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Research Article

Navigating the E-Scooter Market in Türkiye: A Theory-Guided Qualitative Analysis

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Abstract: In recent years, rising traffic congestion, environmental concerns, and demand for sustainable transport have boosted the global popularity of micromobility vehicles. Electric scooters (e-scooters), introduced in Türkiye in 2019, have quickly spread across major cities. This study analyzes e-scooter use in Türkiye using Behrendt et al.'s even-dimensional framework, covering environment, human factors, social-cultural aspects, vehicle technology, infrastructure, economics, public health, and regulations. It explores Türkiye-specific dynamics, assessing challenges and opportunities. Key findings highlight infrastructure gaps, high operational costs, sustainability issues, user experience, and regulatory shortcomings. Participants' insights underscore the need for innovative strategies to enhance the sector's sustainability and effectiveness in urban mobility. The study offers tailored recommendations for Türkiye, contributing to global micromobility research. It provides policymakers, industry stakeholders, and researchers with suggestions to improve e-scooters' environmental and social sustainability, supporting their integration into urban transport systems while addressing local needs and conditions.

Keywords: Sustainable business models, sustainable transportation, micromobility, urban mobility, electric scooter

Türkiye'de E-Skuter Pazarında Yol Almak: Teori Temelli Nitel Bir Analiz

Özet: Son yıllarda artan trafik sıkışıklığı, çevresel bozulma ve sürdürülebilir ulaşım çözümlerine olan talep, küresel ölçekte mikromobilite araçlarının yaygınlaşmasını hızlandırmıştır. Elektrikli skuterler (e-skuterler), kısa mesafeli yolculuklar için popüler bir alternatif olarak öne çıkmaktadır. 2019 yılında Türkiye'de kullanılmaya başlanmasından bu yana e-skuterler hızla büyük şehirlerde yaygınlaşmıştır. Bu çalışma, Türkiye'deki e-skuter kullanımını Behrendt vd. tarafından önerilen yedi boyutlu teorik çerçeve kapsamında ele almaktadır. Çalışma; çevre, insan, sosyal ve kültürel faktörler, araç teknolojileri, altyapı, ekonomik dinamikler, halk sağlığı ve düzenleyici politikalar gibi çok boyutlu bir yaklaşım benimsemektedir. Türkiye'ye özgü yerel dinamikleri vurgulayarak sektörün karşılaştığı zorluklar ve sunduğu fırsatlar değerlendirilmiştir. Bulgular, altyapı eksiklikleri, işletme maliyetleri, çevresel sürdürülebilirlik, kullanıcı deneyimi ve mevzuat boşlukları gibi kritik sorunlara işaret etmektedir. Katılımcılardan elde edilen içgörüler, e-skuter sektörünün daha sürdürülebilir ve etkili bir kentsel ulaşım çözümüne dönüşmesi için yenilikçi stratejiler ve politikalar geliştirilmesi gerektiğini ortaya koymaktadır. Bu çalışma, Türkiye bağlamına özgü öneriler sunarak küresel mikromobilite literatürüne katkı sağlamaktadır. Politika yapıcılar, sektör paydaşları ve araştırmacılar için çevresel ve toplumsal sürdürülebilirliği artırmaya yönelik kapsamlı öneriler sunarak, e-skuterlerin kentsel ulaşım sistemlerine entegrasyonunu desteklemektedir.

Anahtar Kelimeler: Sürdürülebilir iş modelleri, sürdürülebilir ulaşım, mikromobilite, kentsel mobilite, elektrikli skuter

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1. Introduction

Over the past decade, urban centers worldwide have faced escalating challenges such as traffic congestion, environmental degradation, and the growing demand for efficient mobility solutions (Caspi, Smart, & Noland, 2020; Litman, 2017). These issues have catalyzed the emergence of micromobility—a transportation category encompassing bicycles, scooters, and, most prominently, electric scooters (e-scooters) (SAE, 2019). With the advent of smartphone applications and user-friendly rental models, e-scooters have transitioned from novelty status to an integral element of modern urban transportation systems (Christoforou et al., 2021). Their rapid global adoption is reflective of their accessibility, environmental promise, and technological innovation, yet also raises critical questions about safety, infrastructure, and long-term sustainability (Trivedi et al., 2019; Güldür et al., 2022).

E-scooters first gained widespread traction in the United States around 2017, subsequently expanding across Europe and Asia (Dündar et al., 2022). Their popularity is often attributed to several factors. They provide a quick, affordable, and convenient alternative to both public transportation and private cars, especially for short-distance trips under 5 kilometers (Caspi et al., 2020). Furthermore, e-scooters align with global sustainability goals by potentially reducing traffic congestion and local emissions. However, debates persist regarding their overall environmental footprint, particularly when accounting for manufacturing, redistribution practices, and battery disposal (Moreau et al., 2020). Advances in technology, including the proliferation of smartphones and GPS-enabled applications, have further facilitated seamless user experiences, making e-scooters a highly accessible and increasingly favored mobility option (Ekici & Kasap, 2023).

Despite these advantages, unresolved issues continue to challenge their integration into urban transportation networks. Safety concerns, inadequate infrastructure, and debates around environmental impact have sparked discussions among policymakers, leading to the development of new regulations aimed at ensuring their safe and equitable use (Resmi Gazete, 2021). The integration of e-scooters into urban mobility systems thus remains an evolving and complex endeavor, marked by the need to balance innovation with public safety, environmental sustainability, and infrastructure development.

In Türkiye, the adoption of e-scooters mirrors global trends, though it is shaped by unique local dynamics. Since their introduction in 2019, e-scooters have become a common sight in major cities such as Istanbul, Ankara, Izmir, and Bursa (Bölen & Çeliker, 2021; Bildirici, İlyas, Kepenek, & Albayrak, 2024). This rapid expansion has been fueled by several factors. Türkiye's growing urban population and persistent traffic congestion have heightened the demand for alternative mobility solutions, with e-scooters offering shorter travel times on crowded streets (Kılıç & Önler, 2022). The country's predominantly young, tech-savvy population has readily embraced app-based services, further driving adoption (Ekici & Kasap, 2023). Additionally, government and municipal initiatives aimed at reducing greenhouse gas emissions and improving air quality have begun to incorporate e-scooters as part of broader sustainable mobility strategies (Resmi Gazete, 2021).

However, the swift proliferation of e-scooters in Türkiye has not been without challenges. Safety concerns, limited infrastructure, and tensions regarding shared responsibility for vehicle maintenance and road safety compliance remain pressing issues (Güldür et al., 2022). Infrastructure in many Turkish cities, historically designed to prioritize automobiles, often lacks dedicated lanes or pathways for micromobility vehicles, exacerbating safety risks (Önder & Akdemir, 2022). Moreover, concerns about noise levels, pedestrian displacement, and equitable access continue to generate debate among stakeholders, including local governments, operators, and users.

Despite the widespread adoption of e-scooters, systematic research on their multi-dimensional impacts in Türkiye remains limited. Existing studies have largely focused on isolated aspects, such as injury rates (Trivedi et al., 2019), regulatory challenges (Bildirici et al., 2024), or environmental benefits (Moreau et al., 2020), leaving a gap in understanding their broader implications. Addressing this gap, the present study adopts a theory-driven approach to explore the e-scooter phenomenon in Türkiye through the lens of the seven-dimensional framework proposed by Behrendt et al. (2023). This framework encompasses environmental, social, technological, infrastructural, economic, public health, and regulatory perspectives, offering a comprehensive structure to analyze the factors influencing e-scooter adoption and usage.

By applying this holistic framework, the study aims to uncover context-specific opportunities and challenges, examine the regulatory and policy dynamics shaping the e-scooter landscape, and explore the socio-technical interactions that influence user behavior and public perceptions. Through this approach, the research seeks to contribute to the global discourse on micromobility while providing actionable insights for policymakers, stakeholders, and everyday users in Türkiye.

2. Theoretical Framework

The exponential growth of e-scooters has spawned a broad corpus of literature on micromobility's benefits, risks, and governance requirements (Dündar et al., 2022). However, synthesizing these disparate lines of inquiry demands a coherent model—one capable of capturing both micro-level user behaviors and macro-level regulatory dynamics. The seven-dimensional framework championed by Behrendt et al. (2023) fulfills this requirement by offering a structured lens through which micromobility can be interrogated. This section delves into that framework and situates it within the existing research.

Research on micromobility has traversed multiple disciplinary angles, including urban planning, environmental science, public health, behavioral psychology, and technology studies (Litman, 2017; Christoforou et al., 2021). From an urban planning perspective, micromobility instruments like e-scooters can alleviate last-mile gaps, complement mass transit systems, and reduce dependence on private cars (Önder & Akdemir, 2022). Environmentally, they are lauded for their potential to curtail air pollution and greenhouse gas emissions by replacing short-distance car trips (Moreau et al., 2020). Yet, a complete ecological assessment must also account for manufacturing, distribution, and end-of-life disposal processes (Güldür et al., 2022). Public health experts emphasize safety and accident rates (Trivedi et al., 2019), while behavioral researchers investigate user acceptance, habit formation, and risk perception (Ekici & Kasap, 2023). Within these domains, frameworks have emerged to map out the multifaceted nature of micromobility. Some focus on the user's journey—addressing motivation and trip purpose. Others concentrate on technical design—highlighting battery efficiency, durability, and geofencing technologies (Dündar et al., 2022). Behrendt et al.'s seven-dimensional framework synthesizes these approaches into a single, robust theoretical model that holistically captures environmental, social, technological, infrastructural, economic, health, and policy considerations.

Behrendt et al. (2023) propose that micromobility be examined across seven interrelated dimensions, each illuminating a different yet interconnected facet of the phenomenon, as illustrated in Figure 1.

Figure 1. Behrendt et al.'s (2023) Seven-Dimensional Theoretical Framework

2.1. Environmental Dimension

E-scooters are frequently championed as a sustainable urban mobility solution due to their potential to reduce greenhouse gas (GHG) emissions and mitigate local air pollution. However, their overall environmental impact remains a subject of debate, as their sustainability benefits are contingent upon multiple interconnected factors.

While e-scooters run on electricity and do not produce exhaust emissions, their true ecological footprint depends significantly on the energy mix used for electricity generation, as well as the carbon intensity of their production and lifecycle management. The manufacturing of lithium-ion batteries, a critical component of e-scooters, is particularly resource-intensive, involving the extraction of rare metals and complex chemical processing (Hertwich et al., 2019). Additionally, challenges associated with battery disposal and recycling further complicate their environmental credentials, as improper waste management can lead to toxic pollution and resource inefficiencies (Gaines, 2021). Some researchers argue that instead of fully eliminating environmental burdens, e-scooters may merely shift them to other stages of the supply chain, particularly in regions with high-carbon electricity grids (Moreau et al., 2020).

In Türkiye, where rapid urbanization and increasing vehicular emissions heighten the urgency for sustainable transportation alternatives, e-scooters hold promise in reducing per capita transport-related emissions. However, operational inefficiencies such as frequent battery replacements, energy-intensive nighttime charging cycles, and the logistical complexities of redistributing scooters across urban centers can significantly diminish their net environmental benefits (Kılıç & Önler, 2022). Fleet management strategies that prioritize sustainable energy use, optimized deployment, and extended battery lifespans are therefore crucial to maximizing their ecological advantages.

To ensure that e-scooters contribute meaningfully to Türkiye's sustainability goals, an integrated policy framework is necessary. This should include incentives for renewable energy adoption in charging infrastructure, regulations promoting circular economy principles in battery production and disposal, and the development of data-driven fleet management techniques to reduce unnecessary vehicle transport. Without these systemic interventions, the potential environmental benefits of e-scooters may remain largely theoretical rather than practically realized.

2.2. Human, Social, and Cultural

The widespread adoption of e-scooters extends beyond infrastructural readiness and technological advancements; it is equally shaped by deep-rooted social norms, cultural perceptions, and behavioral patterns that influence how individuals engage with new mobility options. In different urban contexts, e-scooters are perceived through diverse lenses—some view them as symbols of modernity and sustainable urban living, representing a shift away from car-dependent lifestyles. In contrast, others remain skeptical due to concerns over safety, regulatory uncertainties, and prevailing cultural attitudes that prioritize private vehicle ownership over shared mobility solutions.

In Türkiye, the societal reception of e-scooters is particularly complex, as mobility preferences continue to be dominated by private automobiles, which are often associated with status, security, and convenience (Ekici & Kasap, 2023). This cultural inclination creates a significant barrier to the mainstreaming of e-scooters, particularly among older generations and higher-income demographics who may perceive shared vehicles as inferior alternatives to personal car ownership. Furthermore, generational divides in technology adoption further shape e-scooter usage patterns, with younger, tech-savvy individuals being more receptive to app-based micromobility solutions, whereas older populations often exhibit resistance due to unfamiliarity or concerns about safety and reliability (Gössling, 2020).

Beyond generational disparities, social inequalities also play a crucial role in e-scooter accessibility and acceptance. Low-income communities may face economic barriers to frequent e-scooter use, particularly if pricing models remain prohibitive relative to other forms of public transport. Additionally, gendered mobility patterns reveal disparities in e-scooter adoption, with safety concerns and infrastructural inadequacies disproportionately deterring female users from integrating e-scooters into their daily commutes (Aldred & Jungnickel, 2014). Addressing these socio-cultural barriers requires

comprehensive public engagement strategies, including targeted awareness campaigns, user education programs, and incentives that encourage equitable access to micromobility options.

To ensure that e-scooters evolve beyond a niche mode of transport and achieve widespread societal integration, policymakers and industry stakeholders must adopt an inclusive, community-centered approach. Initiatives such as subsidized pricing models for marginalized groups, enhanced safety measures, and localized outreach efforts tailored to specific cultural contexts can foster greater public trust and participation. Without these culturally sensitive interventions, even the most technologically advanced e-scooter initiatives risk being confined to select demographics, limiting their transformative potential in Türkiye's urban mobility landscape.

2.3. Vehicle Technology Dimension

At the core of e-scooter adoption lies a dynamic interplay between technological innovation and real-world durability. The effectiveness of e-scooter systems depends on the resilience and efficiency of critical components, including electric motors, battery systems, braking mechanisms, and digital interfaces. These elements must not only ensure smooth operation but also withstand frequent and often intensive usage under variable environmental and infrastructural conditions. Unlike privately owned scooters, shared fleet models are subjected to higher levels of wear and tear, necessitating robust engineering solutions that extend operational lifespan while maintaining safety and user-friendliness.

A key area of technological advancement in e-scooter development is battery innovation. Swappable battery packs have emerged as a pivotal solution, enabling fleet operators to reduce downtime and optimize energy use by replacing depleted batteries in situ rather than transporting entire vehicles to centralized charging hubs (Güldür et al., 2022). This approach enhances operational efficiency, minimizes labor-intensive charging cycles, and contributes to overall sustainability by reducing unnecessary vehicle transport emissions. Moreover, real-time diagnostics and predictive maintenance—powered by IoT sensors and AI-driven analytics—allow for proactive identification of mechanical failures, improving fleet reliability and reducing maintenance costs (Dündar et al., 2022).

In Türkiye, e-scooter providers are actively evaluating how these technologies perform in cities characterized by heterogeneous road conditions, variable climate patterns, and complex traffic dynamics. Urban areas such as İstanbul, with its high levels of congestion and mixed-quality road surfaces, pose distinct challenges that demand locally optimized solutions. For instance, enhanced shock absorption systems, reinforced chassis materials, and adaptive braking mechanisms are essential to ensuring safe and comfortable rides across uneven terrains. Additionally, weatherproofing innovations—such as water-resistant enclosures and anti-slip deck surfaces—can significantly improve safety and usability in regions that experience seasonal rainfall or extreme temperature fluctuations.

As consumer expectations evolve and market competition intensifies, manufacturers and operators must strike a delicate balance between lightweight portability and structural durability. Excessive weight can reduce ease of use and maneuverability, while inadequate durability shortens vehicle lifespans and increases long-term operational costs. The integration of modular design principles—where damaged components can be swiftly replaced without discarding the entire vehicle—further enhances cost-effectiveness and sustainability.

Ultimately, the success of e-scooter technology in Türkiye hinges on context-sensitive innovation, where cutting-edge advancements are adapted to meet local infrastructural, environmental, and consumer demands. By investing in durability-enhancing materials, smart maintenance systems, and ergonomic design, industry stakeholders can ensure that e-scooters remain both practical and appealing, fostering their long-term viability as a sustainable urban mobility solution.

2.4. Infrastructure Dimension

The viability of e-scooters as an effective micromobility solution is inextricably linked to the quality and adaptability of urban infrastructure. Dedicated lanes, safe parking zones, and well-maintained roads are fundamental prerequisites for ensuring secure and efficient rides (Litman, 2017). However, in many

urban environments, particularly those with historically car-centric designs, infrastructure remains insufficiently equipped to accommodate e-scooters. The absence of dedicated spaces often forces riders to share congested roadways with motor vehicles or navigate pedestrian-heavy sidewalks, exacerbating safety risks and contributing to regulatory tensions.

In Türkiye, where urban planning has long prioritized automobiles, the retroactive integration of e-scooters into existing transportation networks presents both a logistical and financial challenge (Önder & Akdemir, 2022). Many major cities, including İstanbul, Ankara, and İzmir, exhibit dense traffic conditions, irregular road maintenance, and a lack of protected micromobility lanes, creating an inhospitable environment for widespread e-scooter adoption. Addressing these shortcomings requires significant policy commitments, targeted infrastructure investments, and adaptive urban design strategies. City planners may need to redesign sidewalks, introduce curbside lanes, or reconfigure intersections to accommodate non-automobile traffic while ensuring pedestrian safety.

A holistic infrastructure strategy should also prioritize multi-modal connectivity, seamlessly integrating e-scooters with public transit hubs. By strategically positioning docking stations near bus terminals, metro entrances, and major commuter nodes, cities can facilitate first-mile/last-mile connectivity, reducing reliance on private vehicles and contributing to more sustainable urban mobility patterns. International case studies have demonstrated that such integration can significantly boost ridership and decrease urban congestion (Shaheen & Cohen, 2019).

Beyond physical infrastructure, the development of digital infrastructure—such as real-time route optimization, geofencing technologies, and smart parking solutions—can further enhance the usability and efficiency of e-scooter systems. Leveraging AI-driven traffic analysis to identify high-risk zones and dynamically adjust infrastructure investments can enable more data-driven, adaptive urban planning (Gössling, 2020).

Without these comprehensive infrastructure investments, e-scooters are likely to remain a marginal or supplementary mode of transport, rather than a transformative urban mobility solution. To fully harness the potential of micromobility in Türkiye, urban policymakers must adopt a proactive, integrated approach that aligns physical, digital, and policy frameworks, ensuring that e-scooters can operate safely, efficiently, and at scale within the evolving transportation ecosystem.

2.5. Economic Dimension

E-scooter firms operate within a highly competitive and evolving market, where profitability and long-term sustainability are contingent on a complex interplay of economic variables. Despite optimistic market forecasts from research firms such as Grand View Research (2021) and Statista (2023), translating projected growth into stable revenue streams remains a formidable challenge. The e-scooter business model is inherently cost-intensive, with major expenditures including fleet maintenance, battery recharging logistics, insurance, and mitigation of vandalism and theft. These operational costs can significantly erode profit margins, necessitating strategic innovations in cost management and revenue generation.

In Türkiye, the economic landscape introduces additional layers of complexity. Regulatory compliance, fluctuating user demand, and disparities in regional purchasing power pose unique challenges for operators (Özçelik, 2021). Market penetration strategies that succeed in major metropolitan areas such as İstanbul, Ankara, or İzmir may not be equally viable in smaller cities, where disposable income levels and urban density differ. Furthermore, macroeconomic conditions, including currency fluctuations and inflationary pressures, can impact both pricing strategies and consumer affordability, making flexible pricing models essential for long-term financial stability.

A critical determinant of profitability in the sector is the balance between customer acquisition costs and lifetime value per user. While large injections of venture capital can accelerate expansion and market penetration, they do not inherently guarantee long-term sustainability if usage rates plateau or operational expenses remain disproportionately high. Many firms therefore diversify revenue streams beyond standard pay-per-ride pricing, incorporating:

- Subscription-based models, offering unlimited or discounted rides for a fixed monthly fee, which enhances customer retention and stabilizes cash flow.
- Loyalty and gamification programs, incentivizing frequent usage through discounts, referral benefits, and promotional campaigns.
- Public-private partnerships, where e-scooter firms collaborate with municipalities and transit authorities to integrate micromobility into broader urban transportation networks. These partnerships may involve revenue-sharing models, designated parking infrastructure, or subsidies that reduce the financial burden on operators.

To achieve sustained economic viability, e-scooter companies must embrace operational efficiency and adaptive business models. Advances in fleet optimization algorithms, demand forecasting, and AI-driven predictive maintenance can significantly reduce costs by minimizing unnecessary vehicle redistribution and improving asset longevity. Additionally, companies that engage in proactive regulatory dialogue with local authorities are better positioned to influence policy frameworks in ways that support industry growth rather than impose restrictive measures.

Ultimately, economic success in Türkiye's e-scooter sector will favor firms that prioritize agility, cost-efficiency, and ecosystem integration. Companies that effectively streamline logistics, enhance consumer accessibility, and establish collaborative partnerships will be best positioned to navigate market uncertainties and capitalize on the growing demand for sustainable urban mobility solutions.

2.6. Public Health Dimension

Micromobility is often lauded for its potential to reduce vehicular emissions, improve urban air quality, and promote more sustainable commuting habits. However, the direct implications of e-scooter adoption for public health extend well beyond environmental benefits, encompassing critical safety concerns, accident risks, and regulatory gaps.

A growing body of research highlights the heightened vulnerability of e-scooter riders to injuries and collisions, particularly in the absence of protective measures such as helmet mandates and dedicated infrastructure (Trivedi et al., 2019). Unlike cyclists, who benefit from a well-established culture of protective gear usage, e-scooter riders often operate without helmets, reflective clothing, or adequate visibility at night, increasing their risk of severe injury in the event of an accident. Furthermore, the upright stance and limited stability of e-scooters make riders more susceptible to falls, particularly when navigating uneven road surfaces or congested urban environments. Studies in other urban settings have linked e-scooter accidents to a range of factors, including reckless riding behavior, lack of experience, and interactions with motor vehicles or pedestrians (Mitchell et al., 2019).

In Türkiye, the absence of centralized, nationwide data on e-scooter-related injuries and fatalities presents a significant challenge to accurately assessing public health risks. While scattered reports of severe and fatal accidents have raised public concern, the lack of standardized reporting mechanisms impedes the ability of policymakers and urban planners to implement evidence-based safety interventions (Güldür et al., 2022). Establishing a comprehensive accident database—tracking incident locations, severity levels, and contributory factors—would be instrumental in identifying high-risk zones, peak accident times, and the user behaviors most frequently associated with collisions.

To mitigate public health risks while preserving the broader environmental and social benefits of e-scooter adoption, a multi-pronged approach is required. Key policy recommendations include:

- Mandatory Safety Regulations: Implementing helmet laws, requiring reflective gear for nighttime riding, and enforcing speed limits in high-risk areas can significantly reduce accident severity.
- Infrastructure Enhancements: The creation of dedicated e-scooter lanes, particularly in high-density urban areas, can help minimize conflicts between riders, pedestrians, and motor vehicles.

- Data-Driven Policy Interventions: Establishing standardized accident reporting protocols and analyzing e-scooter usage trends can inform targeted safety initiatives, such as improved traffic signal integration and designated parking areas.
- Public Awareness Campaigns: Educating users on safe riding practices, traffic rules, and responsible scooter behavior through digital platforms and community outreach programs can help reduce reckless riding and enhance public perception of e-scooter safety.

By integrating evidence-based public health strategies with robust urban mobility policies, Türkiye can optimize the safety and sustainability of its micromobility sector. Without proactive interventions, the public health risks associated with e-scooters could undermine their broader societal and environmental benefits, limiting their potential as a viable, long-term urban transport solution.

2.7. Regulations and Policy Dimension

Governance plays a pivotal role in shaping the integration of e-scooters into urban mobility ecosystems. Effective regulation determines the operational parameters of e-scooter services, including speed limits, user eligibility, parking protocols, and safety requirements, while also influencing the business models of fleet operators. Policymakers must balance the need for innovation and accessibility with broader concerns related to traffic safety, public space management, and equitable access to transportation.

In Türkiye, the 2021 "Elektrikli Skuter Yönetmeliği" established a foundational legal framework to regulate e-scooter operations, introducing guidelines on vehicle specifications, operational limits, and safety measures (Resmi Gazete, 2021). However, local governments retain significant autonomy in shaping additional regulatory measures, leading to municipality-specific policies that impact the scalability and consistency of e-scooter services across the country (Bildirici et al., 2024). Municipal authorities may impose restrictions such as fleet size caps, geofenced no-ride zones, mandatory insurance requirements, and obligations for operators to share real-time mobility data. While these policies aim to enhance safety, prevent sidewalk clutter, and optimize urban traffic flows, they also contribute to a fragmented regulatory landscape, requiring operators to navigate a complex web of local compliance requirements when expanding their services.

One of the central challenges in e-scooter governance is the enforcement of regulations across diverse urban settings. Ensuring compliance with speed restrictions, helmet mandates, and designated parking zones requires robust monitoring mechanisms, yet enforcement capacity varies between cities. Inconsistencies in implementation can create regulatory uncertainty for operators, particularly when different municipalities impose conflicting operational rules. Such disparities complicate national expansion efforts and may deter private sector investment in large-scale micromobility infrastructure.

Moreover, data-driven policymaking remains an evolving domain. Many cities require e-scooter companies to share anonymized ridership data, enabling urban planners to analyze travel patterns and optimize infrastructure development. However, standardizing data-sharing agreements while safeguarding user privacy presents an ongoing policy challenge. Establishing a centralized regulatory framework with localized adaptability could enhance transparency and streamline operations, ensuring that e-scooter services remain both innovative and well-regulated.

For e-scooters to become a sustainable and widely accepted urban mobility solution in Türkiye, regulatory strategies must evolve to balance safety, accessibility, and market viability. National-level guidelines should align with local operational realities, providing a structured yet flexible approach to policy implementation. Best practices from global micromobility governance suggest that public-private collaboration, real-time data integration, and adaptive regulation mechanisms are key to fostering an efficient and scalable e-scooter ecosystem (Shaheen & Cohen, 2020). Therefore, future regulatory advancements should focus on:

- Unified compliance standards that reduce inter-municipal inconsistencies and facilitate national expansion.

- Technology-assisted enforcement, such as AI-driven geofencing and automated violation detection.
- Incentivizing sustainable fleet management, including battery recycling mandates and renewable energy-powered charging infrastructure.
- Public engagement initiatives to enhance safety awareness and promote responsible ridership.

By refining policy frameworks to accommodate both innovation and urban mobility demands, Turkish authorities can foster a well-regulated, efficient, and sustainable micromobility sector, positioning e-scooters as a credible alternative to traditional transport modes.

3. Research Methodology

This section provides a comprehensive overview of the research process, detailing the adopted methodological approach, participant selection criteria, data collection techniques, and analytical procedures. The study is structured around the seven-dimensional framework proposed by Behrendt et al. (2023), ensuring a systematic exploration of Türkiye's e-scooter industry.

3.1. Research Approach (Theory-Grounded Qualitative Method)

This study employs a theory-grounded qualitative research approach, leveraging the seven-dimensional micromobility framework proposed by Behrendt et al. (2023) as its guiding theoretical foundation. This methodological choice facilitates a structured yet flexible exploration of the e-scooter sector in Türkiye, allowing for both the validation of existing theoretical constructs and the identification of unique context-specific insights.

By utilizing a qualitative methodology, the research prioritizes in-depth perspectives from industry professionals, capturing the complexities of regulatory, infrastructural, technological, and social dynamics that influence e-scooter adoption. The qualitative nature of this study also enables contextual interpretation, ensuring that findings are not only aligned with global micromobility discourse but also reflective of Türkiye's unique urban mobility landscape.

3.2. Participant Selection and Sampling Strategy

3.2.1. Industry Expert Participation

The study engaged three leading e-scooter firms operating in Türkiye. These companies were selected based on their extensive industry experience, having been active in the sector for at least five years. Their operations span multiple urban centers, providing a holistic perspective on the sector's technological, regulatory, and operational challenges.

To ensure multi-level insight, participants from these companies were key decision-makers holding high-ranking managerial roles, including:

- General Managers, responsible for overarching business strategies and regulatory compliance,
- Operations Managers, overseeing day-to-day fleet logistics and urban deployment strategies, and
- R&D Managers, contributing insights on technology development, sustainability measures, and innovation.

3.2.2. Purposive Sampling Strategy

A purposive sampling method was employed, ensuring that participants had direct experience with the operational and regulatory complexities of the e-scooter industry. The selection criteria focused on:

- Multi-regional operations, ensuring diversity in urban deployment challenges,
- Extensive market experience, providing deep sectoral knowledge, and
- Engagement with policymakers, to capture perspectives on regulatory frameworks.

Initially, seven firms were invited to participate in the study, with direct contact made through formal requests. Of these, three companies voluntarily agreed to participate, representing different facets of the e-scooter ecosystem.

3.3. Ethical Considerations

The study adhered to strict ethical guidelines to ensure participant confidentiality, data integrity, and compliance with academic research standards.

3.3.1. Informed Consent

Prior to data collection, all participants received a detailed study briefing, outlining:

- The purpose of the research,
- The intended use of collected data, and
- Their rights as participants, including the right to withdraw at any stage.

Written informed consent was obtained from all participants to ensure voluntary participation.

3.3.2. Data Anonymization

To maintain confidentiality, the following measures were implemented:

- Company names and participant identities were anonymized, with firms coded as Firm A, Firm B, and Firm C.
- Sensitive operational data (such as market shares and strategic planning details) were masked to prevent indirect identification.

3.3.3. Data Security & Ethical Approval

All collected data were securely stored, with restricted access limited to the research team. Ethical approval was formally obtained from the relevant institutional review board before data collection commenced.

By adhering to these robust ethical protocols, the study ensures data integrity, participant protection, and compliance with international research ethics standards, thereby enhancing the reliability and credibility of its findings.

3.4. Data Collection Methods

This section details the methodological approach employed for data collection, with a primary focus on in-depth interviews and, where applicable, observational techniques. The selection of these methods was driven by the need to obtain nuanced, context-specific insights into the e-scooter sector in Türkiye. The procedures undertaken to ensure rigor and reliability in the data collection process are outlined below.

3.4.1. In-Depth Interviews

In-depth interviews were selected as the primary data collection method due to their ability to capture rich, qualitative insights from key stakeholders in the e-scooter industry. This method facilitated a deeper understanding of the challenges, opportunities, and operational dynamics shaping the sector, allowing participants to articulate their experiences, perspectives, and strategic outlooks in a detailed manner.

3.4.1.1. Interview Structure

To maintain a balance between methodological consistency and respondent flexibility, semi-structured interviews were conducted. This approach ensured that core themes were consistently explored across interviews while allowing participants the latitude to elaborate on topics relevant to their expertise.

The interview questions were systematically designed based on the seven-dimensional theoretical framework proposed by Behrendt et al. (2023), ensuring a holistic examination of the e-scooter ecosystem:

- Environment: Questions assessed the environmental impact of e-scooters, focusing on sustainability practices, carbon footprint reduction, battery management, and energy consumption models.
- Human, Social, and Cultural Factors: Discussions centered on user demographics, behavioral trends, safety concerns, public perception, and the socio-cultural integration of e-scooters into urban mobility.
- Vehicle Technology: Participants provided insights into technological advancements, durability, safety standards, battery efficiency, and ongoing research and development efforts.
- Infrastructure: Topics included the adequacy of current urban infrastructure, parking challenges, traffic integration, and collaboration with municipal authorities to improve e-scooter accessibility.
- Economic Dynamics: The financial viability of the sector was explored through questions on market competition, pricing models, consumer affordability, investment trends, and the economic impact of external disruptions, such as the COVID-19 pandemic.
- Public Health: The discussions evaluated both the positive and negative public health implications of e-scooter adoption, including its role in reducing air and noise pollution as well as potential accident-related risks.
- Regulations and Policy: Participants were asked about the evolving regulatory landscape, compliance challenges, legal frameworks, and anticipated policy developments shaping the sector’s future.

3.3.1.2. Interview Procedure

To ensure accessibility, convenience, and participant confidentiality, interviews were conducted remotely using Zoom, facilitating broader participation from stakeholders across different regions of Türkiye. The procedural steps followed were as follows:

- Each interview lasted approximately 45 to 60 minutes, allowing sufficient time for in-depth discussions while minimizing respondent fatigue.
- Participants were provided with a pre-interview briefing, outlining the study’s objectives, confidentiality measures, and their right to withdraw at any stage without consequences.

- Sensitive or proprietary business information was not requested; instead, questions were framed to elicit general industry insights and expert opinions.
- All interviews were recorded and transcribed verbatim for subsequent thematic analysis, ensuring data accuracy and analytical rigor.
- Ethical considerations were strictly observed, with informed consent obtained from all participants, and data anonymization measures implemented to protect respondent identities.

By employing a systematic, ethically grounded, and theory-driven interview approach, this study ensures the collection of reliable, high-quality qualitative data, enabling a comprehensive exploration of the e-scooter market in Türkiye.

3.5. Data Analysis Procedure

The data analysis followed a rigorous, structured approach based on the seven-dimensional theoretical framework proposed by Behrendt et al. (2023). This framework provided a comprehensive analytical lens for systematically categorizing and interpreting qualitative data on e-scooter adoption and its multidimensional impact. The analysis involved a multi-step process, including systematic coding, thematic analysis, and comparative evaluation against existing micromobility research. Special emphasis was placed on identifying Türkiye-specific contextual factors that shape e-scooter adoption differently from other global settings.

3.5.1. Planning the Coding Process

The qualitative data, primarily derived from in-depth interviews, were coded according to seven predefined dimensions, ensuring a holistic examination of e-scooter operations and their broader implications:

- Environment
- Human, Social, and Cultural
- Vehicle Technology
- Infrastructure
- Economic
- Public Health
- Regulations and Policy

A qualitative data analysis software was employed to systematically organize, tag, and retrieve excerpts from interview transcripts. Each excerpt was categorized under its corresponding dimension, ensuring a clear, structured, and replicable coding process. This method allowed for efficient cross-referencing of themes, facilitating deeper insights into sectoral challenges and opportunities.

3.5.2. Thematic Analysis

Thematic analysis was conducted in three main phases: (i) data familiarization and initial coding, (ii) theme development, and (iii) comparative analysis. The process commenced with an iterative, in-depth reading of all transcripts to ensure a comprehensive understanding of the content.

3.5.2.1. Generating Initial Codes

During this phase, initial codes were generated by identifying key phrases, statements, and conceptual insights within the transcripts. Codes were derived from direct quotations or concise summaries of participant responses, ensuring authentic representation of stakeholder perspectives.

- Example: The statement "Reducing carbon footprint should be prioritized" was coded under the Environment dimension.
- Example: The statement "Most users are young and use scooters mainly for leisure" was coded under the Human, Social, and Cultural dimension.

To ensure reliability, inter-coder agreement was assessed by involving multiple researchers in the coding process. Discrepancies were resolved through discussion and consensus, enhancing the credibility and consistency of the findings.

3.5.2.2. Developing Themes from Codes

Once initial codes were established, thematically similar codes were clustered into overarching themes, allowing for higher-order interpretation of findings. This process involved identifying relationships between codes and constructing thematic categories that encapsulated broader trends and patterns.

- Example: Codes such as "lack of bike lanes" and "parking problems" were consolidated into the theme "insufficient micromobility infrastructure."
- Example: Codes related to pricing concerns and affordability were grouped under "economic accessibility of e-scooter services."

These emergent themes provided deeper insights into sector-wide challenges and user experiences, forming the foundation for subsequent comparative analysis.

3.5.3. Analysis and Comparison

Following thematic categorization, the coded data were systematically compared against the seven-dimensional theoretical framework to assess alignment with existing micromobility research. Particular attention was given to:

- Identifying unique local dynamics in Türkiye that influence e-scooter adoption differently compared to other international case studies.
- Assessing gaps between theoretical expectations and empirical findings, particularly in dimensions such as infrastructure limitations, user behavior, and policy gaps.
- Refining Behrendt et al.'s (2023) framework by incorporating Türkiye-specific sub-dimensions, allowing for a more context-sensitive analytical approach.

Figure 2 illustrates the adaptation of Behrendt et al.'s (2023) theoretical model to Türkiye's unique urban mobility context, integrating localized socio-economic, infrastructural, and regulatory factors.

By employing this structured, theory-driven methodology, the study ensures scientific rigor, replicability, and contextual relevance, contributing valuable insights to the global discourse on micromobility and sustainable urban transport.

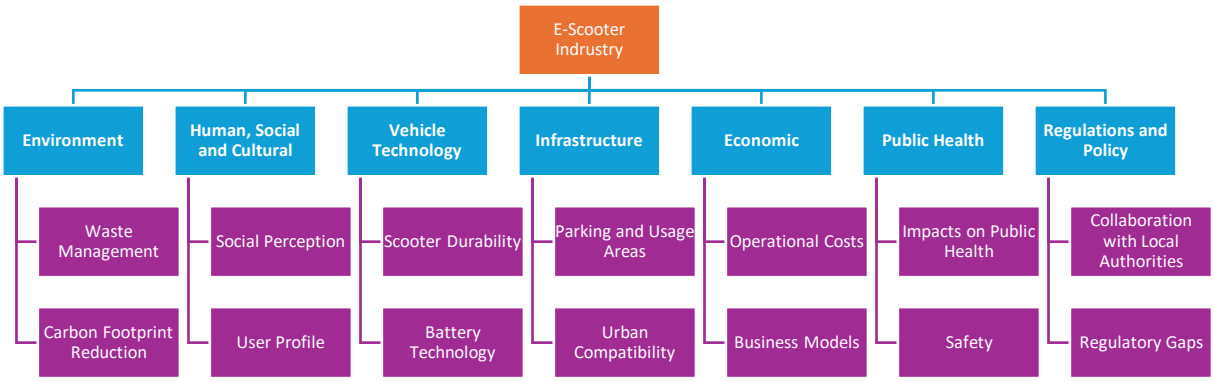

Figure 2. Adaptation of Behrendt et al.'s (2023) Theoretical Framework to the Context of Türkiye

4. Findings

This section presents the empirical results derived from a qualitative analysis based on Grounded Theory, a methodological approach that facilitates the systematic development of theory from qualitative data (Behrandt et al., 2017). By employing an iterative process of data collection, coding, and thematic analysis, this study ensures that its findings are deeply embedded in the perspectives and lived experiences of key stakeholders in Türkiye's e-scooter sector.

The results are structured across seven critical dimensions—environmental, social, technological, infrastructural, economic, public health, and regulatory aspects of shared micromobility—providing a comprehensive, theory-driven perspective on the opportunities and challenges facing e-scooter adoption. The analysis captures both recurring trends and unique insights, forming a robust foundation for further theoretical development and policy recommendations.

4.1. Environmental Impact

4.1.1. Carbon Footprint Reduction

E-scooter operators are actively seeking low-emission alternatives to reduce their overall carbon footprint, with a growing emphasis on electrification of operational fleets:

- "We are replacing our gasoline-powered operational vehicles with electric ones." – Representative of Company A
- "I can say that we are currently 90% ahead in reducing carbon emissions. Other companies are progressing similarly." – Representative of Company C
- "Diesel is still the largest source of carbon emissions in our operations, and we are working on switching to electric vehicles to address this." – Representative of Company B

4.1.2. Waste Management

A circular economy approach is being increasingly integrated into battery disposal and recycling efforts to minimize environmental impact:

- "We hand over used batteries to municipalities and collaborate with recycling companies." – Representative of Company C
- "Even the first batteries we bought are still operating at 80% efficiency, which minimizes waste generation." – Representative of Company B

- "We collaborate with suppliers like Go Battery to ensure our batteries are renewable." – Representative of Company C

4.2. Human, Social, and Cultural Factors

4.2.1. User Profile

E-scooter adoption is highly skewed toward younger demographics, with recreational and short-distance commuting being primary usage motivations:

- "80% of our users are between the ages of 16 and 30." – Representative of Company C
- "People mostly use scooters for fun and short-distance commuting." – Representative of Company A
- "University students, in particular, prefer scooters for commuting to school or visiting libraries." – Representative of Company C

4.2.2. Public Perception

While social acceptance is growing, concerns related to parking behavior and public adaptation remain significant:

- "The scooter sector is still very new, and the adaptation process is ongoing. It will take time for people to get used to this technology." – Representative of Company A
- "There can be a negative perception among the public when some users fail to park scooters properly." – Representative of Company B
- "Scooters are now perceived as ordinary items on the streets and no longer attract as much attention." – Representative of Company A

4.3. Vehicle Technology

4.3.1. Battery Technology

Advancements in battery longevity and management systems are crucial for sustainability and operational efficiency:

- "The current batteries have an average lifespan of two years, and this period is gradually increasing." – Representative of Company C
- "Battery management systems (BMS) help us maintain the maximum performance of our batteries." – Representative of Company C
- "We prefer innovative solutions in our supply chain to ensure our batteries are renewable." – Representative of Company B

4.3.2. Scooter Durability

Fleet operators are investing in maintenance protocols and refurbishment strategies to extend the operational lifespan of scooters:

- "The lifespan of scooters, which used to be six months, has now increased to 36 months, making our operations more efficient." – Representative of Company B
- "We refurbish old scooters and put them back in the field, which reduces waste." – Representative of Company C

- "We have developed periodic maintenance systems to enhance the durability of our scooters." – Representative of Company A

4.4. Infrastructure

4.4.1. Urban Suitability

The lack of dedicated micromobility infrastructure, particularly bicycle lanes, presents a significant challenge to safe integration into urban mobility networks:

- "Bicycle lanes are insufficient in Turkish cities, so scooters sometimes have to share the same space with pedestrians." – Representative of Company B
- "We are working with local authorities on smart locker and charging systems." – Representative of Company B
- "If proper infrastructure were available, bicycles could have been used instead of scooters." – Representative of Company A

4.4.2. Parking and Usage Areas

Improper scooter parking remains a major public concern, necessitating structured parking solutions:

- "Scooters parked incorrectly on sidewalks disturb the public. To solve this problem, we need to establish designated parking areas." – Representative of Company B
- "Local governments need to contribute more to parking regulations." – Representative of Company A
- "Collective parking areas could facilitate better integration of scooters into society." – Representative of Company C

4.5. Economic Considerations

4.5.1. Business Models

E-scooters are positioned as a cost-effective alternative to traditional transport options:

- "Scooters have a daily usage rate of 5.5, which is above European standards." – Representative of Company C
- "They are 70% cheaper than taxis, which makes them a popular choice among users." – Representative of Company C
- "Shared mobility reduces the rate of individual vehicle ownership and offers an economical solution." – Representative of Company A

4.5.2. Operational Costs

Operational costs are heavily influenced by fuel and energy sources, necessitating a shift toward electrification:

- "Diesel is still our largest operational cost. We are working on switching to electric vehicles to reduce it." – Representative of Company B
- "The swappable battery system increases operational efficiency and lowers costs." – Representative of Company C
- "We are working on local energy solutions for charging operations." – Representative of Company B

4.6. Public Health Implications

4.6.1. Safety

Enhanced safety regulations and protective measures are critical to minimizing accidents:

- "We are working on providing protective gear for scooter users." – Representative of Company A
- "Fatal accidents are still an issue, and regulations are needed in this area." – Representative of Company A
- "We plan to offer safety training to users." – Representative of Company C

4.6.2. Impact on Public Health

E-scooters influence urban mobility patterns by offering an alternative to public transport and walking:

- "Scooters offer an alternative to walking." – Representative of Company B
- "After the pandemic, personal vehicles have become more preferred." – Representative of Company A
- "Scooters keep individuals away from crowded public transportation." – Representative of Company C

4.7. Regulatory and Policy Considerations

4.7.1. Regulatory Gaps

Inadequate and restrictive regulations hinder the full-scale adoption of e-scooters:

- "More comprehensive regulations are needed for the proper organization of scooters in cities." – Representative of Company B
- "Existing regulations are mostly insufficient and restrict scooter usage." – Representative of Company A
- "Users over the age of 45 generally do not prefer scooters, and specific regulations could be introduced for this age group." – Representative of Company C

4.7.2. Collaboration with Local Authorities

Stronger partnerships with municipalities are necessary for infrastructure development:

- "We are working with local authorities on scooter parking areas and charging stations." – Representative of Company B
- "Operators should be more involved in sustainable infrastructure development projects." – Representative of Company C
- "We are conducting joint efforts with local authorities to develop parking regulations." – Representative of Company A

5. Conclusion

As cities worldwide grapple with rising congestion, air pollution, and the urgent need for sustainable transport solutions, shared e-scooter mobility emerges as a transformative innovation in urban mobility. However, its success is not guaranteed; it hinges on how effectively operators, policymakers, and urban planners address infrastructural deficiencies, economic constraints, environmental contradictions, user experience limitations, and regulatory gaps.

The findings of this study emphasize that sustainable micromobility is not solely a function of technological advancement but rather a multidimensional challenge requiring social, economic, and policy-driven solutions. A well-designed e-scooter ecosystem—backed by strategic investments in infrastructure, adaptive regulatory frameworks, electrification of operations, and inclusive public engagement initiatives—can significantly reduce urban emissions, enhance mobility equity, and improve the overall efficiency of city transport networks.

Ultimately, the future of shared e-scooter mobility depends on its ability to evolve in response to emerging urban challenges. By embracing data-driven decision-making, cross-sector collaboration, and sustainable innovation, Türkiye has the opportunity to position itself at the forefront of smart, green, and inclusive urban transport solutions. However, realizing this potential requires bold policy interventions, industry leadership, and societal adaptation. If navigated strategically, shared e-scooters can become an integral component of resilient, low-carbon, and people-centric cities of the future, setting a benchmark for sustainable urban mobility on a global scale.

5.1. Infrastructure as a Foundational Bottleneck

The most frequently cited challenge is the lack of dedicated infrastructure, including insufficient bike lanes and inadequate parking solutions. The absence of designated spaces forces e-scooters to compete for space with pedestrians, exacerbating safety risks and operational inefficiencies. Without urban planning reforms that incorporate micromobility-friendly infrastructure, the sector’s ability to scale remains constrained. Strategic collaboration between operators and local governments is essential to developing smart, data-driven parking solutions and integrated charging networks that enhance accessibility and reduce conflicts with other road users.

5.2. The Cost-Sustainability Trade-off

Operational costs continue to pose a major financial challenge. Despite the promise of low-emission mobility, the dependence on diesel-powered collection and maintenance vehicles creates a paradox that undermines environmental gains. Transitioning to fully electric service fleets is an industry aspiration, yet a lack of affordable and suitable electric utility vehicles in the current market remains a bottleneck. Addressing this issue requires public-private partnerships and policy incentives that facilitate investment in clean energy solutions for fleet operations.

5.3. The Environmental Paradox: Beyond Zero Emissions

Although e-scooters are marketed as an environmentally friendly alternative, their full life-cycle impact reveals an embedded sustainability paradox. While zero tailpipe emissions contribute to air quality improvements, the manufacturing, disposal, and energy-intensive logistics of fleet management generate significant hidden carbon costs. Advancements in battery technology, circular economy initiatives, and optimized fleet deployment are imperative to align the sector’s environmental narrative with its actual sustainability outcomes.

5.4. Enhancing User Experience to Drive Adoption

User satisfaction and accessibility play a crucial role in determining the long-term adoption of shared e-scooters. Participants emphasized the need for well-maintained fleets, intuitive service design, and

enhanced safety measures to improve overall user experience. Issues such as improper parking and vehicle malfunctions not only inconvenience riders but also shape public perception, influencing regulatory responses and policy decisions. Addressing these concerns through proactive maintenance strategies, user education campaigns, and technological enhancements (e.g., geofencing for designated parking) can help elevate user trust and service reliability.

5.5. Public Perception: Overcoming Skepticism Through Cultural Integration

The sociocultural acceptance of e-scooters remains an evolving process. While younger demographics have embraced this mode of transport, widespread adoption is hindered by safety concerns, unfamiliarity, and negative perceptions related to improper usage. The transition from novelty to mainstream urban mobility solution requires comprehensive public engagement strategies, including community-driven awareness programs, corporate responsibility initiatives, and transparent safety data reporting.

5.6. The Role of Policy in Shaping the Future

Regulatory inconsistencies and gaps represent one of the most significant structural obstacles to the sector's growth. Participants noted that current policies are either insufficient or overly restrictive, impeding innovation while failing to address fundamental urban mobility challenges. To unlock the full potential of shared e-scooters, a balanced regulatory framework is needed—one that prioritizes safety, promotes sustainability, and fosters business viability. Establishing collaborative regulatory models that include municipal governments, industry stakeholders, and urban planners will be essential in creating fair and forward-thinking policies that support micromobility as an integral component of urban transport ecosystems.

5.7. The Path Forward: Building a Sustainable Micromobility Ecosystem

The findings underscore that the future of shared e-scooter mobility in Türkiye depends on a multi-stakeholder approach—one that integrates technological innovation, regulatory support, urban planning reforms, and user-centric service enhancements. The sector's long-term success and sustainability hinge on the following strategic imperatives:

- Infrastructure Development: Investment in dedicated micromobility lanes, geofenced parking solutions, and multimodal transport integration.
- Fleet Electrification: Adoption of renewable energy sources and electrification of operational fleets to mitigate environmental contradictions.
- Battery Circularity: Strengthening battery recycling programs and sustainable sourcing initiatives to minimize ecological impact.
- User-Centric Innovation: Leveraging real-time diagnostics, AI-driven fleet management, and geospatial analytics to optimize service efficiency and safety.
- Regulatory Harmonization: Developing evidence-based policies that balance urban mobility needs with sustainability goals, ensuring a structured yet innovation-friendly regulatory environment.
- Public Awareness and Cultural Integration: Implementing educational campaigns and community engagement initiatives to normalize shared mobility and address behavioral resistance.

As urbanization accelerates and cities seek cleaner, more efficient transportation alternatives, e-scooters hold immense potential to redefine urban mobility. However, their long-term viability depends on how effectively operators, policymakers, and urban planners navigate the current challenges and implement forward-thinking solutions. By aligning sustainability goals with operational realities, fostering cross-

sector collaboration, and embracing adaptive innovation, Türkiye can position itself as a leader in sustainable micromobility solutions on a global scale.

Researchers' Contribution Rate Statement

The authors' contribution rates to the study are equal.

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There is no conflict of interest with any institution or person within the scope of the study.

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