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CHARACTERISATION OF NORWEGIAN BATTERY ELECTRIC VEHICLE OWNERS BY LEVEL OF ADOPTION

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Executive Summary

In this paper we investigate differences between groups of Norwegian electric vehicle owners sorted by their adoption level. The grouping is based on adoption theory and the share of battery electric vehicles in new car sale numbers. We investigate Norwegian adopters' preference, values, and drive for choosing a battery electric vehicle. The main data source is a yearly survey between 2015 and 2020 with Norwegian electric vehicle drivers as respondents. The motivation of the study is to reveal different choices by the adopter groups, contributing to policy recommendations and incentives for other countries. However, the Norwegian case is also a special case, having economic advantages which many other countries do not have the access to. We assess the validity of the results and policy recommendations by analysing the results of a survey amongst the Nordic countries on investment choices concerning battery electric vehicles.

Keywords: BEV (battery electric vehicle), market development, user behaviour

1 Introduction

As a response to local pollution and aims to reduce greenhouse gas emissions in the atmosphere, many countries have applied extensive measures. Targeting the transport sector, Norway has focused on electromobility, and have introduced and upheld beneficial local and national policies, making it convenient and affordable to adopt electric vehicles [1]. This accelerated the sales and the adoption of battery electric vehicles (BEVs), and data on new vehicle registrations in 2022 (year to date) show that 83,7% of new registrations are BEVs [2].

The multiple incentives in Norway were launched throughout different periods of the adoption phases. The added value taxes have traditionally been high, and already in 1991, the BEV users were exempted from this tax. This reduced the price considerably and accelerated the import of BEV's onto the Norwegian market [1]. In the late 1990´s exemption from toll road fees were introduced, and after a test period of free parking, this was fully

established in 1998 [1]. These measures contributed to expand the share of BEV's onto the Norwegian market, starting the diffusion of the early market phase. In this phase, the innovation process also took place in Norway. Even though international car producers dominated the market in the long run, the technology development was important for policy incentives. The exemption from VAT and BEV's access to the bus lanes were pointed to be of the most important incentives launched in the early market phase. Numbers from the former Norwegian EV-producer, Th!nk, shows that the demand for BEV's increased considerably after the launch of these policies [1]. In 2009, the bus lane access became a permanent incentive, and all BEV's could also use ferry connections without cost [3].

Two key documents were launched in 2012: This was "The Climate Message" and "The Climate settlement" [4]. The documents pointed out clear goals for the transport sector and put a maximum limit of GhG emission for new cars in 2020. The limit shouldn't exceed an average of 85g of CO_2 per km. The climate message also emphasised several measures to make the Norwegian car park more climate friendly, such as low emission technology for taxis, facilitate the use of electric vehicles and the launch of new electrification infrastructure. These measures contributed to the spread of BEV's in other sectors as well, enforcing the spread of technology onto freight operators and other transporters.

The measure above has contributed to decreasing the barriers for people to purchase BEVs and has been important for the increasing adoption in Norway. A report from 2020 suggests that BEV owners have become more similar to ICEV owners. They have also become richer, emphasising economic incentives when purchasing a BEV. There are also specific trends to own a BEV as a second car [5]. Gradually, the state authorities have reversed many of these exemptions, ferry fees and toll road tickets where reintroduced in 2018, and the bus lane access became more restricted. It is therefore likely to assume that there are some differences between people who purchased BEV's in the early market phase, compared to those purchasing it after the incentives became more prominent, and later removed. To determine and discuss these differences will be the main aim of this paper.

1.1 Previous literature on BEV adoption

The diffusion phase of BEV's in Norway started already in the 1970s. The period from 1990 to 2009 is known to be the "technology niche creation-phase". And as stated above, several policies were launched during this period with the main intent to nurture the BEV industry and to create a market for this industry [6]. The BEV users in Norway have evolved from a typical innovator and early adopter group in 2014-2015 to early majority in 2018. During this evolution, the group of BEV users has become more similar to internal combustion engine vehicle (ICEV) users [5].

Several things seem to affect people to adopt BEVs, and many studies have been on Norwegian adopters since they have come long in the diffusion phases. [7] points to that in small communities such as Norway, pricing incentives are the most efficient measure that affect people to adopt BEV. The same results are also confirmed with [3], which suggests the purchase tax and VAT exemption as the most important incentive affecting people to adopt BEV's. The people responding to reduced use costs are often highly educated, with lower income, and living in the third largest city of Norway, Trondheim [3]. [5] also states that most people owning BEVs, also has high income, and adds that very few has minority background. Their study also confirms that BEV owners usually live in large cities and suburbs. Users that are concerned with incentives being removed, are often over-emphasising the importance of the incentives itself [3]. Households holding 1 BEV are families consisting of couples with kids, together with households consisting of singles. This group the age span is often between 25 to 44 years old. Couples with kids and couples without kids are dominating the group owning 2 BEV's [5]. A qualitative study executed by [8] investigates BEV users through in depth-interviews and found that the BEV users were a very heterogenous group, that for economical and practical purposes adopted a BEV. They also emphasised to be environmentally friendly, taking pride in their vehicle.

[9] finds that local policies relating to electromobility in Oslo and Bergen contributed increase in the relative advantage of BEV's and therefore to spike the sales of BEV's in the municipalities. The policies increasing the

relative advantage, were in particularly policies that expanded the charging infrastructure and giving access to bus lanes.

Studies on electromobility in other countries also investigate criteria for users to adopt BEV's. [10] detects barriers for adopting BEV's in China through surveys. Experienced drivers emphasised battery cost and purchase cost as an important incentive to adopt BEV. The increase in the amount of public charging infrastructure, installing new charging infrastructure, and purchase subsidies were also measures emphasised as important incentives by all the BEV users. The cost considerations as the most powerful incentives for adopting BEV in China were also confirmed by [11]. Also, only 33,6% of the respondents not owning a car were interested in purchasing BEV [10]. Of the respondents already owning a vehicle, 46,8% were interested in purchasing a BEV as a second family car. The Chinese BEV population has developed to an early majority, and [12] investigating motives behind BEV purchase comparing China and the early adopter staged South Korea. The environmental concern was higher in China than in Korea. In Korea it was the economic motives which was the most important motive to buy a BEV [12]. The Chinese early majority also had a stronger level of symbolic perception towards their vehicle and were sensitive to the fact that driving a BEV would contribute to an image of being environmentally conscious and responsible. The Chinese where although less satisfied, and emphasized a lack of charging points, and a too high purchasing price. The Koreans BEV users where more satisfied, due to the large price exemptions. A study has also investigated the difference in willingness to pay between Chinese and US BEV users, which suggests that users from the US are willing to pay higher prices for BEV's than Chinese users. The study also suggests that the Chinese respondents are more receptive to BEV's than American respondents regardless of the subsidies. This is due to key distinctions of the Chinese market, that is not prominent in the US. 2/3 of the Chinese adopters are first time car buyers, who typically have less experience with both gasoline and plug-in vehicle technology [13]. People with more experience with BEV's where also more willing to adopt them [11]. The more people who are in favour of BEV technology, and are aware of environmental protection, the more are other willing to adopt them [14]. Based on the earlier research, BEV users have had specific traits and have been emphasising different things when adopting BEV's. Over the years, these users have become more similar to the rest of the vehicle user over the years. The main aim of this paper will be to characterise how Norwegian BEV users has developed from the early marked phase until today, and which incentives they emphasised in each adoption phase.

It is important to investigate the drive for each of this group to purchase a BEV, since investigating Norwegian adopters' preference, values, and drive for choosing the BEV may contribute to exclusive information on adopter choices. This knowledge may contribute to recommend policies and incentives for other countries. The main aim of this study is to address this issue by investigating how BEV users have changed from 2015 to 2020, depending on how long they have owned a BEV. Based on previous literature, it is reasonable to assume that there will be distinct differences between a user adopting a BEV in 2013, versus a user adopting it in 2020. We therefore aim to investigate these research questions:

- What incentives were emphasized by first movers and early adopter's when purchasing BEV's in Norway?
- How may the adoption experiences from Norway be used in policy making for further BEV acceleration in other European countries?

First, we investigate data from a yearly survey amongst Norwegian BEV users between 2015 and 2020 to see what influenced different stages of first movers, early adopters and early majority when adopting BEVs. The second part is to investigate numbers from European countries (EU + EFTA + UK + Turkey), to see what stage each country is in, depending on the theory. ()

2 Theory of Diffusion of Innovation

The increase in market share for BEV's in the Norwegian market, demands for an investigation of different type of user groups. In [15], Rogers theory of diffusion of innovation is presented. The theory is based on different

characteristics related to groups that adopt new innovations at different times, which are presented in short in this chapter.

The first adopters are Innovators. In this study we will refer to these adopters as first movers, the very first people to adopt a BEV. They are characterised as a deviation from the social system, having high technological competence. The first movers might be closely related to the innovation process, and a prerequisite to be a first mover is control over substantial financial resources and must be able to cope with non-profitable investments. The innovator also plays a crucial role in the diffusion process. An early adopter is someone that starts using the innovation earlier than the rest of the participants in the social system. Rogers describe an early adopter as an opinion leader and is quite respected by his or her peers. This person often ends as a role model to whom later adopters turn for advice. Further on, Rogers describe early adopters as more educated, having higher social status, and are in general more wealthy than later adopters. They are well integrated into the social system, trust science and cope well with risk taking.

In the social system among the first movers and the early adopters, the early majority, late majority, and the laggards also exist. The early majority are the most numerous groups of adopters and deliberate for a while before deciding on adopting a new technology. They are the last group to adopt before the other half of the social system. The late majority adopts a technology later than the rest and are in general sceptical towards new innovations. The laggards are the last adopters and has their point of reference in the past. Comparing socioeconomic characteristics between early adopters and late adopters, Roger's point to a small difference in age. Early adopters have higher years of formal education, are more favourable of change, coping well with risks and uncertainty.

The stages of diffusion of innovation is shown in Figure 1. The 2,5% first that adopts an innovation are known as first movers. The second group ranges from 2,5% to 16% and are early adopters. From 16% to 50% are regarded to be early majority. The late majority are from 50% to 84%, while the last 16% that adopts an innovation are called laggards. In our study we limit the social system to new vehicle buyers and define the stages of adoption in line with the percentage of BEVs sold per year compared to total new vehicle sale.

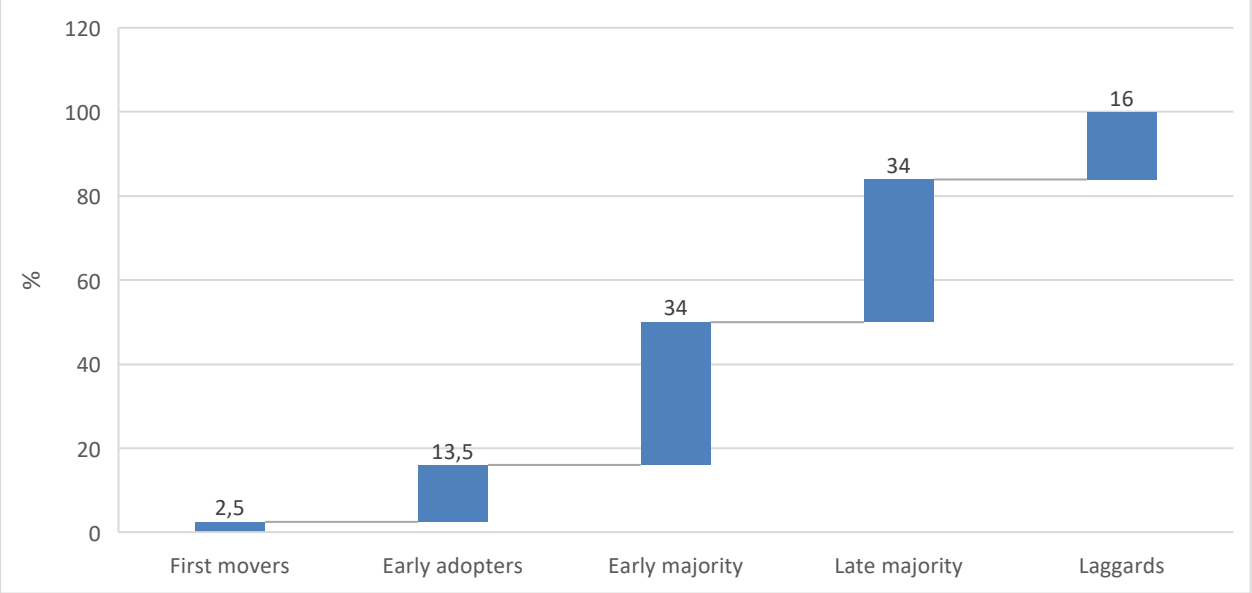

Figure 1: Adopter stages from Roger's "Diffusion of Innovation" [15].

3 Data and methods

The main data source in this study is a survey held by the Norwegian EV association between 2015 and 2020. This is a yearly survey amongst members of the EV association, and the number of respondents is in the order of 10 000 each year. Most of the questions are repeated each year.

The reasons for choosing data between 2015 and 2020 is based on our theory, "Diffusion of innovation", and numbers on new BEV registration obtained from European Alternative Fuel Associations (EAFO) [2]. The numbers from Norway from the year 2011 to 2020 is showed in Table 1.

Table 1: New registrations of passenger BEV's in Norway. Source: [2]

First movers	Early adopters			Early majority					Late majority
2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1,5%	3,10%	5,8%	12,6%	17,1%	15,7%	20,8%	31,2%	42,3%	54,3%

According to Roger's curve, the Norwegian new registrations of BEV's went into the phase of early adopters already in 2012. The early majority stage was reached in 2015, and late majority stage in 2020.

With data from 2015, it will be possible to investigate how respondents that obtained a BEV four years earlier answers. This gives us important insight in first mover reasons for obtaining a BEV. Applying data from 2015, investigating respondents that obtained BEV two or more years prior, will welly catch the important factors for BEV adoption in the early adopter stage. By applying data from 2020, investigating people that obtained a BEV two or more years earlier, will give us great insight on early majority reasons for adopting BEV.

We chose newly registered passenger cars because we know that these are cars that most likely are in everyday use. If we chose to investigate the total amount of BEVs in the car park, it might be large parts of a country's total car park that are old vehicles being used less frequently.

The surveys have been distributed mostly through the BEV associations channels, and it is therefore reason to believe that the results will be reliable to the populations of BEV users.

Table 2: Classification of adopters in the surveys and number of respondents per year.

Group	Definition of each group from the dataset	No. of observations
Early majority	Dataset 2020: Those who has owned BEV for 1-4 years.	6784
	Dataset 2019: Those who has owned BEV for 0-4 year	7997
	Dataset 2018: Those who has owned BEV for 0-3 year	6766
	Dataset 2017: Those who has owned BEV for 0-2 year	7183
Early adopters	Dataset 2018: Those who has owned BEV for 4-5 years	718
	Dataset 2017: Those who has owned BEV for 3-5 years	1547
	Dataset 2016: Those who has owned BEV for 2-4 years	914
	Dataset 2015: Those who has owned BEV for 1-3 years	3107
First movers	Dataset 2016: Those who has owned BEV for more than 5 years	139
	Dataset 2015: Those who has owned BEV for more than 4 years	423

In addition to the Norwegian survey described above, the Nordic EV barometer is held yearly. This is a narrow survey focusing only on the next car purchase of the respondent. A representative sample of the populations in Denmark, Finland, Iceland, Norway and Sweden are interviewed through a web-based questionnaire.

The method applied in this paper includes a descriptive analysis of the data from the survey held by the Norwegian EV Association, with the theory of diffusion of innovation as a framework for classification of BEV users. This is further discussed in a European setting using new car registration data from EAFO and the Nordic EV barometer to discuss the main barriers for higher EV adoption on a European level.

4 Results

In this chapter, we present differences between the defined adoption groups, with results from both the Norwegian and Nordic survey. Some of the demographic differences between the groups are shown in Figure 2. Here, we see that the first movers have a higher share of men, higher age and education levels, and are more often in smaller households compared to the early adopters and early majority. The part of females increases further out as the adoption groups evolve. The education level decreases throughout the adoption groups. Usually, first movers where also often households of 1-2 and 3-4 people.

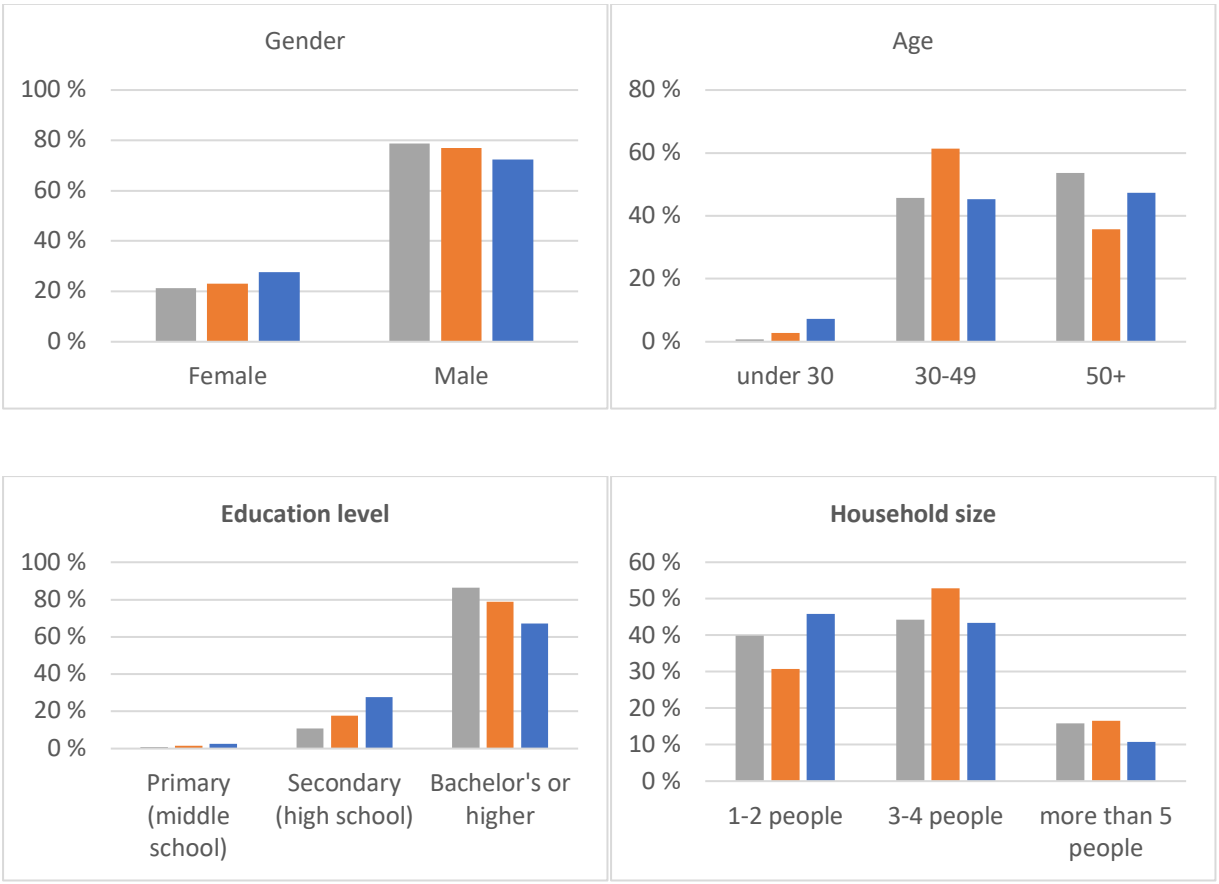

Figure 2: Sociographic differences across the three adopter groups: First movers (grey), Early adopters (orange), Early majority (blue). Top left: Gender distribution. Top right: Age distribution. Bottom left: Education distribution. Bottom right: Household size distribution.

In Figure 3, results regarding vehicle choice, travel mode choice and purchase inspiration are presented. Regarding car purchasing choice, this question is also asked in the Nordic EV barometer. However, the latter is sampled in a representative part of the population, while the sample in Figure 3 are members of the EV association. We see that the limited sample, theoretically representing adopters up to and including the early majority, state

that only 2-4 % would have bought a petrol or gasoline car. In the Nordic survey, the equivalent numbers are 26 % (Norway), 34 % (Sweden), 30 % (Denmark), 45 % (Finland) and 39 % (Iceland).

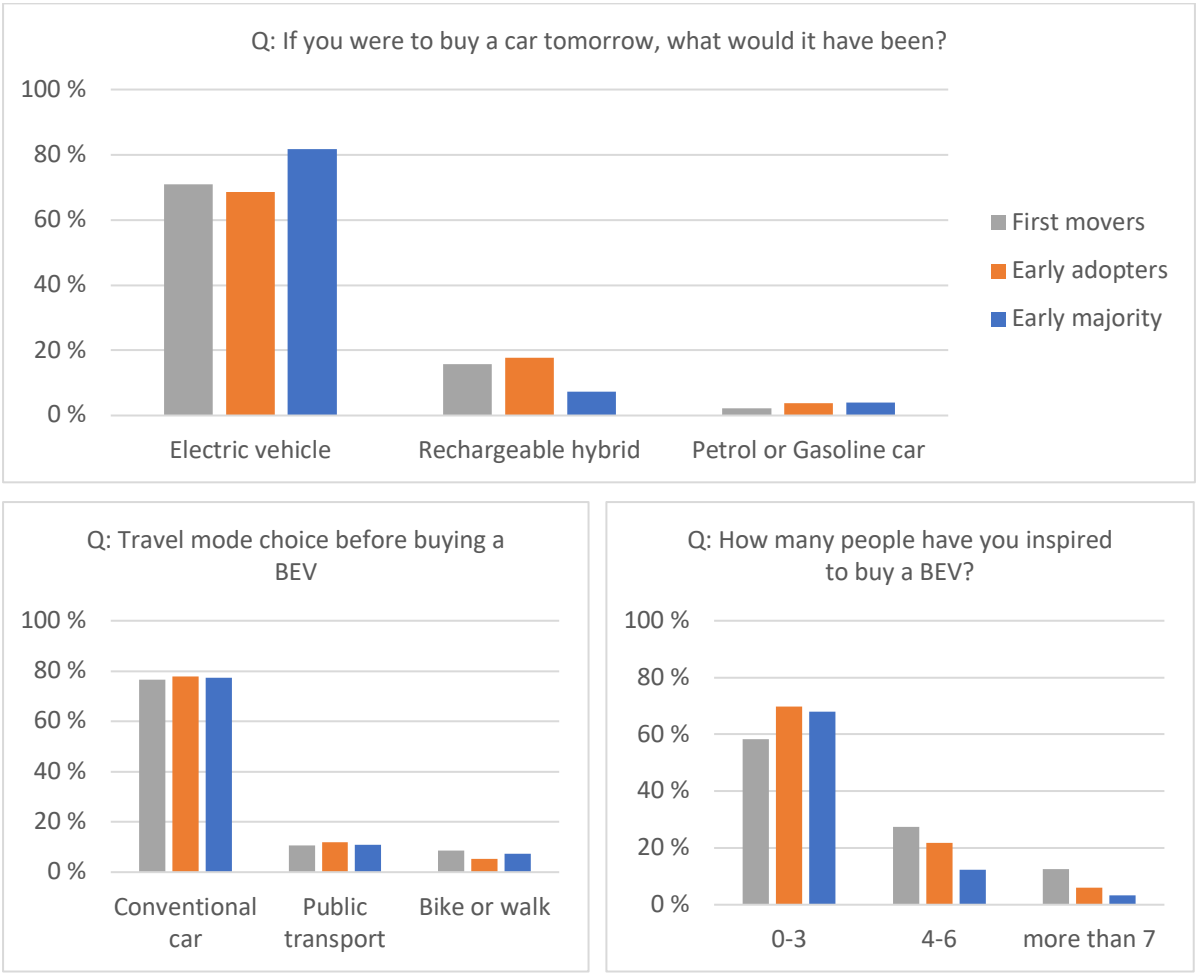

Figure 3: BEV uses and their choice of vehicle

When looking at the drivers for buying a BEV, as shown in Figure 4, we see that the first movers emphasized to be climate friendly, while the early majority emphasized low operating costs. Regarding the most important information source used before buying a BEV, the first movers found information about BEV's in media before purchasing. However, the early majority got information to a higher degree from friends, family and on web pages.

In Figure 5, the differences in opinions by early adopters between 2015 and 2017 regarding drivers for buying a BEV are presented.

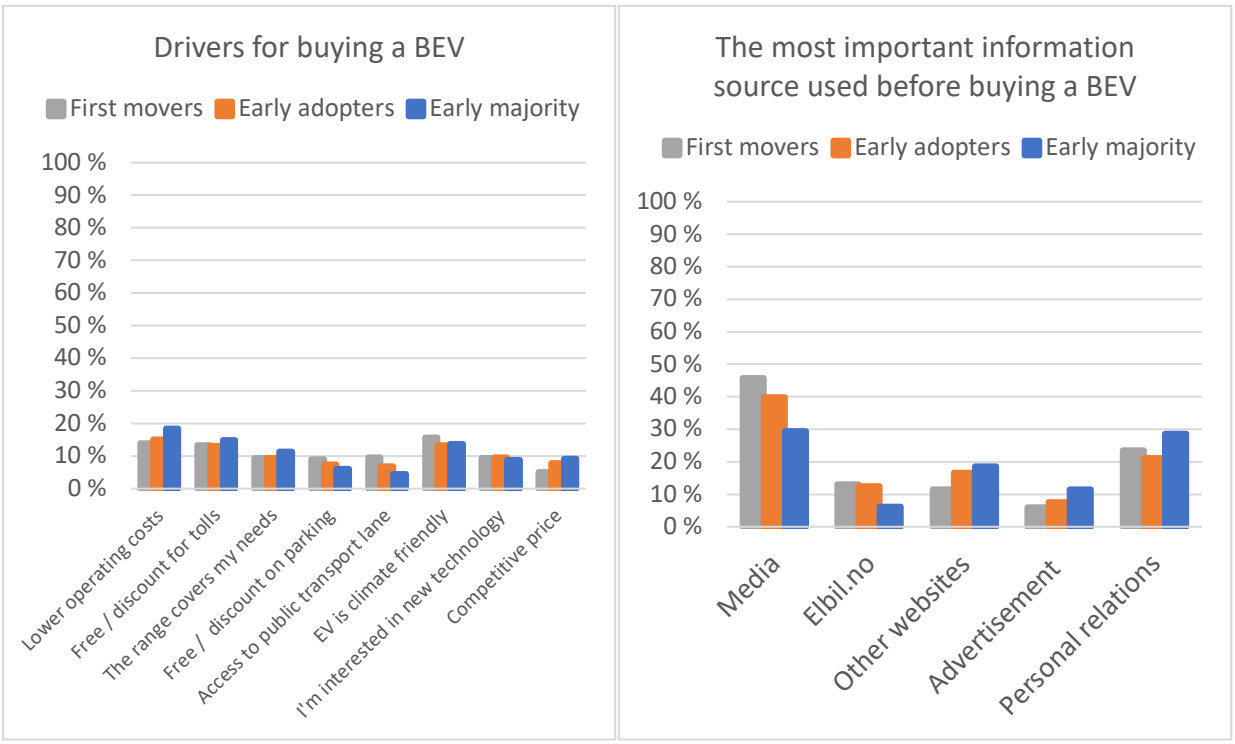

Figure 4: Expressed opinions for the three adopter groups regarding drivers for buying an BEV (left) and important information source when buying an BEV (right). Each concentric curve represents a 10 % increase from 0% (centre of figure)

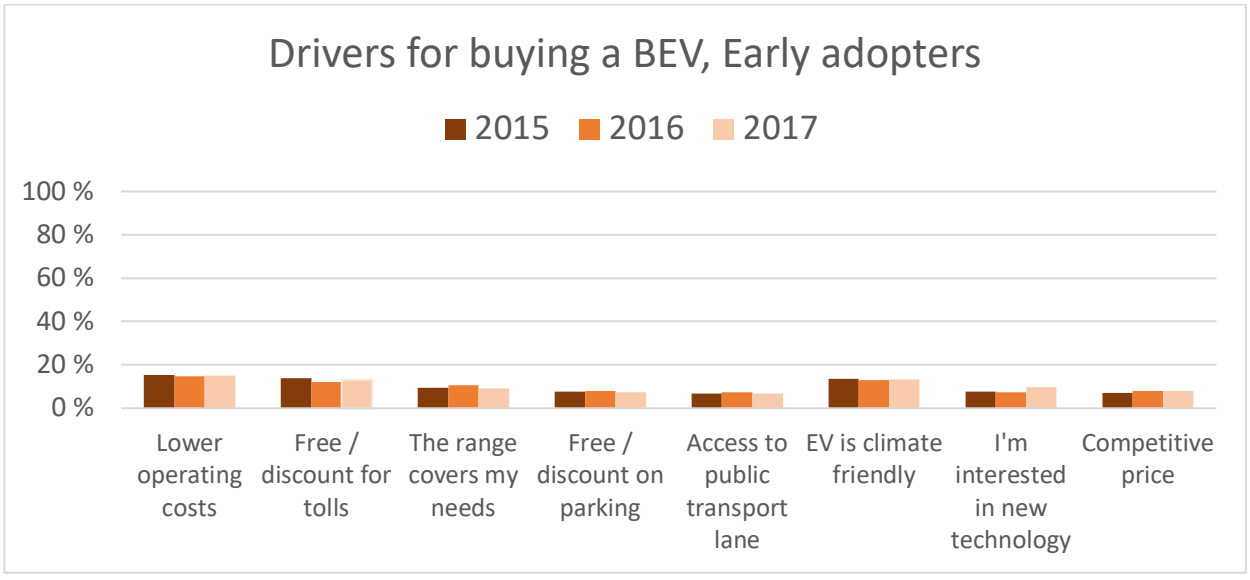

Figure 5:Differences over time in stated drivers for buying a BEV by early adopters, 2015-2017.

4.4 European adoption stages

In Figure 6, the innovation stages in European countries are shown, split into the four different categories first movers, early adopters, and early majority. As first movers, there are overweight of Southern and Eastern European countries. In the early adopter group, we find that the Northern European countries are dominating. The countries that have come furthest in the acceleration process is Iceland, Norway, and the Netherlands. A clear distinction between Western and Eastern Europe is apparent in the graphic representation of the numbers.

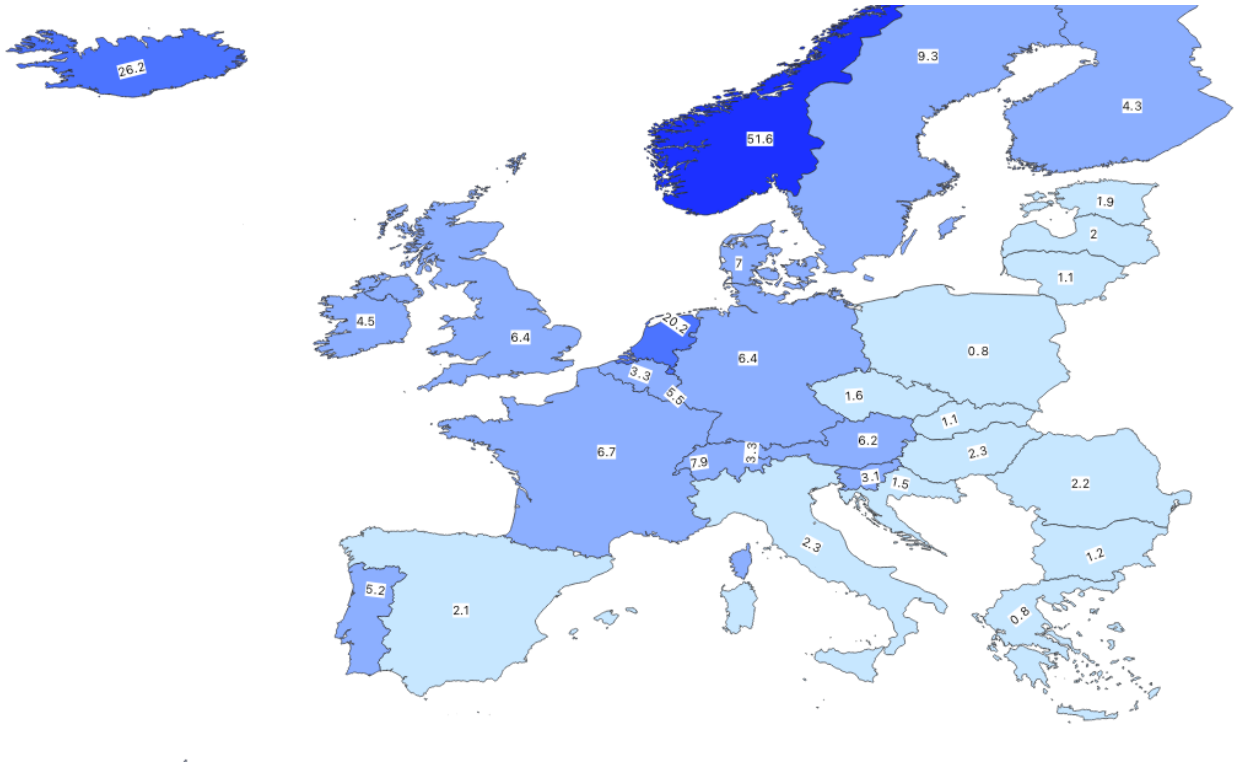

Figure 6: BEV Distribution across Europe. Dark blue: Late majority (50%-84%). Blue: Early majority (16%-50%). Light blue: Early adopters (2,5%-16%). Turquoise: First movers (0%-2,5%).

5 Discussion

This study aims to improve the understandings of BEV adopters in Norway and drivers for different adoption phases. Based on the Diffusion of Innovation theory, people that adopt new technologies have different characteristics. Based on this, they should also emphasise different kinds of incentives. Knowing the emphasis of each adopter group in Norway, may contribute with valuable knowledge about incentives to put in place for other countries aiming accelerate electromobility.

The application of the theory should not be done without consideration to the representativeness of the sample. Therefore, it is important to emphasize that the sample in the Norwegian survey consist of people already driving a BEV. The results are in general in line with the expectations based on the presented literature review. In addition, as shown in Figure 5, there are some small variations over time in the responses, but it seems like the early adopter group is relatively consistent. Although there might be some persons participating in the survey repeatedly each year, the results increase the robustness in the application of the innovation theory.

5.1 Diffusion of innovation theory and BEV users in Norway

The Diffusion of innovation theory draws on both socioeconomic traits and personal traits in each adopter group. According to the theory, there are little differences in age between the early adopters and the later adopters. Our results, as shown in Figure 2, do not align completely with this. Instead, the early adopters have a higher amount of people between 30 and 49 years old than the rest of the adopter groups. Our results point to that the education level among people adopting technology in the early stages are higher than later adopters. This align with the theory, stating that early adopters are more likely to have higher education than late adopters. First movers are also specified as highly technological competent, which also might be related to the amount of higher education among them.

There are several reasons for purchasing a BEV, and the driver for purchasing varies between each adopter group. In our results the first movers emphasize being climate friendly, the access to public transport, and environmental discount on parking in public parking lanes. Overall, the first movers are emphasising economic incentives in a smaller degree than the later adopter groups early adopter and early majority. The theory establishes that first movers often have a substantial high amount of money since they are investing in a technology very early in the innovating process. Because of this, the first movers do not seem to emphasise economic incentives as much as the later adopter groups. This is visible in our respondents and might contribute to a smaller emphasis on economic incentives, since they are already quite affluent.

The first movers emphasise being climate friendly more than the later adopters when purchasing a BEV. The diffusion of innovation theory points to that first movers emphasise knowledge and science to a high degree, and therefore acquire a lot of knowledge. This might be seen in relation to their BEV adoption and their concern on climate change and environmental research.

The theory points to early adopters work as opinion leaders, being used as reference points for providing information for later adopters. In our results, the first movers and the early adopters get most of their information from the media, or the newspapers, while the early majority favours to consult other people that owns a BEV, such as family or friends.

5.2 Transferability to European countries

Our results show some incentives that are clearly emphasised by different adopter groups, and in this section, we will attempt to draw some main learning point from out adopter study, transferring them to other countries in Europe.

Electric mobility is relatively new for large parts of Eastern and Southern Europe, and many of them are in the first mover adopter group, having a very small share of BEVs of new car sales. To accelerate and make it a desired means of transport, the evidence from our result might give important insights for policy makers in the respective countries. As we saw from our results, it wasn't necessarily economic incentives that drove the adoption for the first movers, since they already hold substantial amounts of money. This group seemed more driven by exclusive accesses and being environmentally friendly when choosing a BEV. Therefore, exclusive access to for example bus lanes or restricted parking areas might apply to the first mover group. This group also emphasise the environmental aspects of the BEV technology. The first movers rely on science and knowledge in their decision. The authorities can based on this run information campaigns with information about BEV and their impact of emission reduction and other environmental benefits.

For the countries in the early adopter phase, which is mostly North-western Europe, another set of incentives could be more efficient. We see that price reductions are more efficient for this group. However, it is worth mentioning that Norway is in a special position regarding both general wealth and taxes on fossil fuelled cars, which is not necessarily transferable to other countries. Therefore, any incentive which increases the economic situation of car ownership in the advantage of BEVs should be prioritised.

These kinds of incentives should also be continued when entering the early majority phase, to continue the adoption and accelerating the BEV share.

6 Conclusion

This study has related the theory of diffusion of innovation on BEV users to classify them in different stages of adoption after percentage of new cars sold being BEVs. With the Norwegian BEV users already being in the late majority phase, large parts of Europe are still in the first mover and early adopter stage. While the first movers are driven by e.g. environmental reasons, it seems to be necessary with economic incentives to accelerate the transition to the other adoption stages to increase the BEV share in general.

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