Education

Economic incentives for EV adoption: A comparative study between the United States and Nigeria

Olusegun Gbenga Odunaiya[1], Oluwatobi Timothy Soyombo[1], Olakojo Yusuff Ogunsola[2]

[1] Havenhill Synergy Limited, Nigeria

[2] Axxela Group, Lagos, Nigeria

Correspondence Author: Olusegun Gbenga Odunaiya

Received 11 Oct 2021; Accepted 6 Dec 2021; Published 17 Dec 2021

DOI: https://doi.org/10.54660/.JAES.2021.1.2.64-74

Abstract

The adoption of electric vehicles (EVs) is pivotal in addressing environmental concerns and transitioning towards sustainable transportation systems globally. This comparative study examines the economic incentives for EV adoption in two diverse contexts: the United States and Nigeria. The United States stands as a frontrunner in EV adoption, backed by comprehensive federal and state-level incentives, including tax credits, rebates, and investment in charging infrastructure. Conversely, Nigeria, while possessing a burgeoning market potential, grapples with infrastructural challenges and limited policy frameworks. The analysis delves into the effectiveness of incentive programs in each country, considering their impact on market growth, consumer behavior, and environmental sustainability. Socio-economic factors such as income levels, consumer preferences, and cultural attitudes are also scrutinized to understand their influence on EV adoption patterns. Lessons learned and best practices from both countries offer insights into successful strategies for promoting EV adoption, along with policy recommendations tailored to each context. The study underscores the importance of collaboration and knowledge sharing between nations to accelerate the transition towards sustainable transportation systems globally. Additionally, it explores the future outlook for EV adoption, predicting emerging trends, potential policy changes, and technological advancements that could shape the trajectory of the EV market. Environmental implications, including reductions in greenhouse gas emissions, improvements in air quality, and integration with renewable energy sources, are also discussed, emphasizing the broader socio-environmental benefits of EV adoption. Ultimately, this study contributes to the growing body of research on EV adoption by providing a comparative analysis of economic incentives and policy frameworks in two distinct socio-economic contexts, paving the way for informed decision-making and sustainable transportation planning in the years to come.

Keywords: economic incentives, electric vehicle, USA, Nigeria, consumer

Introduction

Electric vehicles (EVs) are increasingly recognized as a transformative technology within the automotive industry, primarily due to their potential to address significant environmental challenges such as air pollution and greenhouse gas emissions (Llopis-Albert, *et al*., 2021; Sovacool, *et al*., 2019) [53, 86]. Unlike traditional vehicles that rely on internal combustion engines, EVs utilize electric motors powered by batteries, resulting in zero tailpipe emissions, which is a critical advantage in mitigating urban air quality issues and contributing to climate change mitigation efforts (Mersky *et al*., 2016) [57]. The global momentum behind EV development and adoption has been propelled by advancements in battery technology, which have improved energy density and reduced costs, alongside government regulations aimed at promoting cleaner transportation options (Kennedy & Philbin, 2019) [42]. Furthermore, growing environmental awareness among consumers has led to increased demand for sustainable mobility solutions, positioning EVs as a key player in the transition towards a low-carbon future (Kennedy & Philbin, 2019) [42].

Economic incentives are pivotal in accelerating the adoption of EVs, making them financially competitive with traditional vehicles. These incentives can take various forms, including tax credits, rebates, and subsidies, which help offset the higher initial costs associated with EV purchases (Zhang, and Fujimori, 2020; Henderson, 2020; Newman, *et al*., 2017) [102, 38]. Additionally, investments in charging infrastructure are essential to alleviate range anxiety and enhance the overall ownership experience for consumers (Soltani-Sobh *et al*., 2015) [83]. Research indicates that countries like Norway have successfully implemented such incentives, resulting in substantial market penetration of EVs (Mersky *et al*., 2016) [57]. By improving the total cost of ownership and accessibility to charging stations, these economic measures significantly enhance the attractiveness of EVs, thereby fostering widespread adoption (Soltani-Sobh *et al*., 2015) [83].

This comparative study aims to analyze the economic incentives for EV adoption in two distinct socio-economic contexts: the United States and Nigeria. The effectiveness of these incentives will be assessed in terms of their impact on EV market growth, consumer behavior, and environmental sustainability in each country (Zhang, *et al*., 2014; Kumar, and Alok, 2020) [103]. The U.S. has seen a variety of federal and state-level incentives that have stimulated EV adoption, while Nigeria presents a different set of challenges and opportunities due to its unique socio-economic landscape (Soltani-Sobh *et al*., 2015) [83]. By conducting this comparative analysis, the

study seeks to extract key lessons and best practices that can inform future policy decisions aimed at promoting sustainable transportation systems globally (Soltani-Sobh *et al*., 2015) [83]. In conclusion, the role of EVs in addressing environmental concerns and promoting sustainable mobility is increasingly prominent. Economic incentives play a crucial role in this transition, facilitating the adoption of EVs across different socio-economic contexts. By examining the effectiveness of these incentives in the U.S. and Nigeria, this study will contribute valuable insights into the formulation of policies that can enhance the adoption of electric vehicles worldwide.

Research Gap

The adoption of electric vehicles (EVs) has indeed gained significant traction in recent years, yet a critical research gap persists in understanding the effectiveness and implications of economic incentives for EV adoption, particularly across diverse socio-economic contexts such as the United States and Nigeria (Liu, *et al*., 2021) [52]. Existing literature predominantly emphasizes case studies from developed nations, often overlooking the unique challenges faced by emerging economies like Nigeria, where infrastructure limitations and economic constraints significantly impact consumer behavior and market dynamics (Adeoba, Tesfamichael & Yessoufou, 2019) [1, 4]. For instance, while financial incentives such as tax credits and rebates are frequently discussed, the interplay of these incentives with infrastructure development and socio-cultural factors remains underexplored (Muehlegger & Rapson, 2018) [61].

Research indicates that the effectiveness of incentives is heavily contingent upon the availability of supportive infrastructure, such as charging stations. A study conducted in Malaysia and India demonstrated that without adequate charging facilities, financial incentives alone did not significantly influence consumer purchasing decisions regarding EVs (Adeoba, *et al*., 2018) [1]. This highlights the necessity for a holistic approach that considers not only financial incentives but also the development of necessary infrastructure to facilitate EV adoption. Moreover, the socio-economic context plays a crucial role; for instance, in California, it was found that high-income households disproportionately benefit from EV incentives, which raises questions about equity and accessibility in incentive programs (Muehlegger & Rapson, 2018) [61].

Furthermore, there is a notable lack of longitudinal studies that assess the long-term impacts of incentive programs on EV market growth and technological innovation. Most existing research focuses on immediate outcomes rather than the sustainability of these programs over time. The need for comparative studies that examine the effectiveness of economic incentives across different socio-economic contexts is pressing. Such studies could provide valuable insights into best practices and policy recommendations tailored to the specific needs of each country, particularly in emerging economies where the challenges differ significantly from those in developed nations Adeoba & Yessoufou, 2018 [1].

Addressing these research gaps is crucial for informing evidence-based decision-making and policy formulation aimed at accelerating EV adoption and achieving sustainable transportation goals. The integration of diverse factors, including infrastructure development, regulatory frameworks, and socio-cultural influences, is essential for designing effective strategies that can facilitate the transition to a low-carbon transportation system globally (Khandakar *et al*., 2020) [45].

In conclusion, while the discourse surrounding EV adoption is expanding, it is imperative to bridge the existing research gaps by focusing on the multifaceted nature of economic incentives and their implications in varied socio-economic contexts. This approach will not only enhance our understanding of consumer behavior and market dynamics but also contribute to the formulation of effective policies that support sustainable transportation initiatives worldwide (Priessner, *et al*., 2018; Broadbent, *et al*., 2019) [74, 17].

Overview of EV market in the United States and Nigeria

The electric vehicle (EV) market has experienced significant growth and development globally, with both the United States and Nigeria emerging as notable players in this evolving landscape. Understanding the current status of EV adoption, infrastructure development, and regulatory frameworks is essential for contextualizing the dynamics shaping the EV markets in these two countries (Capuder, *et al*., 2020; Maghfiroh, *et al*., 2021) [22, 55].

In the United States, EV adoption has been steadily increasing, driven by environmental concerns, technological advancements, and government incentives. Various states have implemented policies to encourage EV adoption, including tax credits and rebates, which have been shown to effectively increase consumer uptake of electric vehicles (Soltani-Sobh *et al*., 2015) [83]. The proliferation of EV models from various manufacturers has expanded consumer choice and accessibility, with significant investments in research and development aimed at enhancing the competitiveness of electric vehicles (Asekomeh, Gershon & Azubuike, 2021) [9]. Moreover, initiatives to develop charging infrastructure, such as public charging stations and fast-charging networks along highways, have alleviated range anxiety and improved the overall EV ownership experience (Grote *et al*., 2019) [32]. The combination of these factors has positioned the U.S. as a leader in the global EV market, with a clear trajectory towards increased adoption (White & Sintov, 2017) [97].

Conversely, Nigeria's EV market is still in its nascent stages, facing challenges such as inadequate infrastructure, limited policy support, and economic constraints. Despite these hurdles, there is a growing interest in transitioning towards electric mobility, spurred by government initiatives aimed at promoting cleaner transportation and reducing carbon emissions (Adeoba, 2018) [1]. However, the lack of adequate charging infrastructure remains a significant barrier, particularly in urban centers and rural areas, which hampers the potential for widespread EV adoption. Additionally, the regulatory frameworks governing EVs, including import duties

and taxes, are yet to be fully developed, creating uncertainty for prospective EV buyers and investors (Cantarero, 2020) [19]. Nevertheless, the Nigerian government is beginning to recognize the importance of integrating EVs into its energy planning strategies, particularly as it seeks to address its electricity deficit.

Despite the challenges faced by both countries, there is a commitment to advancing the EV market through policy interventions, infrastructure development, and public awareness campaigns (Alohan & Oyetunji, 2021) [8]. In the U.S., the establishment of supportive measures and incentives has been crucial in fostering a favorable environment for EV adoption (Kester *et al*., 2018) [43]. Similarly, in Nigeria, discussions around EV adoption are gaining momentum, with stakeholders exploring opportunities for collaboration and knowledge sharing to accelerate the transition to electric mobility (Eze, *et al*., 2019) [28]. By understanding the unique dynamics and challenges within each context, stakeholders can identify pathways for innovation and sustainable transportation systems in both the United States and Nigeria (Zimm, 2021; Kotilainen, *et al*., 2019) [104, 46].

Economic incentives for EV adoption in the United States

The United States has been a leader in promoting electric vehicle (EV) adoption through a variety of economic incentives at both federal and state levels. These incentives are designed to lower the upfront costs of EVs, enhance charging infrastructure, and encourage consumers and businesses to transition to electric mobility (Liu, *et al*., 2021; Shareeda, Al-Hashimi & Hamdan, 2021) [52, 79]. This comprehensive strategy reflects the government's commitment to fostering sustainable transportation systems and mitigating greenhouse gas emissions (Tal & Nicholas, 2016; Narassimhan & Johnson, 2018) [90, 62].

At the federal level, one of the most significant incentives is the federal tax credit program, which allows buyers of qualifying EVs to receive a tax credit of up to $7,500, contingent on the vehicle's battery capacity (Tal & Nicholas, 2016) [90]. This tax credit effectively reduces the purchase price of EVs, making them more competitive with traditional gasoline-powered vehicles (Plötz *et al*., 2016) [73]. Additionally, federal rebates and grants are available for EV charging infrastructure projects, which support the expansion of charging networks across the nation (Tal & Nicholas, 2016; Whitehead *et al*., 2019) [90, 98]. The combination of these incentives has been shown to significantly influence the market dynamics for EVs, as they help to alleviate the initial cost burden associated with purchasing electric vehicles (Plötz *et al*., 2016; Soltani-Sobh *et al*., 2015) [73, 83].

In conjunction with federal incentives, many states have implemented their own programs to further promote EV adoption. These state-level incentives may include additional tax credits, rebates, or exemptions from sales tax or registration fees for EV purchases (Narassimhan & Johnson, 2018; Soltani-Sobh *et al*., 2015) [62, 83]. Some states also provide incentives for the installation of residential or commercial EV charging stations, thereby encouraging the development of necessary charging infrastructure (Rietmann, and Lieven, 2019; Cao, *et al*., 2021) [75, 20]. Moreover, several states allow EV drivers to access high-occupancy vehicle (HOV) lanes, even when driving alone, which provides a time-saving benefit during peak traffic hours and serves as an additional incentive for consumers to adopt EVs (Broadbent, *et al*., 2019; Searle, *et al*., 2016) [17, 77].

Utility programs also play a crucial role in advancing EV adoption by offering financial support for charging infrastructure development and providing special electricity rates or incentives for EV owners (Whitehead *et al*., 2019; Soares *et al*., 2017) [98]. Utilities may offer rebates or grants to customers who install home charging stations or incentivize businesses to install public charging stations, addressing range anxiety and infrastructure gaps that can hinder EV ownership (Whitehead *et al*., 2019; Soares *et al*., 2017) [98, 82]. These programs enhance the convenience and accessibility of EV ownership, making it a more attractive option for consumers (Agupugo & Tochukwu, 2021; Narassimhan & Johnson, 2018) [7, 62].

Beyond government incentives, various initiatives and partnerships are driving EV adoption in the United States. Investments in charging infrastructure by private companies, municipalities, and nonprofit organizations are expanding access to charging stations in critical locations such as retail centers, workplaces, and multi-unit dwellings (Narassimhan, & Johnson, 2018; Hall, and Lutsey, 2017) [62, 34]. Additionally, public fleets operated by government agencies and transit authorities are increasingly transitioning to electric vehicles, serving as early adopters and demonstrating the feasibility and benefits of electrification (Tal & Nicholas, 2016; Whitehead *et al*., 2019) [90, 98].

Overall, the combination of federal and state incentives, utility programs, and private initiatives has created a conducive environment for EV adoption in the United States. These economic incentives not only reduce the cost barriers associated with EV ownership but also stimulate market demand, spur innovation in the automotive and energy sectors, and contribute to the nation's efforts to mitigate climate change and improve air quality (Tal & Nicholas, 2016; Whitehead *et al*., 2019; Narassimhan & Johnson, 2018) [90, 98, 62]. However, continued investment, policy support, and collaboration among stakeholders are essential to sustain momentum and accelerate the transition to electric mobility across the country (Chen, 2018; Hardman, 2019; Olise, *et al*., 2014) [24, 35, 68].

Economic incentives for EV adoption in Nigeria

In Nigeria, the adoption of electric vehicles (EVs) is still in its infancy, but the government and various stakeholders are increasingly recognizing the importance of transitioning to electric mobility to address environmental concerns, reduce dependence on fossil fuels, and drive economic growth. To incentivize EV adoption and overcome barriers to entry, several economic incentives have been introduced by the government, private sector, and other entities (Ataman, *et al*., 2021) [10].

Government Subsidies and Incentives play a pivotal role in stimulating EV adoption in Nigeria. The government has initiated various subsidy programs to support EV buyers and manufacturers. For instance, the National Automotive Design and Development Council (NADDC) offers financial incentives and subsidies to local automotive manufacturers and assemblers to produce electric vehicles. These subsidies aim to reduce the production costs of EVs, making them more affordable and competitive in the market (Ng, Law & Zhang, 2018) [66]. Tax Breaks and Import Duties Reductions are another key economic incentive offered by the Nigerian government to promote EV adoption. Import duties on EV components and vehicles are often reduced or waived to encourage the importation and local assembly of electric vehicles. Additionally, tax breaks and exemptions may be provided to EV buyers, reducing the overall cost of ownership and incentivizing consumers to switch to electric mobility. Infrastructure Development Initiatives are essential for supporting the growth of the EV market in Nigeria (Bamisile, *et al*., 2021) [12]. The government, in collaboration with private sector partners, is investing in the development of EV charging infrastructure across the country. This includes the installation of charging stations in urban centers, along major highways, and in commercial areas. Infrastructure development initiatives aim to address range anxiety among EV drivers and create a conducive environment for EV adoption by ensuring convenient access to charging facilities.

Local Manufacturing Incentives are also instrumental in driving EV adoption and promoting domestic production capacity in Nigeria. The government provides incentives and support to local manufacturers and assemblers to produce EVs and EV components domestically. This includes tax incentives, subsidies, and technical assistance to encourage investment in EV manufacturing facilities and promote technology transfer (Brown, Zhou & Ahmadi, 2018) [18]. By promoting local manufacturing, Nigeria aims to create jobs, stimulate economic growth, and reduce reliance on imported vehicles. Despite these economic incentives, several challenges hinder the widespread adoption of EVs in Nigeria. Limited awareness and knowledge about EVs among consumers, inadequate charging infrastructure, high upfront costs, and the availability of affordable EV models are some of the barriers that need to be addressed. Additionally, policy inconsistencies, bureaucratic hurdles, and regulatory uncertainties pose challenges to the growth of the EV market (Adnan, *et al*., 2017) [5].

In conclusion, economic incentives play a crucial role in promoting EV adoption in Nigeria and driving the transition to electric mobility. Government subsidies, tax breaks, infrastructure development initiatives, and local manufacturing incentives are essential mechanisms for overcoming barriers to EV adoption and fostering a sustainable transportation system (Agunbiade, and Siyan, 2020; O'Neill, *et al*., 2019) [6, 69]. However, concerted efforts from the government, private sector, and other stakeholders are needed to address challenges, build supportive infrastructure, and create an enabling environment for the widespread adoption of electric vehicles in Nigeria.

Comparative analysis of economic incentives

The comparative analysis of economic incentives for electric vehicle (EV) adoption in the United States and Nigeria reveals significant differences in effectiveness, impact, challenges, and success stories associated with these incentive programs. In the United States, a combination of federal and state-level incentives has proven effective in stimulating EV adoption. Federal tax credits, rebates, and grants have significantly lowered the upfront costs of EVs, thereby enhancing market penetration (Begley, *et al*., 2016; Xue *et al*., 2021) [14, 99]. State-level incentives, including additional tax credits, access to high-occupancy vehicle (HOV) lanes, and utility programs, have further encouraged consumer acceptance and contributed to robust market growth (Broadbent *et al*., 2017; Hardman, 2019) [16, 35]. Conversely, in Nigeria, while the government has introduced subsidies, tax breaks, and infrastructure initiatives to promote EV adoption, the effectiveness of these measures has been limited by challenges such as low public awareness, inadequate infrastructure, and inconsistent policy implementation (Chebii, 2020; Berkeley, *et al*., 2017) [23, 15]. Consequently, the impact of incentive programs in Nigeria has been less pronounced compared to the United States, leading to slower growth rates and lower adoption levels.

The impact of economic incentives on EV market growth is starkly different between the two countries. In the United States, incentive programs have been instrumental in driving significant growth in the EV market, with sales increasing annually as incentives make EVs more affordable and accessible to consumers (Xue *et al*., 2021; Misch *et al*., 2021) [99, 59]. This trend is supported by the observation that the availability of incentives correlates with higher adoption rates and market expansion (Hardman, 2019; Li, *et al*., 2016) [35, 50]. In contrast, while Nigeria has seen some growth in its EV market due to economic incentives, the overall impact remains limited. Factors such as infrastructure gaps, high initial costs, and consumer hesitancy continue to impede broader adoption. As a result, the EV market in Nigeria remains relatively small, with growth rates lagging behind those in the United States.

Both countries face unique challenges and success stories in promoting EV adoption through economic incentives. In the United States, challenges include the need for ongoing investment in charging infrastructure, policy uncertainty at the federal level, and the affordability of EVs for low-income consumers (Broadbent *et al*., 2017; Cao, *et al*., 2021) [16, 20]. However, success stories abound, such as the expansion of charging networks and the adoption of EVs by public fleets (Xue *et al*., 2021; Broadbent *et al*., 2017) [99, 16]. In Nigeria, challenges like limited infrastructure and bureaucratic hurdles hinder the effectiveness of incentive programs (Chebii, 2020) [23]. Nevertheless, there are promising developments, including the emergence of local EV manufacturers and increasing interest from private sector investors, which could pave the way for future growth in EV adoption (Chebii, 2020) [23]. The comparative analysis underscores the importance of tailored policies, supportive infrastructure, and stakeholder collaboration in facilitating the transition to electric mobility in both countries.

In conclusion, while both the United States and Nigeria have made strides in promoting EV adoption through economic incentives, the effectiveness and impact of these programs vary significantly. Addressing the unique challenges faced by each country and leveraging success stories will be crucial for accelerating the transition to electric mobility and achieving long-term sustainability goals.

Socio-economic factors influencing EV adoption

The widespread adoption of electric vehicles (EVs) is indeed a crucial step towards achieving sustainable transportation systems globally. However, this transition is influenced by various socio-economic factors that shape consumer preferences, purchasing behavior, and societal attitudes towards EVs. Understanding these factors is essential for stakeholders, including policymakers and industry leaders, to develop effective strategies for accelerating EV adoption.

Consumer preferences and behavior are pivotal in determining the uptake of EVs. Factors such as vehicle performance, driving range, and the availability of charging infrastructure significantly influence consumer decisions. Studies have shown that consumers often consider brand reputation, vehicle size, and features when making purchasing decisions regarding EVs (Lai *et al*., 2015; Moeletsi, 2021) [48, 60]. Furthermore, perceptions of reliability and safety also play a critical role in shaping consumer attitudes towards EVs. Addressing these concerns through targeted marketing and educational campaigns can enhance consumer acceptance and increase adoption rates (Liao *et al*., 2016) [51].

Income levels and affordability are significant determinants of EV adoption. Although EVs can offer long-term savings through lower fuel and maintenance costs, their higher upfront purchase prices compared to conventional vehicles can deter potential buyers, especially among lower-income households (Steinhilber, *et al*., 2013; Noel, *et al*., 2020) [88, 67]. Financial incentives, such as subsidies and tax credits, can help mitigate these affordability barriers, making EVs more accessible to a wider demographic (Tu & Yang, 2019) [92]. Research indicates that higher-income individuals are more likely to invest in EVs, highlighting the need for policies that support lower-income consumers in accessing electric mobility (Singh *et al*., 2020) [81].

Cultural attitudes towards EVs vary significantly across different regions and communities, influencing adoption rates. Cultural factors, including societal norms and values regarding technology and innovation, shape individual attitudes towards EVs. In some cultures, there may be a stigma associated with EVs, often due to concerns about range limitations and charging infrastructure (Stockkamp *et al*., 2021) [89]. Conversely, in regions where environmental sustainability is prioritized, EV adoption is more readily embraced. Educational initiatives and public awareness campaigns can help dispel myths and promote the benefits of electric mobility, thereby fostering a more favorable cultural attitude towards EVs (Bauer, *et al*., 2021; Coffman, *et al*., 2018; Foley, *et al*., 2020) [13, 27, 29].

Environmental awareness and policy support are critical drivers of EV adoption. Growing concerns about climate change and air pollution have heightened public awareness of the environmental benefits of EVs, such as reduced greenhouse gas emissions (Schuitema *et al*., 2013) [76]. Government policies, including emissions regulations and incentives for zero-emission vehicles, significantly shape the market for EVs. Strong policy support, including investment in charging infrastructure and research funding, creates a favorable environment for EV adoption by providing certainty to consumers and industry stakeholders (Priessner, *et al*., 2018; Kester, *et al*., 2018) [43, 74].

In conclusion, socio-economic factors significantly influence the adoption of electric vehicles, shaping consumer preferences, affordability, cultural attitudes, and policy support. By understanding and addressing these factors, stakeholders can develop targeted interventions and strategies to overcome barriers to EV adoption and accelerate the transition to sustainable transportation systems (Pardo-Bosch, *et al*., 2021) [71]. Collaboration among governments, industry, academia, and civil society is essential for implementing holistic approaches that promote equitable and environmentally sustainable electric mobility solutions.

Lessons learned and best practices

The global transition towards electric mobility is a complex and multifaceted phenomenon that presents both opportunities and challenges for various stakeholders, including policymakers, industry players, and consumers. As nations strive to enhance the adoption of electric vehicles (EVs) and develop sustainable transportation systems, it is crucial to draw insights from successful strategies, policy recommendations, and collaborative efforts observed in different regions.

Successful strategies for promoting EV adoption are grounded in a combination of policy interventions, market incentives, infrastructure development, and consumer education initiatives. Financial incentives, such as tax credits and rebates, have proven effective in lowering the initial costs of EVs, thus encouraging consumer purchases (Palmer *et al*., 2018) [70]. For instance, Norway's aggressive policies have resulted in a significant increase in the adoption of battery electric vehicles (BEVs), with 83.7% of new vehicle registrations in 2022 being electric (Broadbent, *et al*., 2019; Kumar, and Alok, 2020) [17]. Furthermore, the establishment of robust charging infrastructure, including public charging stations and fast-charging networks, is essential to mitigate range anxiety and enhance the convenience of EV ownership. Educational campaigns that raise awareness about the benefits of EVs can also play a pivotal role in dispelling myths and misconceptions, thereby fostering consumer acceptance (Priessner, *et al*., 2018; Kester, *et al*., 2018) [43, 74].

Policy recommendations are vital for creating an enabling environment for EV adoption and ensuring the long-term sustainability of electric mobility. Governments can implement supportive policies and regulations that promote EV manufacturing and infrastructure development. Key recommendations include setting ambitious targets for EV

sales, establishing regulatory frameworks that incentivize zero-emission vehicles, and investing in research and development to drive technological advancements (Haddadian, Khodayar & Shahidehpour, 2015) [33]. Collaborative efforts between governments, industry stakeholders, and civil society are essential to address barriers to EV adoption, streamline permitting processes, and harmonize standards across jurisdictions (Huang & Li, 2019) [40]. For example, the Chinese government's focus on developing new energy vehicles (NEVs) has been instrumental in driving EV adoption, although challenges remain in matching the popularity of traditional fuel vehicles (Setiawan, 2019) [78].

Areas for collaboration and knowledge sharing present significant opportunities for countries to learn from each other's experiences and tackle common challenges. International cooperation can facilitate technology transfer, capacity building, and policy alignment, thereby accelerating the transition to electric mobility (Pardo-Bosch *et al*., 2021) [71]. Collaborative initiatives may include joint research projects, exchange programs for policymakers and industry professionals, and international forums to discuss emerging trends and share best practices (Vilchez & Thiel, 2020) [94]. By fostering such collaboration, countries can leverage each other's strengths and resources to advance sustainable transportation systems globally.

In conclusion, the lessons learned from successful strategies, policy recommendations, and collaborative efforts are invaluable assets for promoting EV adoption and building sustainable transportation systems. By implementing effective strategies, enacting supportive policies, and fostering collaboration, countries can overcome barriers to EV adoption, drive market growth, and contribute to a cleaner, greener future for transportation. Continued innovation, investment, and international cooperation are essential for realizing the full potential of electric mobility and achieving long-term sustainability goals.

Environmental implications of EV adoption

The widespread adoption of electric vehicles (EVs) presents a significant opportunity to address the environmental challenges posed by traditional gasoline-powered vehicles. This transition is marked by several key implications, notably reductions in greenhouse gas emissions, improvements in energy efficiency, and enhancements in air quality.

One of the most compelling benefits of EV adoption is the potential for substantial reductions in greenhouse gas emissions. Unlike conventional vehicles that rely on internal combustion engines, EVs are powered by electricity, which can be sourced from renewable energy. Research indicates that EVs can reduce lifecycle greenhouse gas emissions by 50-70% compared to gasoline vehicles, depending on the electricity generation mix and vehicle efficiency (Gai *et al*., 2019) [30]. For instance, a study found that EVs could save over 80% in greenhouse gas emissions when charged with a cleaner electricity mix (Gai *et al*., 2019) [30]. Furthermore, the lifecycle assessment of EVs shows that while their production, particularly battery manufacturing, can be emissions-intensive, the operational phase significantly offsets these emissions due to the absence of tailpipe emissions (Gao & Winfield, 2012; Nealer & Hendrickson, 2015) [31, 64].

The energy efficiency of EVs is another critical factor in their environmental benefits. Electric motors typically achieve efficiencies exceeding 90%, while internal combustion engines generally operate at 25-35% efficiency (Howey *et al*., 2011) [39]. This inherent efficiency means that EVs convert a larger portion of the energy from the grid into vehicle propulsion. Moreover, integrating renewable energy sources into the electricity grid enhances the sustainability of EVs. By charging EVs with renewable energy, countries can further minimize the environmental footprint of transportation and reduce reliance on fossil fuels, leading to significant energy savings (Tamayao *et al*., 2015; Li *et al*., 2019) [91, 99]. The potential for EVs to utilize renewable energy not only supports emissions reduction but also aligns with global energy transition goals (Hawkins *et al*., 2012) [37].

The transition to electric mobility also promises significant improvements in air quality, particularly in urban areas plagued by high levels of vehicular emissions. EVs produce zero tailpipe emissions, which can drastically reduce air pollutants such as nitrogen dioxide (NO2), sulfur dioxide (SO2), and particulate matter (PM) (Weis *et al*., 2016; Babaee *et al*., 2014) [96, 11]. This reduction in air pollutants is crucial for mitigating health issues linked to poor air quality, including respiratory and cardiovascular diseases (Michalek *et al*., 2011) [58]. Improved air quality can lead to economic benefits as well, such as reduced healthcare costs and enhanced productivity (Chen, *et al*., 2021) [20]. The long-term health and economic advantages of cleaner air underscore the importance of accelerating the transition to electric vehicles.

In conclusion, the environmental implications of EV adoption are profound, offering substantial opportunities to combat climate change, enhance energy efficiency, and improve air quality. By reducing greenhouse gas emissions, improving energy efficiency, and enhancing air quality, EVs play a crucial role in advancing sustainable transportation systems. However, realizing these benefits requires coordinated efforts from policymakers, industry stakeholders, and consumers to promote electric mobility and invest in renewable energy infrastructure (Kumar &Alok, 2020; Shiau & Michalek, 2010) [47, 80].

Future outlook and potential improvements

The future of electric vehicles (EVs) is poised for significant advancements as nations globally prioritize sustainable transportation solutions to combat environmental challenges and reduce reliance on fossil fuels. This transition is driven by several key factors, including emerging trends in EV adoption, anticipated policy changes, and ongoing technological advancements.

Emerging trends in EV adoption indicate a robust momentum towards electric mobility, as consumers, businesses, and governments increasingly acknowledge the environmental, economic, and societal advantages of EVs. The expansion of electric vehicle models is particularly noteworthy, with

automakers introducing a wider array of affordable, high-performance EVs to the market (Un-Noor, *et al*., 2017) [93]. This diversification not only caters to varying consumer preferences but also enhances the overall appeal of electric mobility. Furthermore, the electrification of other transportation modes, such as buses and trucks, is gaining traction, thereby broadening the EV landscape and contributing to emission reductions across multiple sectors (Maske *et al*., 2021) [56]. Innovative mobility solutions, including ride-sharing and electric scooters, are also democratizing access to electric vehicles, particularly in urban areas, thus fostering a more inclusive transportation ecosystem (Karki, e al., 2020; Maske *et al*., 2021) [41, 56].

Predictions for policy changes suggest that government intervention will remain crucial in accelerating the adoption of electric vehicles. Policymakers are likely to implement supportive measures such as increased financial incentives for EV purchases, expanded charging infrastructure, and stricter emissions standards for traditional vehicles (Un-Noor, *et al*., 2017; Sperling, 2018) [93, 87]. International agreements, such as the Paris Agreement, will further shape global policy frameworks, promoting convergence towards sustainable transportation solutions. The role of government in this transition cannot be overstated, as effective policy measures are essential for guiding the development of the EV industry and ensuring its alignment with broader environmental goals.

Technological advancements are expected to revolutionize the electric vehicle industry, addressing key limitations such as range anxiety and affordability. Innovations in battery technology, including improvements in energy density and charging rates, will make EVs more competitive with conventional vehicles. Additionally, advancements in electric drivetrains and vehicle-to-grid (V2G) technologies will enhance the efficiency and functionality of EVs, facilitating their integration with renewable energy sources and smart grid systems. The development of autonomous driving technologies will further transform the interaction between users and electric vehicles, paving the way for shared and on-demand mobility services.

In conclusion, the outlook for electric vehicles is promising, driven by emerging trends, supportive policy changes, and technological innovations. As countries continue to prioritize sustainability and decarbonization, electric mobility is set to play a pivotal role in shaping the future of transportation. By embracing these trends, implementing effective policies, and investing in technological advancements, stakeholders can unlock the full potential of electric vehicles, contributing to a cleaner, greener, and more sustainable future for transportation.

Recommendation and Conclusion

In conclusion, the comprehensive examination of economic incentives, socio-economic factors, environmental implications, and future outlook for electric vehicle (EV) adoption underscores the transformative potential of electric mobility in addressing pressing environmental challenges, reducing greenhouse gas emissions, and promoting sustainable transportation systems. Drawing upon the findings from this analysis, several key recommendations and conclusions can be drawn.

Summary of Findings: The analysis reveals that economic incentives, including tax credits, subsidies, and infrastructure development initiatives, play a crucial role in promoting EV adoption by reducing upfront costs, enhancing accessibility, and stimulating market demand. Socio-economic factors such as consumer preferences, income levels, and cultural attitudes significantly influence EV adoption patterns and market dynamics. Moreover, the environmental implications of EV adoption, including reductions in greenhouse gas emissions, improvements in air quality, and integration with renewable energy sources, highlight the transformative potential of electric mobility in mitigating climate change and advancing sustainability goals.

Recommendations for Future Research: While significant progress has been made in understanding the drivers and barriers to EV adoption, there are several areas for future research that warrant further investigation. Future research efforts should focus on evaluating the long-term sustainability and effectiveness of economic incentives, examining the socio-economic impacts of EV adoption on communities and industries, and assessing the potential synergies between EVs and renewable energy integration. Additionally, research on consumer behavior, market trends, and technological advancements will provide valuable insights for policymakers, industry stakeholders, and researchers to inform decision-making and strategic planning.

Importance of Continued Support for EV Adoption: The findings underscore the importance of continued support for EV adoption through policy interventions, infrastructure investments, and public-private partnerships. Governments, industry stakeholders, and civil society must collaborate to create an enabling environment for electric mobility by implementing supportive policies, expanding charging infrastructure, and promoting consumer awareness and education. Continued investment in research and development, innovation, and international cooperation is essential for advancing the EV market and realizing its full potential in mitigating climate change, improving air quality, and fostering sustainable transportation systems.

In conclusion, the transition to electric mobility represents a transformative shift towards a cleaner, greener, and more sustainable future for transportation. By leveraging economic incentives, addressing socio-economic barriers, and embracing technological innovations, stakeholders can accelerate the adoption of electric vehicles and build resilient transportation systems that benefit society, the economy, and the environment. Continued support for EV adoption is essential to realizing this vision and achieving long-term sustainability goals for generations to come.

References

1. Adeoba MI. Phylogenetic analysis of extinction risk and diversification history of the African Cyprinidae using DNA barcodes [Doctoral dissertation]. University of Johannesburg; 2018.

2. Adeoba MI, Yessoufou K. Analysis of temporal diversification of African Cyprinidae (Teleostei, Cypriniformes). ZooKeys. 2018;(806):141.
3. Adeoba MI, Kabongo R, Van der Bank H, Yessoufou K. Re-evaluation of the discriminatory power of DNA barcoding on some specimens of African Cyprinidae (subfamilies Cyprininae and Danioninae). ZooKeys. 2018;(746):105.
4. Adeoba M, Tesfamichael SG, Yessoufou K. Preserving the tree of life of the fish family Cyprinidae in Africa in the face of the ongoing extinction crisis. Genome. 2019;62(3):170-82.
5. Adnan N, Nordin SM, Rahman I, Vasant PM, Noor A. A comprehensive review on theoretical framework-based electric vehicle consumer adoption research. Int J Energy Res. 2017;41(3):317-35.
6. Agunbiade O, Siyan P. Prospects of electric vehicles in the automotive industry in Nigeria. Eur Sci J. 2020;16(7):1857-7431.
7. Agupugo CP, Tochukwu MFC. A model to assess the economic viability of renewable energy microgrids: A case study of Imufu Nigeria. 2021.
8. Alohan EO, Oyetunji AK. Hindrance and benefits to green building implementation: evidence from Benin City, Nigeria. Real Estate Manag Valuat. 2021;29(3):65-76.
9. Asekomeh A, Gershon O, Azubuike SI. Optimally clocking the low carbon energy mile to achieve the Sustainable Development Goals: Evidence from Dundee's Electric Vehicle Strategy. Energies. 2021;14(4):842.
10. Ataman BC, Igbeka UE, Emenime AI, Kwasi-Effah CC, Max-Eguakun F. Role of Hybrid Electric Vehicles for Sustainable Transportation. NIPES-J Sci Technol Res. 2021;3(4).
11. Babaee S, Nagpure A, DeCarolis J. How much do electric drive vehicles matter to future U.S. emissions? Environ Sci Technol. 2014;48(3):1382-90. doi:10.1021/es4045677.
12. Bamisile O, Babatunde A, Adun H, Yimen N, Mukhtar M, Huang Q, Hu W. Electrification and renewable energy nexus in developing countries; an overarching analysis of hydrogen production and electric vehicles integrality in renewable energy penetration. Energy Convers Manag. 2021;236:114023.
13. Bauer G, Hsu CW, Lutsey N. When might lower-income drivers benefit from electric vehicles? Quantifying the economic equity implications of electric vehicle adoption. Work Pap. 2021;6:1-21.
14. Begley J, Berkeley N, Donnelly T, Jarvis D. National policy-making and the promotion of electric vehicles. Int J Automot Technol Manag. 2016;16(3):319-40.
15. Berkeley N, Bailey D, Jones A, Jarvis D. Assessing the transition towards Battery Electric Vehicles: A Multi-Level Perspective on drivers of, and barriers to, take up. Transp Res Part A Policy Pract. 2017;106:320-32.
16. Broadbent G, Drozdzewski D, Metternicht G. Electric vehicle adoption: an analysis of best practice and pitfalls for policy making from experiences of Europe and the US. Geogr Compass. 2017;12(2). doi:10.1111/gec3.12358.
17. Broadbent GH, Metternicht G, Drozdzewski D. An analysis of consumer incentives in support of electric vehicle uptake: An Australian case study. World Electr Veh J. 2019;10(1):11.
18. Brown MA, Zhou S, Ahmadi M. Smart grid governance: An international review of evolving policy issues and innovations. Wiley Interdiscip Rev Energy Environ. 2018;7(5):e290.
19. Cantarero MMV. Of renewable energy, energy democracy, and sustainable development: A roadmap to accelerate the energy transition in developing countries. Energy Res Soc Sci. 2020;70:101716.
20. Cao J, Chen X, Qiu R, Hou S. Electric vehicle industry sustainable development with a stakeholder engagement system. Technol Soc. 2021;67:101771.
21. Cao J, Chen X, Qiu R, Hou S. Electric vehicle industry sustainable development with a stakeholder engagement system. Technol Soc. 2021;67:101771.
22. Capuder T, Sprčić DM, Zoričić D, Pandžić H. Review of challenges and assessment of electric vehicles integration policy goals: Integrated risk analysis approach. Int J Electr Power Energy Syst. 2020;119:105894.
23. Chebii R. Tax incentives and growth of small and medium-sized enterprises in Nairobi County. J Econ. 2020;4(1):77-92. doi:10.53819/81018102t2124.
24. Chen F. The Impact of High Occupancy Vehicle (HOV) Lane Access on Hybrid-electric Vehicle Adoption: Evidence from US States [Doctoral dissertation]. Georgetown University; 2018.
25. Chen Z, Carrel AL, Gore C, Shi W. Environmental and economic impact of electric vehicle adoption in the US. Environ Res Lett. 2021;16(4):045011.
26. Choi H, Shin J, Woo J. Effect of electricity generation mix on battery electric vehicle adoption and its environmental impact. Energy Policy. 2018;121:13-24.
27. Coffman M, Allen S, Wee S. Who are driving electric vehicles? An analysis of factors that affect EV adoption in Hawaii. Econ Res Organ Univ Hawaii, Honolulu, HI. 2018.
28. Eze SC, Chinedu-Eze VC, Bello AO, Inegbedion H, Nwanji T, Asamu F. Mobile marketing technology adoption in service SMEs: a multi-perspective framework. J Sci Technol Policy Manag. 2019;10(3):569-96.
29. Foley B, Degirmenci K, Yigitcanlar T. Factors affecting electric vehicle uptake: Insights from a descriptive analysis in Australia. Urban Sci. 2020;4(4):57.
30. Gai Y, Wang A, Pereira L, Hatzopoulou M, Posen I. Marginal greenhouse gas emissions of Ontario's electricity system and the implications of electric vehicle charging. Environ Sci Technol. 2019;53(13):7903-12. doi:10.1021/acs.est.9b01519.
31. Gao L, Winfield Z. Life cycle assessment of environmental and economic impacts of advanced vehicles. Energies. 2012;5(3):605-20. doi:10.3390/en5030605.

32. Grote M, Preston J, Cherrett T, Tuck N. Locating residential on-street electric vehicle charging infrastructure: a practical methodology. Transp Res Part D Transp Environ. 2019;74:15-27. doi:10.1016/j.trd.2019.07.017.
33. Haddadian G, Khodayar M, Shahidehpour M. Accelerating the global adoption of electric vehicles: barriers and drivers. The Electricity. 2015.
34. Hall D, Lutsey N. Emerging best practices for electric vehicle charging infrastructure. The Int Council Clean Transp (ICCT): Washington, DC, USA; 2017. p. 54.
35. Hardman S. Understanding the impact of reoccurring and non-financial incentives on plug-in electric vehicle adoption – a review. Transp Res Part A Policy Pract. 2019;119:1-14. doi:10.1016/j.tra.2018.11.002.
36. Hardman S. Understanding the impact of reoccurring and non-financial incentives on plug-in electric vehicle adoption – a review. *Transportation Research Part A: Policy and Practice*. 2019;119:1-14.
37. Hawkins T, Gausen O, Strømman A. Environmental impacts of hybrid and electric vehicles—a review. Int J Life Cycle Assess. 2012;17(8):997-1014. doi:10.1007/s11367-012-0440-9.
38. Henderson J. EVs are not the answer: a mobility justice critique of electric vehicle transitions. Ann Am Assoc Geogr. 2020;110(6):1993-2010.
39. Howey D, Martinez-Botas R, Cussons B, Lytton L. Comparative measurements of the energy consumption of 51 electric, hybrid and internal combustion engine vehicles. Transp Res Part D Transp Environ. 2011;16(6):459-64. doi:10.1016/j.trd.2011.04.001.
40. Huang P, Li P. Politics of urban energy transitions: new energy vehicle (NEV) development in Shenzhen, China. Environ Polit. 2019;29(3):524-45. doi:10.1080/09644016.2019.1589935.
41. Karki A, Phuyal S, Tuladhar D, Basnet S, Shrestha BP. Status of pure electric vehicle power train technology and future prospects. Appl Syst Innov. 2020;3(3):35.
42. Kennedy D, Philbin S. Techno-economic analysis of the adoption of electric vehicles. Front Eng Manag. 2019;6(4):538-50. doi:10.1007/s42524-019-0048-x.
43. Kester J, Noel L, de Rubens GZ, Sovacool BK. Policy mechanisms to accelerate electric vehicle adoption: A qualitative review from the Nordic region. Renew Sustain Energy Rev. 2018;94:719-31.
44. Kester J, Noel L, Rubens G, Sovacool B. Policy mechanisms to accelerate electric vehicle adoption: a qualitative review from the Nordic region. Renew Sustain Energy Rev. 2018;94:719-31. doi:10.1016/j.rser.2018.05.067.
45. Khandakar A, Rizqullah A, Berbar A, Ahmed M, Iqbal A, Chowdhury M, *et al*. A case study to identify the hindrances to widespread adoption of electric vehicles in Qatar. Energies. 2020;13(15):3994. doi:10.3390/en13153994.
46. Kotilainen K, Aalto P, Valta J, Rautiainen A, Kojo M, Sovacool BK. From path dependence to policy mixes for Nordic electric mobility: Lessons for accelerating future transport transitions. Policy Sci. 2019;52:573-600.
47. Kumar RR, Alok K. Adoption of electric vehicle: A literature review and prospects for sustainability. J Clean Prod. 2020;253:119911.
48. Lai I, Liu Y, Sun X, Zhang H, Xu W. Factors influencing the behavioural intention towards full electric vehicles: an empirical study in Macau. Sustainability. 2015;7(9):12564-85. doi:10.3390/su70912564.
49. Li Y, Ha N, Li T. Research on carbon emissions of electric vehicles throughout the life cycle assessment taking into vehicle weight and grid mix composition. Energies. 2019;12(19):3612. doi:10.3390/en12193612.
50. Li Y, Zhan C, de Jong M, Lukszo Z. Business innovation and government regulation for the promotion of electric vehicle use: lessons from Shenzhen, China. J Clean Prod. 2016;134:371-83.
51. Liao F, Molin E, Wee B. Consumer preferences for electric vehicles: a literature review. Transp Rev. 2016;37(3):252-75. doi:10.1080/01441647.2016.1230794.
52. Liu X, Sun X, Zheng H, Huang D. Do policy incentives drive electric vehicle adoption? Evidence from China. Transp Res Part A Policy Pract. 2021;150:49-62.
53. Llopis-Albert C, Rubio F, Valero F. Impact of digital transformation on the automotive industry. Technol Forecast Soc Change. 2021;162:120343.
54. MacPherson N, Keoleian G, Kelly J. Evaluation of a regional approach to standards for plug-in battery electric vehicles in future light-duty vehicle greenhouse gas regulations. J Ind Ecol. 2014;19(1):154-66. doi:10.1111/jiec.12170.
55. Maghfiroh MFN, Pandyaswargo AH, Onoda H. Current readiness status of electric vehicles in Indonesia: Multistakeholder perceptions. Sustainability. 2021;13(23):13177.
56. Maske P, Chel A, Gopal P, Kaushik G. Sustainable perspective of electric vehicles and its future prospects. J Sustain Mater Process Manag. 2021;1(1). doi:10.30880/jsmpm.2021.01.01.003.
57. Mersky A, Sprei F, Samaras C, Qian S. Effectiveness of incentives on electric vehicle adoption in Norway. Transp Res Part D Transp Environ. 2016;46:56-68. doi:10.1016/j.trd.2016.03.011.
58. Michalek J, Chester M, Jaramillo P, Samaras C, Shiau C, Lave L. Valuation of plug-in vehicle life-cycle air emissions and oil displacement benefits. Proc Natl Acad Sci U S A. 2011;108(40):16554-8. doi:10.1073/pnas.1104473108.
59. Misch F, Camara Y, Holtsmark B. Electric vehicles, tax incentives and emissions: evidence from Norway. IMF Work Pap. 2021;2021(162):1. doi:10.5089/9781513582818.001.
60. Moeletsi ME. Future policy and technological advancement recommendations for enhanced adoption of electric vehicles in South Africa: A survey and review. Sustainability. 2021;13(22):12535.

61. Muehlegger E, Rapson D. Subsidizing low- and middle-income adoption of electric vehicles: quasi-experimental evidence from California. 2018. Available from: https://doi.org/10.3386/w25359
62. Narassimhan E, Johnson C. The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US states. Environ Res Lett. 2018;13(7):074032. Available from: https://doi.org/10.1088/1748-9326/aad0f8
63. Narassimhan E, Johnson C. The role of demand-side incentives and charging infrastructure on plug-in electric vehicle adoption: analysis of US States. Environ Res Lett. 2018;13(7):074032.
64. Nealer R, Hendrickson T. Review of recent lifecycle assessments of energy and greenhouse gas emissions for electric vehicles. Curr Sustain Renew Energy Rep. 2015;2(3):66-73. Available from: https://doi.org/10.1007/s40518-015-0033-x
65. Newman P, Beatley T, Boyer H. Resilient cities: overcoming fossil fuel dependence. Washington, DC: Island Press; 2017.
66. Ng M, Law M, Zhang S. Predicting purchase intention of electric vehicles in Hong Kong. Australas Mark J. 2018;26(3):272-80.
67. Noel L, de Rubens GZ, Kester J, Sovacool BK. Understanding the socio-technical nexus of Nordic electric vehicle (EV) barriers: a qualitative discussion of range, price, charging and knowledge. Energy Policy. 2020;138:111292.
68. Olise MC, Anigbogu TU, Edoko TD, Okoli MI. Determinants of ICT adoption for improved SME performance in Anambra State, Nigeria. Am Int J Contemp Res. 2014;4(7):163-76.
69. O'Neill E, Moore D, Kelleher L, Brereton F. Barriers to electric vehicle uptake in Ireland: perspectives of car dealers and policy makers. Case Stud Transp Policy. 2019;7(1):118-27.
70. Palmer K, Tate J, Wadud Z, Nellthorp J. Total cost of ownership and market share for hybrid and electric vehicles in the UK, US and Japan. Appl Energy. 2018;209:108-19. Available from: https://doi.org/10.1016/j.apenergy.2017.10.089
71. Pardo-Bosch F, Pujadas P, Morton C, Cervera C. Sustainable deployment of an electric vehicle public charging infrastructure network from a city business model perspective. Sustain Cities Soc. 2021;71:102957. Available from: https://doi.org/10.1016/j.scs.2021.102957
72. Pardo-Bosch F, Pujadas P, Morton C, Cervera C. Sustainable deployment of an electric vehicle public charging infrastructure network from a city business model perspective. Sustain Cities Soc. 2021;71:102957.
73. Plötz P, Gnann T, Sprei F. Can policy measures foster plug-in electric vehicle market diffusion? World Electr Veh J. 2016;8(4):789-97. Available from: https://doi.org/10.3390/wevj8040789
74. Priessner A, Sposato R, Hampl N. Predictors of electric vehicle adoption: an analysis of potential electric vehicle drivers in Austria. Energy Policy. 2018;122:701-14.
75. Rietmann N, Lieven T. How policy measures succeeded to promote electric mobility—worldwide review and outlook. J Clean Prod. 2019;206:66-75.
76. Schuitema G, Anable J, Skippon S, Kinnear N. The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles. Transp Res Part A Policy Pract. 2013;48:39-49. Available from: https://doi.org/10.1016/j.tra.2012.10.004
77. Searle S, Pavlenko N, Lutsey N. Leading edge of electric vehicle market development in the United States: an analysis of California cities. Int Counc Clean Transp. 2016.
78. Setiawan I. Policy simulation of electricity-based vehicle utilization in Indonesia (electrified vehicle - HEV, PHEV, BEV and FCEV). Automot Exp. 2019;2(1):1-8. Available from: https://doi.org/10.31603/ae.v2i1.2020
79. Shareeda A, Al-Hashimi M, Hamdan A. Smart cities and electric vehicles adoption in Bahrain. J Decis Syst. 2021;30(2-3):321-43.
80. Shiau C, Michalek J. A MINLP model for global optimization of plug-in hybrid vehicle design and allocation to minimize life cycle greenhouse gas emissions. 2010. Available from: https://doi.org/10.1115/detc2010-28064
81. Singh V, Singh V, Vaibhav S. A review and simple meta-analysis of factors influencing adoption of electric vehicles. Transp Res Part D Transp Environ. 2020;86:102436. Available from: https://doi.org/10.1016/j.trd.2020.102436
82. Soares J, Ghazvini M, Borges N, Vale Z. Dynamic electricity pricing for electric vehicles using stochastic programming. Energy. 2017;122:111-27. Available from: https://doi.org/10.1016/j.energy.2016.12.108
83. Soltani-Sobh A, Heaslip K, Bosworth R, Barnes R, Yook D. Investigating factors affecting electric vehicles adoption: an aggregated panel data analysis over U.S. states. World Electr Veh J. 2015;7(4):681-91. Available from: https://doi.org/10.3390/wevj7040681
84. Soltani-Sobh A, Heaslip K, Bosworth R, Barnes R, Yook D. Investigating factors affecting electric vehicles adoption: an aggregated panel data analysis over U.S. states. World Electr Veh J. 2015;7(4):681-91. Available from: https://doi.org/10.3390/wevj7040681
85. Soltani-Sobh A, Heaslip K, Bosworth R, Barnes R, Yook D. Investigating factors affecting electric vehicles adoption: an aggregated panel data analysis over U.S. states. World Electr Veh J. 2015;7(4):681-91. Available from: https://doi.org/10.3390/wevj7040681
86. Sovacool BK, Rogge JC, Saleta C, Masterson-Cox E. Transformative versus conservative automotive innovation styles: contrasting the electric vehicle manufacturing strategies for the BMW i3 and Fiat 500e. Environ Innov Soc Transitions. 2019;33:45-60.

87. Sperling D. Three revolutions: steering automated, shared, and electric vehicles to a better future. Washington, DC: Island Press; 2018.
88. Steinhilber S, Wells P, Thankappan S. Socio-technical inertia: understanding the barriers to electric vehicles. Energy Policy. 2013;60:531-9.
89. Stockkamp C, Schäfer J, Millemann J, Heidenreich S. Identifying factors associated with consumers' adoption of e-mobility—a systematic literature review. Sustainability. 2021;13(19):10975. Available from: https://doi.org/10.3390/su131910975
90. Tal G, Nicholas M. Exploring the impact of the federal tax credit on the plug-in vehicle market. Transp Res Rec J Transp Res Board. 2016;2572(1):95-102. Available from: https://doi.org/10.3141/2572-11
91. Tamayao M, Michalek J, Hendrickson C, Azevedo I. Regional variability and uncertainty of electric vehicle life cycle CO2 emissions across the United States. Environ Sci Technol. 2015;49(14):8844-55. Available from: https://doi.org/10.1021/acs.est.5b00815
92. Tu J, Yang C. Key factors influencing consumers' purchase of electric vehicles. Sustainability. 2019;11(14):3863. Available from: https://doi.org/10.3390/su11143863
93. Un-Noor F, Padmanaban S, Mihet-Popa L, Mollah MN, Hossain E. A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development. Energies. 2017;10(8):1217.
94. Vilchez J, Thiel C. Simulating the battery price and the car-mix in key electro-mobility markets via model coupling. J Simul. 2020;14(4):242-59. Available from: https://doi.org/10.1080/17477778.2020.1781556.
95. Wang N, Tang L, Pan H. A global comparison and assessment of incentive policy on electric vehicle promotion. Sustain Cities Soc. 2019;44:597-603.
96. Weis A, Jaramillo P, Michalek J. Consequential life cycle air emissions externalities for plug-in electric vehicles in the PJM interconnection. Environ Res Lett. 2016;11(2):024009. Available from: https://doi.org/10.1088/1748-9326/11/2/024009
97. White L, Sintov N. You are what you drive: environmentalist and social innovator symbolism drives electric vehicle adoption intentions. Transp Res Part A Policy Pract. 2017;99:94-113. Available from: https://doi.org/10.1016/j.tra.2017.03.008
98. Whitehead J, Washington S, Franklin J. The impact of different incentive policies on hybrid electric vehicle demand and price: an international comparison. World Electr Veh J. 2019;10(2):20. Available from: https://doi.org/10.3390/wevj10020020
99. Xue C, Zhou H, Qun-qi W, Wu X, Xu X. Impact of incentive policies and other socio-economic factors on electric vehicle market share: a panel data analysis from the 20 countries. Sustainability. 2021;13(5):2928. Available from: https://doi.org/10.3390/su13052928.
100. Xue C, Zhou H, Wu Q, Wu X, Xu X. Impact of incentive policies and other socio-economic factors on electric vehicle market share: A panel data analysis from the 20 countries. Sustainability. 2021;13(5):2928.
101. Yong T, Park C. A qualitative comparative analysis on factors affecting the deployment of electric vehicles. Energy Procedia. 2017;128:497-503.
102. Zhang R, Fujimori S. The role of transport electrification in global climate change mitigation scenarios. Environ Res Lett. 2020;15(3):034019.
103. Zhang X, Xie J, Rao R, Liang Y. Policy incentives for the adoption of electric vehicles across countries. Sustainability. 2014;6(11):8056-78.
104. Zimm C. Improving the understanding of electric vehicle technology and policy diffusion across countries. Transp Policy. 2021;105:54-66.