Transportation Research Part D 125 (2023) 103982

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Electric cars as a path to sustainable travel behaviour: Insights from Nord-Jæren

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ARTICLE INFO

Keywords:
Electric vehicles
Sustainable mobility
Travel behaviour
Behaviour spillover
Moral licensing
Structural equation modelling

ABSTRACT

This study examines whether promoting electric cars (EVs) to achieve greener mobility undermines the efforts to reduce car use. It specifically explores the concept of moral licensing, wherein individuals use EVs as a way to feel good about their environmental impact while continuing to drive. The study uses travel data (n = 1223) from Nord-Jæren, Norway, to develop a Structural Equation Model (SEM) that explores the relationship between environmental beliefs, attitudes, and travel behaviour (i.e., use of conventional car, electric car, bus, and bicycle). The results confirm that pro-environmental beliefs have a “spillover effect” on EV use due to existing car attitudes. The relative convenience of the car over alternative options has been found to be the most important mitigating factor in the influence of environmental beliefs on behaviour. Consequently, to reduce car use and promote more sustainable travel options, it is essential to simultaneously improve these alternatives while restricting car traffic.

1. Introduction

Electric vehicles (EVs) are often viewed as a technological innovation that provides a green mobility option and a solution to environmental problems caused by car use (Jochem et al., 2016). At the same time, recent EV models have been able to offer similar levels of comfort, range and speed as conventional cars. Therefore, they provide an attractive alternative for reducing the environmental impact of urban transport compared to shifting towards active travel or public transport, which especially in car-oriented urban areas requires higher willingness and effort. However, even though EVs can be argued to be greener compared to conventional vehicles, they are still associated with many issues related to car use, such as traffic congestion, particle emissions, noise nuisance, safety issues, and high energy demand (Jochem et al., 2016).

Many studies focus on how to make access to EVs easier and more attractive (e.g., Jia and Chen (2021) and Liao et al. (2017)), since adoption rates are still relatively low in most countries. However, two questions that arise are whether promoting EVs as an environmentally friendly solution while incentivising them at the same time results in (i) preserving existing car-oriented urban planning and existing car use levels due to compensatory beliefs and moral licensing (i.e., one pro-environmental action creates the perception that a person is allowed to perform another less environmentally friendly action), and (ii) undermining the efforts to increase the use of public transport and active mobility.

Currently, the majority of studies that aim to examine the potential impact of a wider EV adoption on travel behaviour and mode

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https://doi.org/10.1016/j.trd.2023.103982
Received 5 April 2023; Received in revised form 6 October 2023; Accepted 10 November 2023
Available online 18 November 2023
1361-9209/

choice are either small scale surveys or pilots (e.g., Daramy-Williams et al. (2019); Du et al. (2023); Hardman (2021); Langbroek et al. (2018b)). Consequently, this study attempts to contribute to the existing body of the literature that focuses on investigating the impact of promoting and incentivising EVs on travel behaviour in contexts with significant levels of EV adoption rates. Therefore, the aim of this study is to examine if and how spillover effects (i.e., one pro-environmental action leads to another positive or negative environmental action) influence travel behaviour when a significant level of EV adoption has been registered. Norway provides an ideal case study as it has one of the highest EV adoption rates in the world; 78% of new car sales and 19% of the private vehicle fleet was electric as of 2022 (Norwegian Electric Vehicle Association, 2023b; Norwegian Electric Vehicle Association, 2023a). To achieve the study's aim, the travel behaviour, i.e., the frequency of use of conventional cars, electric vehicles, buses and bicycles, of commuters of Nord-Jæren, Norway is examined. A Structural Equation Model is developed based on data from the Regional Travel Survey of 2019. To explore the existence of spillover effects, mode-specific attitudes were also considered as a mediator of the impact of pro-environmental beliefs on travel behaviour.

2. Background

2.1. Electric vehicles and sustainability

The lack of local exhaust emissions made EVs an important tool for governments to reduce local air pollution and global emissions from transport (Hawkins et al., 2013). EVs offer several additional benefits compared to conventional internal combustion engine vehicles, like being significantly more energy efficient and requiring less maintenance (Helmers & Marx, 2012). If powered with low-carbon electricity sources, EVs can reduce greenhouse gas emissions by at least 50% compared to conventional vehicles (IEA, 2021). The combination of EVs with clean energy sources can have a positive contribution in mitigating important environmental issues, like climate change, air quality, and preservation of fossil fuels (Hawkins et al., 2013). Increasing the lifetime span of EVs can further improve their environmental contribution, since the environmental footprint of their production is more significant than that of conventional vehicles (Hawkins et al., 2013).

However, EVs also present several challenges such as the production of their battery which requires the exploitation of non-renewable natural resources, including heavy metals, such as lithium, cobalt, nickel, graphite, copper, steel and aluminium (Mills, 2020). Apart from that, EVs are equally responsible for PM particle emissions as conventional vehicles (Timmers & Achten, 2016), since they are produced by the friction of tyres with road surface and the friction caused while braking (Stojanovic et al., 2022). These particles are extremely harmful and are associated with a number of health problems (Timmers & Achten, 2016). In addition, despite the lack of a combustion engine, EVs are still responsible for noise nuisance, especially for speeds higher than 30 km/h (Amundsen & Klæboe, 2005).

Moreover, sustainable mobility concerns more than solving the problem of air and noise pollution. There are more issues related to car use, such as waste of public space to create the necessary infrastructure (roads, charging and parking spots, etc), the high energy consumption per person moved, traffic safety and traffic congestion. In some cases, the costs associated with these problems might be bigger than the potential environmental benefits of EVs. For example, according to van Wee (2014), the cost of all environmental problems caused by car use in the Netherlands was approximately 2.1–8.5 billion Euro in 2008, while the cost of road crashes for 2007 was 12 billion Euro, and the cost of traffic congestion for 2010 was 2.8–3.7 billion Euro. Consequently, focusing merely on reduced local exhaust of EVs could be misleading.

If a wider adoption of EVs results in higher car use because individuals tend to use their cars more often than before or because more individuals have access to a car, then EVs could potentially be contributing to existing sustainability issues related to car use, like traffic congestion and road crashes. In addition, if the promotion of EVs leads to people shifting away from public transport and active mobility, the impact of EVs on the sustainability of urban transport systems could be detrimental. Therefore, understanding how a wide adoption of EVs influences travel behaviour is essential in order to ensure that EVs actually replace conventional cars and promote more environmentally friendly behaviour, contributing thus to create a more sustainable urban transport system.

2.2. Electric vehicle adoption and potential behaviour spillover

Even though there is still a need to understand how the wider adoption of EVs is going to influence travel behaviour, several small-scale surveys and pilots offer a good first indication of its expected impacts on car use (e.g., Daramy-Williams et al. (2019); Du et al. (2023); Hardman (2021); Langbroek et al. (2018b)). These studies have observed that EVs are more likely to be used at least as intensively as conventional cars and more probably lead to an increase in travel demand. A travel diary study of Langbroek et al. (2017) found that EV users make significantly more trips and use their car for a significantly larger percentage of their total travel distance compared to conventional car users. Those observations suggest that a wider adoption of EVs will still require a considerable amount of energy consumption and as well as contribute to other external effects such as traffic congestion. Finally, Langbroek et al. (2018a) observed that adopting an EV is more likely to create higher travel demand by attracting people that would otherwise use more sustainable travel modes, specifically for commuting trips.

According to Du et al. (2023), environmental awareness can have counterproductive results due to the extensive use of EVs. Their scenario analysis suggests that promoting and incentivising the use of EVs will leads to an increase in both travel demand and travel distances, and consequently to higher energy consumption, especially if they are bought to replace a conventional car. Several studies in the field of environmental behaviour have explored whether taking positive action for the environment leads to taking further similar actions or whether it discourages individuals from engaging in additional environmentally friendly behaviour (e.g., Gholamzadehmir et al. (2019); Kaklamanou et al. (2015); Maki et al. (2019)). For example, they aim to understand if individuals that start to conserve energy in their homes are more or less likely to engage in further environmental behaviour, such as conserving water as well. This phenomenon, referred to as "spillover effects", "compensatory beliefs" or "moral licensing" presented mixed results in the literature. A *meta*-analysis on "behaviour spillover" found that past pro-environmental behaviour has a small positive impact on the intent to perform future environmental actions, but the relationship with actual behaviour is small and negative (Maki et al., 2019).

There are a few proposed mechanisms for positive or negative behavioural spillover. One potential mechanism is "compensatory green beliefs", whereby individuals keep a mental accounting of their positive and negative environmental behaviours. A study in the UK found that between 4 and 16% of participants agreed with statements such as "not driving a car compensates for flying on holiday" or "recycling compensates for driving a car" (Kaklamanou et al., 2015). These flawed trade-offs may stem in part from a misunderstanding of the climate impacts of different behavioural changes (Wynes et al., 2020).

Another potential mechanism for behavioural spillover effects is "moral licensing". Studies on moral licensing suggest that individuals who were conscious about their past "good deeds" (i.e., pro-environmental behaviour) felt like they were granted a "license" to conduct less environmentally friendly behaviour in the future (Gholamzadehmir et al., 2019). However, this mechanism is disputed in other studies, as they found no moral licensing effects on individuals' intention to perform future behaviour (Urban et al., 2021). Recall, however, that Maki et al. (2019) found spillover effects only for actual behaviour, not intention.

These studies are highly relevant to the emerging uptake and use of EVs. Two studies from Norway have examined the presence of spillover effects on the purchase and use of EVs. One survey on recent car-buyers found that EV owners had a weaker relationship between car use and introjected norms, such as feeling guilty for unnecessary car usage, as well as with the awareness of the environmental consequences of personal car use too (Klöckner et al., 2013). This suggests that EV users may feel that buying a more environmentally friendly car releases them from concerns about the environmental impacts of driving. A more recent study explicitly modelled the role of compensatory beliefs ("I have invested in environmentally friendly technology; so it does not matter if I drive more often now and then") among EV and hybrid-electric vehicle purchasers, and found that EV purchasers are more likely to engage in these beliefs compared to hybrid-electric vehicle owners (Nayum & Thøgersen, 2022).

Concluding, there is a need for more research regarding the existence of such spillover effects stemming from pro-environmental beliefs due to the purchase of an EV, in a location where EV adoption is currently considered significant. More specifically, there needs to be a better understanding on whether travel behaviour is subject to such compensatory beliefs and whether EVs provide a moral licensing tool to environmentally aware car users so they can continue performing an existing unsustainable behaviour (i.e., car use) and possibly even result in higher car use levels. Furthermore, if moral licensing leads to substituting more sustainable ways of transport, like public transport and cycling, then EVs could have an adverse effect on the sustainability of urban transport systems.

2.3. The role of attitudes in predicting behaviour

Understanding the impact of spillover effects stemming from pro-environmental beliefs on travel behaviour is essential to estimate the overall contribution of EVs to sustainable mobility. However, environmental awareness is not the only factor that influences travel behaviour and mode choice. The attitude towards a behaviour has been found to be an important factor that leads to displaying this behaviour. More specifically, a *meta*-analysis on cognitive mechanisms behind travel mode choice suggests that even though environmental concerns showed a negative association with car use, a positive attitude toward the car are positively associated with car use (Hoffmann et al., 2017). Moreover, positive attitudes towards alternative travel modes have been found to be negatively associated to car use and positively to the use of these alternatives (Hoffmann et al., 2017). Finally, hedonic or affective motives, such as having fun or enjoying a particular mode of travel, have been argued to play a role in mode choice (Anable & Gatersleben, 2005; Mokhtarian et al., 2015; Souche-Le Corvec & Zhao, 2020; Steg, 2005; Susilo & Cats, 2014).

Therefore, apart from pro-environmental beliefs, mode-specific attitudes and symbolic or affective motives are also considered in our study phrased similar to previous studies (e.g., Anable, 2005; Anable & Wright, 2013). The main hypothesis in our study is that individuals with positive attitudes toward the car are more likely to use the car, and thus EVs too. The question is whether this influences the impact of positive environmental beliefs on car use. While strong environmental beliefs should lead to less car use in general, this relationship may be offset by the perception that EVs constitute an environmentally friendly travel alternative. In general, it is interesting to observe how positive attitudes toward different transport modes interferes to the impact of positive environmental beliefs on travel mode choice. Consequently, mode-specific attitudes and symbolic or affective motives are not treated as independent variables, but as dependent variables influenced by environmental awareness. In other words, this study aims to fill the knowledge gap on how environmental beliefs influence travel behaviour, considering attitudes as factors that mediate this relationship, by focusing on a location where EV adoption is relatively widespread, i.e. Norway.

2.4. Zero growth goal and electric vehicles in Norway: The case of Nord-Jæren

In 2012, Norway adopted the Zero Growth Goal aiming to halt the continuous increase in urban car traffic, while promoting more sustainable travel options like public transport, cycling and walking (OECD, 2021). For this reason, the Urban Growth Agreements (UGAs) were introduced as a tool to mitigate the adverse effects of car use, like noise, congestion, air pollutants and road accidents, while reallocating road space to other uses than driving and parking private cars (Westskog et al., 2020; OECD, 2021). However, long before adopting the Zero Growth Goal, Norway implemented several incentives aiming to promote the wider adoption of EVs, such as exceptions from registration and value-added taxes, free parking and ferry tickets, access to bus lanes or exemptions from UGA measures, like road tolls (Bjerkan et al., 2016; Bjerkan et al., 2021; Figenbaum et al., 2015; Ingeborgrud & Ryghaug, 2019; Schulz &

Rode, 2022). Several studies showed that these incentives played a vital role on the wider uptake of EVs since practical factors like purchase and operation costs have been found to be stronger motives to buy an EV than their environmental benefits (Figenbaum et al., 2015; Ingeborgrud & Ryghaug, 2019; Schulz & Rode, 2022).

To work towards Norway's Zero Growth Goal, Nord-Jæren - Norway's third largest urban region (Statistics Norway, 2022) - adopted an Urban Growth Agreement in 2018. One of the measures that were implemented in Nord-Jæren was the introduction of road tolls around its main urban cores in October 2018. However, in line with Norway's strategy to promote the electrification of private cars, EVs were initially given free access through road tolls. In 2019, 86% of households in Nord-Jæren had access to at least one private vehicle, with 31% having two vehicles and 7% having at least three (UrbanetAnalyse, 2019). From those, 18% had access to an electric car, which corresponds to a 900% increase in a 5-year period (UrbanetAnalyse, 2019). The high levels of car ownership in Nord-Jæren resulted in a high level of car use too. Almost 60% of all trips in Nord-Jæren in 2019 were made by private car, while public transport and bicycle account only for 10% and 8% respectively (UrbanetAnalyse, 2019). Moreover, unpublished data from the Regional Travel Surveys of 2018 and 2019 show that the introduction of road tolls and implicitly incentivising EVs over conventional cars led to a 7.4% reduction in conventional cars' use (from 44.6% to 37.2%) and a 3.6% increase in EVs' use (from 5.2% to 8.8%), while cycling decreased by 3.1% and public transport use remained relatively stable.

Therefore, even though UGA measures like the road tolls have effectively reduced the use of conventional cars in Nord-Jæren, some of the demand was absorbed by EVs. This suggests that despite local efforts to achieve the Zero Growth Goal, incentivising EVs and promoting them as a green travel option may have sent mixed signals about what constitutes pro-environmental travel behaviour. Considering that UGAs were implemented specifically to achieve lower car use on a local scale, with a clear aim to allow the reallocation of road space to other uses than driving and parking private cars, Nord-Jæren has been chosen as a case.

3. Methods

This study aims to explore how pro-environmental beliefs influence travel behaviour using a case study. More specifically, it aims at understanding if and how wider EV adoption works as a moral licensing tool for people to continue car use. This allows us to explore if pro-environmental beliefs create spillover effects to the use of EVs, suggesting that commuters with environmental concerns will choose to use their EV more frequently, instead of choosing public transport or cycling. In addition, it aims to explore how mode-specific attitudes influence the use of different modes and consequently the potential to shift from car use to other alternatives, like public transport or active mobility.

There is a plethora of theories on the relationship of attitudes and behaviour, with more recent studies arguing that this relationship is bidirectional (De Vos, 2022; Kroesen et al., 2017). However, since this study focuses on understanding behaviour only the influence of attitudes on travel behaviour is examined. Apart from mode-specific attitudes (i.e., preference, affect, perceived quality), the impact of environmental beliefs on travel behaviour is examined assuming attitudes to have a mediating role. This way, the presence of spillover effects from pro-environmental beliefs on travel behaviour can be examined considering also the relationship between attitudes and behaviour.

A Structural Equation Model (SEM) is developed using revealed preference data from the Regional Travel Survey of 2019 (n = 1223). This approach allows to measure abstract constructs, like attitudes, based on observed and measurable items (measurement model) and simultaneously explore the relationship between these constructs and other observable variables, like behaviour (structural model). Therefore, travel behaviour is treated as a dependent variable, which is assumed to be influenced by mode-specific attitudes.

In this study, four different types of behaviour are considered, meaning it is measured with four distinct variables. These are the frequency of use of four travel options: conventional internal combustion engine vehicle (ICEV), electric vehicle (EV), bus and bicycle. Apart from the behaviour related to the four travel options, three types of mode-specific attitudes are also constructed, consisting of preferences, emotional response, and perceived quality. These are attitude towards the car, which is assumed to influence ICEV or EV use, the attitude towards the bus, which is assumed to influence bus use, and finally, the attitude towards the bike, which is assumed to influence bike use. The impact of each mode-specific attitude on the other modes is also considered. Aspects related to the individuals are also included, such as their personal or social norms and beliefs about the environment.

In the Fig. 1, the conceptual structural part of the SEM model that will be applied for the case of Nord-Jæren is shown below, presenting the expected relationship between travel behaviour, mode-specific attitudes and personal norms and beliefs.

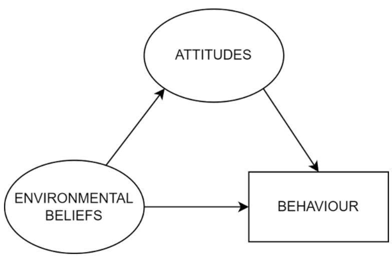

Fig. 1. Conceptual structural model.

4. Data analysis and descriptive statistics

For this study we use travel data for 1223 commuters in Nord-Jæren from the Regional Travel Survey of 2019. Table 1 presents the sociodemographic characteristics of the sample.

Through this dataset, travel behaviour has been defined as the frequency of use of different transport modes during a week. These modes of transport are the car (ICEV or EV), the bus or the bicycle. The frequency is defined in a 6-point scale depending on how many days per week on average they use each mode to commute. Table 2 show the sample's frequency of use per mode. These frequencies have been used as the four distinct variables that define behaviour in the SEM model.

According to Table 2, in a 3-month period approximately 31% have never used a car, meaning that 69% of all commuters have used either an ICEV or an EV as driver or passenger at least once. Approximately 62% used them at least once per week, with 41% using them 5–7 days per week. If only ICEVs are considered, approximately 42% has never used them, meaning that 58% have used an ICEV at least once in 3 months. More specifically, around 51% have been using them at least once per week, with 32% using them 5–7 days per week. For EVs, 87% have never used them, which means that only 13% have used one at least once in those 3 months. Around 12% used an EV at least once per week, with more than 7% using them 5–7 days per week.

Similar patterns are observed for bus and bicycle use. Approximately 78% of the respondents have never used the bus in the 3-month period, meaning that 23% used the bus at least once. Around 18% of them took the bus to work at least once per week,

Table 1
Sociodemographic characteristics of sample (n = 1223).

Characteristics	Items	Respondents (%)
Gender	Male	603 (49.30%)
	Female	618 (50.53%)
	N/A	2 (0.16%)
Age groups	18–25	78 (6.38%)
	26–35	286 (23.39%)
	36–45	354 (28.95%)
	46–55	272 (22.24%)
	56–65	214 (17.50%)
	65+	17 (1.39%)
	N/A	2 (0.16%)
Household income	< 200,000 NOK	6 (0.49%)
	200,000 – 399,999 NOK	29 (2.37%)
	400,000 – 599,999 NOK	115 (9.40%)
	600,000 – 799,999 NOK	107 (8.75%)
	800,000 – 999,999 NOK	148 (12.10%)
	1,000,000 – 1,599,999 NOK	436 (35.65%)
	1,600,000 – 1,999,999 NOK	88 (7.85%)
	>= 2,000,000 NOK	110 (7.03%)
	N/A	184 (15.04%)
Education	9-year school or lower	9 (0.74%)
	Basic course/one-year education beyond 9-year school	18 (1.47%)
	Upper secondary school / vocational school (3 years)	355 (29.03%)
	College or university education or higher	835 (68.27%)
	N/A	6 (0.50%)
Car ownership	Yes	1131 (92.48%)
	No	92 (7.52%)
	N/A	0 (0%)
Car license	Yes	1150 (94.03%)
	No	73 (5.97%)
	N/A	0 (0%)
Bike ownership	Yes	897 (73.34%)
	No	198 (16.19%)
	N/A	128 (10.47%)

Table 2
Mode use frequency in a 3-month period (n = 1223).

Frequency of use	Car as driver or passenger			Bus	Bicycle
	ICEV	EV	Any type of car*		
5 – 7 times a week	31.97% (391)	7.28% (89)	41.21% (504)	7.77% (95)	10.55% (127)
3 – 4 times a week	9.57% (117)	3.27% (40)	10.96% (134)	4.09% (50)	8.26% (101)
1 – 2 times a week	9.73% (119)	1.72% (21)	9.57% (117)	6.05% (74)	8.18% (100)
1 – 3 times a month	4.74% (58)	0.65% (8)	4.74% (58)	3.35% (41)	2.21% (27)
Less often	2.29% (28)	0.25% (3)	2.37% (29)	1.23% (15)	0.98% (12)
Never	41.70% (510)	86.84% (1062)	31.15% (381)	77.51% (948)	69.83% (854)

* Any type of car: frequency that respondents mentioned they used either an ICEV or an EV during a week.

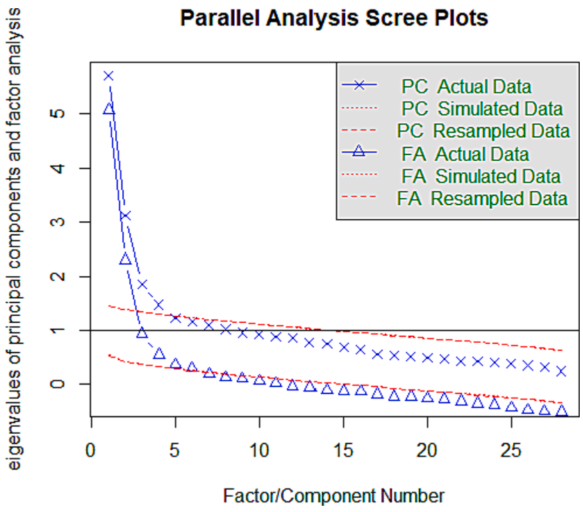

Fig. 2. Parallel Analysis Scree Plot.

while around 8% took it 5–7 days per week. For bicycles, 70% of the respondents have never used them to go to work, while around 30% used them at least once. From those, almost 18% have used a bicycle at least once per week, with around 11% using them 5–7 days per week. Given these travel patterns and considering that it is Norway's worst urban region in terms of car use levels (UrbanetAnalyse, 2019), Nord-Jæren can be characterised as a car-dependent region with high levels of car ownership and car use.

In the 2019 survey, respondents were also asked to rate several attitudinal statements on a 5-point Likert scale. In total, 28 statement were included, which can be divided into four main groups according to their content, i.e., attitude towards the car, attitude towards public transport, attitude towards the bike, and personal norms and beliefs. These 28 statements were tested for common method bias issues using Harman's Single Factor Test. This test assumes that all items can fit into one latent construct, resulting in a good model fit. In this case, fitting all items into once latent variable did not result into a good model fit (CFI = 0.626, TLI = 0.582, RMSEA = 0.122, SRMR = 0.118, GFI = 0.951, AGFI = 0.933), suggesting that the data from the attitudinal questions are not prone to a single factor issue.

Consequently, a factor analysis was conducted to test the homogeneity of these initial groups and to observe if all statements should be considered. As can be seen in Fig. 2, factor analysis suggests that the number of factors is five and that items related to the car are split into two groups (see Table 3). The first group (Factor 1) consists of aspects associated with the attitude towards the car shaped by the relative convenience of car use and its benefits compared to its alternative options. The second group (Factor 5) consists of symbolic-affective motives towards the car, which are related to the feelings of an individual experience when travelling. In general, there are mixed findings concerning the influence of symbolic-affective factors on travel behaviour (Anable et al., 2006). Several studies argue that people often make decision about their travel just to experience the "fun" of travelling, like experience the thrill of driving or choose the mode that allows them to combine their trip with enjoyable acts like enjoy the scenery, listen to music or release stress (Anable et al., 2006).

To examine the impact of symbolic-affective motives on commuters' travel behaviour, the proposed conceptual model of this study has been adapted as shown in Fig. 3. This adapted model explores the imapct of environmental beliefs on behaviour and tests whether mode-specific attitudes and symbolic-affective motives are mediators of this relationship.

Further, the analysis showed that 20 statements are sufficient to describe the five factors for this study. One of the factors includes nine indicators related to the attitude towards the bus or Kolumbus, the bus service provider in Nord-Jæren. For simplicity and to increase the reliability of the results, we selected the ones that had a factor loading higher than 0.7. Table 4 presents the 16 statements that constitute the five latent constructs that were considered in our study.

The statements associated with each indicator in Table 4 suggest that each latent construct has a distinct definition. More specifically, car attitude refers to aspects related to the relative perceived convenience of the car shaped by its mobility benefits compared to alternative options. Conversely, bike attitude reflects individuals' perceptions of cycling conditions in their area and whether they identify as bicycle users. Bus attitude solely pertains to the experiences of individuals with the local bus service provider, Kolumbus. Thus, it focuses on their perception about the services offered by Kolumbus rather than their general views on travelling by bus. Finally, symbolic-affective motives consist of items related to the emotional states and feelings experienced when driving a car.

By using the responses of the 1223 participants in the attitudinal statements of Table 4, together with their revealed travel behaviour (i.e., frequency of use of each mode of transport), the proposed SEM has been estimated to explore the relationship between environmental beliefs, attitudes, and travel behaviour.

Table 3
Factor analysis (only values above 0.4 are presented).

Statement (translated from Norwegian)	Indicator	Factor 1 (Car attitude)	Factor 2 (Bus attitude)	Factor 3 (Bike attitude)	Factor 4 (Environmental attitude)	Factor 5 (Symbolic-affective motives)
I prefer to use a car over other modes of transport for most of my travels.	car preference	0.66				
I like driving just for fun.	fun					0.62
Driving gives me a way to express myself.	expression					0.71
I usually look for other transport options before I decide to use a car.	avoid					
I depend on the car in my everyday life.	dependency					
I am not interested in reducing my car use.	pro-car					
I am interested in reducing my car use.	anti-car					
I think it is easiest to travel by environmentally friendly means of transport (public transport, bicycle or walking).	ease of use	−0.52				
All in all, what is your impression of Kolumbus?	satisfaction		0.80			
Kolumbus provides good service.	level of service		0.78			
Kolumbus enjoys great trust among people.	trust		0.76			
Kolumbus is forward-looking.	novelty		0.73			
Kolumbus contributes positively to the environment.	green mode		0.55			
Kolumbus provides a comfortable journey.	comfort		0.75			
I'm not the type of person who travels by bus.	no bus user					
How do you feel about finding information about Kolumbus' service?	information		0.40			
How likely are you to recommend Kolumbus to a friend or colleague?	recommendation		0.66			
Kolumbus makes Rogaland a better place.	area improvement		0.69			
I find cycling stressful.	stress			−0.69		
Cycling can be the fastest way to travel.	speed			0.41		
I like cycling as a mode of transport.	bike preference			0.73		
I feel that I should cycle more to stay fit.	health					
I'm not the type of person who rides a bike	nonbiker			−0.72		
All in all, how satisfied are you with the conditions for cycling on the journey to and from work	cycling conditions					
I put the environment before my own interests when it comes to my transport choices	environment				0.40	
I feel a moral obligation to reduce my greenhouse gas emissions	emissions				0.84	
People should be allowed to use a car as much as they want	freedom	0.40				
Cronbach's alpha		0.63	0.88	0.74	0.70	0.61

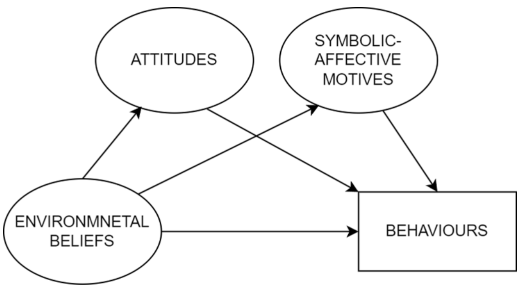

Fig. 3. Updated conceptual model.

Table 4
Attitudinal questions included in the analysis.

Latent variable	Indicator	Statement (translated from Norwegian)
Car attitude	car preference	I prefer to use a car over other modes of transport for most of my trips
	ease of use *	I think it is easiest to travel by car than by environmentally friendly means of transport (public transport, bicycle or walking)
	freedom	People should be allowed to use a car as much as they want
Bike attitude	bike preference	I like cycling as a mode of transport
	biker *	I'm the type of person who rides a bike
	stress	I find cycling stressful
	speed	Cycling can be the fastest way to travel.
Bus attitude	level of service	Kolumbus provides good service
	satisfaction	All in all, what is your impression of Kolumbus?
	trust	Kolumbus enjoys great trust among people
	novelty	Kolumbus is innovative
	comfort	Kolumbus provides an easy journey
Environmental beliefs	environment	I put the environment before my own interests when it comes to my transport choices
	emissions	I feel a moral obligation to reduce my greenhouse gas emissions
Symbolic-affective motives	fun	I like driving just for fun
	expression	Driving gives me a way to express myself

* Negative statements have been reverse coded.

5. Results

In this section, the estimated SEM results are presented and discussed. The model consists of a measurement and a structural model. First, the estimated measurement model from the confirmatory factor analysis is presented in Table 5. The results of the structural model as well as the goodness-of-fit indexes of the entire SEM model are presented in Table 6.

All 16 indicators have been proved to be statistically significant for their associated latent variable. By looking at the Cronbach's alpha to test the unidimensionality of each latent variable, we observe that all factors have an alpha higher than 0.6. This means that the items within each latent variable are measuring the same underlying construct and are consistent with each other. In addition, the fact that Cronbach's alpha for bus attitude did not change shows that despite dropping 4 items the internal consistency of the variable has not been altered.

The five latent constructs were simultaneously used to estimate the structural part of SEM (Table 6). ICEV ownership and EV ownership have been included in the model as control variables for ICEV use and EV use to account for the fact the several individuals might not have the option to choose between the two alternatives.

All measurements of model fit presented in Table 6 suggest that the estimated SEM model has a good fit to the data. More specifically, the p-value of χ^2 is 0.000 which indicates statistical significance, while RMSEA is slightly above 0.05 and SRMR is lower than 0.08 which is another indication of a good model fit (Fabrigar et al., 1999; Hu and Bentler, 1999). The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) are 0.925 and 0.902, respectively. For both indices any value higher than 0.9 represents an acceptable model

Table 5
Measurement model.

Latent Variables	Estimate (Standardised)	Std. Error	p-value
Car attitude (α = 0.63)			
~ car preference	0.723	0.053	0.000
~ ease of use	0.598	0.043	0.000
~ freedom	0.527	0.037	0.000
Bike attitude (α = 0.74)			
~ bike preference	0.855	0.040	0.000
~ biker	0.645	0.039	0.000
~ stress	−0.528	0.036	0.000
~ speed	0.576	0.039	0.000
Bus attitude (α = 0.88)			
~ level of service	0.818	0.027	0.000
~ satisfaction	0.786	0.024	0.000
~ trust	0.777	0.026	0.000
~ novelty	0.741	0.028	0.000
~ comfort	0.724	0.033	0.000
Environmental beliefs (α = 0.70)	0.655	0.047	0.000
~ environment			
~ emissions			
Symbolic-affective motives (α = 0.61)	0.667	0.063	0.000
~ expression			
~ fun			

Table 6
Structural model.

Latent Variables	Estimate (Standardised)	Std. Error	p-value
ICEV use			
~ Car attitude	0.794	0.093	0
~ Bus attitude	0.03	0.042	0.398
~ Bike attitude	0.155	0.065	0.01
~ Environmental beliefs	0.186	0.126	0.07
~ Symbolic-affective motives	-0.058	0.052	0.192
~ ICEV ownership	0.189	0.085	0
EV use			
~ Car attitude	0.309	0.072	0.001
~ Bus attitude	0.005	0.035	0.874
~ Bike attitude	0.008	0.049	0.854
~ Environmental beliefs	0.257	0.097	0.001
~ Symbolic-affective motives	-0.013	0.043	0.725
~ EV ownership	0.554	0.075	0
Bus use			
~ Car attitude	-0.886	0.106	0
~ Bus attitude	0.051	0.044	0.189
~ Bike attitude	-0.43	0.079	0
~ Environmental beliefs	-0.376	0.143	0.002
~ Symbolic-affective motives	0.046	0.056	0.368
Bike use			
~ Car attitude	-0.476	0.081	0
~ Bus attitude	-0.066	0.039	0.032
~ Bike attitude	0.432	0.054	0
~ Environmental beliefs	-0.253	0.11	0.003
~ Symbolic-affective motives	0.052	0.048	0.188
Car attitude			
~ Environmental beliefs	-0.785	0.131	0
Bus attitude			
~ Environmental beliefs	0.237	0.04	0
Bike attitude			
~ Environmental beliefs	0.447	0.048	0
Symbolic-affective motives			
~ Environmental beliefs	-0.312	0.052	0
Covariances:			
ICEV use ~~ EV use	-0.448	0.039	0
Car attitude ~~ Bike attitude	-0.51	0.052	0
Number of observations = 1223			
Degrees of freedom = 176			
Chi-squared (χ^2) = 789.288			
P-value (of chi-squared) = 0.000			
Comparative Fit Index (CFI) = 0.925			
Tucker-Lewis Index (TLI) = 0.902			
Minimum Discrepancy Function divided by Degrees of Freedom (CMIN/df) = 4.485			

(*continued on next page*)

Table 6 (*continued*)

Latent Variables	Estimate (Standardised)	Std. Error	p-value
Normed Fit Index (NFI) = 0.906			
Goodness of Fit Index (GFI) = 0.993			
Adjusted Goodness of Fit Index (AGFI)= 0.989			
Root Mean Square Error of Approximation (RMSEA) = 0.053			
Standardized Root Mean Square Residual (SRMR) = 0.047			

fit (Kline, 2016). Finally, the Goodness of Fit Index (GFI) is 0.996 and the Adjusted Goodness of Fit Index (AGFI) is 0.993, which indicates a good model fit since they are both higher than 0.9 (Baumgartner & Homburg, 1996). A graphical representation of the estimated SEM model is presented in Fig. 4. The graph includes the effects that are found to be statistically significant at a 0.10 confidence level.

To properly interpret the results of the estimated SEM, it is important to explore the existence of direct and indirect effects of environmental beliefs through mode-specific attitudes and symbolic-affective motives. This will indicate if mode-specific attitudes and car-related symbolic-affective motives have a mediating role on the impact of environmental beliefs on behaviour. Table 7 presents the results of the mediation analysis of the direct and indirect effects of environmental beliefs and symbolic-affective motives in the estimated SEM.

The results of the structural model (Table 6) and mediation analysis (Table 7) indicate that, as expected, environmental beliefs have a negative impact on ICEV use (-0.342), suggesting that those who put the environment before their own interest are less likely to drive a conventional car. More specifically, an indirect effect on ICEV use is observed through car attitude (-0.623) and bike attitude (0.069), suggesting that they both mediate the effect of environmental beliefs on ICEV use. Considering that a positive direct effect (0.186) from

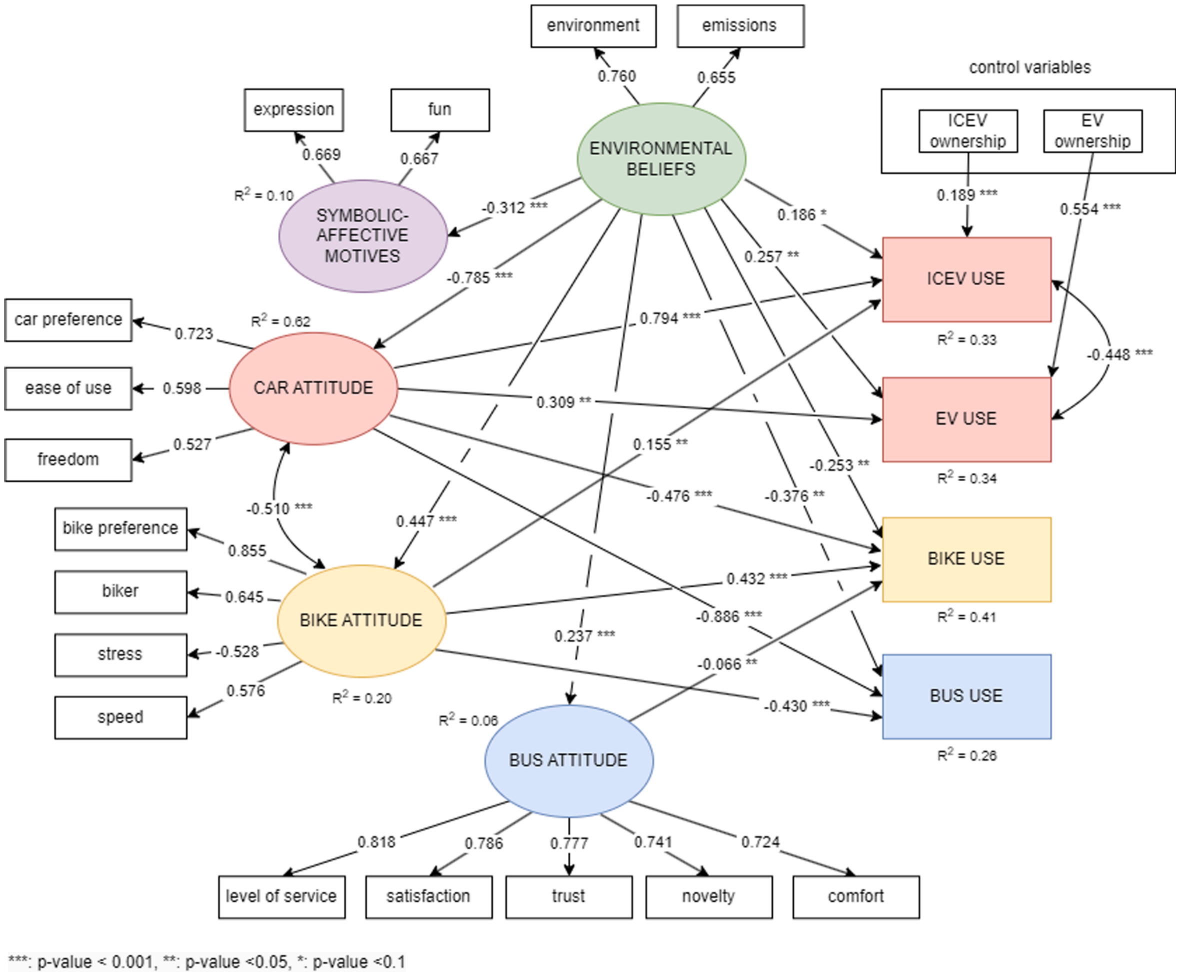

Fig. 4. Estimated Attitude-Behaviour model.

Table 7
Mediation analysis of SEM results.

From	To	Total effect	Direct effect	Indirect effect through:			
				Car attitude	Bike attitude	Bus attitude	Symbolic-affective motives
Environmental beliefs	ICEV use	−0.342 ***	0.186 *	−0.623 ***	0.069 **	0.007	0.018
	EV use	0.023	0.257 ***	−0.242 **	0.004	0.001	0.004
	Bus use	0.125 **	−0.376 **	0.695 ***	−0.192 ***	−0.012	−0.014
	Bike use	0.282 ***	−0.253 **	0.373 ***	0.193 ***	−0.016 **	−0.016

***: p-value $<$ 0.001, **: p-value $<$ 0.05, *: p-value $<$ 0.1.

environmental beliefs to ICEV use has been observed, car attitude has a competitive partial mediation role, meaning it reduces the influence of environmental beliefs on ICEV use, while bike attitude has a complementary relationship to environmental beliefs. This implies that even though pro-environmental beliefs can lead to a reduction of ICEV use, their influence mainly depends on the existing attitude towards the car and to a lower extent from the attitude towards its alternatives. In other words, reducing car attitude can have a more significant additional effect on an attempt to reduce car use via environmental awareness compared to increasing bike attitude. Even though car attitude is important, car-related symbolic-affective motives have no impact on ICEV use, and neither do they mitigate the influence of environmental beliefs.

Contrary to ICEV use, the total effect of environmental beliefs on EV use has been found to be insignificant, suggesting that it there is not a direct impact unless car attitude is considered as a mediator in our model. When mode-specific attitudes are considered as mediators, a negative indirect effect is observed through car attitude (-0.242). The positive sign of the direct positive impact on EV use (0.257) indicates that car attitude has a competitive role on the impact of positive environmental beliefs on EV use. In addition, the fact that the total effect is insignificant suggests that the effect of environmental beliefs on EV use is suppressed by the car attitude. In other words, pro-environmental beliefs are not going to lead to a reduction in car use, perhaps due to the utilitarian convenience of car use. This is an indication of the existence of spillover effects influencing the use of EVs stemming from environmental beliefs. Interfering directly with car attitude seems the only way to reduce EV use. Similarly to ICEV use, car-related symbolic-affective motives have no influence on either EV use or its relationship with pro-environmental beliefs.

Environmental beliefs have been found to have a positive total impact on both bike use (0.282) and bus use (0.125). However, in both cases, this impact is moderated through attitudes. As regards bike use, all mode-specific attitudes apart from symbolic-affective motives have been found to have a mitigating effect on the impact of environmental beliefs. More specifically, a positive indirect effect has been observed through both car attitude (0.373) and bike attitude (0.193), while a negative indirect impact has been observed though bus attitude (-0.016). Considering the direct impact of environmental beliefs on bike use has a positive sign (0.253) in the mediation analysis, car attitude and bike attitude have a partial competitive partial mitigation role, while bus attitude has a complementary partial mitigation role. This indicates that even though environmental beliefs lead to an increase in cycling by influencing car and bike attitude, they also have a smaller negative effect by making an alternative option like the bus more attractive as well. Despite this small negative effect, the overall effect of environmental beliefs on bike use is positive, with the attitude towards the car playing a more important role that the attitude towards the bike.

Environmental beliefs have an indirect impact on bus use, not through bus attitude as would be logically expected, but through car attitude (0.695) and bike attitude (-0.192). The estimated negative direct impact in the mediation analysis (-0.376) indicates that car attitude has a competitive partial mediation role, while bike attitude has a complementary mediation role on the impact of environmental beliefs on bus use. This means that the attitude towards the bus itself does not play a role in the decision to use the bus more frequently, but its rather an outcome of the attitude towards its alternative options. This might suggest that bus use in Nord-Jæren is more of a necessity or compromise that commuters make when both car and bicycle are either not available or they are perceived as inconvenient.

Finally, two significant correlations have been observed in our model. These are the correlation between car attitude and bike attitude, and between ICEV and EV use. Car attitude is negatively correlated to bike attitude (-0.510), suggesting that when one increases that other reduces. This is logical, considering that 2 out of 3 indicators of car attitude consists of statements regarding the relative convenience or preference of the car compared to other modes of transport, including cycling. Similarly, ICEV use and EV use are also negatively correlated (-0.495). This suggests that the two are similar behaviours and EVs substitute ICEV use. This is also logical considering that if a person has access to an ICEV, the chances of having access to an EV are lower, hence a lower probability to use one for their commute.

6. Discussion

The results from the analysis of the Regional Travel Survey data of 2019 showed that even though pro-environmental beliefs can lead to a more sustainable travel behaviour, considering the attitude towards the available travel options is essential. Attitudes can mitigate the effect of pro-environmental beliefs, with the attitude towards the car playing the most important role. A positive car attitude has been found to mitigate the effects of pro-environmental beliefs on car use (both ICEV and EV) as well as on its alternatives, i.e., the bus or the bicycle. In addition, car attitude has been found to fully suppress the impact of environmental beliefs on EV use, which indicates the existence of spillover effects stemming from environmental beliefs on commuters' travel behaviour. In this study, car attitude mostly expresses the relative convenience of the car compared to other options, consequently, as long as the car is considered the most convenient travel option, EV users will not reduce their car use levels because buying an EV satisfies their pro-environmental beliefs and works as a moral license to maintain their existing travel behaviour.

These findings support the argument of Du et al. (2023) that environmental awareness may trigger rebound effects, leading to counterintuitive results such as higher travel demand. Our findings are also in line with those of previous small-scale studies in literature. Specifically, our results confirm the findings of Daramy-Williams et al. (2019), Du et al. (2023), Hardman (2021), Langbroek et al. (2017) and Langbroek et al. (2018b), all of whom argue that EVs will more probably result in a higher travel demand. Finally, our findings also agree with Langbroek et al. (2018a) who observed that adopting an EV is probably going to increase travel demand for commuting trips.

According to our analysis, the key to promote sustainable urban mobility options and reduce car use in Nord-Jæren is the relative convenience of the car over all other travel options. Bus use levels in Nord-Jæren should be expected to stay relatively low unless the bus is perceived as equally convenient as the car, which is currently the dominant travel choice. This is in line with the findings of Tennøy et al. (2021) who argue that to improve the competitiveness of public transport in Norwegian cities, apart from improving the public transport system, it is essential to simultaneously restrict car use. Indeed, converting car lanes to bus lanes in Trondheim and restricting the access of EVs to bus lanes in Oslo led to an increase in public transport use in both cases (Tennøy et al., 2021).

As regards bike use, in addition to car attitude, the attitude towards the bicycle also plays a role, which means that apart from reducing relative convenience of the car, there is a minimum level of cycling conditions that needs to be met creating thus a positive attitude towards this travel option. These findings are in line with Pritchard and Lovelace (2022) who argue that an extensive Dutch-style bicycle path network has the potential to increase bicycle share in Nord-Jæren from 8% in 2019 to 26%. Such a network will create the necessary positive attitude towards cycling, by improving safety and thus reducing the stress of cyclists, while also increase the convenience of bicycles compared to the car by providing more direct access to locations. Promoting at the same time the universal use of e-bikes in Nord-Jæren can increase bicycle share to 35% (Pritchard & Lovelace, 2022). However, the impact of car attitude is more significant, suggesting that even though such measures are important, reducing the relative competitiveness of car through restrictive measures as well is also essential.

The findings of our study explain to some extent the changes in the modal share between conventional cars (ICEV) and EVs as well as the reduction of cycling and the steady levels of public transport use in Nord-Jæren after the road toll measure has been implemented in 2019. Disincentivising access to urban centres only for conventional cars, while allowing EVs to have free access probably gave commuters in Nord-Jæren the message that replacing their conventional cars with an EV is a rational, environmental, and socially acceptable choice. Considering also that most buses operating in the area are not electric probably contributed positively to this perception about EVs, as has been observed in similar a context in Stockholm (Langbroek et al., 2017). In addition, providing the same level of convenience to EV users as they previously experienced before replacing their conventional car maintained the existing positive attitude of commuters towards the car. Consequently, as the results of our study indicate, this decision turned EVs into a moral licensing tool that satisfies the pro-environmental beliefs of commuters, without them sacrificing their existing lifestyles.

7. Conclusions

This study explores if and to what extent promoting EVs as an environmentally friendly solution while incentivising them at the same time turns EVs into a moral licensing tool that influences travel behaviour. The findings from the case of Nord-Jæren has confirmed this hypothesis, since in contrast to conventional car use, pro-environmental beliefs have been found to have no influence on EV use, because their effect is suppressed by the relative convenience of using an EV compared to a more sustainable alternative like the bicycle or the bus. Therefore, despite adopting a UGA to reduce the already high levels of car use, incentivising EVs and promoting them as an environmentally friendly travel option for more than three decades made it difficult to change the existing car-oriented lifestyle.

Adopting a similar strategy in other car-oriented areas may also lead to similar outcomes. Most car-oriented urban areas are characterised by high inconvenience of public transport and cycling compared to the car, developing thus a positive attitude towards the latter. One important lesson from the case of Nord-Jæren is that a significant reduction in car use cannot be achieved only by improving alternative travel options. Creating favourable conditions for car travel by incentivising EVs in parallel to this effort can increase travel demand creating several adverse effects, such as higher energy consumption and traffic congestion. To promote more sustainable travel modes, it is not enough to improve them, but it is essential to implement restricting measures on car use as well to ensure that their relative convenience gap with car use is reduced.

Despite the valuable insights that this study provides on the existence of spillover effects stemming from pro-environmental beliefs on travel behaviour, it is important to acknowledge one important limitation related to the consistency of our measurement model. Specifically, even though Cronbach's alpha for car attitude and car-related symbolic-affective motives were found to be higher than 0.6, which is generally considered acceptable in some research contexts, their values suggest a degree of variability in the responses within these factors. It is worth noting that Cronbach's alpha is influenced by various factors, including the number of items in a scale. Considering that these two constructs are conceptually related, this might suggest that combining them into a single factor could be more appropriate. However, symbolic-affective motives in our study have been found to have no influence on commuters' behaviour. Thus, combining them into a single factor could result in misleading conclusions, despite improving Cronbach's alpha. Therefore, we decided to include these concepts as two separate factors in our study. Nonetheless, future studies might benefit from considering them as one single construct, or by measuring the responses regarding more items related to these two concepts.

Finally, another limitation of this study is that it relies on self-reported cross-sectional data, which means that it is not possible to check whether respondents have adjusted their responses on the attitudinal statements to match their reported behaviour and consequently justify it. Longitudinal data can give a higher confidence on the causal relationships that were observed in our study. They also allow to explore how both attitudes and behaviour change through time, exploring the bidirectional relationship of attitudes and behaviour that is often mentioned in literature.

CRediT authorship contribution statement

Ioannis Kosmidis: Conceptualization, Methodology, Data curation, Formal analysis, Visualization, Writing – original draft. **Daniela Müller-Eie:** Conceptualization, Resources, Writing – review & editing. **Alexa Delbosc:** Conceptualization, 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.

Acknowledgments

The authors would like to thank Kolumbus AS for providing access to the Regional Travel Survey data. They would also like to express their gratitude to the two anonymous reviewers for their valuable feedback and constructive comments that significantly improved the quality of this paper.

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