared mobility; Micromobility
15	Natalia Sobrino, Juan Nicolas Gonzalez, Jose Manuel Vassallo ,Maria de los Angeles Baeza	Regulation of shared electric kick scooters in urban areas: Key drivers from expert stakeholders	2023	Transport Policy	Journal	Shared scooters	Shared	Spain	Primary data, Focus Group	62	Urban Population	Micromobility; Electric kick scooter; Shared mobility; Regulation; Transport policy; Focus group
16	Mohamed Abouelela, Emmanouil Chaniotakis, Constantinos Antoniou	Understanding the landscape of shared-e-scooters in North America; Spatiotemporal analysis and policy insights	2023	Transportation Research Part A	Journal	shared–bicycles, e-bikes, skates, self-balancing unicycles, segways, and scooters	Shared	Five North American cities	Secondary data	9 Million	Urban Population	E-scooter-sharing, Dockless-micromobility, E-scooter trips characteristics
17	Ching-Fu Chen, Chiang Fu, Pei-Ya Siao	Exploring electric moped sharing preferences with integrated choice and latent variable approach	2023	Transportation Research Part D	Journal	E-moped	shared	Taiwan	On-line & Onffline	493	Urban Population	E-moped sharing, Preference, Attitudes, Perceptions, Integrated choice and latent variable
18	Alejandro Montes, Nejc Gerˇzinic, Wijnand Veeneman, Niels van Oort, Serge Hoogendoorn	Shared micromobility and public transport integration - A mode choice study using stated preference data	2023	Research in Transportation Economics	Journal	Bus/Tram, Shared Bicycles, Shared Emopeds	Shared	Rotterdam, Netherlands	Primary data,	487	General population	Shared micromobility, Public transport, Mode choice, Choice modelling, Stated choice

19	Aoyong Li , Pengxiang Zhao , Xintao Liu , Ali Mansourian , Kay W. Axhausen ,Xiaobo Qu	Comprehensive comparison of e-scooter sharing mobility: Evidence from 30 European cities	2022	Transportation Research Part D	Journal	E-scooter	Shared	30 European Cities	Primary data,	37 Cities	General population	E-scooter, sharing mobility, Comprehensive comparison, Temporal and statistical distribution, Utilization efficiency, Wasted electricity, COVID-19
20	Ahmad Ilderim Tokey , Shefa Arabia Shioma, Shaila Jamal	Analysis of spatiotemporal dynamics of e-scooter usage in Minneapolis: Effects of the built and social environment	2022	Multimodal Transportation	Journal	E-scooter	Shared	Minneapolis, USA	Primary data,	13367	General population	E-scooter, Micro-mobility, Spatiotemporal pattern, Built environment, Social environment, Land use
21	Simona De Bartolomeoa , Leonardo Caggiania, Michele Ottomanellia	An equity indicator for free-floating electric vehicle-sharing systems	2022	Transportation research Procedia	Conference	Electric vehile	Shared	Bari, Italy	Primary data,	640	General population	equityfree-floatingvehicle-sharing systeme-scooter sharing
22	Jørgen Aarhaug a,b,*, Nils Fearnley a, Espen Johnsson a	E-scooters and public transport – Complement or competition?	2023	Research in Transportation Economics	Journal	Escooters & Public Transport	Shared	Oslo, Norway	Primary data,	1921	Escooter owners	E-scooter, Public transport, Intermodal competition, Oslo Regulation Intermodal trips
23	Fabio D'Andreagiovannia,b,*, Antonella Nardinc, Stefano Carrese	An Analysis of the Service Coverage and Regulation of E-Scooter Sharing in Rome (Italy)	2021	Transportation research Procedia	Conference	e-scooters	shared	Rome, Italy	Secondary data	6	General population	Micromobility; Shared Mobility; E-Scooters; Urban Transport; Geofences; Service Coverage.
24	Tiziana Campisia, Dario Ticalia, Matteo Ignaccolob, Giovanni Tesorierea, Giuseppe Inturric, Vincenza Torrisib	Factors influencing the implementation and deployment of e-vehicles in small cities: a preliminary two-dimensional statistical study on user acceptance	2022	Transportation research Procedia	Conference	e-vehicles	shared	Enna, Italy	Primary data,	40	General population	mobility; bidimensional statistical analysis; sustainable mobility; Likert scale

25	Hugo Badia, Erik Jenelius	Shared e-scooter micromobility: review of use patterns, perceptions and environmental impacts	2022	Transport reviews	Review article	e-scooters	Shared	14 North American states and 5 European countries	Primary data,	19	General population	Dockless e-scooter, free-floating e-scooter shared e-scooter, service micro mobility, sustainable urban transport
26	Khashayar Kazemzadeh , Frances Sprei	Towards an electric scooter level of service: A review and framework	2022	Travel Behaviour and Society	Review article	e-scooters	Shared and privately owned	Articles published on various parts of the world	Secondary data	46	Users and non-users	Electric scooter, Level of service, E-scooter Comfort, Sustainable mobility, Micro-mobility
27	Rebecca L. Sandersa , Michael Branion-Calles , Trisalyn A. Nelson	To scoot or not to scoot: Findings from a recent survey about the benefits and barriers of using E-scooters for riders and non-riders	2020	Transportation Research Part A	Research article	e-scooters	Shared	University staff of Tampe	Survey	1256	Riders and non riders	E-scooters, Electric scooters, Safety Equity, Micro-mobility, Urban mobility
28	Alexandra Bretones , Oriol Marquet	Sociopsychological factors associated with the adoption and usage of electric micromobility. A literature review	2022	Travel Behaviour and Society	Review article	e-scooters	privately owned	General population	Review of published articles	67 research articles	General population	Micromobility, Sociopsychological factors, Electric mobility, Functional values, Non-functional values, Adoption intention
29	Ana Filipa Reis , Patrícia Baptista , Filipe Moura	How to promote the environmental sustainability of shared e-scooters: A life-cycle analysis based on a case study from Lisbon, Portugal,	2023	Journal of Urban Mobility	Review article	e-scooters	Shared	Lisbon, Portugal	Secondary data	NA	CO2 emmision from scooter	Policy-design, Life cycle assessment, Electric scooters, Environmental impacts, Micro-mobility
30	Andrea Chicco a, Marco Diana	Understanding micro-mobility usage patterns: a preliminary comparison between dockless bike sharing and e-scooters in the city of Turin (Italy)	2022	Transportation Research Procedia	Research article	e-scooters	Shared and privately owned	Turin, Italy	Secondary data	32,242 trips	General population	micro-mobility; bike sharing; electric kick scooter; usage patterns; KDE
31	Romano Fistola , Mariano Gallo , Rosa Anna La Rocca	Micro-mobility in the “Virucity”. The Effectiveness of E-scooter Sharing.	2022	Transportation Research Procedia	Research article	e-scooters	Privately owned	Italy	Primary data,	200	General population	Micromobility, e-scooters sharing, Sustainability

32	Rosa Félix, Mauricio Orozco-Fontalvo, Filipe Moura	Socio-economic assessment of shared e-scooters: do the benefits overcome the externalities?	2023	Transportation Research Part D: Transport and Environment	Research article	e-scooters	Shared	Lisbon, Portugal	Primary data,	919	General population	E-scooter impacts, Scooter safety, Scooter externalities, Micromobility benefits, Transport health impacts, Socio-economic assessment
33	Laura Gebhardt , Simone Ehrenberger , Christian Wolf , Rita Cyganski	Can shared E-scooters reduce CO2 emissions by substituting car trips in Germany?	2022	Transportation Research Part D	Research article	e-scooters	Shared	Germany	Secondary data		General population	Micromobility, E-Scooter Potential analysis, Carbon footprint, Greenhouse gas emissions , Environmental implications
34	Kailai Wanga, Xiaodong Qianb, Dillon Taylor Fitch, Yongsung Leee, Jai Malik, Giovanni Circella	What travel modes do shared e-scooters displace? A review of recent research findings	2023	Transport reviews	Review article	e-scooters	Shared	Various countries	Secondary data	Research articles	General population	E-scooters, Micromobility, Mode substitution, Car use, Transportation planning
36	Bach, Xavier; Marquet, Oriol; Miralles-Guasch, Carme	Assessing social and spatial access equity in regulatory frameworks for moped-style scooter sharing services	2023	Transport Policy	Research article	Motorcycles	Individual and rented	Barcilona	Primary data	15 respondents	General population	Moped-style scooter sharing, Micromobility, Shared mobility, Equity, Transport policy, Pub'lic-private collaboration
37	Panagiotis G. Tzouras a, Lambros Mitropoulos b, Eirini Stavropoulou b, Eleni Antoniou a, Katerina Koliou a, Christos Karolemeas c, Antonis Karaloulis c, Konstantinos Mitropoulos b, Marilena Tarousi b, Eleni I. Vlahogianni d, Konstantinos Kepaptsoglou a	Agent-based models for simulating e-scooter sharing services: A review and a qualitative assessment	2023	International Journal of Transportation Science and Technology	Review article	e-scooters	Shared e-scooters	260 European cities	Secondary data	Males aged between 18 and 54	General population	E-scooter Agent-based models, Micromobility, Traffic simulation, Qualitative assessment

38	Mouratidis, Kostas; Peters, Sebastian; van Wee, Bert	Transportation technologies, sharing economy, and teleactivities: Implications for built environment and travel	2021	Transportation Research Part D: Transport and Environment	Review article	e-scooters	Shared	Across the world	Secondary data	NA	General population	Transportation technologies, sharing economy, and teleactivities: Implications for built environment and travel
39	Sanders, Rebecca L.; da Silva Brum-Bastos, Vanessa; Nelson, Trisalyn A.	Insights from a pilot investigating the impacts of shared E-scooter use on physical activity using a single-case design methodology	2022	Journal of Transport & Health	Research article	e-scooters	shared	Residents of Tampe	Primary data	16 freequent scooter users	General population	E-scooters, Electric scooters, Micromobility, Physical activity, Active transportation, Single case design
40	Oeschger, Giulia; Carroll, Páraic; Caulfield, Brian	Micromobility and public transport integration: The current state of knowledge	2020	Transportation Research Part D: Transport and Environment	Review article	e-scooters	Shared	Various countries	Secondary data	NA	General population	Micromobility and public transport integration: The current state of knowledge
41	Krauss, Konstantin; Krail, Michael; Axhausen, Kay W.	What drives the utility of shared transport services for urban travellers? A stated preference survey in German cities	2022	Travel Behaviour and Society	Research article	e-scooters	shared	Germany	Primary data,	1445	General population	Shared mobility, Urban mobility, Stated Preference, Modal choice, Mobility-as-a-Service

E-scooters provide a sustainable and affordable mode of transportation, particularly for short distances and connecting commuters to major transit hubs (Hélie Moreau, 2020) (Kailai Wanga, 2023). From the carbon emission point of view, the e- scooters are better than the ICE vehicles (Hugo Badia, 2022). But according to Poulino et al, 2018 and Hawkins et al, 2013 their respective production carbon output is almost the same (Ana Filipa Reis, 2023). Weiss et al, 2015, made a significant point by saying that the e-bikes are most preferred alternatives for those who would walk earlier. This can prove to be a burden on our environment as these vehicles are run on electricity which are not completely free of carbon footprint (Ana Filipa Reis, 2023). Moreu et al, 2020, quote that a shared e-scooter needs a life expectancy of at least 9.5 months to be declared as a green solution of the current problem of mobility. It has been observed that the life expectancy of the shared e-scooter can be increased if there is a smooth and pliable pavement or sidewalk which can potentially bring down the wear and tear of the parts of the e-scooters. Shared e-scooters have been making the urban life easy. But it cannot be ignored that factors associated with mobility of e-scooters from parked place to the dock or other destination involves some form of carbon-based fuel. A survey conducted in Lisbon, Portugal, highlighted that due to relentless vandalism, the e-scooters were collected every day from their parked locations in vans which were powered by fossil-fuels (Ana Filipa Reis, 2023). Fluctuo et al, 2022, quote that "Lisbon as a case study because it is the second city in Europe with the most shared e-scooter trips per capita. It is also among the cities where e-scooters count for 61% of the whole shared mobility services, compared to the 43% of Madrid and 53% of Milan" (Rosa Félix, 2023). It is important to understand the impact of the shared e-scooters holistically. Kostas Mouratidis opine that people who opted for shared e-scooter services mostly resided close to the city. He also notes that shared e-scooter users are mostly younger men (Kailai Wang, 2021), who are concerned about the environment and with good access to public transport (Kailai Wang, 2021) (Hugo Badia, 2022)(Mouratidis, Bike-sharing, car-sharing, e-scooters, and Uber: Who are the shared mobility users and where do they live? , 2022) (Jørgen Aarhaug, 2023). Substantiating this was a study conducted in Oslo, Norway. Distance covered by e-scooter riders was measured which revealed that, as per responses, the shortest distance mentioned is 0 km and max distance mentioned is 22kms (Jørgen Aarhaug, 2023). It is also noted that e-scooter sharing people ranked "e-scooters saves time and are quicker than walking" as first and "just wanted to try it out once" as second and "saves cost" as third. Young individuals also opined that "riding is fun" was the most preferred choice (Ricardo Chahine, 2024). Research conducted in Lisbon, Portugal revealed e-scooters contributed to avoiding environmental costs valued at €41,000 linked to the release of pollutants and greenhouse gases. The positive societal gains derived from physical activity totalled €657,000. However, the presence of air pollution increased the overall socio-economic burdens related to shared e-scooters by €143,000. Additionally, road accidents escalated the costs substantially, reaching nearly €6 million (Rosa Félix, 2023). Metropolitan cities are cramped because of the traffic woes and shifting from a four-wheeler to a two-wheeler can potentially reduce the congestion. Smith and Schwieterman, 2018, conducted a multi-modal analysis on the first and last mile connectivity to the public transport in the city of Chicago. It was found that e-scooters are the cost-effective alternative to the public transport. They also noted that these e-scooters cannot replace the long distance travel options owing to the increased trip cost (Kailai Wanga, 2023) Shared e-scooters are the best alternative to this problem. A study conducted in Oslo revealed that using e-scooters to commute instead of public transport would bring down the travel time by 50% (Jørgen Aarhaug, 2023) (Hugo Badia, 2022). As a contrary to this a study conducted across 5 European countries revealed that those who were using the cars preferred a shared model of cars and not two wheelers (Gustav Bosehans, 2023). Reck and Axhausen ,2021, conducted a survey across France, Brussels, Atlanta, and Arlington revealed that the main motivation to adopt to e-scooters was convenience derived from shorter travel time and flexibility of door-to-door trips (Hugo Badia, 2022). They also noted that in France e-scooter sharing service was being advertised as an effectual supporter to feed the public transport.

Research gaps:

E-scooters can be categorized as an innovative product. Hence there is sufficient gap in the scholarly information regarding this product. Anderson -Hall et al, 2019, identifies that usage of e-scooters is growing at a quick pace and consolidated planning strategies for integrating micro-mobility and urban planning is lagging which is causing policy and practice mismatch and hence these exists user discomfort. It was also found that there is lack of analyses on the user experience of e-scooters and further research must be conducted in this direction. Research on analysis of interaction between pedestrians and e-scooter users is another area that must be investigated. LOS (Level of service) is a favourable path to bridge the gap between practice and research by quantifying e-scooter rider experience. Fishman and Cherry, 2016, have stated in their research that "there is lack of research or even initial discussion" on the SLOS. (Almannaa et al., 2021a,b; Cao et al., 2021; Laa & Leth, 2020), opine that male, young and well educated over representation of e-scooters needs to be further investigated. (Khashayar Kazemzadeh, 2022). Lack of understanding and streamlined regulations has led to the new option, not being promoted by the policy makers (Yujie Guo, 2023). Bretones & Marquet, 2021, found that there is a call for further investigation into the sociopsychological elements linked to the adoption and usage of e-micromibility, particularly in diverse cultural and geographical settings (Alexandra Bretones, 2022). There is a call for further investigation into the sociopsychological elements linked to the adoption and usage of e-micromibility, particularly in diverse cultural and geographical settings. (Alexandra Bretones, 2022). Research on analysing the user experience of e-scooters is lagging. Also deeper study has to be conducted on analysing the relationship between the interaction of e-scooters with the other road users, particularly the pedestrians (Khashayar Kazemzadeh, 2022). Also, there might have been lack of study on environmental sustainability of e-scooters and their shared versions at the time of study (Ana Filipa Reis, 2023).

This study aims to explore how shared e-scooters are reshaping urban commuting patterns in Bangalore. Through a comprehensive investigation covering various aspects of shared e-scooter Accessibility, Convenience, reduction in traffic density, reduction in private vehicle usage, environmental sustainability, cost-effectiveness and impact of weather, this research intends to provide valuable insights into sustainable urban mobility. The primary areas of focus include analysing usage trends and demand, evaluating the effects on traffic congestion and environmental sustainability, assessing user satisfaction and experiences, investigating integration with public transit systems, understanding regulatory frameworks and policy implications, exploring technological advancements and infrastructure requirements, and gauging public perceptions and behavioural changes. By systematically addressing these areas, the study aims to offer evidence-based recommendations and strategies for effectively incorporating shared e-scooters into Bangalore's urban transport system. The ultimate objective is to contribute towards creating a more efficient, sustainable, and user-friendly urban commuting experience, aligning with the broader vision of developing smart and "best for living" cities in the 21st century.

Theoretical framework

Micromibility is a combination of transport modes that can substitute and supplement vehicles operated by fossil fuels reducing the drawback of the vehicles (Khashayar Kazemzadeh, 2022). Shaheen and Cochen, 2019, opine that the phrase "micromibility" was introduced to denote shared vehicles of reduced speed, including bicycles and scooters (both moped and kick-style), which have garnered increased interest as of late (Daniela Arias-Molinares, 2021). Bretones & Marquet, 2021, have adopted model choice theory in their research work. This framework is used to understand how individuals choose between different modes of transport. The two latent variables identified are functional factors (Travel cost, time, and other convenience values) and demographics (age, gender, income, household size) (Alexandra Bretones, 2022).

Leister et al, 2018, describes Micro-mobility as a blend of transportation methods that can replace and complement fossil fuel-operated vehicles, effectively mitigating the disadvantages associated with them (Khashayar Kazemzadeh, 2022). Shared e-scooters refer to the short distance transport vehicle that enable short rentals (Alberica Domitilla Bozzi, 2021). A new mode of transportation that has emerged since 2017 around the world is shared e-scooters. Shared mobility can predominantly be categorized as : automobiles (known as car-sharing), bicycles, both conventional and pedal-assisted (referred to as bike-sharing), and typically electric scooters, which are part of scooter-sharing or micro-mobility initiatives (Romano Fistola, 2022) (Rebecca L. Sanders, 2022). Capsi and Noland, 2019 and Shaheen and Cohen, 2019, discourse that bikes, e-scooters and e-scooters are different types of micromibility solutions operated in both shared and privately owned modes. The unique features of e-scooters demonstrate that the development of the e-scooter riding experience necessitated a specialized framework. (Khashayar Kazemzadeh, 2022).
The 3 main modalities of shared e-scooters are:

- **One- way**: Fixed pickup and drop off point. (Usually at stations). Bookings are mostly via app or websites. The user can pick the vehicle from any of the prescribed stations and is bound to travel the same distance on the return journey as well. Payment is either for the distance travelled or for the time used.
- **Free floating**: Without any fixed pickup or drop off points. In this mode the rider picks the vehicle from the nearest available point rather than a fixed station. The vehicle is located through the app and can be picked up by the rider. Payment is for the distance travelled and the rider can drop off the vehicle at their desired location. Challenge here is to source back the vehicle that has been vandalized at a distant location.
- **Peer - to -peer mode** where private owners of the e-scooters rent it out and receive compensation in return. Payment is made part in advance and balance is adjusted at the time of drop off. In this mode, the rider must drop the vehicle at the destination only (Romano Fistola, 2022) (Rebecca L. Sanders, 2022).

Based on the literature survey and gaps identified, following research objectives and questions were raised.
Research questions

1. What are the various factors which influence the adoption of shared e-scooters in Bangalore urban market?
2. Which of these factors have a major influence on the adoption behaviour of the Bangalore urban people?
3. What are the key demographic traits of individuals using shared e-scooters in Bangalore?

Research objectives

1. To identify the main factors that influence the adoption of shared e-scooters in Bangalore urban District
2. To evaluate the statistical significance of the impact of each factor on the diffusion of shared e-scooters in Bangalore market.
3. To explore the demographic features (Age, Education, Living situation, Employment, Household income, Gender) of shared e-scooter users in Bangalore district.

Hypothesis

1. H1: Accessibility as a factor influence the diffusion of shared e-scooters.
2. H2: Convenience as a factor influence the diffusion of shared e-scooters.
3. H3: The benefit of reduction in private vehicle usage influences the diffusion of shared e-scooters.
4. H4: Increased diffusion of shared e-scooters has an impact on reducing traffic congestion.
5. H5: Preference towards environmental sustainability has an impact on the diffusion of shared e-scooters.
6. H6: Safety Concerns influence the diffusion of shared e-scooters.
7. H7: Cost effectiveness affect the diffusion of shared e-scooters
8. H8: Weather conditions influence the diffusion of shared e-scooters.

Methodology

Participants and practice
A survey was conducted among 132 respondents who are the residents of Bangalore city. The survey adopted purposive and snowball sampling. Participants were briefed about the importance of the study before administering the questionnaire. Questionnaire included questions about demographics and preference towards various factors probably affecting the diffusion of e-scooters. 5-point Likert scale has been used for responses. Complete questionnaire has been given in the Appendix A. Detailed descriptive statistics and Latent variable analysis has been mentioned in separate sections below.
The factors identified for the study are not random in nature. These factors have been identified through the literature review. The data obtained will be analysed using the software Jamovi 2.3.28.

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Data analysis
Descriptive statistics

Table 1: Frequencies of Age

Age	Counts	% of Total	Cumulative %
<25 years	30	22.7 %	22.7 %
25-40 years	42	31.8 %	54.5 %
40-50 years	46	34.8 %	89.4 %
50 years and above	14	10.6 %	100.0 %

Table 2: Frequencies of Education

Education	Counts	% of Total	Cumulative %
High school	3	2.3 %	2.3 %
Graduation	47	35.6 %	37.9 %
Post graduation	82	62.1 %	100.0 %

Table 3: Frequencies of Gender

Gender	Counts	% of Total	Cumulative %
Male	79	59.8 %	59.8 %
Female	53	40.2 %	100.0 %

Table 4: Frequencies of Employment

Employment	Counts	% of Total	Cumulative %
Employed	65	49.2 %	49.2 %
Self-employed	28	21.2 %	70.5 %
Retired	2	1.5 %	72.0 %
Student	28	21.2 %	93.2 %
Home maker	9	6.8 %	100.0 %

Table 5: Frequencies of Household income per month

Household income per month	Counts	% of Total	Cumulative %
<25K	18	13.6 %	13.6 %
25K-75K	39	29.5 %	43.2 %
75K-105K	38	28.8 %	72.0 %
150K and above	37	28.0 %	100.0 %

Among the respondents, maximum number of respondents belonged to the age group 40-50 years, 34.8%, followed by 25-40 years, 31.8%, <25 years with 22.7% respondents and 50 years and above with 10.6%. It can be observed that maximum number of respondents, 62.1%, were post graduates, followed by graduates, 35.6% and least was high school with only 2.3% of the respondents. It can be inferred that the number of male respondents (59.8%) are comparatively higher than the female respondents (40.2%). The data collected revealed that maximum number of respondents were employed, (49.2%), followed by self- employed and students, (21.2% each), home makers with 6.8% and retired with 1.5%. Household income of the respondents was studied and the results obtained were as follows. Maximum number of respondents belong to the income bracket of 25K-75K, followed by 75K-105K (28.8%), 150K and above with 28% and <25K with least number of respondents i.e. 13.6%.

Latent variable constructs

TABLE 6: SCALE RELIABILITY STATISTICS

	Cronbach's α
SCALE	0.822

Cronbach's alpha evaluates the internal consistency or reliability of a group of scale or test items. Frequently employed in fields like psychology, education, and social sciences, it helps determine the reliability of surveys or questionnaires. Values Between 0.7-0.8 are considered acceptable. This indicates that the items measuring the underlying construct, preferability of shared e-scooters, are we—correlated and the results obtained by analysing these factors will yield reliable results (Agarwal et al., 2023).
Factor analysis is a statistical technique, multivariate in nature, which does not differentiate dependent and independent variables. A factor is a linear combination of available variables. Factor analysis is a data reduction technique where the information collected on many variables can be reduced to a few and manageable number of data sets or factors. It also helps in identifying the underlying construct of the data. One of the major uses of factor analysis is in the field of product acceptance rese (*Research Methodology: Concepts and Cases - Deepak Chawla & Neena Sodhi - Google Books*, n.d.). Hence factor analysis has been adopted for this study to identify various attributes that can potentially influence the diffusion of shared e-scooters in Bangalore city.
Step 1: Principal component analysis
Principal component analysis was carried out to understand the underlying structure in the data collected. Analysing the principal components, the variance they explain and the loading scores can reveal key patterns and relationships within the dataset, enhancing the quality of the data analysis and interpretation (*Research Methodology: Concepts and Cases - Deepak Chawla & Neena Sodhi - Google Books*, n.d.)
Assumption Checks

Table 7: Bartlett's Test of Sphericity

χ^2	df	P
356	66	< .001

TABLE 8: KMO MEASURE OF SAMPLING ADEQUACY

	MSA
OVERALL	0.746
C1	0.680
C4	0.660
C5	0.567
RPV1	0.683
RPV3	0.766
ES1	0.803
RPV2	0.536
ES2	0.781
ST2	0.851
ST3	0.744
W2	0.793
W3	0.518

A chi-square value of 356 in Bartlett's test, given 66 degrees of freedom, likely suggests a significant result. This indicates that the correlation matrix significantly differs from an identity matrix, supporting the application of factor analysis for the collected data. Also, the p value is much lesser than .05 indicating that the assumption that the correlation matrix is a identity matrix is rejected, indicating that factor analysis can be executed for the data collected. Additionally, KMO measure of sampling adequacy revealed a value of 0.745 suggesting a favourable level of sampling adequacy, indicating that the variables exhibit a reasonable degree of correlation and are suitable for factor analysis. These tests were used as a basis to carry out the factor analysis (Palit et al., 2022).

Step 2: Confirmatory factor analysis

Table 9: Test for Exact Fit

χ^2	df	P
32.3	21	0.054

Table 10: Fit measures

				RMSEA 90% CI	
CFI	**TLI**	**SRMR**	**RMSEA**	**Lower**	**Upper**
0.955	0.923	0.0515	0.0640	0.00	0.105

Table 11: Fit measures interpretation

SL NO	FIT MEASURES	ACTUAL VALUES	ACCEPTABLE RANGE	GOOD OR ACCEPTABLE
1.	Comparative fit index (CFI)	0.955	Above 0.95	Good
2.	Tucker-Lewis Index (TLI)	0.923	Above 0.9	Good
3.	Standardized Root Mean Square Residual (SRMR)	0.0515	Values closer 0 is better. 0.5-0.6 is considered good fit	Good
4.	Root Mean Square Error of Approximation (RMSEA)	0.0640	Values closer 0 is better. 0.5-0.6 is considered good fit	Acceptable.

From the table we can infer that the model can be considered statistically fit for the study. This study provides a reliable basis for testing the structural relationship between the variables and the factors in Structural Equation Modelling (Azab et al., 2022).

Step 3: Structural equation modelling

TABLE 12: FIT INDICES

			95% Confidence Intervals		
TYPE	**SRMR**	**RMSEA**	**Lower**	**Upper**	**RMSEA p**
CLASSICAL	0.059	0.024	0.000	0.065	0.817
ROBUST	0.055				
SCALED	0.055	0.065	0.031	0.094	0.203

TABLE 13: USER MODEL VERSUS BASELINE MODEL

	Model
COMPARATIVE FIT INDEX (CFI)	0.998
TUCKER-LEWIS INDEX (TLI)	0.997
BENTLER-BONETT NON-NORMED FIT INDEX (NNFI)	0.997
RELATIVE NONCENTRALITY INDEX (RNI)	0.998
BENTLER-BONETT NORMED FIT INDEX (NFI)	0.971
BOLLEN'S RELATIVE FIT INDEX (RFI)	0.956
BOLLEN'S INCREMENTAL FIT INDEX (IFI)	0.998
PARSIMONY NORMED FIT INDEX (PNFI)	0.647

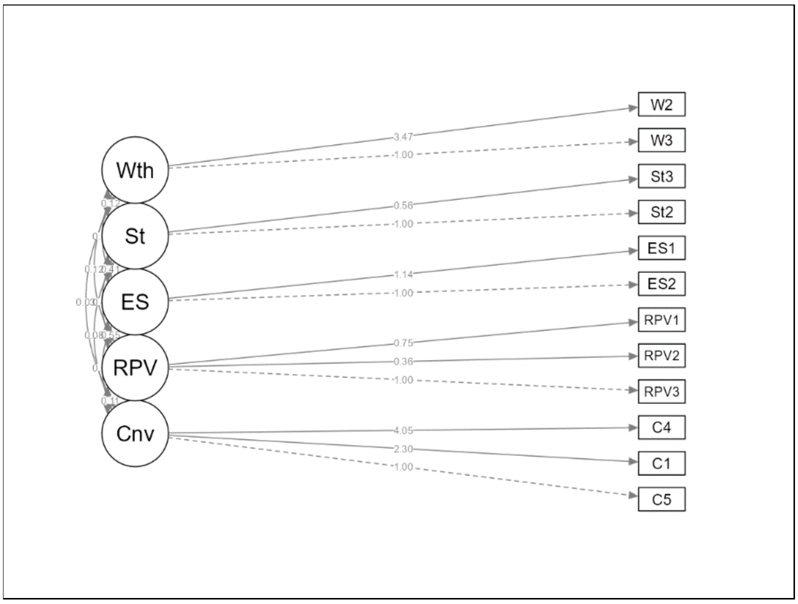

Figure: Path diagram of the latent variables and observed variables.

Source: SEM analysis of the primary data collected, performed using Jamovi.
RMSEA value of 0.024 indicate a perfect fit between the observed and latent variables and the relationship among the variables themselves. CFI values range between 0 and 1. Values close to 1 is considered as a good fit. For the current study, the CFI value is 0.998 which can be considered as a perfect fit. TLI value ranges between 0 and 1. Values closer to 1 is considered as a good fit. For the current study, the TLI value is 0.997 which shows the model is a perfect fit. Hence it can be concluded that the model under study is statistically significant and proven.

Discussion

It has been proven that the latent variable Weather can be measured through the observable variables: "prefer staying indoors rather than using shared e-scooters when it is raining" and "Weather can influence the safety concerns towards the shared e-scooters". Latent variable safety is measured through the observable variables "Adequate safety measures are in place for shared e-scooter users" and "Safety as a priority when it comes to riding." Latent variable environmental sustainability has been measured through the observable variable "Shared e-scooters contribute to reducing the carbon footprint in your city" and "I mostly prefer environmentally sustainable option whenever possible". Latent variable reduction in private vehicle usage has been measured through the observed variables "Shared e-scooters can reduce the number of private vehicles on streets", "How often do you prefer using a shared e-scooter over private vehicle?" and "Given the current traffic condition in Bangalore, using private vehicle when travelling alone should be avoided". Latent variable convenience has been measured through the observable variables "Shared e-scooters can ease the current commuting problem," "Shared e-scooter is convenient for travelling within the city, when compared to walking, cycling or public transport" and "Accessibility to my usual commute destination is currently difficult".

Conclusion

Statistical methods used help us conclude that H2, H3, H5, H6 and H8 stand valid and H1, H4 and H7 fail to contribute sufficiently to the diffusion of shared e-scooters. This means that diffusion of shared e-scooters is impacted by convenience, reduction in private vehicle usage, environmental sustainability, safety concerns and weather conditions in the Bangalore urban market. Whereas the factors accessibility, impact on traffic congestion and cost effectiveness do not impact the diffusion of shared e-scooters in Bangalore urban market. Hence this research paper answers all the research questions raised at the initial stage of research.

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