Journal of Information Systems Engineering and Management
2025, 10(1s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Thematic Literature Review of Factors Influencing Electric Vehicle Adoption in Hunan Province's Public Sector, China

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ARTICLE INFO

Received: 06 Oct 2024

Revised: 01 Dec 2024

Accepted: 10 Dec 2024

ABSTRACT

This study examines factors influencing the adoption of electric vehicles (EVs) in Hunan's urban public transportation sector, focusing on policy incentives, economic challenges, and infrastructure governance. Barriers include insufficient charging infrastructure, limited vehicle performance, and low stakeholder awareness of EV technology. Economic challenges such as high upfront costs, elevated charging tariffs, and uncertain long-term financial benefits further hinder adoption. Governance issues, including fragmented institutional roles, poor coordination between national and local authorities, and weak regulatory frameworks, impede infrastructure development and maintenance. The study develops a study framework grounded in the Socio-Technical System (STS) and the extended Technology Adoption Model (TAM2). It emphasizes the need for integrated strategies to address these challenges and proposes directions for future study to fill existing gaps.

Keywords: Electric vehicle adoption, urban public transportation, policy incentives, infrastructure governance, economic challenges, Hunan, China.

INTRODUCTION

1.1 Background & Rationale

Transportation is a major contributor to global CO2 emissions, accounting for approximately 24%. This stark reality demands the urgent and widespread adoption of electric vehicles (EVs) as a fundamental strategy to combat climate change (International Energy Agency [IEA], 2022). This study will deliver a comprehensive review of existing literature on EV adoption, with a strong emphasis on its global context and technological advancements. Furthermore, it will present a solid conceptual framework that underscores the critical role of governance mechanisms in urban public transportation in China, accompanied by actionable implications and strong recommendations. Despite extensive research on EV adoption in both the private and public sectors globally, there is a glaring gap in studies addressing the impact of governance mechanisms in facilitating this transition, particularly within China's urban public transportation context.

The global momentum for EV adoption is undeniable, driven by an imperative to fight climate change, decrease reliance on fossil fuels, and mitigate urban pollution while enhancing sustainability in urban areas (Bhat, Verma, & Verma, 2022; Achiaw & Kanol, 2021; Carvalho, Delafave, & Balestieri, 2021). Governments, industries, and urban planners must prioritize the transition from internal combustion engine (ICE) vehicles to EVs to achieve international low-carbon development goals, including those outlined in the Paris Agreement and the United Nations Sustainable Development Goals (Fournel, 2022; Liu, Wu, Qian, Wu, & Wang, 2021). Regions like the European Union and Norway have already taken decisive action by implementing robust policy initiatives and incentives to accelerate EV adoption, while advancements in battery technology and charging infrastructure have effectively lowered barriers to entry (Anastasiou, Fuehres, & Sousa-Zomer, 2018; IEA, 2022). In emerging economies such as India and Brazil, targeted policy interventions are proving essential in overcoming financial and infrastructure challenges, thereby promoting EV uptake in both sectors (Carvalho et al., 2021).

In China, the transportation sector is a significant source of CO2 emissions, responsible for 15% of the nation's total emissions (China Meteorological Administration [CMA], 2023). With a steadfast commitment to achieving carbon neutrality by 2060, China recognizes EV adoption as a strategic imperative to address its heavy reliance on fossil fuels. The government's policies to promote EV deployment are further strengthened by substantial advancements in charging infrastructure and vehicle efficiency (Lu, 2022; Chen, Zeng, & Tan, 2021). Urban areas, often hotspots for transportation-related emissions, play an essential role in harnessing the full potential of EVs to reduce carbon footprints. Despite some progress, EV adoption in urban public transportation has stagnated at a mere 10% (Ramasamy, Qian, Zhai, & Liu, 2021). Transitioning public sector fleets to EVs is a crucial pathway toward achieving low-carbon urban development, particularly in cities like Hunan, where air pollution and energy consumption pose significant challenges (Huang, Tian, Lu, & Li, 2017).

Research clearly demonstrates that effective governance mechanisms—including policy incentives, infrastructure planning, and cross-sectoral collaboration—are essential for the successful integration of EVs into urban transit systems (Zhang, Li, & Wang, 2021). While substantial literature exists on global EV adoption, it is imperative to explore the interplay of governance mechanisms within China’s public sector. This study will decisively fill this gap by examining the role of governance mechanisms in urban EV adoption in China, providing clear insights into the policies and actions needed to facilitate a transition to sustainable urban transportation systems. Transportation is a major contributor to global CO2 emissions, accounting for approximately 24%. This stark reality demands the urgent and widespread adoption of electric vehicles (EVs) as a fundamental strategy to combat climate change (International Energy Agency [IEA], 2022). This study will deliver a comprehensive review of existing literature on EV adoption, with a strong emphasis on its global context and technological advancements. Furthermore, it will present a solid conceptual framework that underscores the critical role of governance mechanisms in urban public transportation in China, accompanied by actionable implications and strong recommendations. Despite extensive research on EV adoption in both the private and public sectors globally, there is a glaring gap in studies addressing the impact of governance mechanisms in facilitating this transition, particularly within China's urban public transportation context.

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by examining the role of governance mechanisms in urban EV adoption in China, providing clear insights into the policies and actions needed to facilitate a transition to sustainable urban transportation systems.

1.2 Purpose & Scope

This study unequivocally focuses on examining the critical relationship between technical and economic factors and the governance mechanisms of infrastructure that drive the adoption of electric vehicles in urban public transportation. By concentrating on Hunan Province, this research will deliver essential insights that will shape effective policy development and implementation strategies, directly supporting China's ambitious goals for carbon reduction and sustainable urban growth. Hunan serves as a pivotal case study, exemplifying the unique challenges and opportunities faced by second-tier economic regions in China. Furthermore, this study will specifically address the urban public transportation sector—namely buses, taxis, and municipal vehicles—because of its substantial potential to significantly reduce carbon emissions and its distinct operational characteristics compared to urban private transportation.

1.3 Research Questions

In response to the problem statement, this study has established five critical research questions:

1. How do charging infrastructure, electric vehicle performance, and technical knowledge (as technical factors) influence the adoption of electric vehicle transportation in the urban public sector of Hunan, China?

2. To what extent do the vehicle costs, charging facility costs, and economic benefits (as economic factors) have a significant impact on the adoption of electric vehicle transportation in the urban public sector of Hunan, China?

3. In what ways do the charging infrastructure, electric vehicle performance, and technical knowledge (as technical factors) create indirect effects on the adoption of electric vehicle transportation in the urban public sector of Hunan, China, mediated by infrastructure governance mechanisms?

4. Similarly, do vehicle costs, charging facility costs, and economic benefits (as economic factors) exert indirect influences on the adoption of electric vehicle transportation in the urban public sector of Hunan, China, through the mediation of infrastructure governance mechanisms?

5. To what extent do Infrastructure governance mechanisms play a crucial role in influencing the adoption of electric vehicle transportation in the urban public sector of Hunan, China?

1.4 Research Objectives

In line with the problem statement, this study developed five study objectives and they are: (1) The charging infrastructure, electric vehicle performance, and technical knowledge (technical factors) respectively as independent variables exert direct influence on the adoption of urban public sector electric vehicle transportation in Hunan, China, (2) The vehicle cost, charging facilities cost, and economic benefits (economic factors) respectively as independent variables exert direct influence on the adoption of urban public sector electric vehicle transportation in Hunan, China, (3) The charging infrastructure, electric vehicle performance, and technical knowledge (technical factors) respectively as independent variables exert indirect influence on the adoption of urban public sector electric vehicle transportation in Hunan, China through the mediation of infrastructure governance mechanisms, (4) The vehicle cost, charging facilities cost, and economic benefits (economic factors) respectively as independent variables exert indirect influence on the adoption of urban public sector electric vehicle transportation in Hunan, China through the mediation of infrastructure governance mechanisms, and; (5) Infrastructure governance mechanisms exert influence on the adoption of urban public electric vehicle transportation in Hunan, China.

1.5 Theoretical Significance

The significance of this study is underscored by its thorough analysis of the critical factors driving the adoption of electric vehicles in urban public sector transportation. By employing two robust theoretical frameworks - (1) the Extension of the Technology Acceptance Model (TAM2) (Venkatesh & Davis, 2000) and (2) the Socio-Technical Systems Theory (Mumford, 2006)—this research delivers a compelling multi-dimensional perspective on the adoption process. First, the Extension of the Technology Acceptance Model (TAM2) provides a clear understanding of how users accept and utilize technology, placing particular emphasis on the impact of technical knowledge and

electric vehicle performance on adoption within the urban public transportation sector. This study decisively expands the application of TAM by integrating economic factors and infrastructure governance mechanisms, illustrating that technological acceptance is driven not only by technical considerations but also by economic viability and institutional frameworks (Venkatesh & Davis, 2000). Second, the Socio-Technical Systems Theory rigorously examines the interconnections between social and technical dimensions in organizational structures. This framework solidifies the analysis of how technical and economic factors interact through governance mechanisms. By aligning with Socio-Technical Systems Theory, this study highlights the dynamic interactions among technological infrastructure, economic incentives, and institutional governance, providing a comprehensive and assertive understanding of how these elements co-evolve to propel the adoption of innovative technologies, such as electric vehicles, in public transportation.

THEMATIC LITERATURE REVIEW

2.1 Factors Influencing the Adoption of Electric Vehicles in Hunan

Several key themes emerge from studies examining factors influencing the adoption of electric vehicles in Hunan, underscoring the pivotal role of urban infrastructure governance mechanisms and strategic policy measures. One major theme focuses on government policies and financial incentives, with research emphasizing the impact of preferential policies such as purchase subsidies, tax exemptions, and license plate concessions on consumer decisions in favor of electric vehicles (Liu, Chen, Liu, & Yan, 2020). These studies highlight that well-designed, targeted incentives are instrumental in encouraging broader adoption of electrical vehicles by reducing upfront costs and regulatory barriers. Another significant theme is the integration of environmental and corporate sustainability goals. For instance, Liu et al. (2021) demonstrate how promoting the environmental benefits of electric vehicles and aligning them with corporate sustainability initiatives can drive adoption among manufacturing companies. Policy directives like the "Notice on Launching the First Batch of Pilots for the Full Electrification of Public Sector Vehicles" also play a critical role in accelerating the transition to electrical vehicles within the public sector, showcasing the government's commitment to reducing emissions and fostering sustainable transportation.

Urban infrastructure development and innovation constitute a third theme, with case studies from Hunan illustrating best practices in deploying charging infrastructure. In Yueyang, for example, Liu and Zhang (2021) report that local authorities achieved significant progress by collaborating with power utilities and charging service providers to ensure widespread availability of charging facilities. Similarly, in Changde, Chen et al. (2021) highlights the integration of renewable energy sources, such as solar power, into EV charging networks, demonstrating how innovation in infrastructure can support low-carbon, sustainable urban development. Finally, multi-stakeholder collaboration emerges as a cornerstone for effective urban infrastructure governance. Studies emphasize that the success of electrical vehicles adoption hinges on coordinated efforts among government agencies, utility companies, charging service providers, and end-users (Wang et al., 2019). This collaborative approach ensures not only the efficient deployment of charging infrastructure but also its ongoing management and responsiveness to user needs. Together, these insights underscore the importance of robust governance mechanisms, strategic incentives, and collaborative frameworks in advancing the adoption of electrical vehicles in Hunan. By drawing on best practices from various cities, stakeholders can foster sustainable urban transport solutions that align with both regional and national low-carbon development goals.

2.2 Technical Factors and Electric Vehicle Adoption

Several key themes emerge from studies on the factors driving the adoption of electric vehicles in Hunan, underscoring the essential role of urban infrastructure governance and strategic policy measures. First and foremost, government policies and financial incentives are pivotal. Research unequivocally demonstrates that preferential policies—such as purchase subsidies, tax exemptions, and license plate concessions—significantly influence consumer decisions to choose electric vehicles (Liu, Chen, Liu, & Yan, 2020). These well-crafted and targeted incentives are crucial for driving widespread adoption by effectively reducing upfront costs and eliminating regulatory barriers. In addition, the integration of environmental and corporate sustainability goals cannot be overlooked. Liu et al. (2021) illustrate how promoting the environmental advantages of electric vehicles and aligning these benefits with corporate sustainability initiatives can decisively drive adoption within manufacturing companies. Furthermore, policy directives like the "Notice on Launching the First Batch of Pilots for the Full

Electrification of Public Sector Vehicles" are critical in accelerating the public sector's transition to electric vehicles, demonstrating the government's unwavering commitment to reducing emissions and advancing sustainable transportation.

Urban infrastructure development and innovation represent another vital theme. Case studies from Hunan exemplify best practices in the deployment of charging infrastructure. In Yueyang, Liu and Zhang (2021) reveal that local authorities have achieved remarkable progress by actively collaborating with power utilities and charging service providers to guarantee the widespread availability of charging facilities. Likewise, in Changde, Chen et al. (2021) emphasize the successful integration of renewable energy sources, such as solar power, into electric vehicle charging networks, illustrating how infrastructure innovation is central to supporting low-carbon, sustainable urban development. Finally, multi-stakeholder collaboration stands as a cornerstone of effective urban infrastructure governance. Studies convincingly show that the successful adoption of electric vehicles relies on cohesive efforts among government agencies, utility companies, charging service providers, and end-users (Wang et al., 2019). This collaborative approach not only guarantees the efficient deployment of charging infrastructure but also ensures its ongoing management and responsiveness to user needs.

In summary, these insights highlight the critical importance of robust governance mechanisms, strategic incentives, and collaborative frameworks in driving the adoption of electric vehicles in Hunan. By leveraging best practices from various cities, stakeholders can effectively foster sustainable urban transportation solutions that align seamlessly with both regional and national low-carbon development goals. In this study, technical factors are defined as the elements of the technology and infrastructure necessary for the effective implementation and operation of electric vehicles. These factors are categorized into three primary dimensions: charging infrastructure (Bakker & Trip, 2013), vehicle performance (Wang, Zheng, & Han, 2018), and technical knowledge (Zhou, Wu, Wu, & Wang, 2020). Each dimension is instrumental in evaluating electrical vehicle adoption's feasibility, efficiency, and effectiveness. Charging infrastructure encompasses the network of charging stations and associated facilities that support EVs (Chawla, Mohnot, Mishra, Harsh, & Singh, 2023). It is assessed based on criteria such as the availability, accessibility, and geographic distribution of public charging stations, with key metrics including station density and operational efficiency. Vehicle performance focuses on the functional capabilities and reliability of electrical vehicles deployed in urban public transportation, incorporating measures like range per charge, energy efficiency, breakdown frequency, and user satisfaction (Wang et al., 2018). Data to evaluate performance can be obtained from transportation agencies and user feedback surveys. Technical knowledge refers to the expertise and understanding of electrical vehicle technology among transportation operators, maintenance personnel, and policymakers. This includes knowledge of maintenance, operation, troubleshooting, and overall familiarity with electrical vehicle systems, as assessed through surveys (Zhou et al., 2020).

The development of charging infrastructure is essential for driving the widespread adoption of electric vehicles (Zink, Valdes & Wuth, 2020). This infrastructure is a critical factor that directly affects the practicality of electric vehicles and shapes consumer purchasing decisions. Recent technological advancements have accelerated electric vehicle adoption by enabling rapid energy transfer, enhancing charging efficiency, and introducing next-generation super-fast charging solutions that deliver unmatched convenience (Pang, Ye, & Zhang, 2023; Rafiq, Parthiban, Rajkumari, Adil, Nasir, & Dogra, 2024). The availability of charging stations is a decisive element influencing adoption intentions (Pandak, Piaralal, & Rethina, 2024). Critical features, such as favorable electricity tariffs, robust batteries, and complimentary charging options, significantly boost adoption rates (Harahap et al., 2023). A robust nationwide public charging infrastructure is imperative for facilitating both local and long-distance travel, meeting consumer demands for accessibility near homes and workplaces (Reiner, Beard, Park, & Kinnear, 2020). Nevertheless, challenges must be addressed. Research conducted by Bhat et al. (2022) and Imran & Mohammad (2022) highlights that poor facilitating conditions can adversely impact adoption intentions. Moreover, some experts assert that charging infrastructure alone is insufficient to drive adoption (Habich-Sobiegalla, Kostka, & Anzinger, 2019), while inadequate physical infrastructure remains a significant barrier (Verma, Verma, & Khan, 2020). The effects of various types of infrastructure—private, semi-public, and public—differ markedly, as shown by Zink et al. (2020).

Performance expectations are another critical factor influencing adoption decisions. Key metrics such as driving range, energy efficiency, and user satisfaction drive consumers' intentions to embrace electric vehicles (Wang, Ozden, & Tsang, 2023). High-performance expectations are directly correlated with increased adoption rates (Bhat

et al., 2022), though the significance of functional attributes can shift depending on consumer motivations (Peters, Van der Werff, & Steg, 2018). Fleet managers, for example, prioritize technical attributes during electric vehicle procurement, emphasizing their practical implications (Di Foggia, 2021). The perception of electric vehicle functionality is pivotal; general awareness and understanding are fundamental to fostering adoption (Reiner et al., 2020). Additionally, technical knowledge is a crucial determinant of electric vehicle adoption. Familiarity with the operation, maintenance, and troubleshooting of electric vehicles significantly boosts user confidence and acceptance (Zhou et al., 2020; Reiner et al., 2020). Sustainability awareness and hands-on experience further enhance the intention to repurchase electric vehicles (Pan, Wang, Li, & Wu, 2024). Conversely, a lack of technical readiness and awareness obstructs adoption (Gupta & Rhoads, 2022; Habich-Sobiegalla et al., 2019). This underscores the vital need for educational initiatives and increased exposure to electric vehicle technologies to close knowledge gaps and ensure widespread acceptance (Pandak et al., 2024).

In conclusion, the adoption of electric vehicles is driven by a complex interplay of technical factors. Charging infrastructure is a fundamental requirement, while vehicle performance directly influences consumer satisfaction and adoption intentions. Technical knowledge is the crucial link between technology and user acceptance; shortcomings in this area can hinder progress. These elements collectively highlight the pressing challenges and significant opportunities in advancing electric vehicle adoption.

2.3 Economic Factors and Electric Vehicle Adoption

In this study, economic factors are defined as the financial and market-related elements that influence the feasibility, adoption, and sustainability of electric vehicles. These factors are crucial in evaluating the overall cost-effectiveness, funding, and economic implications associated with transitioning to electric public transportation. The key economic factors have been operationalized to include vehicle cost, charging facilities, and economic benefits, which are considered the second set of independent variables in this study. Vehicle cost refers to the initial purchase price of electric vehicles as well as the ongoing maintenance and operational expenses. The study evaluates vehicle cost by comparing the total cost of ownership (TCO) between electric buses and taxis and their internal combustion engine counterparts. TCO includes the purchase price, maintenance costs, fuel/charging costs, and depreciation (Hawkins et al., 2020). Charging facilities cost pertains to the physical infrastructure where electric vehicles are charged, including the types of chargers (e.g., fast chargers, standard chargers), their power output, and the waiting time for charging. This is assessed by evaluating the number, type, and utilization rate of charging facilities in public transportation hubs (Li, Song, Liu, & Xie, 2019). Economic benefits relate to the financial advantages of using electric vehicles compared to conventional vehicles, such as savings on fuel, reduced maintenance expenses, and potential government subsidies or incentives. These benefits are assessed through cost-benefit analyses and financial performance reports from public transportation fleets (Buhmann, Rialp-Criado, & Rialp-Criado, 2024).

Several studies have highlighted the importance of vehicle cost in the adoption of electric vehicles. Pandak et al. (2024) identified purchase price as a significant predictor of consumers' intentions to adopt electric vehicles. Di Foggia (2021) found that fleet managers' decisions to procure electric vehicles are heavily influenced by financial information, including vehicle costs, and expected payback periods. Similarly, Wang et al. (2023) reported that price value positively affects the intention to adopt electric vehicles, with Li, Wang, and Xie (2020) also noting that the purchase price is a key factor influencing consumers' willingness to adopt electric vehicles. However, Gupta & Rhoads (2022) observed that the high upfront cost of electric vehicles represents a significant barrier to adoption, particularly in developing countries. Imran Mohammad (2022) further supported this by suggesting that consumers prioritize price over all other factors when deciding to adopt electric vehicles. Financial considerations, particularly the cost of charging, also play a substantial role in adoption decisions (Reiner et al., 2020), with Gupta and Rhoads (2022) noting that lower energy costs could encourage adoption. Kester et al. (2018) also indicated that cost-reduction strategies could accelerate the adoption of electric vehicles in various countries.

Perceived economic benefits significantly influence the intention to adopt electric vehicles. Bhat et al. (2022) found that perceived benefits positively impact customers' intentions to adopt electric vehicles, and Featherman, Jia, Califf, and Hajli (2021) reported that these perceived advantages play a role in purchasing decisions. Li et al. (2020) noted that a greater perception of economic benefits makes consumers more willing to adopt electric vehicles. However, Deka (2022) found that the desire for personal gain does not directly influence the formation of adoption intentions. Conversely, Sovacool et al. (2019) found that perceived benefits are indeed a determinant of willingness

to adopt electric vehicles. Reiner et al. (2020) emphasized that perceptions regarding economic benefits are crucial in driving electric vehicle adoption, underlining their importance in the decision-making process.

Economic impacts extend beyond individual adoption decisions. A study by Lin, Chen, and Xie (2018) examined the economic implications of electric vehicle deployment in China, revealing that the development of electric vehicle infrastructure generates numerous jobs. These jobs are associated with the manufacturing, installation, and maintenance of charging stations, as well as the production of electric vehicle components, stimulating economic growth. Furthermore, efficient governance mechanisms in electric vehicle infrastructure attract investment and enhance revenue generation. Zhang, Su, and Gao (2019) explored the economic benefits of electric vehicle charging infrastructure development in China, showing that charging stations contribute not only to the electric vehicle market but also generate revenue through charging, parking, and service fees. The adoption of electric vehicles, supported by effective governance mechanisms, can also reduce dependence on fossil fuels and lower operating costs, leading to savings for both individuals and businesses (Ghosh & Dey, 2024).

In summary, the purchase price of electric vehicles plays a significant role in influencing the intentions of urban public sectors to adopt them, with high upfront costs acting as a barrier, especially in developing countries. Perceived economic benefits, such as cost savings and government incentives, positively impact adoption intentions, though personal gain does not always directly drive these intentions. Additionally, the development of electric vehicle infrastructure can create jobs and stimulate economic growth, particularly in regions like China. Efficient governance of electric vehicle infrastructure further contributes to reduced reliance on fossil fuels, lowering operating costs and generating additional savings for both consumers and businesses.

2.4 Technical Factors and Infrastructure Governance Mechanisms

Technical factors, such as charging infrastructure, vehicle performance, and technical knowledge, play a crucial role in the adoption of electric vehicles, as highlighted by Li et al. (2020). These attributes are central to the decision-making process for customers in various contexts, with research indicating their significant influence on the adoption of electric vehicles. Li et al. (2020) found that the availability of charging stations, the performance of electric vehicles, and the technical knowledge of consumers substantially affect their willingness to adopt these vehicles. Similarly, Wang et al. (2023) reaffirmed that technical factors, including charging infrastructure, vehicle performance, and technical knowledge, are critical determinants in the adoption of electric vehicles across different domains. Harahap et al. (2023) extended this view by emphasizing the role of infrastructure governance mechanisms, which act as a conduit through which technical factors, such as charging infrastructure, vehicle performance, and technical knowledge, can accelerate the adoption of electric vehicles. Furthermore, governance mechanisms in areas like economic regulation, social infrastructure, and installation practices were identified as key contributors to enhancing the effect of these technical factors on the adoption process.

The economic impact of electric vehicles has also been a subject of significant study, particularly in the context of job creation and industry growth. Zhang et al. (2018) conducted a pivotal study analyzing the job creation potential of China's electric vehicle industry. Their findings revealed that the rapid expansion of the electric vehicle market has led to the creation of numerous jobs across various sectors, including manufacturing, research, and development (R&D), and infrastructure development. Li et al. (2017) further reported that the increasing demand for electric vehicles has spurred revenue growth in industries such as automotive manufacturing, battery production, and the development of charging infrastructure. This growing demand is contributing to the overall economic development of regions involved in the electric vehicle market.

Several studies have also highlighted the broader economic benefits of electric vehicle adoption. Zhang et al. (2019) conducted an economic assessment in China, concluding that the widespread adoption of electric vehicles has the potential to significantly contribute to economic growth by attracting investment, improving productivity, and enhancing overall competitiveness. Similarly, Chen et al. (2018) explored the economic impact of electric vehicles in California, finding that their adoption could lead to considerable economic benefits, including increased tax revenues, reduced healthcare costs, and enhanced productivity. Further supporting these findings, studies by Wang et al. (2016) in Europe and Han et al. (2015) in South Korea highlighted the positive economic outcomes associated with electric vehicle adoption, such as job creation, income generation, and overall economic growth. These studies collectively demonstrate that the transition to electric vehicles offers substantial economic benefits, driving growth

across various sectors, creating job opportunities, and contributing to broader economic development, particularly in regions like Hunan.

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2.6 Infrastructure Governance Mechanisms and Electric Vehicle Adoption in Hunan Province

An evaluation of the current governance mechanisms for electric vehicle infrastructure in Hunan is crucial for assessing the effectiveness of existing practices and identifying areas that require improvement. Several studies have shed light on the key factors that influence the success of these governance mechanisms. Chen et al. (2017) emphasized the importance of government support, financial incentives, and technological advancements in promoting the development of electric vehicle charging infrastructure in China. They highlighted the necessity of proactive policy measures to encourage private investment and facilitate the deployment of charging stations. This insight aligns with an assessment of Hunan's governance practices, where the level of government support and financial incentives provided to stakeholders plays a vital role in influencing infrastructure development. Similarly, Jiang et al. (2018) examined the challenges in the construction of electric vehicle charging infrastructure across China, identifying issues such as inadequate planning, uncoordinated development, and underinvestment as significant barriers to the effectiveness of governance mechanisms. Liu et al. (2021) further explored the impact of urban electric vehicle infrastructure on residents' travel patterns in Changsha, noting that while the development of charging stations has improved the accessibility of electric vehicles, challenges remain in terms of the distribution and availability of charging facilities. These studies underscore the need for better planning, coordination, and investment strategies to address the weaknesses within Hunan's governance structures and processes.

Equally important is the examination of coordination and collaboration between government agencies and relevant stakeholders, as this can significantly influence the effectiveness of governance mechanisms in the electric vehicle infrastructure sector. Li et al. (2019) conducted a regression analysis to explore the impact of government policies, charging infrastructure availability, and financial incentives on electric vehicle adoption in Hunan. Their study found a positive correlation between the presence of supportive policies, the availability of charging infrastructure, and higher rates of electric vehicle adoption. In a similar vein, Yang et al. (2020) utilized statistical techniques, including correlation analysis, to identify the factors that influence electric vehicle adoption in Hunan. Their findings highlighted the crucial role of the accessibility and proximity of charging stations, particularly within residential areas, in driving electric vehicle adoption. In summary, several studies have identified key factors that significantly impact the success of governance mechanisms for electric vehicle infrastructure. Assessing the effectiveness of these governance mechanisms in Hunan is essential for evaluating their current state and identifying areas where improvements are necessary to foster the successful adoption and deployment of electric vehicles.

2.7 Underpinning Theories

2.7.1 Social Technical System Theory (STS Theory)

A Social Technical System (STS) refers to an organizational framework that emphasizes the interrelatedness of social and technical aspects within any system. STS Theory emphasizes the interdependence between social and technical elements within complex systems. It posits that optimal performance and innovation arise from the co-evolution and alignment of both social (human, organizational, cultural) and technical (technological, infrastructural) subsystems. This theory is particularly relevant for studying systems where human and technological elements interact intensively, such as urban public sector transportation systems adopting Electrical vehicles. The adoption of electrical vehicles in Hunan's urban public sector transportation system involves various challenges, such as technological reliability, infrastructure development, public acceptance, and economic viability. STS Theory highlights the importance of involving multiple stakeholders in the decision-making process. Engaging policymakers, public transport operators, technical experts, and the public ensures that diverse perspectives are considered, leading to more robust and acceptable solutions. By applying STS Theory, policymakers can design and implement governance mechanisms that foster the co-evolution of social and technical elements. The interplay of technical and economic factors requires a flexible and adaptive governance approach. STS Theory supports the development of systems that can adapt to technological advancements and changing economic conditions, ensuring long-term sustainability. In summary, the Social Technical System (STS) Theory is instrumental in studying the adoption of electric vehicles in Hunan’s urban public sector transportation. Through effective governance mechanisms that integrate technical advancements and economic incentives, Hunan can achieve a sustainable and efficient urban transportation system powered by electric vehicles.

2.7.2 Extension of Technology Acceptance Model (TAM2)

An extension to the technology acceptance model (TAM2) was developed by Venkatesh and Davis that outlined perceived usefulness and usage intentions as they related to the processes of social influence and cognitive instrumental. Venkatesh and Davis reported that perceived usefulness is based on usage intentions in many empirical TAMs. It is important to understand the determinants of the perceived usefulness construct because it drives usage intentions and how these determinants influence changes over time, with increasing system usage. The extended Technology Acceptance Model (TAM2) is highly relevant to understanding the adoption of urban public electric vehicle (EV) transportation in Hunan, China, as it provides a framework for analyzing the factors influencing individuals' and organizations' acceptance of new technologies. TAM2 builds on the original TAM by incorporating additional external variables, such as social influence and cognitive instrumental processes, which are crucial in shaping user perceptions and behaviors toward new technology, including electrical vehicles. In the context of urban public electrical vehicle transportation in Hunan, TAM2 can help explain how various psychological and social factors contribute to the adoption of electric vehicles by public transportation systems and users. According to TAM2, perceived usefulness and perceived ease of use are central drivers of technology acceptance. For public transport operators in Hunan, the perceived usefulness of electric vehicles would be determined by factors such as reduced operational costs, improved energy efficiency, and compliance with environmental regulations. Electrical vehicles are seen as practical alternatives to conventional gas-powered buses,

as they offer long-term financial savings due to lower fuel and maintenance costs while contributing to the city's sustainability goals by reducing emissions and improving air quality.

Perceived ease of use is another critical element in TAM2, relating to how effortless it is to adopt and integrate electric vehicles into existing transportation systems. In Hunan, this could include the availability of charging infrastructure, the technological complexity of managing electric buses, and the training required for drivers and maintenance staff. If operators find that electrical vehicles are easy to incorporate into their fleets without significant disruptions or steep learning curves, they are more likely to adopt the technology. TAM2 also introduces social influence factors, such as subjective norms, where individuals or organizations feel pressure from others to adopt a technology. In Hunan, this could manifest in the form of government policies and public expectations, as the push for sustainable urban development becomes a significant part of local and national agendas. If public transportation bodies perceive that adopting electrical vehicles aligns with societal norms and government initiatives, such as reducing carbon emissions, they may feel a stronger obligation to transition to electric buses. Cognitive instrumental processes, another aspect of TAM2, focus on how users evaluate the relevance of the technology to their work or operations. For public transportation authorities in Hunan, this might involve assessing the compatibility of electric vehicles with existing public transportation goals, such as reliability, route efficiency, and passenger capacity. Electric vehicles are more likely to be adopted if they meet these operational objectives. In summary, TAM2's constructs—perceived usefulness, perceived ease of use, social influence, and cognitive instrumental processes—are directly applicable to understanding how public transportation authorities and stakeholders in Hunan approach the adoption of electric vehicles. These factors provide insights into both the technological and social dynamics that influence decision-making, helping to explain why certain technologies, like electric vehicles, gain traction in urban transportation systems.

STUDY FRAMEWORK

This study adapts an established study framework to examine electric vehicle adoption in the public transportation system, and to address the lack of studies examining infrastructure governance in Hunan. By using a validated framework, the study gains credibility, aligns with relevant technical and economic factors, and allows for comparative analysis. Adapting the framework to Hunan's unique context ensures relevance, providing an efficient and robust approach to exploring electric vehicle adoption dynamics within local infrastructure governance.

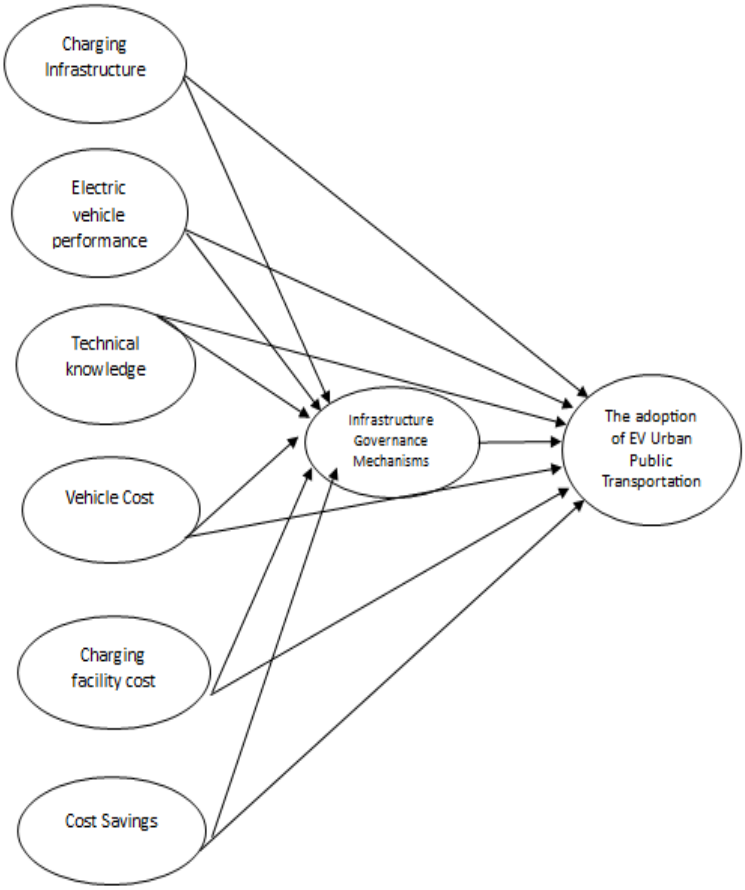

Figure 1: Study Framework & its Proposed Relationships

IMPLICATIONS FOR FUTURE STUDY

The findings from this study underscore several implications for future study in the realm of electric vehicles infrastructure governance and adoption, particularly within the context of Hunan and similar regions.

1. Longitudinal Studies on Policy Impact: Future study should focus on longitudinal studies that examine the long-term effects of government policies and financial incentives on electrical vehicles infrastructure development and adoption. This will provide insights into the sustainability and effectiveness of different governance strategies over time.

2. Comparative Analyses Across Regions: Comparative studies between Hunan and other provinces or countries with varying governance structures could illuminate best practices and strategies for overcoming common challenges in electric vehicles infrastructure development. Such analyses could help identify context-specific factors that contribute to successful implementation.

3. Stakeholder Engagement Models: Study should explore effective models for stakeholder engagement, focusing on how collaboration between government agencies, private investors, and the community can enhance the deployment of electric vehicles infrastructure. Understanding the dynamics of stakeholder relationships can lead to improved coordination and resource allocation.

4. Technological Innovation Assessment: Investigating the role of technological innovations in electric vehicles infrastructure, including smart charging solutions and renewable energy integration, is essential. Future studies could evaluate how these technologies can improve the efficiency and effectiveness of charging networks and enhance user experience.

5. User-Centric Study: Further study should emphasize user perspectives and experiences related to electric vehicles adoption and infrastructure use. Understanding consumer attitudes, preferences, and behaviors can provide valuable insights into the barriers and facilitators of electric vehicles uptake.

6. Economic and Environmental Evaluations: Future studies could explore how renewable energy integration affects EV adoption, and should also focus on the economic and environmental impacts of electric vehicles infrastructure development. Cost-benefit analyses that consider both direct financial implications and broader societal benefits, such as reduced emissions and improved air quality, will enhance the understanding of the overall value of investing in electric vehicles infrastructure.

By addressing these areas, future study can contribute to the development of more effective governance mechanisms for electric vehicles infrastructure, ultimately facilitating the transition to sustainable urban transportation systems.

CONCLUSIONS

In conclusion, the adoption and integration of electric vehicles into urban public transportation systems, particularly in Hunan, are influenced by a combination of economic, technical, and governance factors. Economic considerations such as vehicle costs, charging infrastructure, and the perceived economic benefits of EVs play a significant role in shaping the willingness of both consumers and stakeholders to embrace this transition. High upfront costs, despite being a barrier, can be mitigated by financial incentives, cost reductions, and the long-term economic advantages associated with lower operational expenses. Additionally, the development of electric vehicles infrastructure, particularly in terms of charging stations, contributes to economic growth by creating jobs and stimulating investment in related industries, further reinforcing the positive impact of electric vehicles adoption on the broader economy.

Technical factors such as the availability of charging infrastructure, vehicle performance, and technical knowledge are also critical determinants of electric vehicles adoption. The effectiveness of governance mechanisms in managing these technical factors is essential for ensuring that the infrastructure is not only accessible but also efficient and well-coordinated. Proactive policies, investment strategies, and collaboration among various stakeholders are necessary to overcome the existing challenges and gaps in infrastructure development. The evidence suggests that government support, alongside effective planning, and coordination, can significantly enhance the deployment of charging stations and the overall adoption of electric vehicles

Finally, this study offers actionable insights into how governance mechanisms can accelerate EV adoption in urban transportation. The role of governance in facilitating the transition to electric vehicles cannot be overstated, as it provides the necessary framework to drive investment, encourage innovation, and foster collaboration among stakeholders. A thorough assessment of the current governance mechanisms is essential for identifying weaknesses and opportunities for improvement, ultimately ensuring that Hunan is equipped to meet the growing demand for sustainable transportation solutions and make substantial progress toward a greener and more economically resilient future.

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