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Can educational and policy interventions enhance EV adoption in Vietnam? Consumer insights

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ABSTRACT

Driven by its commitment to achieving net-zero emissions in the transportation sector by 2050, the Vietnamese government has promoted the adoption of electric vehicles (EVs), including electric motorcycles (EMs) and electric cars (ECs). However, persistent adoption barriers may continue to constrain EV penetration and sales growth. While several studies have tested solutions to overcome these barriers, research that examines potential policy interventions for both ECs and EMs remains limited. This study aims to evaluate whether educational and policy interventions addressing key barriers to EV adoption in Vietnam can enhance uptake. A structured questionnaire was conducted among consumers in major cities across Vietnam, yielding 716 valid responses, and these were analyzed using binary logistic regression and rank-order logit models. The results indicate that providing additional information about fuel and maintenance costs, as well as the total cost of ownership (TCO), increases the likelihood of EV take-up. Furthermore, potential widespread implementation of battery-swapping technology (BST) also holds promise for boosting EV adoption. The study contributes valuable new insights for policymakers and industry stakeholders into how public awareness enhancement and infrastructural improvement can accelerate EV uptake in Vietnam and other nascent markets.

1. Introduction

At the 26th United Nations Climate Change Conference in 2021, Vietnam made a commitment to attain net zero by 2050 (Barnes, 2022). To act upon the commitment, in July 2022, the government approved Decision No. 876/QD-TTg, with a target of 100% of on-road vehicles using green or electricity sources by 2050 (Prime Minister of Vietnam, 2022). The decision also set a near-term goal of 50% of on-road vehicles doing likewise by 2030. To achieve these targets, the government introduced incentive policies for electric cars (ECs), reducing registration fees (Government of Vietnam, 2022) and excise tax (National Assembly of Vietnam, 2022) (see Appendix A). As a result, EC sales in Vietnam have grown significantly since 2022, albeit from a low base, seeing a fourfold increase between 2022 and 2023, as shown in Fig. 1.[1]

This growth is attributed to supportive government policies and the launch in 2022 of EC production by VinFast, a local automotive manufacturer. By way of comparison, conventional car (CC) sales had remained relatively stable over the preceding years, although they saw a post-COVID surge in 2022. Nevertheless, despite their rapid sales growth, ECs still account for less than 10% of new car sales.

Unlike ECs, electric motorcycles (EMs) have lacked policy incentives, but EM sales have still grown by 30–35% in recent years (Tú, 2023), with their 2023 market share estimated at around 10% (UNEP, 2023). Recent announcements regarding upcoming restrictions on conventional motorcycle (CM) travel in the cities of Hanoi and Ho Chi Minh City are expected to further boost EM sales (Ha and Linh, 2025).

Unlike other countries, Vietnam is unique in having a local auto manufacturer that holds a near monopolistic position in the EC market, with VinFast accounting for 99.40% of ECs sold in 2023 and playing an important role in supporting Vietnam's transport decarbonization strategy (Báo Giao thông, 2024; Government of Canada, 2023; Kelly Blue Book, 2024; TC Group, 2024; VAMA, 2024a). While VinFast does

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[1] Data collected from Government of Canada (2023); Hyundai Thành Công Việt Nam (2022); Kelly Blue Book (2024); TC Group (2023, 2024); Vietnam Automobile Manufacturers' Association [VAMA] (2022, 2024a); VinFast (2022, 2024).

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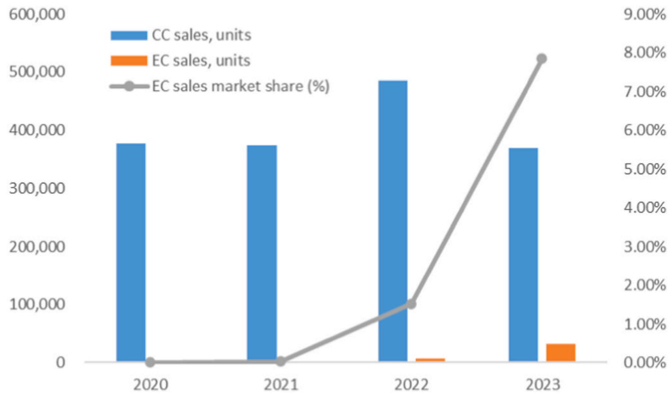

Fig. 1. EC and CC sales, and market share of EC sales in Vietnam from 2020 to 2023.

not possess a monopoly in the EM market, characterized by the presence of numerous affordable domestic and international competitors, it nonetheless retains a significant 43% market share. Collectively, domestic brands account for approximately 70% of the EM market (Ho, 2025).

To achieve the government's 2030 target of replacing half of the existing cars on the road, EC sales in Vietnam would have to grow at least 30% annually to reach 50% for new car sales, and to grow ~92% per annum to reach a 50% market share of all cars overall (i.e. including the second-hand market) (see Fig. 2). For the 2050 target of replacing all existing cars with ECs, the annual EC growth rates are 9.89% to reach the milestone of all new sales being electric, and 21.55% to replace all cars overall (see Fig. 2). These targets are very ambitious even when compared to Norway, which is the global leader in EC adoption and has a long history of EC research and development (since the 1970s) and EC policy incentives (since the 1990s) (Figenbaum et al., 2015). Vietnam's current stage of EC adoption is comparable to Norway's in 2013, when new EC sales accounted for about 5.37% of the market, corresponding to 0.87% of the total car fleet (see Fig. 3). A decade later, in 2023, EC sales constituted an impressive 81.28% of new car sales in Norway, although ECs still only represented 24.28% of the total car market fleet (see Fig. 3). In this light, and with VinFast currently in a growth phase, only the Vietnamese 2030 target for new EC sales is deemed feasible. If such sales matched the pace of growth seen in Norway between 2013 and 2020, they could account for more than 50% of new car sales by 2030. However, replacing half of the car fleet with ECs by 2030 or all of it by 2050 is unlikely because even Norway is far from these milestones today (see Fig. 3). Although the contribution of VinFast to the process is significant, it is unlikely to be able to deliver the targets on its own and the market would have to be expanded at some stage to other producers.

For the EM market to reach the 2030 target of replacing half of the existing motorcycles on the road, EM sales need to grow by at least 22.73% per year for new sales and 99.18% per year overall (see Fig. 2). To achieve the 2050 target of replacing all petrol motorcycles, the annual growth rates must be 8.20% for new motorcycle sales and 22.67% overall (see Fig. 2). Achieving such ambitious targets will be very difficult without additional strong policy incentives, and to have any hope of doing so, several barriers to EV adoption, some of which involve perception, must be mitigated.

In the global context, there are a variety of common barriers to widespread EV adoption. Financial barriers, such as high purchase price, uncertain resale value and high battery replacement costs, have been widely demonstrated to impede EV adoption (Axsen et al., 2013; Bhat and Verma, 2024; Murtiningrum et al., 2022; Noel et al., 2020; Rizki et al., 2024; Weinert et al., 2008), while charging-related barriers include the unavailability of public charging, the inconvenience of private charging, and long charging durations (Coffman et al., 2017; Ma et al., 2019; Patt et al., 2019; Rizki et al., 2024; Weinert et al., 2008). In European countries, the UK and China, short battery life is the top technical barrier to widespread EC adoption (Berkeley et al., 2018; Biresselioglu et al., 2018; She et al., 2017). While research conducted in Indonesia by Lazuardy et al. (2024) suggests that battery life is also a key influence on EM adoption, they do not clarify whether it acts as a barrier. Limited driving range has also been cited widely as a key technical hurdle to EC adoption, especially in developed markets such as the US, the UK and Europe (Berkeley et al., 2018; Egbue and Long, 2012; Jia and Chen, 2021; Noel et al., 2019), but driving range as a barrier to EM adoption has been much less researched. Guerra (2019) suggested that an extended driving range exerts a positive impact on EM adoption in Indonesia, which might indirectly indicate that consumers perceive the existing range of EMs as a limitation.

In the Vietnamese context, several barriers to EV adoption have been documented. In Ho Chi Minh City, Truong et al. (2024) identified driving range, charging time, private charging availability, battery replacement cost and public charging station coverage as primary barriers to both EC and EM adoption. Nguyen-Phuoc et al. (2024) indicated that perceived risk, including range and safety issues, deters EM adoption in Ho Chi Minh City and Da Nang. In Hanoi, the country's capital, Nguyen et al. (2022) found that charging facilities, driving range and charging time were significant constraints on EC purchase intention, while Trung and Urmee (2024) highlighted high initial prices, infrastructure gaps, safety issues, charging duration and battery quality as the main hurdles to EM adoption in Hanoi. However, existing studies have not adequately examined whether faster charging solutions, particularly battery-swapping technology (BST), could help overcome key barriers to EV adoption. Currently, across Vietnam, VinFast has around 2942 fast-charging stations,[5] and approximately 150,000 charging ports at a so-called 'density' of 3.5 km (travel distance) between urban stations (Anh, 2023; Google, n.d.). However, only Selex Motors, a Vietnamese EM manufacturer, has deployed BST, with over 100 swapping stations in major cities such as Ho Chi Minh City, Hanoi and Da Nang (Selex Motors, n.d.). In terms of ECs, no official announcement of battery-swapping installations has been made by VinFast or any other brand. Expanding the density of fast charger installation can mitigate challenges such as inadequate charging infrastructure, limited driving range and lengthy charging times, while broader application of BST could further reduce these barriers as well as addressing concerns regarding battery life. However, the role of BST in EV adoption, particularly for EMs, has been largely overlooked in research, even in motorcycle-dominated markets.

As noted above, high purchase prices are often (perceived as) a major obstacle to EV adoption. Yet, the impact on EV adoption of better total cost of ownership (TCO) information, especially for EMs, has received limited attention in the current literature. Consumers may lack awareness or understanding of the long-term costs associated with EV ownership, leading them to focus disproportionately on the upfront purchase price. Providing TCO information can serve an educational purpose by highlighting potential long-term savings, which may shift consumer attention away from short-term costs and ultimately encourage faster EV adoption. This study seeks to address these gaps in the current literature by investigating how additional cost information and BST availability could influence EV adoption in Vietnam. Specifically, to better understand Vietnamese consumer preferences, it seeks to answer the following research questions:

1. How do different cost-related scenarios (purchase price, fuel and maintenance costs, and TCO) affect individuals' preferences for ECs and EMs?
2. How do different charging infrastructure scenarios (current network, full petrol-station coverage, and BST systems) affect individuals' preferences for ECs and EMs?

[5] Chargers with a capacity starting at 60 kW.

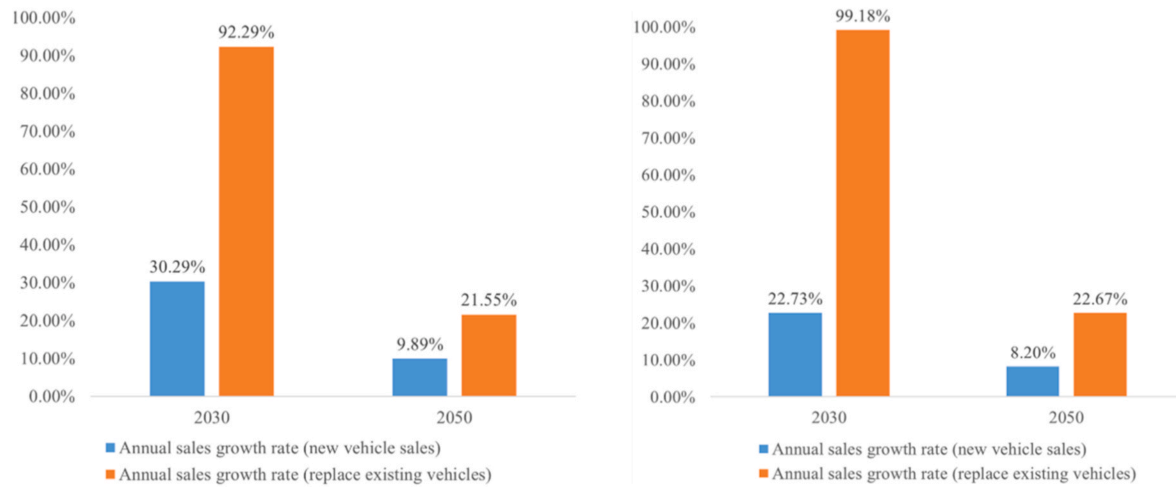

Fig. 2. EC[2] (left) and EM[3] (right) sales growth required to achieve government targets.

[2] Data collected from Báo Giao thông (2024); Government of Canada (2023); Kelly Blue Book (2024); TC Group (2024); VAMA (2024a).
[3] Data collected from Báo Giao thông (2024); Thương (2024); Vietnam Association of Motorcycle Manufacturers [VAMM] (2024); Vũ (2023).

3. How do consumer characteristics influence EV adoption in a variety of cost and charging infrastructure scenarios?

EV adoption rates have far-reaching implications for Vietnam in a broader sense. First, the transition to EVs could drive employment growth by creating a cumulative total of 6.5 million manufacturing jobs by 2050 (Wang and Rogate, 2024). Second, Vietnam could reduce petrol and oil import costs by approximately US$498 billion cumulatively by 2050, and cut environmental costs by US$30 million and US$6.4 billion in 2030 and 2050, respectively (Wang and Rogate, 2024). Third, the pace of new EV sales directly affects the speed at which older, more polluting vehicles are retired, thereby exerting a significant influence on both environmental and public health outcomes. Finally, given the impact on consumer welfare and the achievement of net-zero goals, any policy or informational intervention that alters EV demand requires a comprehensive cost–benefit assessment.

This paper contributes to the literature on factors influencing EV adoption in several ways. First, it is among the first to provide insights into how cost-related educational interventions, which emphasize more economic solutions, affect the adoption of both ECs and EMs in a nascent EV market. Existing studies that examined the impact of cost information have focused primarily on ECs in developed countries, such as the US and China (Dumortier et al., 2015; Ji and Gan, 2022). By incorporating EMs, this study offers a more comprehensive view of consumer preferences, particularly in motorcycle-dominated countries. The study's second contribution to the literature is in its examination of how charging-related policy interventions can influence EV adoption, including the placement of charging stations in close proximity to customers and the use of BST technology. Third, the research enriches the literature in terms of how EV preferences under a variety of cost and infrastructure scenarios are affected by consumer characteristics, which is useful for developing better-tailored policy solutions.

The study is highly relevant in the context of Vietnam's ambitious transition towards net-zero emissions and its rapid but still limited

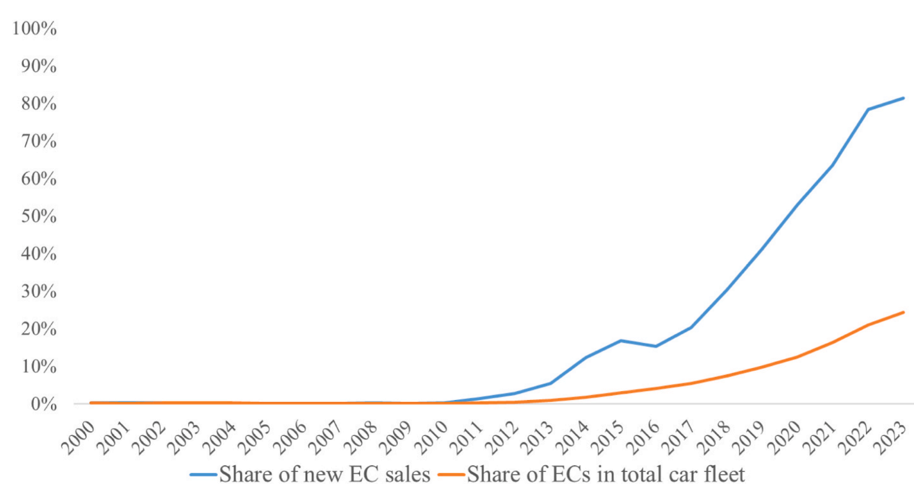

Fig. 3. EC sales growth in Norway between 2000 and 2023.[4].

[4] Data collected from Andrew (n.d.); Statens vegvesen (n.d.).

adoption of EVs. Despite strong policy commitments and recent market growth, EV uptake remains insufficient to meet national targets, highlighting the need for more effective and scalable interventions. Unlike existing studies that focus primarily on identifying barriers or characterizing consumer attitudes, this study provides empirical evidence of whether practical interventions – specifically, cost-related information and charging infrastructure improvements – can actively shift consumer preferences. This is particularly important in a motorcycle-dominated and lower-middle-income country such as Vietnam, where affordability constraints and infrastructure limitations play a critical role in technology adoption. By examining both ECs and EMs within a unified framework, the study offers policy-relevant insights that are directly applicable to emerging economies facing similar structural and behavioural challenges.

The remainder of the paper is organized as follows: Section 2 presents the theoretical framework and a literature review; Section 3 outlines the TCO analysis, survey design, method of data collection and econometric models used; Section 4 provides results and discussion of sample characteristics, and the effects of cost-related information and faster charging facilities on EV adoption, and Section 5 concludes with the key findings, policy implications and limitations of the study, together with recommendations for further research.

2. Theoretical framework and literature review

2.1. Theoretical framework

The Diffusion of Innovations (DoI) theory proposed by Rogers (2003) outlines the stages by which new technology is adopted by consumers, including knowledge, persuasion, decision, implementation and confirmation aspects. The theory divides adopters into five categories according to their speed of adoption, starting with innovators, then early adopters, the early majority, the later majority and, lastly, the laggards. The innovators are considered venturesome; they are early engagers, rapidly adopting the innovation when a high level of uncertainty still surrounds it, and they account for only 2.5% of the population. Early adopters are considered more risk-averse than the innovators but still seek new products, constituting 13.5% of the population. These adopters are also regarded as opinion leaders, respected by their peers and from whom potential adopters normally seek advice. The early majority, the largest proportion of the population at 34%, tend to be more cautious about new products and usually seek evidence from their peers. The late majority also account for 34% of the population, but they are relatively sceptical of innovations and typically only adopt new technology as a result of peer pressure. Finally, the laggards, representing 16% of the population, are regarded as extremely resistant to adopting innovations and often do so only when forced.

Consumers might be unwilling to adopt EVs owing to several barriers, either real or perceived. Some customer perceptions of EVs might be outdated or simply myths, and the experiences of innovators and early adopters are critical if EVs are to become accepted by the early majority. In the knowledge phase of the innovation adoption process, the early adopter might conduct objective research to gather accurate information and form an informed understanding prior to the decision stage. Later adopters, meanwhile, especially the early and late majorities that together represent 68% of the population, are more likely to absorb subjective knowledge of an innovation from their peers, which might include false information, thereby impeding purchase intentions. For any policymaker pursuing the goal of broader acceptance of new technology, such as EVs, it is critical that they understand and address the issues that will help with acceptance among these early and late majority groups.

2.2. The effect of cost-related information on EV adoption

Although the TCO of EVs is often lower than that of conventional vehicles (CVs), consumers tend to focus on the initial cost, thereby reducing their likelihood of EV purchase. In addition, Krause et al. (2013) found that misperceptions of fuel and maintenance costs can also significantly affect the likelihood of EC adoption. For example, consumers who underestimate the fuel savings of ECs and overestimate their maintenance costs are less likely to adopt them. Many papers have focused on TCO modelling for EVs (Cox and Mutel, 2018; Franzò et al., 2022; Liu et al., 2021; Malima and Moyo, 2023; Palmer et al., 2018; Parker et al., 2021); however, the effect of providing additional cost information on EV purchase intention, especially for EMs, has not been widely demonstrated and/or has generated mixed results. Several studies have shown that the provision of TCO information increases the likelihood of EC adoption, particularly for the small-sized car segment (Dumortier et al., 2015; Ji and Gan, 2022) but not, according to Dumortier et al. (2015), for the small-sized SUV segment. Moreover, there are contradictory results for the effect on EC adoption of providing fuel savings information (Dumortier et al., 2015; Ji and Gan, 2022; Nixon and Saphores, 2011).[6] Research on the effects on EM adoption of providing additional cost-related information remains relatively limited because most of the associated studies have focused on developed countries, in which cars rather than motorcycles are the primary mode of transport. Research has suggested that their lower fuel costs increase the adoption of EMs in Indonesia (Rizki et al., 2024), while research in Taiwan indicates a positive effect on EM adoption of providing fuel savings information (Filippini et al., 2021). Aside from the impact of fuel savings information, the influence on EM adoption of information about maintenance costs and TCO is underexplored, with only limited evidence available.

2.3. The effect of faster charging facilities on EV adoption

Consumers are used to the convenience of rapid mid-journey refuelling of CVs, and slow EV recharging can be regarded as an extreme inconvenience that hinders EV adoption. As a result, manufacturers have made great efforts to improve charging technology and reduce charging times. Krause et al. (2018) found that fast charging, taking a maximum of 3 h, had a positive effect on EV usage, especially where longer daily travel distances were involved (Neaimeh et al., 2017). However, Haustein et al. (2021) found that, in Sweden, the effect on EV purchase intentions of fast charging was positive but insignificant, while Ghasri et al. (2019) found that, in Australia, reducing charging time from 6.5 h to 1.5 h only increased the probability of EV adoption by 4.32%. Indeed, improvements to charging times have not yet been sufficiently persuasive to meet consumer expectations for truly fast charging, and this has given rise to the notion of battery swapping instead. Battery swapping allows EV users to rapidly exchange depleted batteries for fully charged ones at a swapping station (Widrick et al., 2018). BST and battery-swapping stations (BSSs) could be a factor that addresses concerns about range, charging availability and battery replacement costs. Egbue and Long (2012) reported that a majority of their respondents did not have EC purchase intentions but showed high levels of interest in 1-min battery-swapping ideas. Several studies have explored factors that might positively affect adoption intent in relation to BST, including perceived usefulness/benefits, attitudes, subjective norms, and knowledge (Adu-Gyamfi et al., 2022a; Adu-Gyamfi et al., 2022b). In China, households have indicated a willingness to pay around 400 Chinese Yuan (~USD55) a year to support BSS construction (Tan et al., 2022), while Korean consumers are willing to pay around 107,000 Korean Won (~USD80) to utilize BSSs (Lee and Kim, 2024). Murugan and Marisamynathan (2024) found that, were BSSs to be integrated into normal

[6] Dumortier et al. (2015) found the effect on EC adoption of the provision of fuel savings information to be insignificant but, elsewhere, the cost benefits were found to be significant in promoting EC adoption (Ji and Gan, 2022; Krause et al., 2013; Nixon and Saphores, 2011).

refuelling stations, Indian consumers increased their willingness to buy ECs by 20%. Thus, battery swapping is a promising option for promoting EV adoption, but it is currently outside policy focus in Vietnam. This study addresses the associated gaps in the current body of literature by assessing the potential effects of BST on both EC and EM adoption.

2.4. Research gap

The existing literature demonstrates a significant imbalance in how adoption solutions are examined among different vehicle types. Current literature persists in a 'problem identification' loop, wherein few studies move beyond this stage to test the effectiveness of solutions that might overcome such barriers. While some studies have focused primarily on financial incentives such as subsidies and price reductions as solutions to promote EV adoption (Liu and Xiao, 2018; Ngoc and Nishiuchi, 2023), these approaches typically impose financial burdens on governments or industry stakeholders, and relatively little research has examined the role of public education as to the long-term economic benefits of EVs as a more sustainable policy intervention. A small amount of literature suggests that providing operational costs and TCO information can enhance EC preferment (Dumortier et al., 2015; Ji and Gan, 2022; Nixon and Saphores, 2011), but studies on EMs are even more scarce, leaving a gap in our understanding of whether such interventions would be effective for them. Our paper provides a comprehensive analysis of potential EV adoption in response to education interventions focused on cost information for both ECs and EMs.

In terms of the charging-related challenges to EV adoption, BST has been established as a promising solution for these issues but recent literature presents a stark contradiction. In India, consumers are estimated to be 20% more likely to purchase ECs were BSSs available at all petrol stations (Murugan and Marisamynathan, 2024), although such infrastructure expansion may be financially impractical, leading to an implementation gap. In contrast, Patel et al. (2024) utilized mathematical modelling to project a modest 6% to 10% BST-generated increase in EV adoption by 2070 in comparison to point charging alone. Their findings are purely theoretical, and do not take into consideration the added convenience of a battery-swapping network, which might account for the relatively low rate of increased EV adoption reported. This absence of physical charging location considerations represents a further research gap and our paper seeks to address this and others by investigating consumer preferences in a variety of different charging scenarios, providing more practical and consumer-oriented solutions.

3. Methodology

3.1. TCO analysis

Prior to designing our survey, car and motorbike brands and models had to be chosen for TCO analysis. The choices made were guided by the popularity of relevant models in Vietnam. Three cars were selected by technology type: the Mazda CX-5 (conventional car, CC), the VinFast VF e34 (electric car, EC) and the Toyota Corolla Cross (hybrid electric car, HEC). All three models were in the same price range and car segment (C-class SUVs). The VinFast VF e34 was Vietnam's best-selling EC in 2023, while the Mazda CX-5 has been a top-selling CC in Vietnam since 2022 (VAMA, 2023, 2024b, 2024c). For motorcycles, owing to the relative dearth of hybrid and plug-in hybrid motorcycles in Vietnam, only one CM and one EM were chosen. The chosen CM was the Honda Vision, one of the most popular and affordable mid-segment automatic motorcycles in Vietnam (VAMM, 2023); for the EM, VinFast's mid-segment Feliz S was chosen.

The motorcycle TCOs were calculated in terms of initial capital costs, operating costs and resale value. The initial capital costs included purchase price, one-time registration fee, one-time licence-plate fee, and annual civil liability fee. Operating costs were calculated on an annual basis and covered energy and maintenance costs. The car TCOs were calculated on a similar basis but included some additional fees. In particular, the initial capital costs had additional annual road fees and inspection fees, while the operating costs also included annual insurance premiums, road fees and inspection fees.

The standard ownership term for both cars and motorcycles was assumed to be 10 years, which aligns with typical private car ownership patterns in Vietnam, and is also consistent with TCO calculations from previous research (Dumortier et al., 2015; Ouyang et al., 2021; Sharma et al., 2012). The discount rate was determined by the current cash rate at the time of 4.5% (State Bank of Vietnam, 2023). All the vehicle costs were adjusted for inflation, which was assumed at 3.029% per year, based on the average annual inflation rate over the last 10 years (World Bank, n.d.). The annual travel distance for cars was assumed to be 10, 870 km, based on odometer readings of 100 cars on sale on the Cho Tot platform (www.chotot.com; Cho Tot, n.d.), one of the largest second-hand automotive marketplaces in Vietnam. For motorcycles, the annual travel distance assumed was 6814 km, averaged from previous studies and statistics (Dung et al., 2015; Huu and Ngoc, 2021; Tran et al., 2024; VTV Online, 2020). For energy cost calculations, RON 95-III petrol was used as the main fuel type for CVs, with an initial cost of 19,630 VND per litre. For EVs, the monthly electricity costs in 2024 were assumed to be 3151 VND per kWh at level 6 of the retail price for household electricity, determined on the basis of annual electricity consumption from previous findings, which included 3340 kW in 2018 (Le and Pitts, 2019) and 4350 kW in 2022 (Le et al., 2023). The detailed TCO calculations over 10 years for the selected motorcycles and cars are shown in Table 1.

3.2. Survey design

The survey was aimed at those in Vietnam expecting to purchase a car or motorcycle in the next 10 years to determine their willingness to purchase an EV. It was designed and hosted on Microsoft Forms. There were several screening criteria for survey participants. Respondents had to be at least 18 years old, currently living in Vietnam, and intending to purchase a motorcycle or car within the next 10 years. The survey consisted of three main sections. First, a sociodemographic segment gathered information about gender, age, income, level of education, employment status and living accommodation. Second was a section on vehicle ownership, mobility patterns, and consumers' vehicle purchase intentions within the next 10 years. The final section of the survey presented a set of scenarios designed to study whether EV interest would change on the basis of the provision of additional information associated with costs and charging options. Respondents expressing an intent to purchase a car were asked to rank their most and least preferred car (CC, EC or HEC) in six scenarios, while those interested in motorcycles were only asked to indicate their preference in relation to two options (EM and CM) in five scenarios. Those intending to purchase both a car and a motorcycle were allocated to both sets of scenarios. The cost-related scenarios comprised general vehicle information and vehicle purchase price (Scenario 1), a repeat of Scenario 1 with the addition of fuel and maintenance cost information (Scenario 2), and a repeat of Scenario 2 plus resale price and TCO information (Scenario 3) (see Tables 2 and 3).

The charging-related scenarios consisted of the current fast-charging (within 30 min) infrastructure at 3.5-km intervals[7] (Scenario 4), fast charging at every petrol station (Scenario 5), and BST at 3.5-km intervals (Scenario 6) (see Table 4). To avoid brand bias, car- and motorcycle-related information was provided in a generic form, alongside key performance characteristics. The survey questions involved multiple-choice and multiple-answer formats, as well as question responses based on a five-point Likert scale (1 = 'Strongly disagree'; 5 = 'Strongly agree'). A

[7] The fast-charging station frequency (or 'density') is assumed to be 3.5 km because VinFast claims to have charging stations within 3.5 km of each other in 80 out of 85 cities across Vietnam (Anh, 2023).

Table 1
TCO results for selected motorcycles and cars (currency: VND).

	CM	EM	CC	EC	HEC
Initial capital costs					
Retail price [a]	31,113,818	46,900,000	749,000,000	830,000,000	905,000,000
Registration fee [b]	1,555,691	2,345,000	74,900,000	0	90,500,000
Licence-plate fee [c]	2,000,000	4,000,000	20,000,000	20,000,000	20,000,000
Civil liability fee [d]	60,000	55,000	437,000	437,000	437,000
Inspection fee [e]			340,000	340,000	340,000
Road fee [f]			1,560,000	1,560,000	1,560,000
Total purchase price	**34,729,509**	**53,300,000**	**846,237,000**	**852,337,000**	**1,017,837,000**
Operating costs					
Civil liability fees [d]	485,487	445,359	3,505,582	3,505,582	3,505,582
Inspection fees [e]			2,753,130	2,753,130	2,753,130
Road fees [f]			12,632,009	12,632,009	12,632,009
Energy costs	**22,405,564**	**4,123,788**	**130,141,116**	**42,125,476**	**78,084,670**
Maintenance [g]	**10,126,719**	**4,074,671**	**52,822,890**	**23,354,933**	**39,351,460**
Insurance [h]			71,923,783	82,742,347	90,219,065
Residual value & Ownership					
Resale value [i]	(7,896,631)	(5,992,451)	(218,483,286)	(128,219,789)	(300,774,490)
TCO	**59,851,007**	**55,951,367**	**901,565,226**	**891,263,689**	**943,641,426**

Notes.
[a] Data based on: CM (www.honda.com.vn), EM (vinfast.com), CC (mazdamotors.vn), EC (vinfast.com) and HEC (www.toyota.com.vn).
[b] Based on Decree 10/2022/ND-CP, EM and CM are 5% of retail price. CC and HEC are calculated at 10% of retail price while EC is exempted (Government of Vietnam, 2022).
[c] Data based on Circular No. 229/2016/TT-BTC (Ministry of Finance, 2016a).
[d] Data based on Circular No. 04/2021/TT-BTC (Ministry of Finance, 2021), with analysis conducted by the authors.
[e] Data based on Circular No. 238/2016/TT-BTC (Ministry of Finance, 2016b), with analysis conducted by the authors.
[f] Data based on Circular No. 293/2016/TT-BTC (Ministry of Finance, 2016c), with analysis conducted by the authors.
[g] Data based on: CM (Hoàng Việt Motors, n.d.), EM (VinFast, n.d.), CC (Ô tô Honda Thái Bình, 2020), EC (VinFast, 2022a) and HEC (Toyota Thăng Long, 2023), with analysis conducted by the authors.
[h] Insurance is not required for motorcycles, but car insurance is based on IBAOHIEM and ranged from 1.35 to 1.57% of the car value at the time of signing insurance contract (IBAOHIEM, n.d.). The analysis is conducted by the authors.
[i] The resale value of vehicles was estimated according to the projected depreciation rate over 10 years, obtained from the Cho Tot platform (www.chotot.com).

Table 2
Cost-related information across three scenarios for the car group.

	CC (Option A)	EC (Option B)	HEC (Option C)
Scenario 1 (basic car information)			
Dimensions [a]	4590 × 1845 × 1680	4300 × 1768 × 1613	4460 × 1825 × 1620
Horsepower [a]	156	147	169
Acceleration (0–100 km/h) [a]	12 s	8.25 s	7.5 s
Government incentives [b]	None	(i) Free registration fee (normally 10% of retail price) (ii) Excise tax at 3%	None
Purchase price (including on-road costs)	846,237,000 VND	852,337,000 VND	1,017,837,000 VND
Scenario 2 (Scenario 1 + maintenance & fuel costs)			
Maintenance cost over 10 years	52,822,890.36 VND	20,435,246.24 VND	36,431,772.70 VND
Fuel cost over 10 years	130,141,116.03 VND	42,125,476.02 VND	78,084,669.62 VND
Scenario 3 (Scenario 2 + resale value & TCO)			
Expected resale value in current prices	218,483,285.85 VND	128,219,788.71 VND	300,774,489.72 VND
TCO over 10 years	901,565,225.64 VND	891,263,689.02 VND	943,641,426.15 VND
Please rate the three options according to your level of preference based on scale of 1 (highest), 2 (neutral/average) and 3 (lowest):			**A** ⋄ **B** ⋄ **C** ⋄

Notes.
[a] Data based on: CC (mazdamotors.vn), EC (vinfast.com) and HEC (www.toyota.com.vn).
[b] Data based on Decree 10/2022/ND-CP (Government of Vietnam, 2022) and Law No. 03/2022/QH15 (National Assembly of Vietnam, 2022).

pilot study was conducted with 10 people to test for any language, technical and/or ethical issues prior to the survey's formal launch.

3.3. Data collection

The survey was distributed between 16 November and 26 December 2024 via online platforms, including Facebook, Zalo and Instagram, the most popular social media platforms in Vietnam. Participants were informed that the survey could take up to 15 min to complete. Convenience sampling was utilized because it facilitates easier and faster data collection and has been proven effective for explanatory research purposes (Roberts, 2014). To research the larger sample size, the snowball technique was utilized, asking initial respondents to share the survey with their friends, family, relatives, colleagues and acquaintances. A total of 1225 responses were collected, of which 716 proved valid after excluding incomplete responses and responses from those not intending to buy any vehicle in the next 10 years. Of these 716 responses, 237 were potential buyers only of motorcycles, 248 were potential buyers only of cars, and 231 were potential buyers of both. For the purposes of analysis, the vehicle-specific responses of this latter group were incorporated as

Table 3
Cost-related information across three scenarios for the motorcycle group.

Type	CM	EM
Scenario 1 (basic motorcycle information)		
Dimensions (L × W × H) [a]	1871 × 686 × 1101	1912 × 693 × 1128
Weight [a]	94	130
Storage compartment size (L) [a]	18	25
Maximum speed (km/h) [a]	110	78
Purchase price (including on-road costs)	34,729,509 VND	53,300,000 VND
Scenario 2 (Scenario 1 + maintenance & fuel costs)		
Maintenance cost over 10 years	10,126,718.54 VND	4,074,670.50 VND
Fuel cost over 10 years	22,405,564.09 VND	4,123,788.26 VND
Scenario 3 (Scenario 2 + resale value & TCO)		
Expected resale value in current prices	7,896,631.03 VND	5,992,451.21 VND
TCO over 10 years	59,851,007 VND	55,951,366.85 VND
Please choose:	⋄	⋄

Notes.
[a] Data based on: CM (www.honda.com.vn) and EM (vinfast.com).

Table 4
Charging-related scenarios for the car and motorcycle groups.

Scenario	Description	Choice	
		Car group	Motorcycle group
Scenario 4	EVs could charge up to 80% in 30 min at charging stations every 3.5 km or less.	Option A (CC) Option B (EC) Option C (HEC)	Option A (CM) Option B (EM)
Scenario 5	EVs could charge up to 80% in 30 min at every petrol station.	Option A (CC) Option B (EC) Option C (HEC)	Not applicable
Scenario 6	EVs could swap in a fully charged battery within 10 min at battery-swapping stations every 3.5 km or less.	Option A (CC) Option B (EC) Option C (HEC)	Option A (CM) Option B (EM)

appropriate into both the car and motorcycle groups, giving respective final sample sizes for the two of 479 (248 + 231) and 468 (237 + 231).

3.4. Econometric models

3.4.1. Binary logistic regression model

In the situational questionnaire, respondents were asked to rank or choose their preferred vehicles. For the car group, the CC is used as the comparison baseline. If respondents rank the EC or the HEC above the CC, we code the response as a 1; otherwise, we code it as 0. Likewise, the CM is considered the baseline for the motorcycle group, and we coded a choice for the EM as a 1 and a choice for the CM as a 0. In this case, with binary outcomes, linear regression is inappropriate owing to heteroscedastic errors and unrealistic probability estimates (O'Garra et al., 2005), and logit or probit regression models are preferable approaches. We chose a binary logistic regression model because of its wide implementation in EV adoption studies (Iogansen et al., 2026; Ling et al., 2021; Zhang et al., 2011). The model was estimated using Stata 17.0 to assess the effects of additional EV information (cost-related scenarios), potential policy solutions (charging-related scenarios), sociodemographic factors and travel patterns on individuals' vehicle-choice preferences across conventional, electric and hybrid vehicles. The probability of the binary logistic regression model can be expressed as:

$$P(Y_i = 1) = 1 \Big/ \left(1 + \exp\left(\sum_{n=1}^{K} \beta_n X_{in}\right)\right) \tag{1}$$

where $P(Y_i = 1)$ is the probability that the dependent variable Y_i equals 1. The dependent variable Y_i represent the respondent's preference for an EV or HEC rather than a CV. K is the number of independent variables in the model and β_n is the corresponding coefficient for the n-th independent variable X_{in}. X_{in} is the value of the n-th independent variable for the i-th individual. In this case, the independent variables are cost-related scenarios, charging-related scenarios, sociodemographic characteristics and travel patterns.

To enhance interpretability, the results are reported as marginal effects at the mean, which indicate the change in the predicted probability of selecting an EC, HEC or EM in preference to its conventional counterpart for a one-unit change in each explanatory variable, holding others at their means. Standard errors are clustered at the respondent level because the dataset comprises repeated observations per respondent based on scenario questions.

3.4.2. Rank-ordered logit (ROL) model

Because the survey was not structured as a control–treatment experiment, the study employs a rank-ordered logit model as a robustness check on the impact on EV adoption of providing cost-related information and faster charging facilities. This model is selected to ensure comparability with prior studies as to whether additional cost information has an impact on consumers' car choices (Dumortier et al., 2015; Ji and Gan, 2022). In addition, it is considered more appropriate than a multinomial logit model because it fully captures information from the ordinal rankings within the choice set, enabling more effective model parameter estimation (Dumortier et al., 2015).

In the scenario questions featured in the third section of the survey, respondents were asked to rank three vehicle types according to preference. A random utility model is employed that assumes there are J alternatives ($j = 1, \ldots, J$) and N individuals ($i = 1, \ldots, N$). For an individual i, the utility associated with alternative j is denoted by U_{ij}. The underlying assumption is that the true utility U_{ij} is not directly observable by the researcher. Thus, the random utility model is constructed, which decomposes the total utility into two components: a deterministic component and a random component. In this case, the deterministic component, V_{ij}, is observable by the researcher whereas the random component, ε_{ij}, is a random error term in the utility model. The model equation is defined as $U_{ij} = V_{ij} + \varepsilon_{ij}$, in which $V_{ij} = \beta X_{ij}$, with β being the estimated coefficient and X_{ij} the explanatory variable.

The three vehicle-type alternatives mean that $J = 3$. The higher the probability of an individual i choosing a particular alternative j in preference to the other options, the higher the value of V_{ij}. Given the ranking of alternatives as a vector r_i, where each element r_i^j indicates the ranking of alternative j by respondent i (i.e. $r_i = (r_i^1, r_i^2, r_i^3)$), then the probability that the researcher observes a specific ranking r_i will be:

$$P(r_i|\beta) = P\left(U_{r_i^1} > \ldots > U_{r_i^J}\right) = \prod_{j=1}^{J-1} \left(exp\left(V_{ir_i^j}\right) \Big/ \Sigma_{l=j}^{J}\, exp\left(V_{ir_i^l}\right)\right) \tag{2}$$

An odds ratio is utilized to demonstrate how much the odds of selecting EC, HEC or EM over its counterpart increase or decrease with a one-unit change in an explanatory variable. As per the binary logit model, this rank-ordered logit model was estimated using Stata 17.0.

4. Results and discussion

4.1. Sample characteristics

The descriptive statistics for the results of the survey are shown in Table 5. The total sample size has a predominance of females (59.2%),

Table 5
Descriptive statistics of survey respondents.

Category	Definition	Percentage	Mean	Std dev.
Gender	Male = 1	39.8	1.612	0.507
	Other gender = 2	1.0		
	Other = 2	1.0		
	Female = 3	59.2		
Age	18–24 years old = 1	36.0	1.978	0.889
	25–39 years old = 2	34.8		
	40–54 years old = 3	24.6		
	Above 55 years old = 4	4.6		
Personal monthly income	Below 10 million VND = 1	44.4	1.883	0.991
	10–20 million VND = 2	34.1		
	20–30 million VND = 3	10.3		
	Above 30 million VND = 4	11.2		
Educational attainment	Below high school = 1	3.5	3.458	1.023
	High school = 2	20.4		
	Vocational education/ College = 3	11.9		
	Undergraduate = 4	55.3		
	Postgraduate = 5	8.9		
Employment status	Employed full-time = 1	59.2	2.187	1.765
	Employed part-time or casually = 2	7.4		
	Self-employed as a freelancer = 3	8.9		
	Student = 4	17.6		
	Housewife = 5	0.8		
	Retired = 6	2.2		
	Unemployed = 7	0.3		
	Other = 8	3.5		
Living accommodation	Rented apartment = 1	10.2	3.503	1.348
	Rented house = 2	19.8		
	Owned apartment = 3	7.3		
	Other = 4	27.8		
	Owned house = 5	34.9		
Own/regularly used vehicle	EC = 1	4.0	0.046	0.210
	HEC = 1	1.8	0.021	0.143
	CC = 1	12.6	0.144	0.351
	EM = 1	8.3	0.095	0.293
	CM = 1	68.4	0.810	0.393
	Other = 1	3.4	0.039	0.194
	None = 1	1.5	0.168	0,128
Driving distance	Below 5000 km = 1	35.8	2.415	1.394
	5000–8000 km = 2	25.7		
	8001–12,000 km = 3	15.9		
	12,001–15,000 km = 4	9.6		
	Above 15,000 km = 5	9.9		
	Not applicable = 6	3.1		
Vehicle purchase intention	Car in 5 years	37.4		
	Motorcycle in 5 years	27.0		
	Car and motorcycle in 5 years	13.3		
	Car in 5 to 10 years	13.4		
	Motorcycle in 5 to 10 years	6.1		
	Car and motorcycle in 5 to 10 years	2.8		

with males accounting for 39.8%. The most populous age group among the respondents was 18- to 24-year-olds, and the most common monthly income bracket among our respondents (44%) was below 10 million VND (in 2024, the average monthly income in Vietnam was just under 5.4 million VND (General Statistics Office, 2025)). However, more than 55% of our sample placed in monthly income groups of more than 10 million VND, and most of the respondents had completed some form of higher education, with more than 64% completing undergraduate or postgraduate degrees. Approximately 76% were employed or self-employed, and approximately 59% of the sample were employed full-time. In terms of housing status, around 42% of respondents resided in self-owned accommodation and around 30% in rented accommodation, with the remainder (~28%) living in what is likely to be lower-tier housing. In terms of current vehicle ownership among respondents, more than two-thirds of participants possessed a CM, while around one in five possessed a car. Sixty per cent of car and motorcycle owners drove less than 8000 km a year, which equates to around 22 km (or 13.5 miles) a day. The high proportion (~77%) of motorcycle owners within the study sample might account for the relatively high proportion of participants (37.4%) intending to buy a car within the next five years.

4.2. The effect on EV adoption of providing additional cost information

In the first stage of analysis, we report respondent preferences for conventional, hybrid and electric vehicles depending on the cost information provided to them. In Scenario 1, it is the purchasing cost only; in Scenario 2, it is purchase cost plus energy and maintenance costs, and in Scenario 3, resale values and the TCO are also provided. The distribution of respondents' choices of most preferred vehicle based on these three different cost scenarios is shown in Figs. 4a and 4b.

In Scenario 1, 37% of respondents indicated a preference for an EC, 2% lower than the CC score. Given that government incentives have rendered EC purchase costs only marginally above those of an equivalent CC, it seems that Vietnamese consumers are no longer as significantly hindered by the purchase price of ECs as before. However, for motorcycles, where EMs continue to have much higher upfront (purchase) costs than their CM equivalents, only 26% of respondents preferred the electric option in Scenario 1.

In Scenario 2, a substantial proportion of respondents shifted their preference towards EVs, indicating the positive impact of low maintenance and energy savings information on consumer preferences. More specifically, increases of 15% and 29% in respondents choosing, respectively, an EC or an EM were observed in this scenario.

In Scenario 3, with resale and TCO information also incorporated, customer vehicle preferences showed a high level of alignment with the cost information, particularly for cars. In this scenario, the lower resale prices of EVs relative to their conventional and hybrid counterparts partially offset the EV advantages associated with energy and maintenance costs that were communicated in Scenario 2. Although, in terms of TCO, the EC was still cheaper than the CC or HEC, the cost differences appeared less dramatic. Although EV preferences in Scenario 3 were higher than those in Scenario 1, they dropped quite significantly in comparison to those of Scenario 2, with an 11% decrease in relation to cars and a 12% decrease for motorcycles. The results indicate that consumers are, indeed, sensitive to the cost information provided to them.

The results of our binary and ranked-order logit regressions are presented in Table 6. Both models indicate that the provision of fuel and maintenance cost information (Scenario 2) significantly enhances EC and HEC adoption relative to the provision of initial purchase costs alone (Scenario 1). In particular, the binary logistic model indicates that the probability of adopting an EC rather than a CC increases by 14.3 percentage points. The results are consistent with previous research (Nixon and Saphores, 2011). Other previous research reported that fuel savings information enhanced the selection of 'alternative fuel cars' relative to CCs (Ji and Gan, 2022; Nixon and Saphores, 2011). Our results in both econometric models also showed that provision of fuel and maintenance savings information had a statistically significant effect on opting for an EM instead of a CM, raising the preference for an EM by 28.3 percentage points when compared with the provision of purchase price information

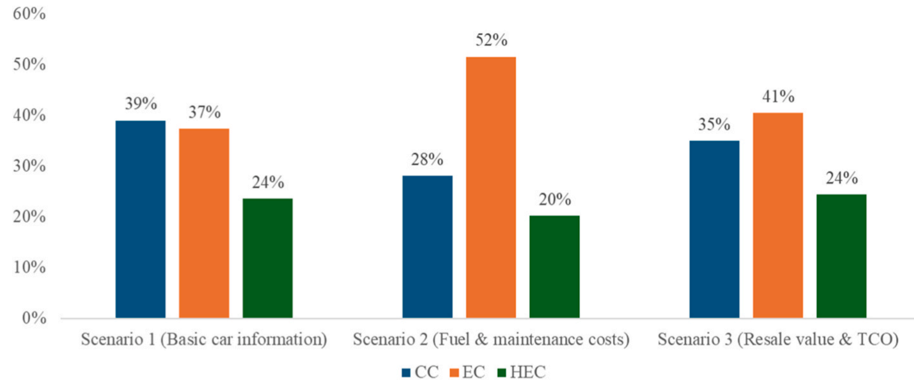

Fig. 4a. Distribution of customer choice of most preferred car type under different cost-information scenarios.

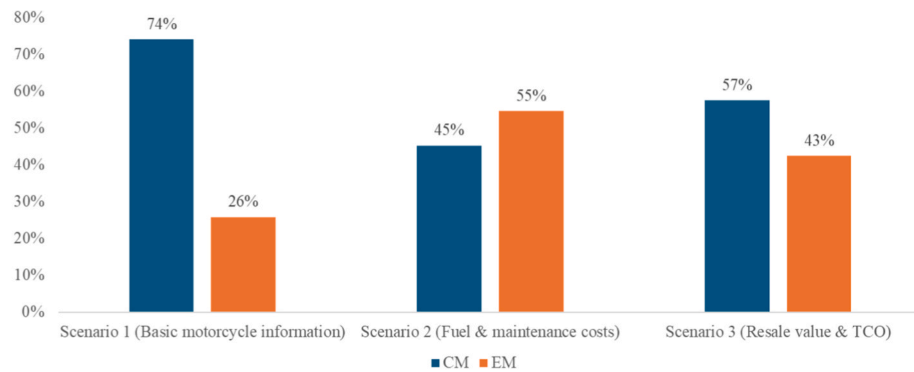

Fig. 4b. Distribution of customer choice of most preferred motorcycle type under different cost-information scenarios.

alone. These results indicate that most consumers are positively influenced by long-term cost savings and are willing to trade them off against the higher initial costs of EVs.

The provision of TCO information (Scenario 3) also increases the likelihood of EV adoption in comparison with purchase price information only. For the car group, both models show that the preference for an EC is marginally statistically significant at a 90% confidence interval. The result is consistent with Ji and Gan (2022), who found that providing TCO information had a positive impact on EC adoption. However, on the basis of the binary logit model, it should be noted that the preference for EC increases by 4.5 percentage points. This might be because the TCO information did not reveal a large difference between the EC and the CC options (see Fig. 4a). Underlying the lower marginal effects in Scenario 3 relative to Scenario 2 is the negative effect of the lower resale value of the EC. For the HEC, its relative cost-competitiveness between Scenario 1 (purchase costs) and Scenario 3 (TCO) remains essentially unchanged, which would explain the lack of any significant changes in HEC preference between the scenarios (see Fig. 4a).

For motorcycles, the negative impact of the anticipated resale value on TCO is somewhat weaker, meaning that the provision of TCO information (Scenario 3) produces a statistically discernible increase in EM preference relative to Scenario 1: the probability of consumers provided with TCO information adopting the EM in preference to the CM is nearly 17.1 percentage points higher than when only the purchase price is given. Nevertheless, the preference for EMs remains its highest in Scenario 2, where EMs display their best cost-competitiveness.

Looking more closely at the sociodemographic characteristics of individuals in the sample, we can see some statistical significances in the car group. For instance, compared to individuals living in self-owned houses, those residing in lower-standard accommodation show a reduction of 9.9 percentage points in choosing the HEC. This could be attributable to higher financial constraints, lack of parking space and/or more unstable housing conditions among this cohort, which together reduce the feasibility of HEC ownership.

Turning to the motorcycle group, those earning less than 10 million VND a month are 20.4 percentage points less likely to prefer an EM to a CM. This suggests that low-income consumers are highly financially constrained, which limits their ability to afford the high purchase price of EMs despite being aware of their potential long-term cost savings. The result is generally consistent with Rizki et al. (2024), who found that, owing to financial limitations, lower-income people prefer EM conversions (i.e., replacing the internal combustion engine of a motorcycle with an electric drivetrain) rather than buying new ones. Furthermore, those with an educational background below undergraduate level show a 9.5 percentage points higher preference for an EM than those with a higher level of education. Prior study in Vietnam by Ha et al. (2023) found that the positive impact of the pull factor on intention is weaker for more knowledgeable individuals, indicating that they are less easily persuaded of EM benefits. From an accommodation perspective, individuals residing in rented or owned apartments and potentially lower-standard accommodation show a lower probability of switching preference from CMs to EMs than those living in self-owned houses. This contrasts with Truong et al. (2024), who found housing type to be an insignificant factor in EM adoption. Their study focused exclusively on Ho Chi Minh City—Vietnam's most advanced and populous city, whereas our study extends to others such as Hanoi and Da Nang, where charging infrastructure may be less developed. Such differences in the study areas might account for the variation in results.

4.3. The effect of policy-based charging solutions on EV adoption

In the second stage of analysis, we report findings on whether educational, technical or policy solutions to overcoming charging constraints are likely to positively influence EV adoption. Figs. 5a and 5b present, respectively, respondents' preferences under three different

Table 6
Results of rank-ordered and binary logit models when providing cost-related information.

	ROLogit				Binary logit					
	CC vs EC		CC vs HEC		CC vs EC		CC vs HEC		CM vs EM	
	Odds ratio	Robust std err.	Odds ratio	Robust std err.	Marginal effects	Delta-method std err.	Marginal effects	Delta-method std err.	Marginal effects	Delta-method std err.
Scenario 2	1.355***	0.073	1.276***	0.087	0.143***	0.025	0.087***	0.024	0.283***	0.024
Scenario 3	1.114*	0.067	1.096	0.081	0.045*	0.025	0.032	0.025	0.171***	0.024
Gender = Male					0.018	0.037	0.050	0.037	−0.030	0.036
Gender = Other					−0.217	0.150	−0.026	0.152	−0.142	0.117
Age = 18–24 years old					0.035	0.097	0.002	0.074	−0.134	0.123
Age = 25–39 years old					−0.017	0.095	0.052	0.074	−0.113	0.125
Age = 40–54 years old					0.004	0.095	0.022	0.073	−0.096	0.127
MonthlyIncome = Below 10 mil VND					−0.065	0.071	−0.016	0.069	−0.204**	0.086
MonthlyIncome = 10–20 mil VND					0.019	0.058	0.009	0.060	−0.102	0.082
MonthlyIncome = 20–30 mil VND					−0.016	0.069	0.003	0.070	−0.126	0.102
Education = Below Undergraduate					0.026	0.042	−0.043	0.039	0.095**	0.038
EmploymentStatus = Employed					0.029	0.048	−0.046	0.047	−0.048	0.046
LivingLocation = Rented apartment					−0.012	0.058	−0.011	0.062	−0.128**	0.057
LivingLocation = Rented house					0.034	0.048	0.001	0.046	−0.015	0.056
LivingLocation = Owned apartment					0.018	0.064	−0.021	0.061	−0.130	0.103
LivingLocation = Other (Shared house)					−0.070	0.054	−0.099**	0.050	−0.079*	0.044
ElectricCar = Do not own					−0.002	0.086	−0.041	0.072	−0.201**	0.100
HybridCar = Do not own					−0.058	0.103	0.031	0.106	0.095	0.135
ConventionalCar = Do not own					0.062	0.053	−0.028	0.056	−0.003	0.063
ElectricMotorcycle = Do not own					−0.028	0.061	0.039	0.063	0.090	0.060
ConventionalMotorcycle = Do not own					0.019	0.057	0.017	0.058	0.091	0.066
Other = Do not own					−0.067	0.085	−0.169*	0.097	−0.001	0.095
AnnualDrivingDistance = Below 5000 km					0.036	0.060	−0.037	0.058	0.047	0.064
AnnualDrivingDistance = 5000–8000 km					0.051	0.062	−0.031	0.060	0.048	0.064
AnnualDrivingDistance = 8001–12,000 km					0.062	0.071	0.035	0.069	0.129*	0.067
AnnualDrivingDistance = 12,001–15,000 km					−0.019	0.074	−0.189***	0.061	0.062	0.077
Observations[a] (N)	1437		1437		1437		1437		1404	
Wald χ^2 (26)	35.990		13.950		49.1		57.780		145.7	
Prob > χ^2	0.000		0.001		0.004		0.000		0.000	
Pseudo R^2					0.025		0.032		0.077	

Notes: (***) 1% level of significance, (**) 5% level of significance, (*) 10% level of significance.
[a] The sample size is equal to the number of respondents times the number of scenarios (479 × 3 for cars and 468 × 3 for motorcycles).

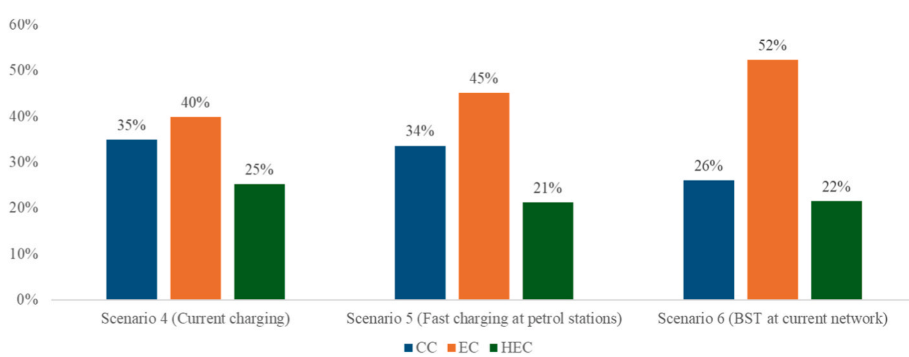

Fig. 5a. Distribution of customers' choice of preferred car type based on different charging infrastructure scenarios.

charging-facility scenarios for the car group (Scenarios 4, 5 and 6) and two such scenarios for the motorcycle group (Scenarios 4 and 6).

In Scenario 4, where fast-charging stations were, effectively, to become available within 3.5 km of their residences, the EC was the most popular choice in the car group, selected by 40%. By contrast, the motorcycle group was less swayed by this: 59% of respondents indicated that CMs would remain their preference, perhaps because of the perceived convenience of nearby petrol stations and shorter refuelling times.

In Scenario 5, with fast chargers at every petrol station, the preference for the EC rose by 5% compared to Scenario 4, to 45%. Most of this increase came at the expense of those who had previously preferred the HEC, rather than reducing the numbers of CC 'enthusiasts'.

Scenario 6, with BSSs within 3.5 km of respondents' residences and the capacity to change the battery within 10 min, had the greatest impact in terms of shifting consumer preferences from CVs to EVs. In the car group, EC preference increased to 52%, with the uplift coming mainly at the expense of the numbers choosing CCs in the previous scenarios. In the motorcycle group, the effect was even more marked, with the preference for EMs jumping to 59%.

The results of the rank-ordered and binary logit models in relation to these charging-related scenarios are presented in Table 7. In Scenario 5, the provision of fast-charging facilities at every petrol station does not significantly affect the preferences for the EC or the HEC relative to Scenario 4's fast-charging stations at 3.5 km intervals. This result is consistent with the patterns depicted in Fig. 5a, in which it appears that a minority who preferred the HEC in Scenario 4 may have shifted their preference to the EC under Scenario 5. By contrast, in Scenario 6, when

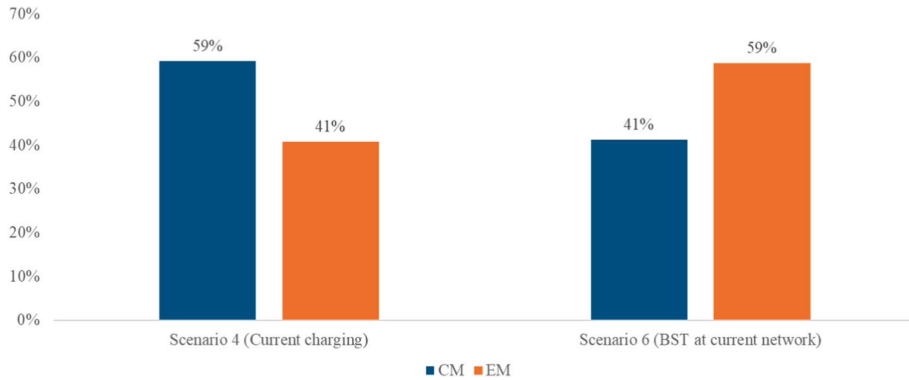

Fig. 5b. Distribution of customers' choice of motorcycle type based on different charging infrastructure scenarios.

Table 7
Results of rank-ordered and binary logit models when proposing policy-based charging solutions.

	ROLogit				Binary logit					
	CC vs EC		CC vs HEC		CC vs EC		CC vs HEC		CM vs EM	
	Odds ratio	Robust std err.	Odds ratio	Robust std err.	Marginal effects	Delta-method std err.	Marginal effects	Delta-method std err.	Marginal effects	Delta-method std err.
Scenario 5	1.355***	0.073	1.276***	0.087	0.035	0.023	0.011	0.024		
Scenario 6	1.114*	0.067	1.096	0.081	0.113***	0.023	0.042*	0.025	0.176***	0.020
Gender = Male					0.033	0.038	0.058	0.037	−0.023	0.041
Gender = Other					−0.091	0.140	−0.176	0.152	−0.270**	0.131
Age = 18–24 years old					0.057	0.100	0.027	0.074	−0.093	0.112
Age = 25–39 years old					0.119	0.097	0.021	0.074	−0.092	0.113
Age = 40–54 years old					0.048	0.098	−0.005	0.073	−0.076	0.114
MonthlyIncome = Below 10 mil VND					−0.102	0.072	−0.079	0.069	−0.152	0.094
MonthlyIncome = 10–20 mil VND					−0.004	0.062	−0.069	0.060	0.023	0.086
MonthlyIncome = 20–30 mil VND					−0.016	0.070	−0.108	0.070	−0.095	0.109
Education = Below Undergraduate					0.008	0.042	−0.011	0.039	0.036	0.046
EmploymentStatus = Employed					0.004	0.050	0.086*	0.047	−0.094*	0.052
LivingLocation = Rented apartment					0.021	0.061	0.026	0.062	−0.157**	0.071
LivingLocation = Rented house					−0.059	0.050	0.069	0.046	−0.042	0.061
LivingLocation = Owned apartment					0.077	0.069	−0.037	0.061	0.007	0.113
LivingLocation = Other (Shared house)					−0.029	0.053	−0.055	0.050	−0.025	0.052
ElectricCar = Do not own					−0.018	0.078	0.074	0.072	−0.187	0.128
HybridCar = Do not own					−0.173**	0.077	−0.022	0.106	0.046	0.188
ConventionalCar = Do not own					0.106*	0.056	−0.036	0.056	0.079	0.072
ElectricMotorcycle = Do not own					−0.045	0.067	−0.018	0.063	0.040	0.069
ConventionalMotorcycle = Do not own					0.019	0.058	−0.008	0.058	0.183***	0.065
Other = Do not own					−0.170*	0.088	−0.122	0.097	0.116	0.101
AnnualDrivingDistance = Below 5000 km					0.063	0.060	−0.016	0.058	0.035	0.073
AnnualDrivingDistance = 5000–8000 km					0.033	0.064	−0.025	0.060	0.049	0.074
AnnualDrivingDistance = 8001–12,000 km					0.061	0.070	0.008	0.069	0.102	0.075
AnnualDrivingDistance = 12,001–15,000 km					−0.054	0.075	−0.190***	0.061	−0.019	0.092
Observations[a] (N)	1437		1437		1437		1437		936	
Wald χ^2 (26)	35.99		13.95		53.86		34.49		97.32	
Prob > χ^2	0.000		0.001		0.000		0.1231		0.000	
Pseudo R^2					0.037		0.033		0.064	

Notes: (***) 1% level of significance, (**) 5% level of significance, (*) 10% level of significance.
[a] The sample size is equal to the number of respondents times the number of scenarios (479 × 3 for cars and 468 × 2 for motorcycles).

the convenience of BST is offered at every public charging station, the preferences for the EC and the EM improve noticeably. Specifically, a policy of integrating BST into current public charging facilities enhances the probability of choosing the EC in preference to the CC by 11.3 percentage points, and dramatically increases the probability of selecting the EM in preference to the CM by 17.6 percentage points. These results suggest that many consumers do not view more ubiquitous charging station locations as a significant enough motivation to shift their vehicle preference to an EV, but the very short charging times notionally on offer from ready BST availability could offer a solution to EV adoption barriers. This view is consistent with Yang et al. (2016), who found that consumers tended to choose the charging infrastructure that offered the shortest charging times rather than that closest to their point of origin, and also with Globisch et al. (2019), who demonstrated that quicker charging times are more influential in EV adoption than the density of charging locations.

Upon closer examination of sociodemographic influences on consumer preferences, the significance of factors in the charging-related scenarios differs from those in the cost-related scenarios captured in Table 6, suggesting that the role of these factors may depend on the type of information provided. In this binary logit model, we found that selecting an HEC in preference to a CC is 8.6 percentage points more likely among those employed than among those without work. In terms of existing vehicle ownership, the probability of choosing an EC rather than a CC is 17.3 percentage points lower among non-HEC owners than among those already owning an HEC, which aligns with prior studies indicating that HEC owners show strong interest in purchasing an EC (Carley et al., 2013; Hidrue et al., 2011). Those without a CC are 10.6 percentage points more likely than CC owners to choose an EC rather than a CC. Consistent with research by Priessner et al. (2018), this suggests that non-car owners are more likely to be EC early adopters than those already possessing a car. Ghasri et al. (2019) also indicate that car ownership reduces the perceived advantage of ECs, which can consequently lower EC purchase intent. Generally, one can surmise that HEC owners' familiarity with electric mobility makes them more open to EC adoption. They may also be more eco-conscious but restrained from purchasing a fully electric vehicle by barriers related to charging infrastructure. Similarly, many CC owners may hold negative perceptions of EV technology and view traditional internal combustion engine vehicles as more convenient.

For the motorcycle group, employed individuals have a 9.4 percentage point lower probability of adopting EMs than those who are not employed. Perhaps faster charging facilities do not increase the EM preference of employed individuals because they have a more hectic schedule and therefore prioritize ease and convenience in their personal vehicle use. Apartment renters are 15.7 percentage points less likely than those living in self-owned houses to choose an EM in preference to a CM. This result is consistent with that under the cost-related scenarios in Table 6, reemphasizing that apartment renters rely heavily on shared or public parking lots, limiting their access to personal charging ports. Finally, when it comes to existing vehicle ownership, those currently without a CM are 18.3 percentage points more likely than those who own a CM to favour the purchase of an EM in the future, which is consistent with Nguyen et al. (2024). This finding might well account for the relatively low willingness to adopt EMs in motorcycle-dominant countries such as Vietnam and Indonesia (Murtiningrum et al., 2022; Truong et al., 2024).

5. Conclusion and policy implications

This study assessed policy options to address key EV adoption barriers in the Vietnamese context. The results indicate that providing additional information on fuel and maintenance costs increases the probability of an EC being chosen in preference to a CC by 14.3 percentage points. Similar information in relation to motorcycles enhanced the probability of EM selection by 28.3 percentage points. Providing TCO information also boosts the likelihood of EC and EM adoption, by 4.5 and 17.1 percentage points, respectively. In terms of better charging facilities, the installation of additional fast-charging infrastructure at existing fuel stations was not significant in boosting EC adoption relative to CCs, but the promise of rapid-use BST did significantly enhance potential EC and EM adoption rates relative to those associated with current fast-charging provision, by 11.3 percentage points for ECs and 17.6 percentage points for EMs. From a DoI perspective, the provision of cost savings information and the convenience of BST can be considered as enhancements of the knowledge and persuasion phases and demonstrate a significant impact on EV adoption, most likely via the early and late majority groups.

Thus, to increase rates of EV adoption, our results suggest that policymakers and industry stakeholders should focus on consumer education and promulgate additional EV-related information that highlights the true ownership costs and financial benefits of EVs. Individuals with high monthly incomes and those living in self-owned houses, who are more capable of managing the higher upfront costs of EMs, are likely to be enthusiastic adopters of EMs when provided with cost-related information. Campaigns should consider incorporating more cost savings information into EV marketing to enhance the perception of EVs' financial benefits. Alternatively, or, indeed, at the same time, cost–benefit information should be featured on EV manufacturer or retailer websites, helping consumers make more informed decisions and encouraging better appreciation of the long-term value of EV ownership.

Our findings also revealed that integrating BST into the current public charging infrastructure would be a popular and effective means by which to address long charging times and limited access, thereby enhancing EV adoption rates. One major challenge to overcome in this regard is the current lack of battery standardization across EV brands. Nevertheless, regardless of its immediate practicality, this is a useful indicator for policymakers when planning future infrastructural policies. As indicated, for BST to be an optimal solution, much greater standardization of batteries will need to be achieved, which could be as difficult commercially as it is technologically. However, if a universal battery standard was to be implemented, EM batteries would be the obvious starting point, and the dominance in the Vietnam EM marketplace of a single domestic manufacturer gives the country an advantage in this respect that few other countries can match. As a result, the government should not only aid businesses in launching BST into current charging stations but also incentivize EV manufacturers to achieve battery standardization, which would maximize the effectiveness of BST in enhancing EV adoption.

The current research is not without its limitations. Our survey sample, derived from a convenience sampling approach, cannot be held to be entirely representative of Vietnam as a whole, and the findings must necessarily be treated with a degree of caution as a result. However, given the random selection process and relatively large sample size, the results are still expected to provide meaningful insights into general trends and patterns.

We also acknowledge that BST in Vietnam is currently only available for EMs; thus, discussions on the potential of BST for EC adoption lack practical evidence. This represents an important direction for future research, should BST infrastructure for ECs evolve and become more widely available. To further advance understanding of EV adoption, future studies could identify and incorporate other perceived barriers, such as environmental issues, social impacts and after-sales service, into their considerations, aiming to propose and test further potential solutions for promoting the EV cause. In addition, comparative studies involving barriers identified in other countries could offer valuable perspectives and policy insights, while more regional levels of research, which could reveal very different perspectives on EV barriers to those prevalent in urban areas, are essential if effective solutions appropriate to these areas are to be identified. Moreover, employing more rigorous behavioural research designs, such as the use of control and treatment groups, will strengthen the validity of future findings. Addressing gaps such as these will not only provide a more comprehensive view of EV adoption but also support the development of more targeted and effective policy interventions.

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CRediT authorship contribution statement

Ha Thanh Tung Nguyen: Data curation, Formal analysis, Investigation, Visualization, Writing – original draft. **Alexandr Akimov:** Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing. **Nguyen Van Tran:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

Table A1
Policy incentives for ECs in Vietnam.

Policy	From	To	Incentive
Registration fee	1/3/2022	1/3/2025	0% registration fee for electric cars (ECs) versus 10–12% (based on purchase price) for conventional cars (CCs)
Registration fee	1/3/2025	1/3/2027	50% of the registration fee compared to CCs
Excise tax	1/3/2022	1/3/2027	3% for ECs versus 35–150% for CCs
Excise tax	1/3/2027	N/A	11% for ECs

Data availability

Data will be made available on request.

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