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Electric Vehicles: An Assessment of Consumer Perceptions Using Importance-Performance Analysis

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Abstract

The electrification of vehicles represents a promising measure for decarbonizing the transport sector. Several countries worldwide have created incentives to promote the mass adoption of electric vehicles (EVs) to mitigate the environmental and energy effects caused by the increased road transport demand; however, many consumers remain skeptical about EVs.
Consumer perceptions and concerns are critical for evaluating a product's market position, identifying opportunities for improvement, and guiding strategic planning. The importance-performance analysis (IPA) represents a simple and effective technique for assessing consumer acceptance of product attributes that have been used in diverse fields.
This study aimed at identifying the key EV attributes that require more attention to improve consumer satisfaction. It analyzed survey data of 278 Norwegian EV owners and identified that instrumental aspects (i.e., driving range, battery recharging time, safety function, energy efficiency), winter driving quality, and environmental effects of EVs, are the most decisive factors when considering what car to buy. The results showed that EVs perform best with respect to environmental aspects, winter driving quality, and interior and exterior design. Finally, based on the IPA results, policymakers and car manufacturers should focus on the instrumental aspects, cost aspects, and winter driving quality of EVs to make EVs more attractive to consumers. Less important are the symbolic aspects of the vehicles, such as it showing the status of the owner.
Our findings provide policymakers and EV manufacturers with a deeper understanding of the needs and perceptions of EV owners with respect to EV attributes, thus helping them develop and implement better strategies for improving the attractiveness of EVs.

Resumé

Elektrificeringen af køretøjer kan reducere drivhusgas udledningerne fra transportsektoren. Adskillige lande verden over har skabt incitamenter til at fremme masseadoptionen af elektriske køretøjer (EV'er) for at afbøde miljø- og energieffekterne forårsaget af den øgede efterspørgsel efter vejtransport; dog er mange forbrugere fortsat skeptiske over for elbiler.
Forbrugeropfattelser og bekymringer er afgørende for at evaluere et produkts markedsposition, identificere muligheder for forbedringer og vejlede strategisk planlægning. Vigtigheds-ydelsesanalysen

(Importance-performance analysis, IPA) repræsenterer en enkel og effektiv teknik til at vurdere forbrugernes accept af produktegenskaber, der er blevet brugt på forskellige områder.
Denne undersøgelse havde til formål at identificere de vigtigste EV-egenskaber, der kræver mere opmærksomhed for at forbedre forbrugernes tilfredshed. Studien analyserede data fra 278 norske elbilejere og identificerede, at instrumentelle aspekter (dvs. rækkevidde, batteriopladningstid, sikkerhedsfunktion, energieffektivitet), vinterkørselskvalitet og miljøeffekter af elbiler er de mest afgørende faktorer, når man overvejer, hvilken bil at købe. Resultaterne viste, at elbiler klarer sig bedst med hensyn til miljøaspekter, vinterkørselskvalitet og indvendigt og udvendigt design. Endelig, baseret på IPA-resultaterne, bør politiske beslutningstagere og bilfabrikanter fokusere på elbilernes instrumentelle aspekter, omkostningsaspekter og vinterkørselskvalitet for at gøre elbiler mere attraktive for forbrugerne. Mindre vigtige er de symbolske aspekter af køretøjerne, såsom at det viser ejerens status.
Vores resultater giver politiske beslutningstagere og elbils producenter en dybere forståelse af ejere av elbilejeres behov og opfattelser med hensyn til elbil-egenskaber, hvilket hjælper dem med at udvikle og implementere bedre strategier til at forbedre elbilernes tiltrækningskraft.

1. Introduction

The global transport demand has been increasing due to factors such as the growing population, urbanization, and economic development, which has improved the purchasing power of millions of people worldwide. Therefore, transportation has accounted for an increasing proportion of total global oil consumption in recent decades (International Energy Agency (IEA), 2011), making it one of the main contributors to global CO_2 emissions and, consequently, global warming (Zhao and Heywood, 2017). In this regard, electric vehicles (EVs) are considered to have the potential to reduce tailpipe emissions, traffic noise, and fossil fuel consumption caused by road transport. Policymakers in many countries have implemented policies to promote the widespread adoption of EVs. These policies have contributed to an increased interest in EVs, the introduction of new EV models, and an increase in the EV share of the global market for passenger cars by 1000% from 2011 to 2016 (IEA, 2017). Nevertheless, by 2019 the number of EVs globally reached only 7.2 million (IEA, 2020).

In general, EVs are categorized into three types: battery EVs (BEVs), plug-in hybrid EVs (PHEVs), and hybrid EVs (HEVs), depending on the powering system. BEVs are pure EVs or all-EVs in which an onboard electric battery pack solely stores energy and powers the electric drivetrain. HEVs combine an internal combustion engine (ICE) and an electric motor for better fuel efficiency, compared to similar-sized vehicles solely powered by ICE; however, all their energy is originally generated by liquid fuel. In comparison, PHEVs have a more robust onboard electric battery pack than HEVs, which can be recharged by the electrical supply through the ICE and regenerative braking.

Research suggests that to increase EV adoption, the following major factors have to be considered: instrumental attributes (e.g. Egbue and Long, 2012; Noppers et al., 2015), cost aspects (e.g. Qian and Soopramanien, 2011; Ziegler, 2012), environmental aspects (Hackbarth and Madlener, 2013; Ziegler, 2012), availability of different EV models (Hoen and Koetse, 2014; Chorus et al., 2013), winter driving functions (Solvoll et al., 2010), and generous policy incentives (Qian and Soopramanien, 2011; Fearnley et al., 2015). However, to the best of our knowledge, few studies have examined the satisfaction of EV owners with these attributes and aspects. Besides, there appears to be a gap in the knowledge related to the disparities between the importance assigned to the above-mentioned factors by consumers purchasing a car and the EV owners' satisfaction with the same elements. Such knowledge can be used to identify improvement areas for EVs to be more attractive, thus contributing to establishing a greener road transport system.

The primary objective of this study is to investigate consumer satisfaction with different EV attributes and to assess the performance of those same attributes in order to generate insight on which attributes that most need the attention of policymakers and car makers. To achieve this objective, a tailor-made web-based questionnaire was developed and distributed to a sample comprised mainly of current EV owners, including BEVs, PHEVs, and HEVs, in the Norwegian market, which is one of the most saturated and mature

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EV car markets worldwide. The data gathered were used to answer three related questions. First, what are the most important factors when considering what car to buy? Second, how well do EVs perform concerning these factors? Third, which of these factors should policymakers and car manufacturers focus on improving to make EVs more attractive to consumers? The third research question is answered using the importance-performance analysis (IPA) and gap analysis techniques. These techniques have been used to assess service quality and provide recommendations related to various transport modes (e.g. Epstein and Givoni, 2016; Ha et al., 2019; Solvoll et al., 2010).

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature on factors influencing EV adoption. Section 3 describes the methodology used to conduct the empirical analysis. Section 4 presents and discusses the results. Section 5 provides some concluding remarks.

2. Factors influencing EV adoption

To achieve widespread adoption of EVs, both policymakers and carmakers need to have an in-depth understanding of the influential factors and potential barriers in the market. The literature on EVs has endeavored to analyse the adoption of EVs by applying theories from various domains and using various societal and geographical contexts. This section provides an overview of factors that have been found in the literature to have an influence on EV adoption.

2.1 Instrumental aspects

Previous studies show that the prospects of widespread EV adoption rely on the improvement of instrumental factors related to car use, such as driving range, battery recharging time, safety function, energy economy, convenience, and performance (Danielis et al., 2020; Graham-Rowea et al., 2012; Hoen and Koetse, 2014). Unsurprisingly, there are uncertainties and anxieties about the performance and safety of EVs, which is reasonable considering that EVs only became common in recent years. Studies suggest that consumers are less willing to adopt new products with high perceived risk related to performance and financial aspects (Aggarwal et al., 1998).

Battery performance is a crucial parameter influencing the driving behaviour of BEV drivers (Azadfar et al., 2015; Neubauer and Wood, 2014), with range anxiety being a common psychological barrier to EV adoption. Range anxiety is a specific form of mental stress which occurs when the driver of a BEV fears that the remaining battery power is insufficient to reach her or his destination (Franke et al., 2016). However, studies indicate that car owners overestimate their range needs (Franke and Krems, 2013; Rauh et al., 2017). Moreover, the concern about the cost of driving EVs and perceived technological risks negatively affects the probability of EV adoption (Kim et al., 2014).

2.2 Policy measures

Policymakers have implemented various incentives to facilitate EV adoption and lower the marginal costs of using such vehicles. Purchase incentives (e.g. rebate upon registration, sales tax exemptions, value-added tax (VAT) exemptions, and tax credit) reduce the cost of purchasing an EV, whereas use-based incentives (e.g. exemptions from road tolls, parking fees, and ferry fares, and allowing access to bus lanes) reduce the marginal cost of driving an EV. In line with the notion of generalized costs, the purchase incentives, use-based incentives, and lower fuel costs contribute to reducing the generalized cost of driving EVs. In Norway, BEVs are exempted from registration tax, VAT and are entitled to reduced annual vehicle license fees (Figenbaum, 2017). Besides, BEV owners were exempted from road tolls, ferry fees, and municipality parking fees until 2017. Recently, local authorities are given authority to decide the policy incentives regarding access to bus lanes, exemption of fees for municipal parking facilities, and ferry services. However, local authorities need to follow the 50% rule, which means that counties and municipalities cannot charge more than 50% of the price for fossil fuel cars on ferries, public parking, and toll roads (Haugneland et al., 2017). BEV owners still benefit from having access to bus lanes, although new rules

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passed in 2016 allow local authorities to limit access to only BEVs carrying one or more passengers (Norsk Elbilforening, 2018).

2.3 Cost aspects

In this study, the cost aspects correspond to the car owners' perceptions of the economic value of car use. The economic value indicates the purchase cost and the perceived refuelling, depreciation, and maintenance costs. In particular, monetary costs strongly influence travel mode use (Verplanken et al., 2008). In addition to purchasing and use-based policy measures (e.g. exemption from road tolls, ferry fares, and parking fees), technological differences make EVs require less maintenance compared to ICE vehicles (Palmer et al., 2018). Moreover, the refuelling (for ICE owners) or recharging costs (for EV owners) represent also a decisive factor in evaluating the marginal cost of driving any type of car. In this regard, increased energy efficiency (Helmers and Marx, 2012), combined with a lower tax rate on electricity (Palmer et al., 2018), reduces operating costs of driving EVs. In Norway, electricity is subject to a much lower tax than fossil fuel (Fridstrøm, 2020). Although fast charging is more expensive than charging at home, it is an alternative when going on a trip or needing to recharge during the day. However, as most people in Norway charge at home daily, the operating expense per km is considerably lower than for petrol and diesel cars (Haugneland, 2020).

2.4 Environmental aspects

Normative theories such as the value-belief-norm theory (Stern, 2000) and the theory of planned behaviour (Ajzen, 1991) are often used as theoretical frameworks to describe consumer behaviour related to protecting the environment. The most successful transformation policies, such as the German Energiewende and Norwegian policy instruments, were first implemented due to the momentum created by green and environmental movements (Fagerberg et al., 2016). EVs are functional innovations with better fuel efficiency than conventional cars with ICEs, have less or zero local carbon emissions, and generate little engine noise, thus improving the overall driving experience (Axsen and Kurani, 2012; Degirmenci and Breitner, 2017). A study by Kim et al. (2014) posits that the intention to purchase an EV is encouraged by environmental concerns and technological acceptance. Other studies find that environmental beliefs and consumer awareness of environmental issues influence EV acceptance (Egbue and Long, 2012; Lane and Potter, 2007; Skippon and Garwood, 2011). However, concern for the environment does not necessarily result in pro-environmental behaviour (Kollmuss and Agyeman, 2002).

2.5 Symbolic attributes

EVs are much more than just a means of transport; they symbolize ideas that have significance beyond the individual level. However, few studies have investigated the potential of EV adoption through symbolic-affective motives (e.g. personal status, and feelings of sensation, independence, and superiority), although in practice, automobile advertisements, TV commercials, and specific automobile magazines demonstrate symbolic-affective appeals either explicitly or implicitly (Heffner et al., 2007; Schuitema et al., 2013; Steg, 2005). Symbolic attributes were important to early consumers of BEVs in Norway and Austria as well as to first buyers of HEVs in California (Gjøen and Hård, 2002; Turrentine and Kurani, 2007). However, also more recent studies have shown the importance of symbolic attributes when it comes to BEV uptake (Haustein et al., 2021). Multiple symbolic meanings are associated with owning EVs, including being pro-environment, being opposed to conflicts over resources, having an inclination to reduce support to oil producers, and desire for new mobility experiences (Gjøen and Hård, 2002; Heffner et al., 2007). Heffner et al. (2007) added that these denotations are linked to further personal connotations, such as ethics, maturity, concern for others, and individuality.

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2.6 Winter driving

Studies have found that wind speed, temperature, and precipitation (rain and snow) are important weather indicators affecting road transport (Agarwal et al., 2005; Bardal and Mathisen, 2015). However, EVs are comparatively more vulnerable to low temperature than ICE vehicles as it adversely impacts EV's battery range and battery performance. In line with this, it has been shown that low temperature degrades the battery charging rate and, as such, extend the charging duration (Motoaki et al., 2018). Moreover, in low temperatures, additional energy is needed for the heating system, further reducing the range (Engström et al., 2019; Zhang et al., 2018). In a study, Noel et al. (2020) reveal that winter weather is one of the barriers to EV adoption and is discussed in the context of its impact on range. In another study, EV owners expressed being least satisfied with the functionality of EVs during winter (Solvoll et al., 2010). Besides, EVs require special tires for a variety of reasons. EVs should have tires with increased load-bearing capacity to handle a battery pack's extra weight and ought to have lower rolling resistance than standard tires to maximize their driving range (Edelstein, 2020).

2.7 Interior and exterior design

It has been suggested that vital for the success of electric cars is that they are designed in a way that is emotionally appealing (Moons and Pelsmacker, 2012). Therefore, a deep understanding of consumer emotions is vital for the design of communication, education, and policies to overcome existing barriers to EV adoption (Schuitema et al., 2013). Oliver and Rosen (2010) and Egbue and Long (2012) mention the size and style of EVs as barriers to the mass adoption of EVs. Technological developments have continued to influence consumers' expectations and improve their experience. However, acquiring knowledge about the consumers' perceptions of these factors remains essential for understanding the behaviour of car owners.

2.8 Availability of car models in the local market

Previous experiments suggest that a car is a highly positional good (Carlsson et al., 2007) and car buyers usually have a strong predisposition to choose a car type that has similar attributes as their current car (Hoen and Geurs, 2011). Additionally, Chorus et al. (2013) and Hoen and Koetse (2014) suggest that having more alternative-fuel models available in the market increases the probability of choosing such vehicles. Moreover, the availability of a variety of EVs in the local market nudges the consumers' availability heuristics, which are useful mental shortcuts for people to make decisions relying on immediate examples when evaluating possible actions or behaviors (Thaler and Sunstein, 2008; Tversky and Kahneman, 1973). Arguably, brand image, perception, and loyalty influence car buyers' purchase decisions (Devaraj et al., 2001; Helveston et al., 2015). Morris (2013) finds that the car purchase path changes over time in the current digital era. However, the influence of car brands on purchase decision-making remains constant through the cycle of the pre-market, in-market, and post-market phases, with 63% of new car buyers initiating their search with a specific brand in mind. Nevertheless, the influence of brand values appear to be somewhat lower in Norway (Jørgensen et al., 2016).

3 Method

3.1 Framework for IPA

Quadrant approach

The IPA is a technique developed by Martilla and James (1977) to identify which attributes to focus on when trying to improve customer satisfaction. The method implies using a two-dimensional grid with the attribute importance on one axis and the attribute performance on the other. Based on their perceived importance and performance, each attribute is positioned within one of four quadrants. The grid with its four quadrants is shown in Figure 1. The labels attached to the quadrants suggest how decision-makers should handle the factors in that quadrant:

1. High importance and high performance – "Keep up the good work": Attributes situated in this category are performing well and indicate opportunities for achieving or maintaining potential competitive advantages of a product or service (Sever, 2015). Consumers are satisfied with these attributes and also

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consider them important. Thus, these attributes represent major strengths and need continued investment (Esmailpour et al., 2020).

2. Low importance and high performance – "Possible overkill": Attributes falling in this category are performing strongly but have low importance to consumers. These attributes have less potential to attract consumers, and resources committed to these attributes should be deployed elsewhere – the best possible reallocation of resources could be to attributes situated in the category 'concentrate here' (Dwyer et al., 2012; Esmailpour et al., 2020).
3. Low importance and low performance – "Low priority": Attributes situated in this category require limited attention from the decision-makers (Padlee et al., 2020). These attributes are performing low and have relatively low importance to consumers. They represent minor weaknesses of a product or service, and therefore investing resources in improving these attributes poses less priority if they do not generate reliable outcomes (Esmailpour et al., 2020; Phadermrod et al., 2019).
4. High importance and low performance – "Concentrate here": This is the most crucial category, and attributes located in this category represent major weaknesses (Sever, 2015). These attributes require immediate attention for improvement from decision-makers, and if left underperformed, they threaten the competitiveness of a product or service (Esmailpour et al., 2020). Attributes in this category require the highest priority when allocating resources and effort (Azzopardi and Nash, 2013).

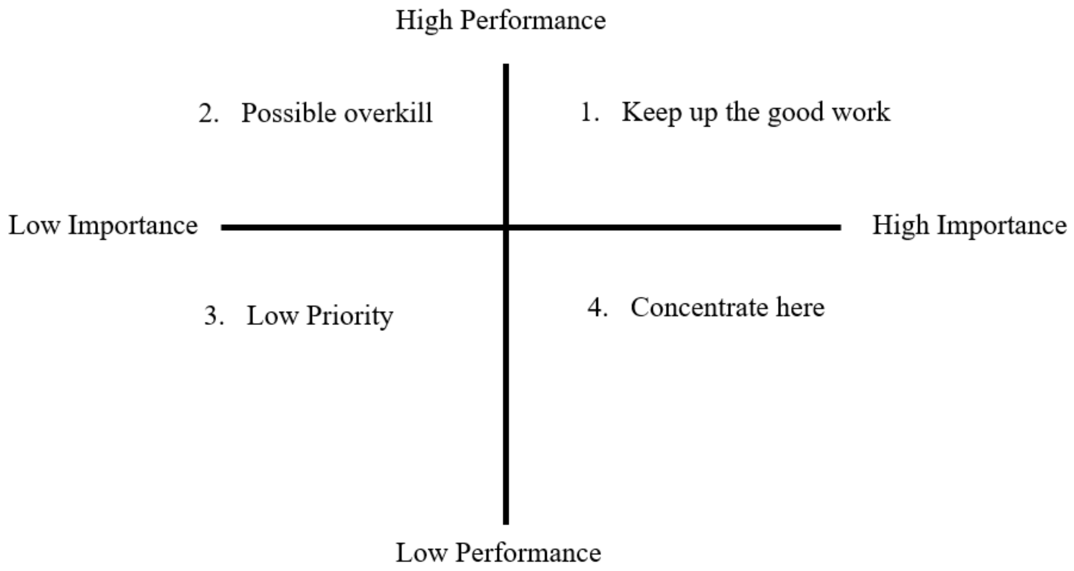

Figure 1. IPA - quadrant model (based on Martilla and James, 1977; Mikulić and Prebežac, 2008).

IPA provides insights by identifying critical attributes to focus on improving when it comes to the performance of a product or service (Abalo et al., 2007; Chu and Choi, 2000). IPA helps the decision-makers prioritize actions to recommend the optimal allocation of limited resources to improve the consumer experience, enhance the loyalty of existing consumers, and attract new consumers (Cao, 2017; Sever, 2015). Intuitively, as indicated by the labels, managers should give low priority to factors of little importance to customers. Instead, the limited resources of an organization should be allocated to factors of high importance, particularly those with low perceived performance.

Since the IPA-technique is both simple and effective, it has been used to make resource allocation recommendations in several industries and services, including tourism (Bi et al., 2019; Dwyer et al., 2012), higher education (Hanssen and Mathisen, 2018; O'Neill and Palmer, 2004), trade shows (Tafesse et al., 2010), healthcare (Abalo et al., 2007; Kinnaer et al., 2020), banking (Joseph et al., 2005), technology (Chen and Ann, 2016) and transportation (Esmailpour et al., 2020; Freitas, 2013; Sum et al., 2019). Applications of IPA are reviewed by Magal et al. (2009) and Mikulić and Prebežac (2008).

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However, no previous studies, to our best knowledge, used IPA to investigate consumers' perception about EV performance. Thus, considering the effectiveness and usefulness of the IPA method, our study offers a novel approach to evaluate EV attributes to improve and sustain consumer satisfaction and ultimately increase EV sales.

Diagonal approach and gap analysis

The traditional IPA (Figure 1) has a weakness in that a minor change in the positioning of a factor can lead to considerable changes in recommendations. To overcome this weakness, gap analysis and the introduction of an iso-rating line or a diagonal line in the IPA analysis are used.

In the gap analysis, the mean performance score of a factor is subtracted from its mean importance score (Hanssen and Mathisen, 2018). Elements with the highest deviation between importance and performance should be prioritized when allocating resources. However, the mathematical differences between the mean of two different constructs (importance and performance) simply explain an intuitive rather than a precise meaning (Azzopardi and Nash, 2013). The weakness of the traditional IPA can also be addressed by drawing an iso-rating line, which is a 45-degree upward slope line along which importance equals performance (see Figure 2). Consequently, there is a zero-performance gap for all combinations of importance and performance along the iso-line. All factors below the iso-line have greater importance than performance, and thus, represent an opportunity for improvement and should be prioritized.

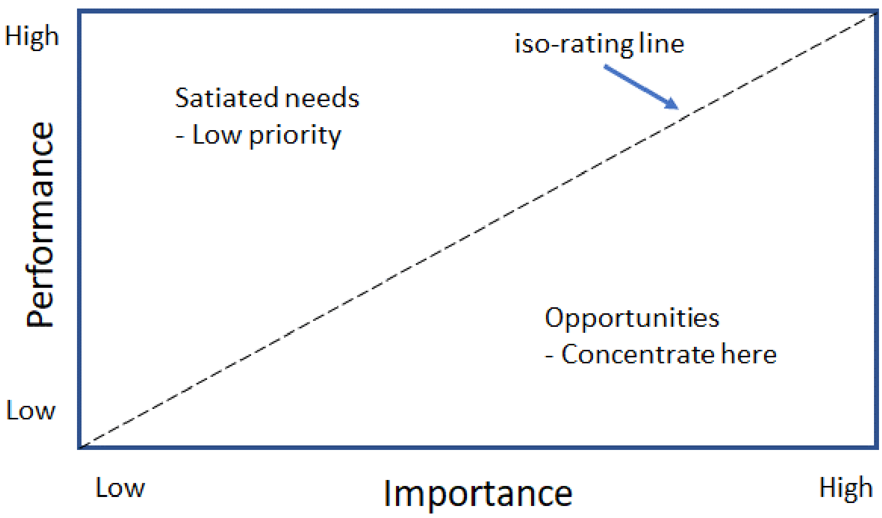

Figure 2. IPA with diagonal model.

Sever (2015) argued that IPA with the diagonal model is a more suitable method for identifying potential areas where the decision-makers need to focus more to improve the condition as this method directly interprets the differences between performance and importance rating. However, IPA analysis with diagonal approach has less interpretability and discriminative power than the quadrants approach because the attributes are located only in two categories (Sever, 2015). Therefore, Esmailpour et al. (2020) suggested combining these two approaches for in-depth understanding. Previously, Abalo et al. (2007), Hanssen and Mathisen (2018) and Dwyer et al. (2012) combined a diagonal approach with the quadrant approach in their studies. This study applies the IPA analysis with both quadrants approach and diagonal approach to generate knowledge that can be used to make EVs more attractive to consumers.

3.2 Survey

Sampling

A web survey was developed using a survey platform used internally at Nord University Business School and used to collect data from electric car owners in Norway. The data were collected between March and May 2019. The invitation to participate in the survey was distributed by traditional mail to 4330 car owners who were randomly drawn from a dataset provided by the Norwegian Public Roads Administration. The invitation letter included a web address where they could find the survey. A total of 451 respondents filled out the questionnaire, yielding a response rate of 10.4%. Among them, 278 (62%) owned electric cars. In this study, we employ the responses provided by the 278 electric car owners to assess the importance and performance of EVs based on consumer perceptions.

Measures

In the first section of the survey, the respondents were asked what type of car (i.e. BEV, PHEV, HEV, and ICEV) they bought most recently, the model of that particular car, the total number of vehicles in the household, and their driving habits. In the present study, to evaluate the performance of EVs, we included the responses from owners of BEVs, PHEVs, and HEVs.

In the demographic section of the survey, respondents stated their gender and marital status. Additionally, using multiple given options, respondents were asked about items such as income before tax, academic qualification, and the population density of the municipality where they lived.

In the next section, the respondents were asked to state the importance of different factors when purchasing a car on a 5-point Likert scale ranging from 1 (not important) to 5 (extremely important). Subsequently, the respondents were asked about their satisfaction with their latest purchased EVs for the same factors using a 5-point Likert scale ranging from 1 (not satisfied) to 5 (extremely satisfied).

The respondents were asked about the economic, instrumental, and environmental aspects; interior and exterior design; winter driving quality; and the symbolic elements of owning a car, and respondents' perception about the availability of the desired car, and use-based policy incentives. The factors were selected based on the literature review presented in Section 2. The items of the attributes were developed based on previous studies that investigated multiple characteristics of cars, including EVs (Bullis, 2013; Button, 2010; Chorus et al., 2013; Egbue and Long, 2012; Hoen and T.Geurs, 2011; Langbroek et al., 2016; Schuitema et al., 2013; Sherman, 1967; Simsekoglu, 2018; Simsekoglu and Nayum, 2019; Solvoll et al., 2010; and Verplanken et al., 2008). The items related to each construct are shown in Table 2.

4 Results

4.1 Sample description

The sample included 197 males (71%) and 80 females (29%). Most of the respondents were married (86%) and aged between 41 and 60 years (59%). Table 1 shows that the majority of the sample (78%) earn more than 500,000 kroner ($54,000) per year. Regarding education, 72% of the respondents have attended university. Moreover, about a quarter of the respondents (26%) drive more than 40 kilometers on an average day, while 59% of the respondents drove at least 30 kilometers on an average day. Finally, the average number of cars owned by the respondents' households was less than 2. Considering that in a large survey among Norwegian BEV owners, based on the entire population, Fevang et al. (2020) finds that the male share of the respondents was 72%, that their average age was 51 and that 88% had higher education from a college or university, indicates that our sample broadly resembles that of Norwegian owners of BEV.

4.2 Scale characteristics

To verify the reliability and validity of each set of measures, we conducted the principal component analysis (PCA). At first, we utilized the iteration and Varimax rotation, which identifies the dimensional structure of the scale measuring the attributes of interest. We used Kaiser's ''eigenvalue>1" criterion to decide the number of the dimension.

As the next step, the correctness and reliability of the constructs were tested using Cronbach's alpha. The thresholds for Cronbach's alpha are up for debate, with different authors suggesting different limits. However, values in the 0.60s and 0.70s have been considered good or adequate (Deković et al., 1991;

Holden et al., 1991). All the constructs in our study had a reliability coefficient close to (or above) 0.70. Besides, for inter-item correlations, which represent a measure of internal consistency reliability, a coefficient around 0.30 is considered satisfactory (Hair et al., 1998; Lund et al., 2012). Table 2 shows that all inter-item correlations in our dataset are above 0.3.

In addition, we also conducted confirmatory factor analysis (CFA) considering the limitations of PCA (Raykov and Marcoulides, 2011). To ensure unidimensionality and discriminate validity, we conducted CFA using the maximum likelihood method. In addition to evaluating the factor loadings, we assessed the output mark of the root mean square error (RMSE), comparative fit index (CFI), and standardized root mean square residual (SRMR) to establish the fitted factor model, finding all of them to be satisfactory.

Table 1 Socio-demographic characteristics of the sample (n=278).

	Sample	
	Count	Percentage
Gender:		
Male	197	71%
Female	80	29%
Age:		
18 – 30	4	1%
31 – 40	50	18%
41 – 50	75	27%
51 – 60	88	32%
61 – 70	46	17%
> 70	15	5%
Personal income before tax:		
< 250 000 NOK	3	1%
250 000 – 350 000 NOK	13	5%
350 000 – 500 000 NOK	46	17%
500 000 – 650 000 NOK	80	29%
650 000 – 800 000 NOK	48	17%
> 800 000 NOK	88	32%
Education:		
Primary school	7	3%
High school, vocational	35	13%
High school, general education	36	13%
≤ 3 years of college / university	77	28%
> 3 years of college/ university	123	44%
Kilometres driven per day:		
< 10 km	24	9%
10 – 20 km	47	17%
20 – 30 km	42	15%
30 – 40 km	43	15%
40 – 50 km	49	18%
> 50 km	73	26%

4.3 Assessment of the importance and performance of different factors

In Table 3, the mean importance (M_i) and mean performance (M_p) of the constructs and items are reported and ranked in descending order. The ranking of the constructs such as instrumental aspects, cost aspects, environmental aspects, winter driving, interior-exterior style, symbolic aspects, perceived use-based policy measures and availability of EV models, which we generated and confirmed in previous steps by conducting

PCA, were calculated based on the mean values of the construct themselves. In addition, the mean values of each item that made up the constructs are also reported in Table 3. According to the respondents, the least important item was “a car that says something about my status” (M_i = 1.92), while the most important item was “driving range” (M_i = 4.65).

Table 2 Principal component analysis (PCA) and confirmatory factor analysis (CFA).

	PCA		CFA
	Cronbach`s Alpha	inter-item correlations	Factor loadings
Cost aspects	0.65	0.32	
Purchase cost			0.55
Maintenance cost			0.56
Refuelling (charging) cost			0.63
Depreciation cost			0.59
Instrumental aspects	0.71	0.38	
Driving range (battery range)			0.62
Safety features			0.44
Fuel (energy) efficiency			0.78
Refuelling (charging) duration			0.64
Interior and exterior design	0.80	0.57	
Interior style/design/look			0.85
Exterior style/design/look			0.87
Car size			0.56
Environmental aspects	0.83	0.56	
Tailpipe emission			0.90
Traffic noise			0.74
Type of energy usage			0.64
Other environmental consequences			0.79
Availability	0.77	0.45	
Availability of dealers nearby			0.70
Availability of different models			0.51
Country of manufacturer			0.77
Manufacturer’s reputation			0.79
Use-based policy measurements	0.76	0.45	
Road toll			0.70
Ferry fare			0.72
Parking fee			0.67
Saving time (e.g. access to bus lanes)			0.71
Winter driving	0.80	0.57	
Tire grip during winter			0.96
Driving performance during winter			0.95
Warmness inside the car in winter			0.42
Symbolic aspects	0.94	0.75	
A car that shows who I am			0.95
A car that says something about me			0.95
A car that says something about my status			0.91
A car that distinguishes me from others			0.89
A car that makes me feel good			0.62

Regarding the constructs, their descending order based on the importance perceived by the respondents was as follows: instrumental aspects, winter driving, environmental aspects, cost aspects, interior and exterior design, use-based policy measures, and symbolic aspects. Unsurprisingly, instrumental attributes

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(M_i= 4.41), such as driving range, energy efficiency, refuelling (recharging) duration, and safety features are, according to the respondents, most important in the car purchase decision-making process, followed by driving functionality during winter periods (M_i = 4.36). The importance of winter driving quality was expected, since the survey was conducted in Norway, where winters tend to be long and cold. Conversely, use-based policy incentives and symbolic aspects were not critical when purchasing a car.

Table 3 The importance and performance of factors influencing EV adoption.

	Mean (ranking)	
	Importance	Performance
Instrumental aspects	**4.41 (1)**	**3.97 (4)**
Driving range (battery range)	4.65 (1)	3.54 (26)
Safety features	4.59 (2)	4.31 (4)
Fuel (energy) efficiency	4.29 (7)	4.12 (10)
Refuelling (charging) duration	4.14 (8)	3.91 (18)
Winter Driving	**4.36 (2)**	**4.11 (2)**
Tire grip during winter	4.36 (5)	4.07 (14)
Driving performance during winter	4.38 (3)	4.09 (12)
Warmness inside the car during winter	4.31 (6)	4.18 (8)
Environmental aspects	**3.89 (3)**	**4.44 (1)**
Tailpipe emission	3.92 (14)	4.59 (2)
Traffic noise	3.57 (18)	4.30 (5)
Type of energy usage	4.38 (4)	4.64 (1)
Other environmental consequences	3.67 (15)	4.24 (6)
Cost aspects	**3.84 (4)**	**3.81 (5)**
Purchase cost	4.14 (9)	3.83 (19)
Maintenance cost	4.13 (10)	3.95 (17)
Refuelling (charging) cost	4.02 (11)	4.22 (7)
Depreciation cost	3.06 (22)	3.40 (27)
Interior and exterior design	**3.69 (5)**	**4.11 (3)**
Interior style/design/look	3.48 (19)	4.13 (9)
Exterior style/design/look	3.61 (17)	4.08 (13)
Car size (spaciousness /seating capacity)	4.01 (12)	4.11 (11)
Availability	**3.26 (6)**	**3.82 (7)**
Availability of dealers nearby	3.43 (21)	3.98 (16)
Availability of different models	3.44 (20)	3.62 (25)
Country of manufacturer	2.24 (27)	3.70 (21)
Manufacturer's reputation	3.93 (13)	3.99 (15)
Use-based policy measures	**2.70 (7)**	**3.67 (6)**
Road toll	3.64 (16)	4.40 (3)
Ferry fare	2.29 (26)	3.62 (24)
Parking fee	2.92 (24)	3.65 (23)
Saving time (e.g. by access to bus lanes)	2.67 (25)	3.71 (20)
Symbolic aspects	**2.23 (8)**	**2.99 (8)**
A car that shows who I am	2.16 (29)	3.01 (28)
A car that says something about me	2.21 (28)	3.00 (29)
A car that says something about my status	1.92 (31)	2.84 (30)
A car that distinguishes me from others	1.93 (30)	2.81 (31)
A car that makes me feel good	2.96 (23)	4.69 (22)

With respect to satisfaction, respondents were most satisfied with the environmental aspects (M_P = 4.44) of their latest purchased electric car, particularly with the type of energy it uses (M_P = 4.64), as both the electricity usage advantages and its production source in Norway satisfy their environmental concerns.

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4.4 Quadrant model

The mean scores for the constructs reported in Table 3 were used to generate the quadrant model shown in Figure 3, which visualizes our findings and functions as a basis for strategy formulation. The horizontal line passing through the matrix represents the grand mean of the perceived performance (M_P = 3.87), whereas the vertical line is the grand mean of the perceived importance (M_i= 3.55). These two lines produce four quadrants, with strategies formulated based on the quadrant in which each construct is placed. In the following, the importance-performance matrix is applied to evaluate the performance of EVs in the Norwegian market.

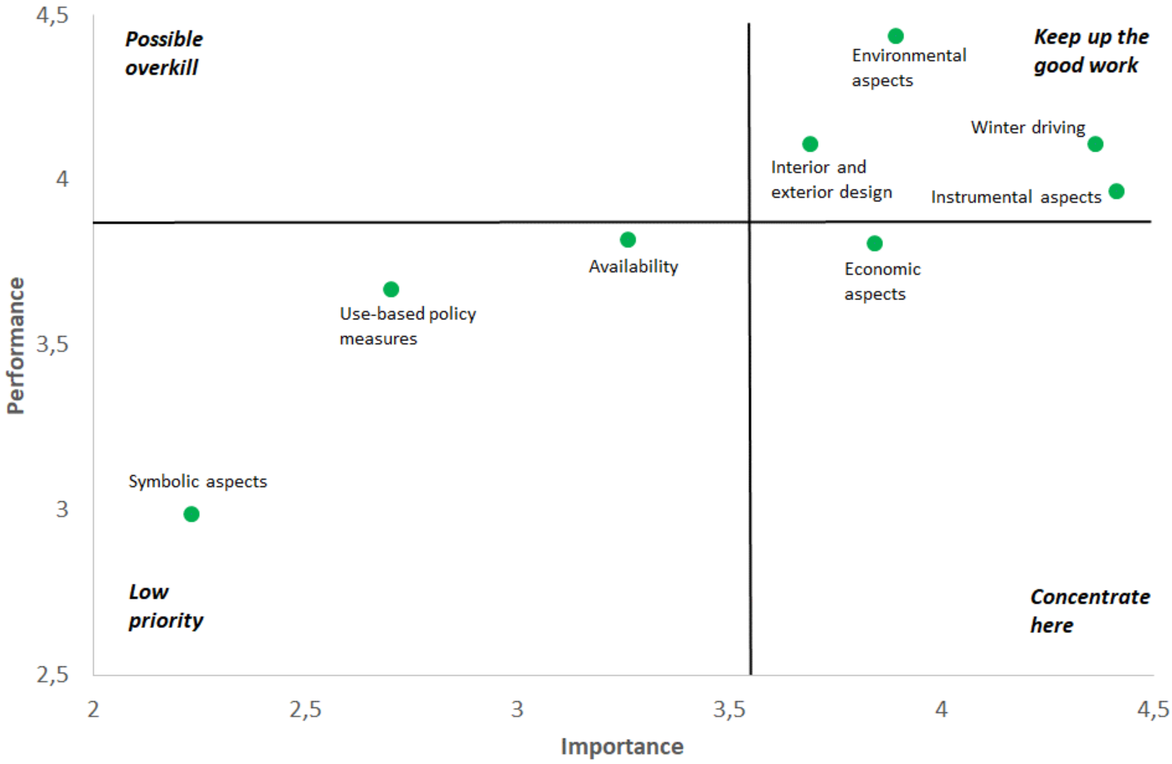

Figure 3. IPA - quadrant model.

Quadrant 1 (Keep up the good work)

The constructs in this quadrant have high importance and high perceived performance. Four of the constructs are located in this quadrant: environmental aspects, instrumental aspects, winter driving, and interior and exterior design. Unsurprisingly, Norwegian owners of EVs appear to be very satisfied with the environmental aspects of their EVs, particularly BEVs which produce zero tailpipe emissions and generate very little engine noise. Moreover, the electricity that drives EV powertrains in Norway is generated primarily from renewable energy sources (hydropower). Since the performances of these factors are of high importance when consumers purchase the EVs they prefer, the current high performance should be upheld to maintain the competitive advantages in the market.

Quadrant 2 (Possible overkill)

No constructs fell into this quadrant.

Quadrant 3 (Low priority)

The constructs in this quadrant have low importance and low perceived performance. This quadrant contains three constructs: policy measures, availability, and symbolic aspects. According to the IPA concept, these constructs represent minor weaknesses and do not pose any immediate competitive threats. Surprisingly, EV use-based policy measures such as exemption of road tolls, ferry fees, parking fees, and access to bus lanes fell into this quadrant, although Norway is quite well-known for its generous policy measures. One reason for the low importance of use-based policy measures might be that even though the

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EV market in Norway is more mature than in many other countries, it is still in the development phase. In line with Rogers' (1983) innovation diffusion theory, the Norwegian EV market is currently in the late majority phase passing the innovator and early adopter phases. This theory suggests that governmental investment, such as policy measures, is a potentially useful tool to attract consumers when the products are in their early phases. Therefore, it could be argued that in the current development phase of the Norwegian EV market, consumers are perhaps not much concerned about the use-based policy measures compared to other factors. The low satisfaction level could be the result of recent changes in use-based policy measures at municipality level (see Section 2.2). However, this finding is based on the responses of EV owners only. Therefore, it is plausible that respondents prioritized other factors (see Table 3) over user-based policy measures when making a decision about purchasing cars. Moreover, according to the 'low priority' category concept, it implies that the necessity of further improvement or allocation of resources depends on the yield and efficacy of use-based policy measures – which suggest further empirical investigation. Finally, it is worth noting that this study is based on a national sample, meaning the respondents both are from municipalities were EVs have access to bus lanes and from municipalities where no such access is given. The perceived importance of access to bus lanes could therefore be different in regions where such access is given, than what is reported here.

Quadrant 4 (Concentrate here)

The constructs in this quadrant have high importance but low perceived performance. This quadrant contains only one construct, namely, cost aspects. In line with this, cost aspects are of importance for attention and allocation of resources to improve performance. These findings suggest that both car manufacturers and policymakers should concentrate on reducing the cost related to purchasing, maintaining, and recharging EVs. Therefore, a lower monetary cost could, arguably, make EVs more attractive to potential buyers and make EV users more satisfied. Technological advancement (e.g. cheaper batteries) and generous policy incentives to manufacturers to encourage technological advancements and to consumers by providing access to more affordable charging options can play an essential role in lowering the economic cost of purchasing and driving EVs.

4.5 Diagonal model and gap analysis

In Figure 4, the points below the iso-line refer to an improvement area of high priority, while the points above the diagonal line refer to low priorities. This implies that constructs below the iso-line demand more focus than those above the iso-line. It should be noted that the iso-lines drawn in Figure 4 and Figure 5 are normalized to take into account that the two scales (i.e. importance and performance) are not necessarily used equally by the respondents. The normalization is done by letting the iso-lines begin at the point where both importance and performance equals and continue through the "intersection" between the average value of the importance of the constructs and the average value of their performance. Consequently, the iso-lines consider that there is a tendency in our dataset that the respondents state a higher level of performance than importance. We have also normalized the values for both performance and importance using a normalization method utilized in a study by Bi, Liu, Fan, and Zhang (2019). Assuming $\overline{IM}$ and $\overline{PF}$ denoting the normalized values of importance and performance respectively, where

$$\overline{IM_i} = \frac{IM_i}{\sum_{i=1}^{n} IM_i}$$

$$\overline{PF_i} = \frac{PF_i}{\sum_{i=1}^{n} PF_i}$$

$i = 1, 2, 3, \ldots n$

The main reason for using the iso-line in an IPA space is, as mentioned in Section 3.1, that in the traditional quadrant model strategy recommendations might change considerably due to small changes in positioning. In Figure 3, for example, a slight change in the performance of instrumental aspects could change the strategy recommendations for this construct considerably. In Figure 4, where the iso-line is drawn, this factor is not as sensitive to changes in perceived performance. The diagonal model reveals that regarding most constructs, performance is perceived as being higher than importance, whereas performance is lower than importance for three constructs only.

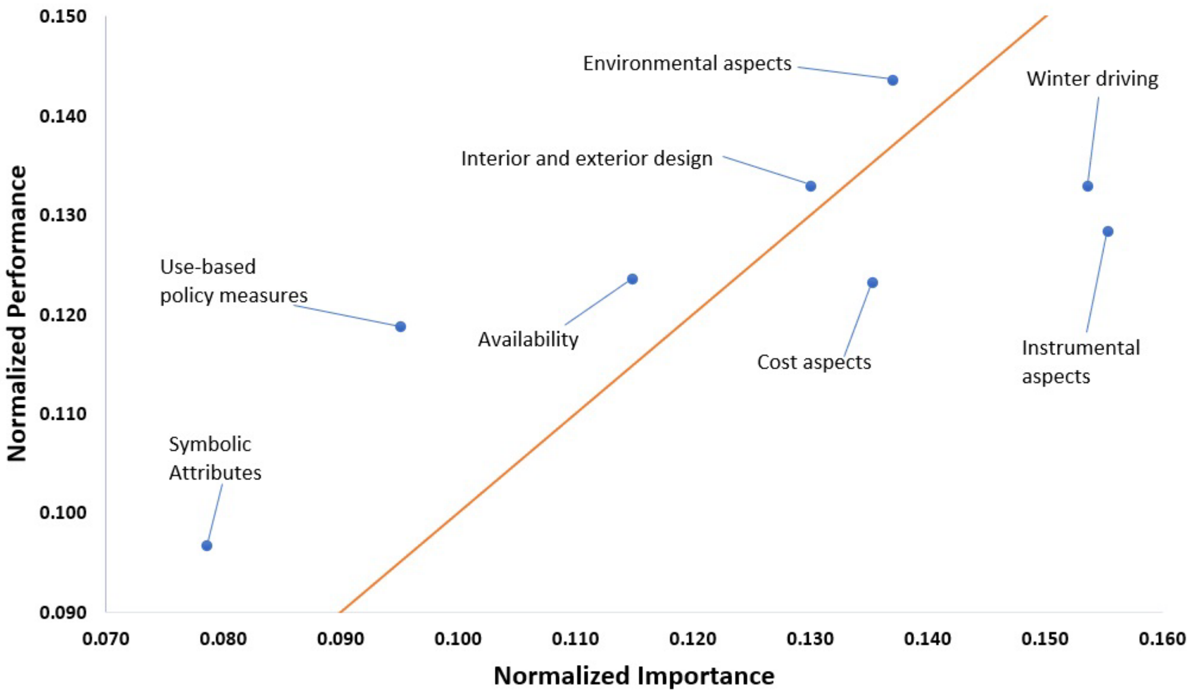

Figure 4. IPA – diagonal-model.

Table 4 Gaps between average normalized importance and normalized performance.

	Normalized importance ($\overline{IM}$)	Normalized performance ($\overline{PF}$)	Gap ($\overline{IM}$ - $\overline{PF}$)	
Instrumental aspects	0.155	0.128	0.027	*
Winter driving	0.154	0.133	0.021	*
Cost aspects	0.135	0.123	0.012	*
Interior and exterior design	0.130	0.133	-0.003	*
Environmental aspects	0.137	0.144	-0.007	*
Availability	0.115	0.124	-0.009	*
Use-based policy measures	0.095	0.119	-0.024	*
Symbolic aspects	0.079	0.097	-0.018	

** Statistically significant difference between normalized importance and normalized performance ($p<0.01$.)*

The gap between the normalized importance and normalized performance for each construct is listed in Table 4. It can be seen that the three constructs in Table 4 with a positive gap between normalized importance and normalized performance also fall below the normalized iso-line in Figure 4. Two of these, namely instrumental aspects, and winter driving quality, are primarily car manufacturers responsible for improving (exemptions are for example related to road winter maintenance and charging infrastructure that are strongly influenced by policymakers), whereas cost aspects can be improved by both car manufacturers and policymakers.

4.6 Implications

The mean importance and mean performance of the items comprising the concepts instrumental aspects, winter driving, and cost aspects are presented in Table 3. By incorporating these items into an IPA with an iso-line, as shown in Figure 5, it can be seen what car manufacturers and policymakers should focus on

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improving to make EVs more attractive. It should be noted that the iso-line in Figure 5 is similar to the one drawn in Figure 4.

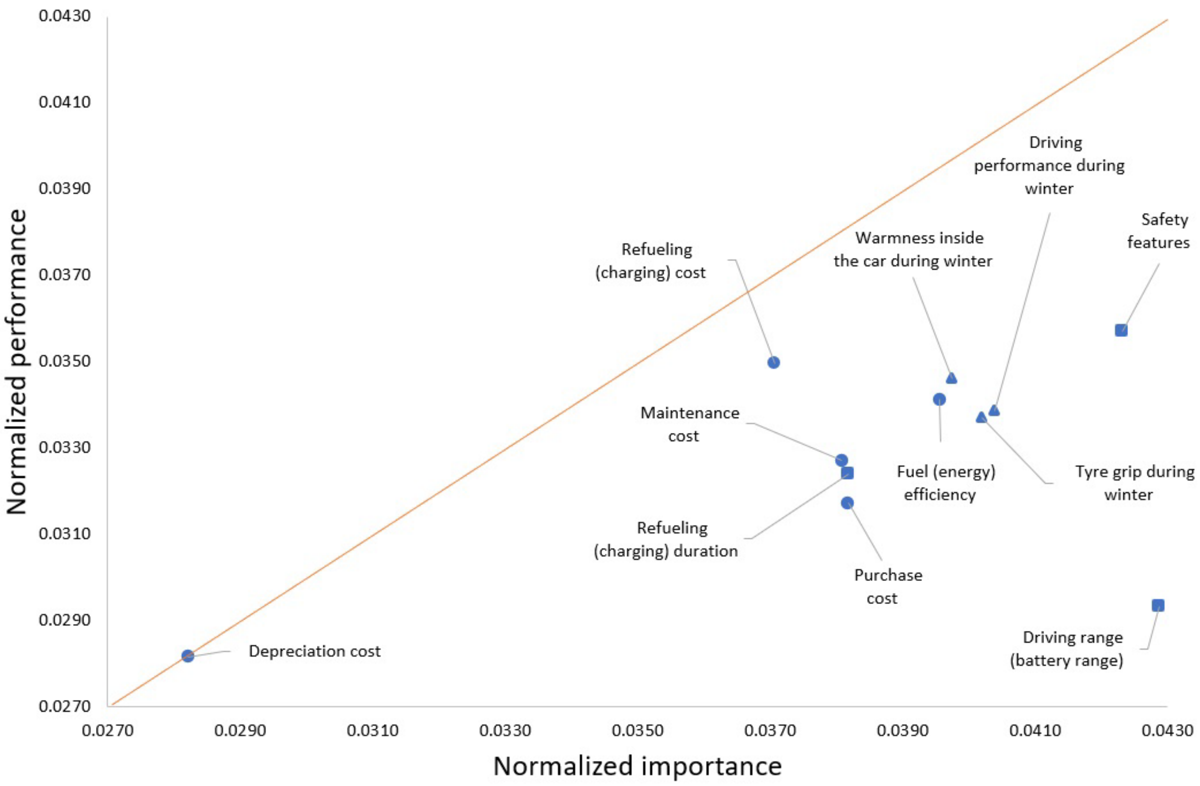

Figure 5. IPA with diagonal approach for items related to cost attributes, winter driving and instrumental aspects of EVs. Winter driving, instrumental attributes and cost aspects are labelled by ▲, ● and ■, respectively.

The item standing out with the greatest deviation between importance and performance is the driving range. Consequently, despite recent years of significant improvement in the driving range of EVs, our data indicate that it is still the most important factor to improve. This finding is in line with previous research indicating that the driving range of EVs is a significant barrier to the acceptance of EVs (e.g. Franke et al., 2012). However, car owners frequently overestimate their range needs (Franke and Krems, 2013; Rauh et al., 2017) as only 4% of daily trip chains are longer than 120 km (Figenbaum et al., 2015). The challenge related to driving range can, therefore, at least partially, be solved if car buyers have a realistic perception of their range needs. This can, for example, be achieved by extracting data from providers such as Google Maps that can help potential car buyers obtain a more precise perception of their driving habits, and consequently, their range needs.

The remaining items related to winter driving and instrumental aspects have a deviation between importance and performance in the range of 0.005 and 0.007. Thus, it is much less important to improve these factors compared to improving the driving range of EVs. In addition, three of these factors, namely driving performance during winter, tire grip during winter, and warmness inside the car during winter, are probably of less importance in countries with a warmer climate than Norway.

It is also worth noting that electric vehicles tend to be heavier than their petrol equivalents (Shaffer et al., 2021). This has safety implications as the likelihood of passengers being killed in a multivehicle accident increases with vehicle weight (Anderson and Auffhammer, 2014). Moreover, car manufacturers' pursuit of a greater driving range have them employ more lithium-ion batteries in the vehicles, thus increasing the potential heat release in the case of an EV fire (Sun et al., 2020). Consequently, both the weight of EVs and fire risk of EVs should be considered to make EVs more attractive. It should also be noted that there is a potential conflict of objectives between increasing the driving range and reducing the fire hazard related to

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using EVs. Finally, with a deviation of 0.31 between importance and performance, the purchase cost is the cost aspect item with the greatest deviation between importance and performance. This indicates that it might be premature for Norwegian authorities to eliminate their policies that contributes to lower purchasing costs of EVs, such as their exemption from registration tax and value-added tax (VAT).

5 Concluding remarks

As policymakers worldwide aim at increasing the adoption of EVs, a deep understanding of the factors influencing people's choice of cars and how EVs measure on these factors is crucial. Therefore, this study aims at generating knowledge that can be used to make EVs more attractive to car buyers.

To achieve this objective, we conducted the importance-performance analysis with the quadrant approach, diagonal approach, and the gap analysis. The data used in our study were obtained from 287 Norwegian EV owners. As such, our data is from one of the most mature EV-markets in the world. The respondents were asked to state how important 31 items are to them when deciding what new car to buy and their satisfaction with their most recently purchased EV when it comes to the same items. The items were grouped into eight constructs.

Three research questions were answered using the collected data. First, most important when considering what car to buy are: (1) instrumental aspects of the vehicle; (2) winter driving quality; and (3) the environmental aspects of the car. Second, EVs perform best with respect to their: (1) environmental aspects; (2) winter driving quality; and (3) interior and exterior design. Third, based on the IPA, policymakers and car manufacturers should focus on improving the following to make EVs more attractive to consumers: (1) instrumental aspects; (2) winter driving performance, and (3) cost aspects related to purchasing and driving EVs. Least important to make EVs more attractive is, according to our data, improving the symbolic aspects of these vehicles. That is, for example, the ability of the EVs to say something about who the owner is.

The constructs mentioned in the paragraph above are all comprised of several items. To produce more robust recommendations, the importance and performance of the items making up the concepts most essential to improve, namely instrumental aspects, cost aspects and winter driving, were plotted in an important-performance with a normalised iso-line running through it. This exercise suggests that the item most important to improve is the driving range of EVs. Additionally, improving the tire grip and driving performance during winter and the safety features of EVs will, according to our data, also make EVs more attractive.

Finally, it should be noted that our study, in line with all empirical studies, has some limitations. First, it can be argued that both the validity and reliability of the study are debatable, as all data analyzed are from the Norwegian car market, which has a higher EV penetration rate than most other car markets, and where a high number of policy measures are implemented to make EVs more attractive. In markets where car owners and purchasers have different preferences or where some factors are considered less important (e.g. winter driving functions), the results from this study might be less valid. Second, some respondents might have answered tactically, which might be, for instance, the case concerning the cost of purchasing EVs. Third, we studied only the responses from EV owners, making it difficult to generalize the findings to all car owners. Further research focusing on both EV and ICEV owners with a larger dataset will therefore be useful.

Despite the aforementioned limitations, this paper represents the first attempt to employ the importance-performance framework for understanding the EV market to offer car manufacturers and policymakers robust recommendations on how to make EVs more attractive, and consequently, contribute to establishing a greener road transport system.

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