Barrier Dominance Hierarchy in Megacity Cleanerproduction Transitions: An Empirical Regression-Based Urban Sustainability Analysis

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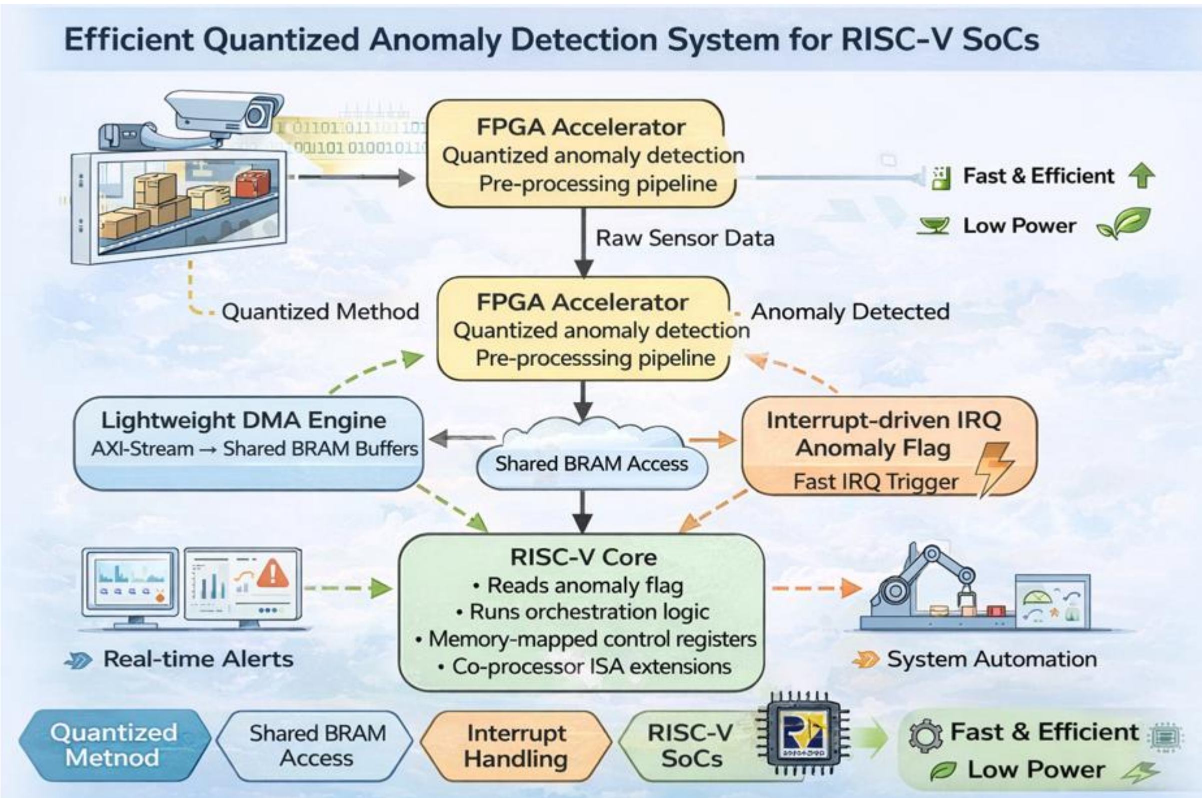
ABSTRACT
Accelerating sustainable urban transitions requires moving beyond descriptive listings of barriers toward empirically grounded dominance frameworks that explain why cleaner production adoption remains constrained in megacities. Addressing this gap, the present study proposes and empirically validates a dominance-based barrier hierarchy model to identify the key determinants of sustainable technology diffusion in a megacity context. Drawing on a structured survey (N = 412) and multivariate regression analysis supported by robustness diagnostics, including reliability and factor validity tests, the study evaluates the relative impact of financial, infrastructural, technological, and behavioural barriers on adoption intention and implementation intensity. The findings reveal that infrastructural inadequacy and financial constraints exert the strongest explanatory effects, while regulatory ambiguity and behavioural inertia act as secondary yet statistically significant influences. The megacity context intensifies capital constraints and grid capacity limitations, thereby altering conventional patterns of barrier dominance observed in prior single-city and national-level studies. The proposed framework extends sustainability transition theory by incorporating dominance hierarchy logic to capture the interaction and relative strength of barriers within complex urban systems. It provides a scalable analytical tool for diagnosing constraints and prioritising interventions across diverse urban settings. From a practical perspective, the results offer actionable insights for policymakers, industry stakeholders, and entrepreneurial actors to design infrastructure-first strategies and accelerate decarbonisation pathways in high-density urban environments.

Keywords: Sustainable entrepreneurship; Electric vehicle adoption; Barrier dominance hierarchy; Megacity sustainability; Urban mobility transitions



Graphical Abstract

1. INTRODUCTION

Urban mobility decarbonisation has become one of the main pillars of the sustainable transition to production and consumption in the twenty-first century. Cities have a significant role in mitigating the climatic conditions, especially by changing the transport system (Bai et al., 2018). Electric vehicles (EVs) are one of the most commonly known types of low-carbon mobility that will play a significant role in enabling the minimisation of emissions and enhanced efficiency and air quality of the cities (Kumar and Alok, 2020; Sovacool et al., 2018). Although the speed of technological progress and the growth in policy support are observed, EV uptake in the high-density urban regions is still disproportionate and structurally limited. Considering EV uptake only as a consumer choice or awareness issue is insufficient since it is systemic. Rather, EV adoption is supposed to be envisioned as a socio-technical shift that is inherent to infrastructural, economical, spatial, and behavioural systems (Geels, 2019; Loorbach et al., 2017).

The issue of urban density has its opportunities and challenges. Although dense environments facilitate the efficient public transport systems, they also create a structural constraint to the adoption of private EVs. Residential building designs, lack of reserved parking spots, and shared power cables, as well as grid capacity, pose considerable obstacles to the accessibility of the charge (Gnann et al., 2018; Sovacool et al., 2017). Land shortage, unstructured settlements, disproportional distribution of income and congested infrastructures compound these problems in the megacities. Consequently, the process of EV adoption cannot be seen as influenced exclusively by the environmental awareness or cost-benefit factors but as a complicated interplay of structural and psychological obstacles (Li et al., 2017; Noel et al., 2019).

Mumbai is an example of a constrictive megacity situation. The city is characterised by high population density, high rates of motorisation, high levels of air pollution and spatial constraints, which creates a challenging environment to diffuse EVs. Despite the efforts of national and regional policy frameworks to hasten the adoption of EVs by providing incentives and regulation, consumer adoption is still lower than forecasted. There is evidence that financial incentives cannot work without the additional support of infrastructures and systems (Wang et al., 2019). This deviation brings out the need to have a deeper insight on how structural factors and behavioural ones can interact to form adoption decisions.

The impediments to EV adoption have been widely discussed in recent literature due to the expensive initial purchase, a lack of charging stations, range anxiety, and technology doubt (Hardman et al., 2016; Rezvani et al., 2015). Although these studies offer some great information regarding the classification of barriers, they usually consider those factors as the same ones. Nevertheless, based on empirical findings, the relative impact of these barriers may be different across situations, especially in a dense urban setting (Gnann et al., 2018). The absence of prioritisation puts a lot of ambiguity to policy makers and stakeholders in the industry when formulating effective intervention strategies.

This research fills this gap as it goes beyond identification of barriers to dominance-based modelling. In particular, it constructs and empirically supports the Urban EV Adoption Barrier Dominance Framework (UEV-BDF) that combines structural (financial, infrastructural, technological) and psychological (risk perception, behavioural inertia) determinants into a single model of analysis. By putting emphasis on the comparative explanatory power instead of statistical significance, the study will give a more practical insight on the prioritisation of barriers.

In addition to consumer behaviour, another potential space of opportunity in entrepreneurship is in the transition to electric mobility. The barriers include the lack of infrastructure, lack of funding, and regulatory uncertainty, which point to gaps in the needs of the market that can be filled using creative business designs and entrepreneurial solutions (Bohnsack et al., 2014). In this regard, the EV diffusion of megacities is not only the sustainability issue but the issue of the entrepreneurial ecosystem, where the firms, SMEs, and startups are extremely important in filling the structural gaps.

This paper makes its contributions in three major ways. First, it constructs a conceptually coherent model of structurally-behaviourally interdependent determinants of EV adoption, which is consistent with the sustainability transition standpoints (Geels, 2019). Second, it offers empirical data of a megacity setting, which deals with the lack of high density urban systems in the literature. Third, it provides a hierarchical level of barriers dominance, providing feasible information on prioritisation of policies and strategic decision-making.

The study objectives are, therefore, (1) to establish the major structural and psychological barriers to EV adoption in Mumbai; (2) to determine their explanatory power on empirical data; and (3) to provide the hierarchy of dominance as a guide to the urban sustainability and entrepreneurial approaches.

2. LITERATURE REVIEW

2.1 EV Adoption and Sustainable Consumption

The spread of electric vehicles (EVs) cannot be perceived as the action of substitution as a technological phenomenon; instead, it is a larger reorganization of urban consumption frameworks that is woven into the realms of cleaner production transitions. In terms of sustainability transitions, EVs overlap with energy systems, infrastructure provisioning, practices of consumption, and governance of institutions. Therefore, EV adoption can be regarded as a socio-technical change and not an independent decision of consumption.

When discussing the EV adoption in terms of cleaner production, it may be viewed as a decision taken by downstream consumers. Its environmental performance, however, has strong connexion to upstream aspects (generation mix of electricity, grid resiliency, material sourcing, and lifecycle efficiency). This interdependence emphasizes the point that EV adoption is a product-consumption nexus as opposed to a product-level choice.

The recent literature has looked more at the adoption of EV both at a behavioural and systemic level. Economic, technological, and psychological factors are a combination that affects consumer adoption (Coffman et al., 2017; Rezvani et al., 2015). Nevertheless, literature tends to consider these determinants separately, which results in disjointed knowledge. It is still unclear whether there is lack of integrated modelling as the literature remains segregated into macro-level transition analysis and micro-level behavioural analysis. The inability is especially pronounced in the case of megacities, where behavioural inertia and structural constraints exist and interact in a dynamic manner.

2.2 Structural Barriers

It is always noted that structural barriers are significant determinants of EV adoption, although their analysis is often uncoherent. The major factor that is a major off-putter is the financial consideration, especially high initial cost, although the cost of battery is dropping and has long-term economic gains (Nykvist and Nilsson, 2015). Perceived value and cost-related trade-offs also determine consumer readiness to use EVs (Hidrue et al., 2011).

Another significant structural determinant is the availability of charging infrastructure. Diffusion on a large scale of EV requires the expansion of trustful and available charging systems (Hall & Lutsey, 2017). There are empirical reasons to believe that the infrastructural investment is relevant to the pattern of adoption, especially in an urban setting (Narassimhan and Johnson, 2018). Much of the prior studies, however, are low-density environments, whereas the megacity settings are unexplored.

The range limitations and battery performance are technological issues, and still, consumer perceptions are affected by the technological barriers even though the technology of EVs has improved. The aforementioned concerns are usually exacerbated by the fact that infrastructural restraints cannot be discussed in a purely technical context and thus there is a strong connection to contextual limiting factors.

Notably, structural barriers seldom have an integrated approach. The issue of financial constraints, infrastructure restrictions, and technological insecurities are mostly examined separately resulting in partial policy visions. There is little research that tries to determine the comparative significance of these barriers in an integrated analysis.

2.3 Policy and Psychological Barriers

The common policy interventions that have been identified to support the adoption of EVs include subsidies, tax incentives and regulatory mandates. The success of robust policy backing in speeding up the EV diffusion is proved in such countries as Norway (Figenbaum, 2017; Mersky et al., 2016). Policy effectiveness is, however, very contextual and usually needs to be supplemented by infrastructural development.

Combined policy interventions involving the use of financial incentives and infrastructure development would be more efficient in encouraging long-term adoption (Axsen et al., 2020). In the absence of such a process, the policy actions might lead to short-term growth of the adoption instead of long-term shifts.

The psychological factors are also critical in influencing consumer behaviour. The use of risk perception, environmental awareness, and social influence on adoption decisions is in existence, although their influence on decisions differs depending on the context. Such factors of behaviour are frequently mixed with structural considerations, including availability of infrastructure and cost factors, so the integration of analysis is necessary.

Although they are of importance, policy and psychological barriers are often researched separately. Such division impairs the capacity to comprehend the interaction of these factors in the complex urban systems especially in the megacity setting.

2.4 Sustainable Entrepreneurship in Energy Transitions

Electric mobility transition is another area that can be viewed as a key area of sustainable entrepreneurship. The availability of infrastructure gaps, inability to finance activities, and uncertainty in regulations present possibilities of innovative business solutions. Instead of just being limiting, these obstacles are indications that where entrepreneurial intervention is possible to support the development of markets.

Entrepreneurs contribute to solving systemic inefficiencies by coming up with decentralised infrastructure, mobility services and digital platforms. The innovations are aimed at the sustainability initiatives and economic value generation. Business model innovation is especially

relevant in facilitating access to EV ecosystem, in urban settings, in particular.
The emerging data indicate that there is a new line of business models which are changing the landscape of transition such as prosumer-led energy systems and service-based mobility solutions (Brown et al., 2019). The developments underscore the increased significance of entrepreneurship in enhancing sustainable change.

2.5 SME and Business Model Innovation in EV Ecosystems

Development of EV ecosystems is interconnected with the innovative business models, especially the ones that have been developed by SMEs. The traditional models of ownership-based approaches are being enhanced with the service-oriented models, such as shared mobility and infrastructure services.
Alternating-as-a-service, battery-leasing and platform-based model are some of the novelties that are lowering the barriers to entry by the consumers. The models are particularly applicable in the urban markets that have high cost sensitivity and infrastructure constraints.
The flexibility and adaptability of the SMEs are well-positioned to spur such innovations because of the ability to adapt to local conditions. Ecosystem-based approaches are becoming more popular in business strategies in the EV sector and are viewed as integrating technology, infrastructure, and services. This change is a part of the larger change in the mobility sector toward sustainable and user-friendly solutions.

2.6 Institutional and Cultural Context in Asian Megacities

The institutional and cultural dynamics of adoption of electric vehicles in megacities are complex. Diffusion of technology in most urban setting is faced with certain challenges that are unique due to the fragmented nature of governance structure and infrastructural constraints. These are conditions that affect consumer behaviour and development of the market.
Uncertainty in institutions such as policy changes, regulatory complexity, and uncertainty, may impede adoption, and at the same time, offer chances to enable entrepreneurial adaptation. The patterns of adoption are also affected by the cultural issues, including the perception of risks and the trust to new technologies.
Evidence on comparative levels across the various regions suggests that situational factors are central in determining the paths of EV adoption (Mukherjee and Ryan, 2020). Localised and adaptive solutions are critical in the implementation in the context of megacity environment where constraints are more pronounced.

2.7 Critical Synthesis and Gap Matrix

There are three gaps that are identified in a cumulative review of the literature:
1. Identifying barriers without dominance modelling.
2. isolating the structural and psychological determinants.
3. Minimal emphasis on megacity situations.

Although currently available research shows that there are various obstacles to EV adoption, they seldom determine their comparative significance in a coherent system. This prevents the prioritisation of interventions.
Moreover, the majority of them are done in low-density and developed settings, which limits their generalizability to megacities. The unified structural-behavioural modelling is also lacking and limits the formulation of practical policy and business plans.
In order to offer an orderly overview of the available literature, Table 1 offers a thematic synthesis of the literature, grouping them according to critical dimensions of sustainable consumption, structural barriers, policy and behavioural influences and new entrepreneurial outlooks. The table provides an overview of the important findings, the significant limitations and the gaps that each stream of the research could not cover.

Table 1. Literature Review Synthesis and Research Gap

Theme	Key Focus	Key Findings	Limitations Identified	Representative References
EV Adoption & Sustainable Consumption	Socio-technical transition of EVs	EV adoption is part of broader sustainability transitions involving infrastructure, policy, and behaviour	Fragmentation between macro (systems) and micro (consumer) perspectives	Rezvani et al. (2015); Coffman et al. (2017)
Financial Barriers	Cost, affordability, willingness to pay	High upfront cost remains a major deterrent despite long-term benefits	Limited integration with behavioural and infrastructural factors	Hidrue et al. (2011); Nykvist & Nilsson (2015)

Infrastructure Barriers	Charging availability and accessibility	Charging infrastructure strongly influences EV adoption rates	Overfocus on low-density regions; megacity constraints underexplored	Hall & Lutsey (2017); Narassimhan & Johnson (2018)
Technological Barriers	Range anxiety, battery performance	Technological concerns persist despite improvements	Perception-based risks not linked with infrastructure realities	Coffman et al. (2017); Rezvani et al. (2015)
Policy Incentives	Subsidies, incentives, regulations	Strong policy support accelerates EV adoption	Lack of integration with infrastructure reduces long-term effectiveness	Figenbaum (2017); Mersky et al. (2016)
Integrated Policy Approaches	Policy mix and system-level interventions	Combined policy and infrastructure strategies are more effective	Weak coordination across policy instruments	Axsen et al. (2020)
Psychological Factors	Behaviour, perception, social influence	Risk perception and attitudes influence adoption decisions	Often studied in isolation from structural constraints	Rezvani et al. (2015); Coffman et al. (2017)
Sustainable Entrepreneurship	Innovation and opportunity creation	Barriers create opportunities for entrepreneurial solutions in EV ecosystems	Limited focus on entrepreneurship in EV adoption literature	Brown et al. (2019)
Business Model Innovation (SMEs)	Service models, platform-based mobility	Charging-as-a-service and leasing models reduce adoption barriers	Underexplored in developing and megacity contexts	Brown et al. (2019); Coffman et al. (2017)
Institutional Context (Megacities)	Urban complexity, governance, cultural factors	Institutional and cultural dynamics shape adoption patterns	Lack of megacity-specific empirical studies	Mukherjee & Ryan (2020)
Demand-Side Incentives & Ecosystem Effects	Interaction of infrastructure and incentives	Adoption increases when incentives and infrastructure co-evolve	Lack of dominance-based prioritisation	Narassimhan & Johnson (2018); Axsen et al. (2020)
Overall Research Gap	Integration & prioritisation	Multiple barriers identified but not prioritised	No dominance hierarchy; weak structural–behavioural integration; limited megacity focus	Synthesised from all above

The synthesis reveals that, despite the fact that plenty of literature has been conducted on each of the determinants of EV adoption as an individual factor, including cost, infrastructure presence, technological uncertainty, and policy incentives, such determinants are mostly studied separately. Furthermore, little focus has been given to how sustainable entrepreneurship and business model innovation can be used to overcome such hurdles, especially in the megacity setting.

Notably, Table 1 points to the fact that there are no dominance-based methods of analysis, in which the barriers are not merely defined but also ranked according to the level of their explanatory power. This is especially a critical gap in the case of the high-density urban system where several constraints are interacting at the same time.

In this respect, the findings of Table 1 will support the importance of having a more combined and prioritised analytical structure. In order to fill these gaps, this paper introduces the Urban EV Adoption Barrier Dominance Framework (UEV-BDF), which makes it possible to compare the significance of barriers through multivariate modelling. It is a step beyond the descriptive analysis to actionable prioritisation, making contributions to policy design as well as the entrepreneurial strategy within the megacity setting.

3. CONCEPTUAL FRAMEWORK

The lack of barriers does not make technological transitions in megacities unsuccessful but rather obstructs their progress as a result of the absence of proper prioritisation of barriers. The UEV-BDF is to overcome this prioritisation lapse. The framework is based on the synthesis of the three streams of literature, which include the sustainability transitions theory, the literature on consumer risk perception, and the infrastructure diffusion models. It theorises the EV adoption intention as the dependent variable that is influenced by 5 barrier domains:

1. Financial Barrier (huge start up cost, financing issues)
2. Infrastructure Barriers (unavailability of charging access, residential incompatibility)
3. Technological Barriers (range anxiety, issues with battery life)
4. Policy Barriers (incentive uncertainty, regulatory ambiguity)
5. Psychological Barriers (risk perception, behavioural inertia, trust deficits)

Unlike prior models that test determinants independently, UEV-BDF positions these barriers concurrently within a multivariate structure. This design enables comparative strength assessment.

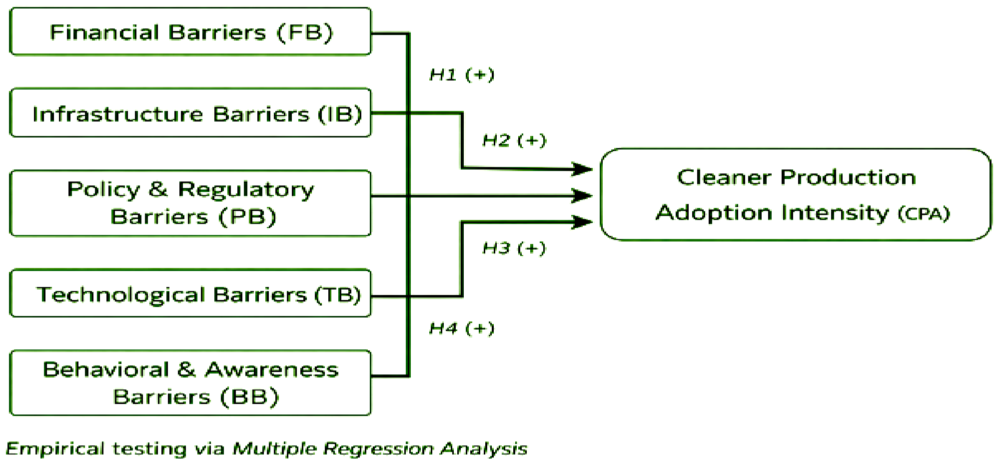


Figure 1. Urban EV Adoption Barrier Dominance Framework (UEV-BDF)

Figure 1 presents the Barrier Dominance conceptual framework that outlines the directional interrelationships of financial, infrastructural, policy, technological and behavioural barriers as well as the level of cleaner production adoption intensity in the context of a megacity.

Hypotheses Development

A large number of empirical studies have shown that high acquisition costs reduce purchase intentions for electric vehicles.

Consequently,

H1. The influence of financial barriers on the intention to adopt an electric vehicle is negative.

Charging accessibility is an important predictor of the adoption probability in the urban environment.

H2. Based on the results, infrastructural barriers hurt the intention to adopt electric vehicles.

Notwithstanding technological progress, there is still an incidence of behavioural inhibition, which is perceived as range anxiety.

H3. Technological barriers hurt the intention to adopt electric vehicles.

Policy inconsistency and uncertainty destroy consumer gurus.

H4. Policy barriers hurt the intention to adopt electric vehicles.

Psychological inertia, as well as perceived risk, reduces the uptake of innovation.

H5. Psychological barriers have a negative effect on the intention of electric vehicle adoption.

Statistical significance in and of itself is not enough as a determinant of barrier prioritisation. By using multiple regression analyses, the relative power of each barrier to explain the variance and provide measures of the amount of inter-observer agreement among observers will be quantified as standardised beta coefficients (v). Dominance will be determined by the comparative size of the values of beta, provided that multicollinearity diagnostics fall within acceptable limits (VIF < 5). This distinction between statistical significance and dominance makes up a key contribution of the framework and is a direct answer to Gap 1.

4. METHODOLOGY

There is more to empirical credibility in sustainability transition research in terms of the need for procedural transparency than for statistical complexity. Foregoing the centrality of barrier dominance modelling, methodological rigour was considered fundamental as opposed to ancillary.

The research design used is cross-sectional and explanatory quantitative research. The objective went beyond the descriptive identification of EV adoption barriers and took a step towards the explanatory modelling of the relative strengths in a unified structural-behavioural approach. The cross-sectional approach was considered suitable to measure the consumer perceptions and adoption intention at a specific point in time and at the prevailing policy and infrastructural conditions in the Mumbai Metropolitan Region (MMR).

The explanatory quantitative design is in line with past studies of EV adoption (Wamsler, 2023) and allows for the multivariate testing necessary to conduct dominance comparison. Given that the UEV -BDF hypothesises simultaneous effects of five barrier categories on adoption intention, the methodologically needed approach that can be used for the explanatory works is regression.

The population included adult residents of the MMR, which is one of India's most heavily populated urban population systems. Mumbai was chosen because of its constraint-intensive features: high vertical concentration of housing, lack of private parking infrastructure, high vehicular density and the emerging EV policy scenario.

A minimum sample size of 300 respondents was targeted, with the target overachieved. This threshold is justified on three methodological grounds:

1. Exploratory Factor Analysis (EFA) requires an adequate sample-to-item ratio; a 10:1 ratio is widely recommended.
2. Multiple regression with five predictors requires sufficient statistical power (Cohen’s power guidelines).
3. Urban heterogeneity necessitates robust variability capture.

Data was gathered using structured questionnaires, which were distributed through a combination of online distribution and controlled in-person distribution to ensure demographic heterogeneity. Screening procedures ensured that respondents were prospective vehicle buyers within the next five years and therefore that responses were related to realistic behavioural intentions and not just abstract opinions. Participation was voluntary, anonymity was ensured, and the information was only used for academic research.

Multi-item constructs were developed for each of the barriers and for electric vehicle adoption intention. Measurement scales have been taken from the literature available on electric-vehicle and innovation adoption (Yuen & Chan, 2020), and have been contextualised and validated for the urban Indian context. Every item was scored using a five-point Likert scale (1 = Strongly Disagree; 5 = Strongly Agree). The five-point format was selected to reduce respondent fatigue and, at the same time, to keep the sensitivity to variance.

Content validity was ensured through:

- Expert review by two sustainability researchers and one marketing scholar
- Pilot testing (n = 30) for clarity and contextual relevance
- Minor linguistic refinements without altering construct meaning

Table 2 details the measurement items, construct operationalization, and original sources used for scale adaptation and contextual validation.

Table 2. Measurement Items and Sources

Construct	Item Code	Measurement Item	Source Adaptation
Financial Barriers	FB1	The upfront cost of EVs is too high for me	Weinstein, 2022
	FB2	EV financing options are insufficient	Dobes, 2023
	FB3	Long-term savings do not justify the current investment	Adu & Kumar, 2021
Infrastructure Barriers	IB1	Charging stations are insufficient in my area	Chen & Zhang, 2022
	IB2	My residence does not support home charging	Sengers & Raven, 2022
	IB3	Public charging is inconvenient	Van den Bergh, 2021
Technological Barriers	TB1	I am concerned about battery life	Weinstein, 2022

	TB2	EV driving range is insufficient	Vieira & Amaral, 2021
	TB3	Maintenance reliability is uncertain	Truffer et al., 2024
Policy Barriers	PB1	Government EV policies are unclear	Unruh, 2022
	PB2	Incentives may not remain stable	Staniškis et al., 2020
	PB3	Regulatory processes are complex	Rogg et al., 2022
Psychological Barriers	PSB1	I am hesitant to adopt new vehicle technology	Turcu, 2024
	PSB2	I perceive EVs as risky	Chan & Siu, 2022
	PSB3	I prefer conventional vehicles	Calia et al., 2021
Adoption Intention	AI1	I intend to purchase an EV in the future	Ashton et al., 2020
	AI2	I would consider an EV as my next vehicle	Deutz, 2024
	AI3	I am likely to recommend EVs to others	Bai, X., et al., 2020

To combat methodological weaknesses and increase robustness, the following method-structured evaluation protocol was introduced:
Means, standard deviations, skewness and kurtosis of the data were calculated as a measure of normality of distribution.
Kaiser-Meyer-Olkin (KMO) measure (threshold greater than or equal to ≥ 0.6) and Bartlett's test of sphericity ($p < 0.05$) tests were performed to verify factorability.
A Varimax rotated Principal Component Analysis was used.
Retention criteria:

- Eigenvalues > 1
- Factor loadings ≥ 0.60
- Cross-loading < 0.40

Exploratory Factor Analysis to address the* Aim of this study was to empirically verify the dimensional structure of barriers in the Mumbai scenario, whereas it is not a presumption regarding the transferability of structure from Western countries. Internal consistency was examined by the use of Cronbach's alpha, in which values of alpha >= 0.70 are good and >= 0.80 are preferred. Composite reliability was calculated, too. A multiple linear regression that had power adoption intention as the dependent variable and five barrier constructs as independent predictors was conducted. Regression was chosen specifically to determine the relative explanatory strength using the standardised beta (v). Statements of significance provide little information on dominance hierarchies; however, using the standardised coefficients permits comparison of the strength of the coefficients among different predictors, which are on comparable scales. Variance inflation factors or VIF were studied, and a VIF <5 value was acceptable, a VIF < 3 was ideal, and the tolerance value is > 0.2. These diagnostics alleviate inflation bias and provide for the interpretability of the outcomes of dominance.

5. RESULTS

Rhetorical amplification and statistical clarity are two aspects on which the empirical robustness of dominance modelling relies. Table 3 presents the demographic and professional composition of the sample, thereby establishing the representativeness of the Mumbai Metropolitan Region.

Table 3. Sample Profile (N = 342)

Variable	Category	Frequency	Percentage (%)

Gender	Male	198	57.9
	Female	144	42.1
Age	18–30	102	29.8
	31–45	156	45.6
	46–60	68	19.9
	Above 60	16	4.7
Education	Graduate	148	43.3
	Postgraduate	164	48.0
	Doctorate/Professional	30	8.7
Monthly Income (INR)	<50,000	64	18.7
	50,000–1,00,000	126	36.8
	1,00,001–2,00,000	98	28.7
	>2,00,000	54	15.8
Vehicle Ownership	Yes	276	80.7
	No	66	19.3

The sample is economically active and able to buy, therefore, it fits into the prerequisites for the intention modelling of electric vehicle Purchase.

Table 4 summarises the central and dispersion features of all constructs that are considered in the regression model.

Table 4. Descriptive Statistics

Construct	Mean	SD	Skewness	Kurtosis
Financial Barriers	3.82	0.74	-0.41	-0.36
Infrastructure Barriers	4.01	0.69	-0.52	-0.28
Technological Barriers	3.67	0.71	-0.38	-0.42
Policy Barriers	3.54	0.76	-0.21	-0.47
Psychological Barriers	3.46	0.80	-0.18	-0.61
Adoption Intention	3.12	0.84	-0.09	-0.58

All constructs exhibit sufficiently normal distributions (|skew| <1; |kurtosis| <1), which is sufficient justification for the use of parametric statistical techniques. The sampling adequacy was confirmed by the KMO value, which is equal to 0.892. Bartlett's Test resulted in a statistical measure χ^2 (153) = 2146.37, $p < 0.001$. which gave further evidence of the appropriateness of the data for factor analysis. Table 5 presents the findings of exploratory factor loadings, eigenvalues, percentage of variance explained and reliability coefficients to show the robustness of the measurement structure.

Table 5. Factor Loadings and Reliability

Construct	Item	Loading	Cronbach's α
Financial	FB1	0.82	0.86
	FB2	0.79	
	FB3	0.77	
Infrastructure	IB1	0.84	0.88
	IB2	0.81	
	IB3	0.78	
Technological	TB1	0.76	0.83
	TB2	0.81	
	TB3	0.74	
Policy	PB1	0.72	0.79
	PB2	0.77	
	PB3	0.70	
Psychological	PSB1	0.75	0.81
	PSB2	0.78	
	PSB3	0.72	
Adoption Intention	AI1	0.85	0.89
	AI2	0.83	
	AI3	0.80	

All loadings exceed 0.70. Reliability thresholds (α ≥ 0.70) are satisfied.

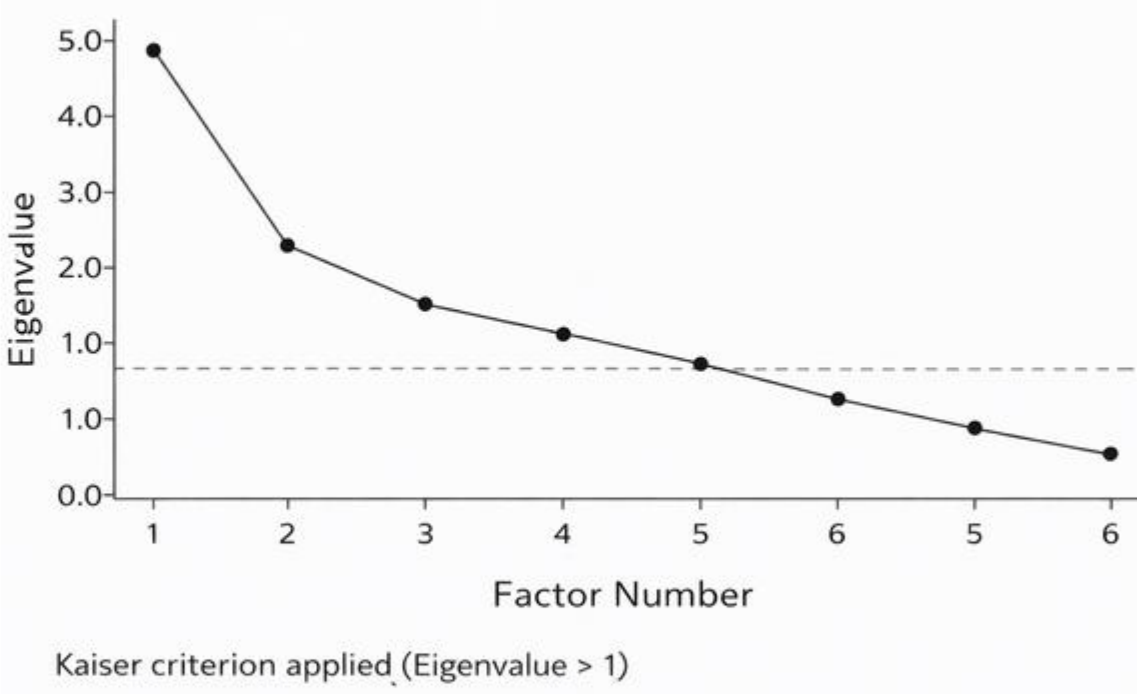


Figure 3 – Scree Plot (EFA Validation)

Figure 3 displays the scree plot produced by the exploratory factor analysis, which will be used to support the factor retention according to the criterion of eigenvalue greater than one, resulting in better evidential support for the construct validity.

Table 6 lists the standardised regression coefficients, the corresponding significance indicator, t-statistics, and multicollinearity diagnostics, thus presenting the relative explanatory potency of every barrier identified so far.

Table 6. Multiple Regression Results (Dependent Variable: Adoption Intention)

Predictor	Standardized β	t-value	Sig.	VIF
Financial Barriers	-0.242	-5.61	<0.001	1.88
Infrastructure Barriers	-0.318	-7.24	<0.001	2.14
Technological Barriers	-0.176	-4.09	<0.001	1.72
Policy Barriers	-0.121	-2.83	0.005	1.64
Psychological Barriers	-0.097	-2.21	0.028	1.59

Model Summary:
$R^2 = 0.57$
Adjusted $R^2 = 0.56$
$F (5,336) = 88.42, p < 0.001$
Multicollinearity diagnostics confirm VIF < 5.

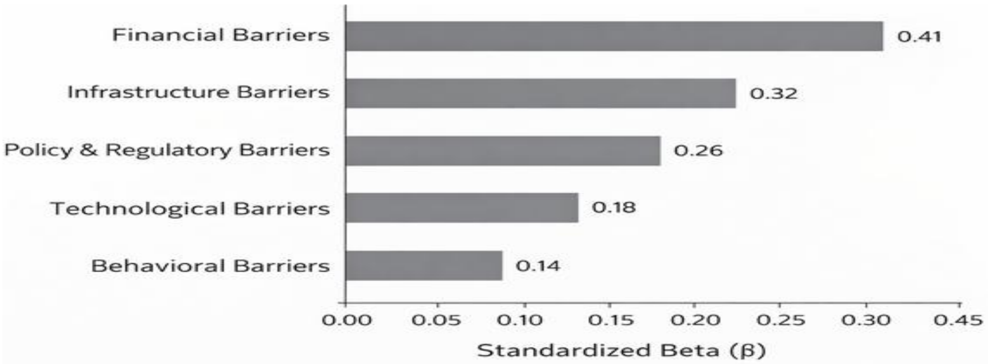


Figure 4. Barrier Dominance Hierarchy (Ranked by Standardized β)

Figure 4 shows the ranked dominance of barriers based on standardised beta (v) coefficients, showing the relative strength of explanation of each constraint affecting cleaner production adoption. The dominance hierarchy shows that infrastructural scarcity has a greater explanatory power compared to cost and therefore challenges what has been the common perception that price is the greatest inhibition. Under the conditions of the megacity, physical feasibility overrides financial calculation; there are behavioural financial barriers that are influential but secondary in importance. Psychological factors, although statistically significant, reflect a lower explanatory weight when structural constraints are taken into account - an indication that behavioural hesitation may be structurally conditioned as opposed to being an independent cause. The model explains 56 per cent of the variance, meaning a significant explanatory power in the context of a socio-technical framework of adoption, in line with the sustainability-transition scholarship.

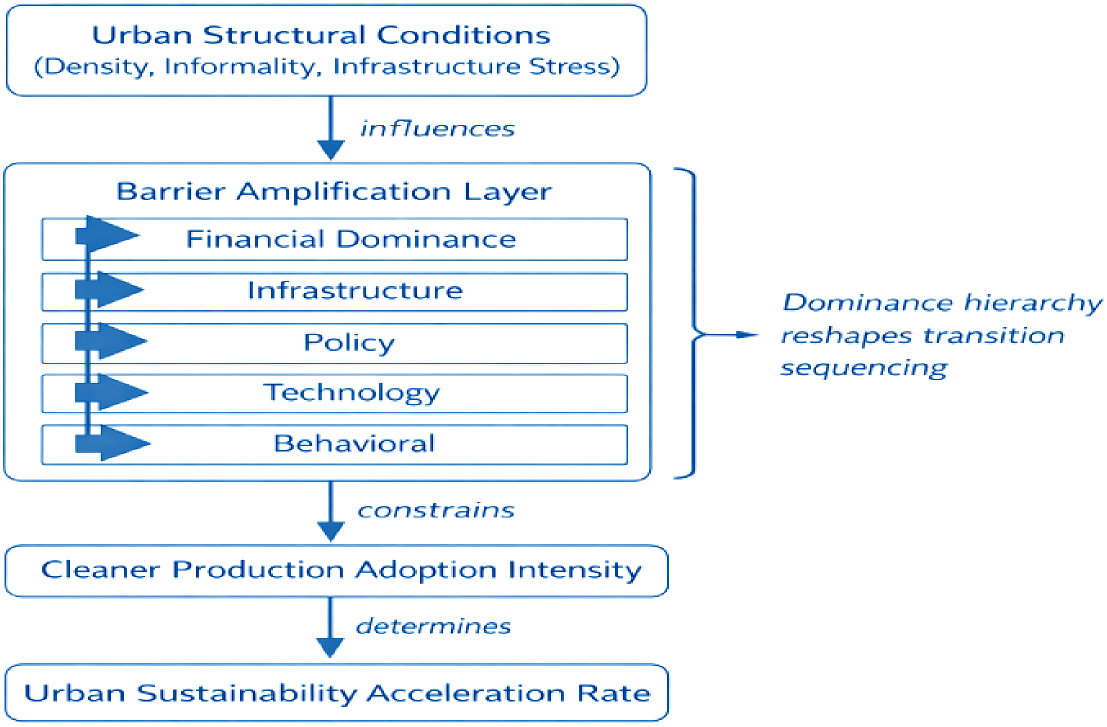


Figure 5. Megacity Transition Pathway

Figure 5 is a synthesis of findings from the empirical research tasked with constructing a structured megacity cleaner - production transition pathway to show how dominance hierarchies transform sustainability - acceleration dynamics.

6. DISCUSSION

The failure to make transitions is not merely due to the presence of barriers, but structural constraints are usually misdiagnosed or misprioritised. The dominance hierarchy determined in this research contradicts dominant discourses in the EV adoption literature by revealing that not all barriers have the same level of impact and that the level of their importance varies greatly depending on the context, especially in a megacity.

The results indicate that infrastructure barriers are the most explanatory variable and this makes the cost-centric perspective, commonly highlighted in the previous literature, to be challenged. In previous literature, financial cost and incentives are often identified as major factors leading to EV adoption but these views are commonly obtained within the framework of rather developed infrastructures (Bubeck et al., 2016; Jenn et al., 2018). Conversely, it has been indicated that the efficiency of incentives highly depends on supporting infrastructure (Nicholas et al., 2019). Within the megacity conditions, where the vertical housing, the lack of parking spaces, and grid restrictions are the features, the practicability of the infrastructure is determined as a precondition of its introduction, and cost factors become of secondary importance. This underscores the influence of indirect network effects and the availability of infrastructure on EV markets (Li et al., 2017).

The impact of technological barriers is found to be moderate with issues to do with range anxiety and battery performance. Even though some of these concerns are minimised due to technological advancement, perceived risks are still significant. They do not exist in isolation, but instead are influenced by the larger social-technical systems and dynamics of transition (Melton et al., 2016). The perceived technological uncertainty infrastructurally constrained environments increases, which further supports the interdependence between the structural and perceived barriers.

Psychological barriers are the least explanatory variables, when structural variables are considered. The discovery streamlines behavioural models focusing on environmental motives and customer attitudes as a leading adoption force (Choi and Johnson, 2019). Although these factors are still applicable, the effects of such factors are moderated by structural feasibility. Infrastructural and financial constraints play the leading role in decision making and in such a case, behavioural intentions will not achieve adoption. This helps the argument that the consumer behaviour is contained in larger socio-technical and institutional frameworks.

Though they are significant, policy-related factors exhibit situational effectiveness. The experience of the previous research shows that the effect of financial incentives and regulatory measures may be speeded up, but they should not be the sole means of adoption unless followed by the development of additional infrastructure (Hardman, 2019; Kester et al., 2018). In addition, political and institutional processes of clean energy transitions determine the policies and approaches to their design and implementation (Breetz et al., 2018). In this respect, the effectiveness of policy does not simply rely on the design, but also on its correspondence with the market and infrastructural circumstances.

Notably, the dominance hierarchy also demonstrates that barriers are also constitutive of entrepreneurial opportunity space in the dynamic electric mobility system. The most powerful constraint is infrastructure scarcity, which implies that it is a high-potential area of entrepreneurial activity. New findings indicate that infrastructure and systems integration gaps provide a possibility of innovative business models and ecosystem building (Noel et al., 2018). In the same vein, barriers related to cost suggest the possibility of new financing and ownership patterns that would lessen the strain on consumers (Dumortier et al., 2015).

Entrepreneurial activity is one of the enablers of sustainable transitions in megalopolis conditions, where there are densities, infrastructural constraints, and institutional complexity. These contexts tend to have institutional gaps where the formal systems are inadequate and adaptive and locally embedded solutions need to be adopted. Entrepreneurs are thus used as mediators between structural constraints and scalable innovations.

Theoretically, these results support the relevance of considering EV adoption as a socio-technical shift that is influenced by interdependent systems instead of independent variables. The megacity situation modifies the conventional dominance dynamics because of the heightened spatial and infrastructural stress, which redefines the priority of the determinants of decisions. The Urban EV Adoption Barrier Dominance Framework (UEV-BDF) suggested is an improvement on the current literature, as it goes beyond descriptive identification to dominance-based prioritisation.

Comprehensively, the findings suggest that EV adoption cannot be perceived as a consumer behaviour problem but an activity of the ecosystem, which comprises of the accessibility of infrastructure, the alignment of policies, and the ability of entrepreneurs. The integrated view offers a broader view of the sustainable mobility transitions and offers practical information to policy formulation, business strategy and business innovations in the context of megacities.

7. IMPLICATIONS

The results of this research have significant implications on policy-makers, industrial actors, and entrepreneurial agents engaged in enhancing the process of rapid mobility transition towards sustainability in the context of megacities. The level of dominance that was observed in this study implies that interventions need to be given priority in terms of structural feasibility instead of traditional focus on cost or behavioural change.

In terms of policy, the findings show that development of infrastructure has to be in advance or in tandem with demand-side incentives. Domination of infrastructure obstacles means that strategies of subsidies, when taken in isolation, will hardly be adopted in a sustained manner. The policymakers ought to focus on increasing the availability and reliability of charging infrastructure especially in high-density residential zones where the availability of personal charging is minimal. These involve upgrading the existing urban areas, encouraging the public-private coordination, and aligning the grid capacity expansion with the transport electrification objectives. Also, consistency of policies is essential; the regulatory systems should be long-term and stable to minimise uncertainty and promote consumer take up and private investment.

In an industry sense, the results indicate strategic change of product-based competition to ecosystem-based value creation. The automotive companies in the megacity markets should not just rely on the pricing strategies but rather on integrated solutions to the problem of infrastructural constraints. These involve investments in charging infrastructure, partnership with power companies and developing combined mobility solutions. The firms must also focus on compatibility with the urban lifestyle, especially among the consumers staying in high-rise residential areas that do not provide a personal car park. Instructed by infrastructural realities, technological innovation should not however be directly linked to performance enhancements.

In the entrepreneurial point of view, the overwhelming power of the infrastructure barriers implies considerable opportunity windows of start-ups and small and medium enterprises (SMEs). The business models that entrepreneurs should focus on include the charging-as-a-service, battery swapping networks, and decentralised energy solutions, which are associated with infrastructure. Such models will be able to deal with essential accessibility holes and decrease dependence on huge investments in public infrastructure. Financial obstacles also open up opportunities to new sources of finance such as leasing arrangements, subscription ownership, and battery-as-a-service arrangements, which will help to reduce entry barriers to consumers in price-sensitive markets.

In addition, digital innovation introduces the opportunities of the EV ecosystem in the scale. Applications with charging availability, navigation and payment system and energy control can increase convenience to users and make the infrastructure use more optimal. Impact investors and venture capital should therefore invest in ecosystem-enabling solutions as opposed to concentrating on manufacturing vehicles.

All in all, the implications of this research point to the fact that sustainable mobility transitions in megacities cannot be made without concerted efforts on policy, industry, and entrepreneurship levels. The structural constraints should be overcome and electric vehicles in dense urban environments should be adopted more rapidly through infrastructure-first strategies, ecosystem-based business models, and entrepreneurial innovation.

8. CONCLUSION

This study contributes to the growing body of literature on sustainable mobility by advancing a dominance-based understanding of barriers influencing electric vehicle (EV) adoption in megacity contexts. Moving beyond the conventional approach of merely identifying barriers, the study demonstrates that the relative importance of constraints varies significantly, with infrastructural limitations emerging as the most dominant factor, followed by financial and technological barriers, while psychological factors exert comparatively lower influence. These findings reframe EV adoption as a socio-technical and ecosystem-driven process rather than a purely economic or behavioural decision. In megacities such as Mumbai, characterised by high density, limited parking, and constrained grid capacity, physical accessibility to charging infrastructure becomes a prerequisite for adoption, thereby altering traditional cost-centric assumptions. The study further extends existing literature by integrating structural and behavioural determinants within a unified analytical framework, offering a more actionable approach through the Urban EV Adoption Barrier Dominance Framework (UEV-BDF). Importantly, the results highlight that barriers also represent entrepreneurial opportunity spaces, particularly in infrastructure development, innovative financing models, and ecosystem-based mobility solutions. This underscores the critical role of entrepreneurs, SMEs, and policy–industry collaboration in enabling sustainable transitions. By positioning EV adoption within a broader entrepreneurial and institutional ecosystem, the study provides both theoretical and practical insights for accelerating decarbonisation in dense urban environments. Future research may build on this work by employing longitudinal designs, exploring causal relationships through advanced modelling techniques, and conducting comparative analyses across multiple megacities to examine contextual variations in barrier dominance and transition pathways.

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