Norwegian School of Economics
Bergen, Fall, 2020

Impact Assessment of Electric Vehicles Incentives on EV Adoption and Road Traffic

The cases of Norway and the Netherlands

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Master Thesis in Energy, Natural Resources and the Environment

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Abstract

The increase in air pollution is a critical issue both at local and global level, as it endangers people' health and accelerates climate change. The United Nations claimed that to keep global warming at 1.5°C, carbon neutrality must be reached by 2050 and neutrality for all other GHG within the end of the century. One of the main drivers of the increase in greenhouse gas emissions is the combustion of fossil fuels in the transport sector. Electric vehicles potentially present an effective solution to decrease emissions in the sector by substituting internal combustion engines with electric ones in the case of battery electric vehicles or adding dual motors in the case of plug-in electric cars. Electric motors do not directly release polluting substances in the air and their negative externalities can be reduced by charging through renewable energy.

To assess the effect of incentives at national and local level on EV adoption, regression models are used and data on registered and sold automobiles is compared before and after the introduction of supporting measures for electric vehicles. To investigate the possible increase in road traffic consequent to favorable electric vehicles' regulations, data on cars' mileage is studied by using the same statistical method. The research focuses on the cases of Norway and the Netherlands due to their widespread governmental and local involvement, ambitious environmental goals and data availability. The analysis demonstrates that the adoption of electric vehicles is significantly correlated with national incentives as well as with the authorities' involvement in raising environmental and commercial awareness. The most effective incentives are financial, decreasing the cost of purchase, while local policies such as the installation of EV charging infrastructures or free ferry rides do not have a significant impact on electric cars' adoption. Finally, data shows that EV incentives do not increase traffic volumes.

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1. Introduction

Road traffic generates numerous negative externalities (Parry, Walls and Harrington, 2007). Locally, air pollution has negative consequences on human health causing respiratory problems and earlier mortality in individuals at increased risk (Brunekreef, 2010; Hoek et al., 2013; Ostro, 2004). At the global level, greenhouse gas emissions accelerate climate change. Electric vehicles (EV), in particular battery electric vehicles (BEV), present a potential alternative to internal combustion engines cars as they significantly reduce air emissions from use thanks to their electric motor (Björnsson and Karlsson, 2017). In terms of EV market share, Norway and the Netherlands are key players in the EV revolution with 2019 passenger vehicle sales shares of 55.8% in the former country and 15.1% in the latter. Norway is currently the main market for electric vehicles in Europe and the first to achieve an EV market share above 50% in 2019 (Demandt 2020; EAFO, 2020; Knoema, 2020; Netherlands Enterprise Agency, 2020). Today the two countries are moving towards their goal of reaching the sale of only zero-emission vehicles by respectively 2025 and 2030 with different approaches: Norway focuses on the polluter pays principle, i.e. nudging consumers towards using zero emission vehicles by making fossil fuel combustion cars more expensive, while the Netherlands also implements command and control measures, i.e. banning the sale of conventional vehicles (Deuten, Gómez Vilchez and Thiel, 2020; Norwegian Government, 2018).

The thesis adds to the current literature on EV incentives by providing an analysis of the context and the impact of governmental involvement of the two European frontrunners on the adoption of electric vehicles to decrease their transport sector emissions. Data on registered vehicles, sales and road traffic in Norway and the Netherlands is studied to test the three following hypotheses:

(1) Policy incentives have a positive effect on electric vehicles adoption

(2) Local policy incentives lead to different EV adoption rates at regional level

(3) EV incentives lead to an increase in road traffic

The present research first presents the current environmental context, a literature review on the topic and the methodology applied in the study, offering a more detailed background of the issue and data used in the analysis. Subsequently, Norway and the Netherlands are described in detail, providing information on their national contexts and EV policies implemented. Analyzing the Netherlands requires to understand the mechanisms and environmental targets of the European Union, as it is a member and must comply to the EU regulations. The last part of the research compares the data across the two countries and provides results for the three hypotheses. While the first hypothesis is not rejected, the second and third are rejected: incentives at national level stimulate the acquisition of electric vehicles by lowering the initial investments and operational costs that buyers incur, while local incentives such as the increase in charging stations available or free ferry rides do not have a significant impact on EV adoption. Moreover, EV policies do not directly increase road traffic. Section 8 discusses the limitations of the thesis before the conclusion in chapter 9.

2. The current context

2.1 Climate change and the transport sector contribution

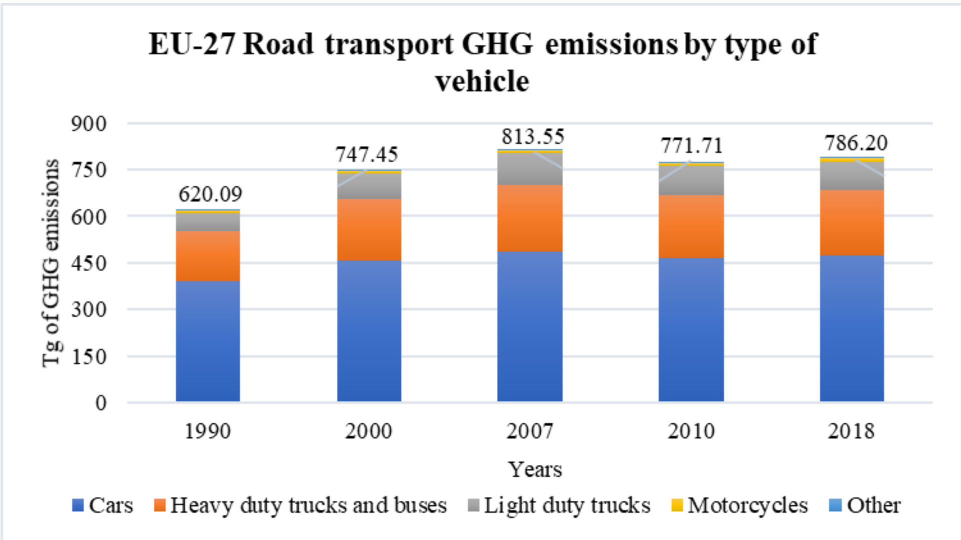
Since the design of the steam engine in 1784, individuals have started to increasingly affect the environment, which led to the beginning of a new epoch: the Anthropocene. Humans' activities remodel nature through land usage, deforestation and the burning of fossil fuels (Crutzen, 2006). At the same time, the world's population has been increasing thanks to the technological and medical progress, and easy access to natural resources, brought by the Industrial Revolution. Together with urbanization, the world economy and energy consumption have largely increased in the 19th century countries now classified as developed (Bairoch and Goertz, 1986).

Fossil fuels are non-renewable resources derived from dead prehistoric plants and animals that were gradually covered by layers of rock. Depending on the combination of organic matter, time spent underground and pressure conditions, various kinds of fossil fuels developed. The most cited are oil, coal and natural gas (U.S. Department of Energy, 2020). The advent of rail in the 1830s in the United Kingdom allowed for a fall in coal prices and its greater adoption instead of low carbon energy sources, like biomass or hydropower (Ahuja, 2015). Today, fossil fuel companies drill or mine in hope of finding and burn them to generate energy, or to refine them to be used as fuel for heating or transportation. In the last two decades, the burning of fossil fuels accounted for around ¾ of human-caused emissions, leading to the greenhouse effect (U.S. Department of Energy, 2020).

The transport sector is a strong contributor to fossil fuel combustion and to the release of GHG emissions as oil is the primary fuel source for vehicles globally. Once crude oil is pumped out, which mainly happens from underground reservoirs, it is processed in refineries to produce fuel oil, gasoline, petroleum gas and other products. In Europe, 94% of the energy needs of the transport sector depend on oil, 87% of which is imported from foreign countries, causing significant imports and environmental costs. In 2015, the expenses for the importation of crude oil in Europe accounted for EUR 187 billion circa (EAFO, 2020), which could be significantly reduced by taking advantage of the renewable resources available on the territory. Oil causes serious environmental issues, like environmental degradation due to its extraction and oil spills, and the release of fine particulates in the air when burned. As traditional crude oil reservoirs are reducing, oil industries are beginning to extract oil from shale and tar sand. These methods require greater energy consumption and cause greater emissions and environmental harm (Environmental and Energy Study Institute, 2020).

Graph n. 1 shows the EU-27 road transport GHG emissions by cars, light and heavy-duty vehicles, motorcycles, and other road transportation for 1990, 2000, 2007, 2010 and 2018. These years were chosen to show the amount of emissions for every decade since 1990, which is taken as reference year for many policies. In 2007, total emissions reached a peak, corresponding to 863.924 million tons of CO_2 equivalent, 191.228 million tons more than in 1990. Emissions have been decreasing until 2015. In 2014, the Netherlands registered 107 g/km of CO_2 release, the lowest average for new cars in the European Union thanks to the high fleet portion of electric vehicles and heavy taxes on inefficient cars (EEA, 2015). From 2016 emissions started to rise again, reaching 828.025 million tons of CO_2 equivalent in 2018. Within the transport sector excluding international maritime, road transport accounts for 95% of all greenhouse gas emissions, of which a little less than half is produced by cars (EEA, 2020). CO_2 emissions are the main greenhouse gas and, in 2018, they corresponded to 98.8% of total GHG emissions in the EU-27 transport sector and to 24.4% of those caused by road transport.

Graph n. 1



Data source: EEA, 2020

Norway and the Netherlands have been at the forefront in the fight against climate change, decreasing their total GHG emissions, largely coming from the transport sector, and increasing competitiveness in their automotive industry. Emissions per capita are lower in Norway thanks to its greater use of renewable energy (European Environment Agency, 2020). In 2019, Norway released 50.3 million tons of CO_2 equivalents, while, in 2018, the Dutch total GHG emissions equaled 188.2 million tons of CO_2 equivalents, 17.8% less than in 1990 (European Environment Agency, 2020). Emissions per capita corresponded to respectively 9.15 million tons of CO_2 equivalents and 9.5 metric tons of CO_2 (Global GHG and CO_2 Emissions, 2020).

As shown in Table 1, which reports data on emissions to air by sector, most emissions in Norway derive from oil and gas extraction (27.6% of total air emissions), the manufacturing industry and transportation. Road traffic causes approximately 8.4 MtCO2e, accounting for 16.7% of total emissions to air. Overall, the transport sector accounted for 30.6% of emissions to air, 15.4 MtCO2e in 2019. With respect to 1990, oil and gas extraction emissions have increased by 70.2% and those relative to road traffic by 16.4%. The factors that caused the rising of CO_2 emissions are the increase in the number of vehicles (Registered vehicles, 2020), a robust income growth, the increased exploitation of the large oil reserves in the country and the population growth propelled by immigration, which led to an increased use of fossil fuels (Norwegian Government, 2018). However, compared to the 1990 levels, emissions to air have dropped by 2.3% thanks to the adoption of environmental policies.

Table 1

Emissions to air in Norway	**Million tons CO_2-equivalents**	**% Change**	
	2019	**1990-2019**	**2018-2019**
Total emissions	50.3	-2.3	-3.4
Oil and gas extraction	13.9	70.2	-1.7
Manufacturing industries and mining	11.7	-40.7	-2.1
Road traffic	8.4	16.4	-7.7
Aviation, navigation, motor equip. etc.	7	20.6	-6.5
Agriculture	4.4	-6	-0.7

Energy supply	1.7	307.4	-4.4
Heating: other industries & households	1	-64.7	15.2
Other	2.2	-17.1	-3.9

Data source: Statistics Norway, 2020

Regarding the Netherlands, despite a 2% decrease in emissions since 2017, the country is still far from reaching the goal set in the National Climate Agreement to reduce emissions by 49% by 2030 with respect to the 1990 (Greenhouse gas emissions down, 2019). In 2018 the energy sector largely decreased its CO_2 emissions, particularly from the extraction of crude petroleum and gas, which achieved its lowest level of emissions since 1990, and manufacturing of refined petroleum. From 1990, the former activity decreased its air pollution by 364 million kg, while the latter by 943 million kg. However, the manufacturing of refined petroleum has slightly increased its CO_2 emissions from 2017. The last component of the energy sector considered is energy supply, which increased by 4,971 million kg since the 1990 level but decreased by 3,607 million kg since 2017. For the energy sector decrease in emissions, the most striking is the one of methane for the extraction of crude petroleum and gas, which moved from 60.51 million kg in 1990 to 8.40 million kg in 2018. From 1990, in the electricity production and mobility (domestic traffic and transport) sectors emissions increased respectively by 6 and 3 billion CO_2 equivalents. In particular, CO_2 emissions from road transport kept increasing after 2014, reaching 30,049 million kg in 2018 (CBS Statline, 2020).

Transport means powered through renewable sources of energy may be an effective method to decrease carbon emissions and environmental damage. In recent years, the market for electric vehicles has expanded fast, now accounting for over 2% of worldwide car sales. In 2018, China was the largest market globally, having 45% of electric vehicles on the road (accounting for 2.3 million cars), followed by Europe (24%) and the United States (22%). Norway keeps detaining the worldwide largest market share for electric car sales (IEA, 2019) and it is the fifth country in Europe for number of charging stations available. As of November 2020, the number of public charging infrastructures for electric vehicles in Europe was 271,337, of which the highest portion (22.65%) was in the Netherlands (EAFO, 2020). Despite a recent increase in car registrations, in 2016 the European Union passengers' car fleet was composed by 53.9% of vehicles using petrol as fuel, 42% using diesel and only 3.4% were alternatively powered (ACEA, 2018). Switching to a fully electric car fleet would be especially beneficial for those countries generating electricity mainly through renewable resources, like Norway. Indeed, 95% of its electricity comes from hydropower, which is a clean energy source as it does not contaminate air like the combustion of fossil fuels. Moreover, it is a renewable resource, largely present in the country; thus, it is more reliable and affordable than oil and natural gas, which are bound to be depleted. However, emissions to air are not null. The functioning of hydropower plants, construction activities, and the production and transportation of building materials still cause pollution and have local environmental effects (The International Energy Agency, 2002).

2.2 The EU and Norwegian environmental commitments

The European Union and Norway have been key supporters of climate action to counter environmental change. At the end of 2016, they signed and ratified the Paris Agreement, which is the first global, legally binding agreement to keep climate change below 2 degrees Celsius, aiming to limit its increase to 1.5°C (United Nations, 2015). To pursue the agreed targets, the signatory countries have presented their Nationally Determined Contribution (NDC), in which they declared their commitment to reduce economy-wide emissions by minimum 40% by 2030 with respect to the 1990 level. The transport sector is defined as priority action area. The GHG reduction goal has been legally established in the Norwegian Climate Change Act (Norwegian Government, 2018) and in the 2030 EU Climate and Energy framework. The framework was adopted in October 2014 and also includes the goal of achieving at least 27% share of final energy consumption for renewable energy and 27% for the improvement in energy efficiency (European Council, 2014).

To reach the cut of 40% of GHG emissions by 2030 in a cost-effective way, the European Union, Norway, Iceland and Liechtenstein adopted the emission trading system (ETS) (EEA Joint Committee, 2007). Introduced in 2005, it is the first and largest international carbon market. It covers nitrous oxide, perfluorocarbons emissions from producing aluminum, together with carbon dioxide emissions from commercial aviation, energy intensive industries, and power and heat production. The emission trading system sets a cap on the total greenhouse gas that a facility can emit. If it is not respected, the company will incur in heavy fines. The firms can trade emission allowances among each other. The cap is lowered over time to ensure a decrease in pollution (European Parliament and Council of the EU, 2018). The transport sector does not belong to the ETS and it is therefore subject to individual binding objectives set by the single states. To achieve the 40% GHG emissions cut objective by 2030, the European Union must decrease its non-ETS sectors emissions by 30% with respect to 2005 (EEA Joint Committee, 2007). Despite the Norwegian and Dutch environmental efforts, the Climate Action Tracker classifies their NDC performance as ‘insufficient’, claiming that if all governments behaved in the same way, global warming would exceed the 2° Celsius limit set by the Paris Agreement. Environmental action must be sped up and environmental targets should be raised in the short term, while efficient and effective regulations must provide a conducive framework for thriving innovation in Europe (Climate Action Tracker, 2019).

The Intergovernmental Panel on Climate Change Special Report (2018) found that to keep global warming at 1.5°C, carbon neutrality must be reached by 2050 and neutrality for all other GHG within the end of the century. Therefore, the EU drew up the 2050 long-term strategy to achieve a climate neutral economy, which is at the core of the European Green Deal presented in December 2019 (European Commission, 2020). In 2017, through the Climate Change Act, Norway set the legally binding goal to become a low carbon society by 2050 to counteract global warming. In practice, this goal would imply a GHG emissions reduction of 80-95% compared to the 1990 level. The country aims to achieve climate neutrality before then, by 2030, by implementing climate protection measures abroad (Norwegian Government, 2018). These targets set an example to all societies regarding the right path to follow to counter climate change. If developing nations like Russia and India follow the Western world early experience choosing to foster growth through fossil fuels and subsequently reduce greenhouse gas emissions, it will be unlikely for global warming to stay within 2°C, in accordance with the Paris agreement (Ahuja, 2015). Investments in renewable energy and green technologies are essential to prevent an irreversible change.

3. Theoretical framework

Policies in support of the transition to electric vehicles in major markets are critical for the expansion of electric mobility. Regulations can be local, i.e. applicable to a certain city or municipality, or global, which are applied at national level. Examples of the former are free parking in a specific town, or access to bus lanes; while global incentives include national tax discounts for vehicle registrations or for yearly road tolls, or subsidies. Policy incentives can be further differentiated between those decreasing the fixed cost of buying an electric vehicle, e.g. by decreasing registration prices or by providing subsidies to incentivize EV adoption; and those lowering the marginal cost of EV, e.g. free parking or exoneration from congestion levies (Langbroek, Franklin and Susilo, 2016). Financial incentives and regulatory measures are usually accompanied by other policies that try to exploit the numerous advantages deriving from an increase in transport electrification, like energy diversification in a sector that is highly dependent on oil and the decrease of carbon emissions and local pollutants. Regulatory measures on charging infrastructures encompass minimum standards granting “EV readiness” in buildings and parking lots, availability of publicly accessible chargers in cities and on highways, and inter-operability standards (IEA, 2019).

Numerous studies have investigated the effectiveness of policy measures for EV adoption and consumers’ willingness to pay for them. Sierzchula et al (2014) used regression models to analyze the impact of financial incentives and socio-economic factors on the purchase of electric vehicles. Helveston et al (2015) examined the role of subsidies while Lin and Greene (2011) considered the presence of charging stations in consumers’ adoption choices of battery electric vehicles and plug-in hybrids. Lieven (2015) looked at the impact of EV incentives in twenty countries and on different consumers groups based on preferences and demographics. Some studies investigated the motivation for behavioral change, claiming that incentives affect the cost of adopting electric vehicles, thus influencing the extrinsic motivation of individuals, which is a consequence of external actions (Ryan and Deci, 2000).

Researchers have found that part of early EV adopters were driven by environmental concerns, despite significant socio-technological barriers like resistance to new technologies and low willingness to pay (Egbue and Long, 2012; Krupa et al., 2014). Bockarjova and Steg (2014) found similar results deriving by Protection Motivation theory (Rogers, 1975).

Through the distribution of a questionnaire among Dutch drivers, the authors found that respondents were significantly more prone to purchase an EV when they considered conventional vehicles to have more negative consequences on the environment and thought that electric vehicles could alleviate the problem. Another driver of EV adoption are social influences. Individual behavior can be affected by social media, advertisements, and social networks. People listen to their friends and neighbors' experiences and suggestions when taking a decision (Pettifor et al., 2017; Jansson, Nordlund and Westin, 2017). However, a study by Zhuge and Shao (2019) that considered six factors potentially influencing EV adoption in Beijing, China, showed that the weight associated to social networks accounted for only 9.7%, mainly driven by friends (5%) and global (2.8%) influences. The weight of environmental awareness was 9.6%, while the primary element affecting people's decisions was vehicles' prices, with a score of 32.3%. Vehicle price is less of an issue for people with higher income and educational attainment, who place a higher weight on other influencing factors. The work of Kamer (2020) supports those of Bockarjova and Steg (2014) and Zhuge and Shao (2019), claiming that the two primary reasons for Dutch people to purchase an electric car are environmental, as they believe they can improve the climate change situation, and economic, being cheaper in use.

The report by Clery and Rhead (2013) statistically analyzed the relationship between levels of education and of environmental concern for 29 countries at an international level. Norway was among the countries analyzed while general conclusions about the Netherlands can be derived from the results of the other European countries examined. Clery and Rhead distinguished between three types of environmental concern: *absolute*, defined as an individual's expressed preoccupation when asked about the environment in isolation; *comparative*, which is a person's concern about the environment when asked to prioritize it compared to other areas of possible concern; and *environmental action*. It is important to notice that the relationship between environmental concern and action can be influenced by other personal and country-level factors such as accessibility and acceptance of different forms of action.

The regression models showed that the relationship between education level and environmental concern differs across countries, with the majority of them exhibiting a significant relation even when controlling for income, sex, age and education. Controlling also for environmental knowledge (model 2) reduced the number of states exhibiting a positive relationship, especially for absolute concern, but remained high for environmental action (18/29 countries). In the Norwegian case, the regression models showed no significant relationship between levels of education and absolute environmental concern, while it was significant for the other two types of concern. The probabilities of an average individual with no or a low-level education qualification, a secondary qualification and a tertiary qualification expressing comparative environmental concern were 41%, 42% and 62% respectively when controlling for all the socio-demographic factors. Regarding the relationship between environmental action and education level the probability was 18%, 28% and 35%. The relation was only significant when controlling for sex, income, age and education level. This as well as the reduction in the relationship between education level and comparative concern when measures of environmental knowledge were added to the models hints to the fact that in Norway the role of education levels in explaining these relationships is partially caused by an underling relation between levels of education and of environmental knowledge. The analysis showed a pattern among most European countries studied in which levels of education significantly relate with all three measures of environmental concern in at least one of the two models. This indicates that it is very likely that in the Netherlands there is a strong link between education levels and levels of environmental concern (Clery and Rhead, 2013). The high level of education in Norway and the Netherlands thus helps explain their success in EV adoption: the increased environmental concern has pushed more people to make more environmentally friendly choices like switching to electric vehicles (Hoekstra and Refa, 2017). These results are in line with the works of Ferguson et al. (2018), analyzing the patterns of EV adoption in Canada, and of Morton et al. (2018), on the spatial pattern of EV demand in the United Kingdom. Both papers found the presence of geographical differences within countries due to availability of charging infrastructures, population density, educational attainment, car availability and income. Findings from regression analysis in the UK have shown that there is a positive relationship between the share of inhabitants with a university degree and the presence of EV in the area. A positive effect is also found with income-level, suggesting that the higher the incomes, the higher is EV adoption. Moreover, the purchase of electric vehicles is shown to be more common in suburban areas and less present in regions with bigger households.

Other researchers have argued that environmental concern depends on the economic development of a country: lower income individuals are less concerned about the environment because they are more worried about having some short-term basic needs such as shelter, food and water availability. As income increases, individuals will start caring more about the environment and higher order needs (Grossman, 1995; Maslow, 1943). Duroy (2005) challenged this view claiming that the level of urbanization, subjective wellbeing and income equality have direct impact on environmental awareness, while education, population pressure and happiness are significantly correlated with climate action. The paper does not deny that wealthier countries are better able to protect the environment thanks to their higher resources, but demonstrates that it is wrong to claim that poorer nations are not worried about the environment. Therefore, the primary obstacle to making more environmentally friendly choices, which in our case regards the adoption of less polluting vehicles, are economic resources.

Earning a high income seems a prerequisite for EV owners and explains why the countries in which EV adoption is highest have a high presence of wealthy individuals. The European Automobile Manufacturers Association data on the correlation between EV market shares and GDP in the EU plus Norway and Switzerland for 2018 shows a positive relationship between the two factors. ACEA finds that an EV market share higher than 3.5% only happens in states with a GDP per capita above EUR 42,000, while countries with a GDP per capita below EUR 29,000 have a market share lower than 1%. This indeed occurs in many southern and eastern European countries, like Spain, Bulgaria, Greece, Romania, Poland and Latvia. Poland had the lowest EV market share in 2018, with 0.4% and a GDP per capita of EUR 12,900 (ACEA, 2019). Lithuania, which is the only country in the EU that does not offer any tax or purchase incentives for EV, had an EV market share of 0.4% and a GDP per capita of EUR 15,900 (ACEA, 2019, 2020). Norway represents a clear exception in Europe, with a market share of 49.1% in 2018, followed by far by Sweden (8%) and the Netherlands (6.3%) (ACEA, 2019, EAFO, 2020, Netherlands Enterprise Agency, 2020). All the other countries' market shares were below 5% and half of them had it below 1%. On average, only 2% of newly registered cars in 2018 in the European Union were electric (ACEA, 2019).

Propulsion in an electric vehicle is less expensive than in a conventional one (The Ministry of Economic Affairs, 2017). However, even small EV have considerably higher catalogue prices than likewise sized traditional car models (van Gijlswijk et al., 2018). The cost of an electric vehicle battery depends on its capacity in kilowatt hours, which determines the range and power of the motor that it propels (Groupe Renault, 2020). Despite a decrease in battery prices, they still correspond to around half the cost of an electric vehicle. Together with their limited kilometers covered by a charge, they are the reasons why many consumers are still hesitant in purchasing them (The Ministry of Economic Affairs, 2017). Indeed, many Dutch

EV drivers with a vehicle range below 250 km claimed that, due to the limited range, they would have not purchased an electric car if they did not have another car at home (Hoekstra and Refa, 2017). Some can argue that the higher initial price is compensated by lower costs of operation. However, many potential buyers might be unwilling to pay upfront for a long-term benefit that will happen after a break-even point set in four or more years from the purchase date, based on the yearly kilometers travelled (van Gijlswijk et al., 2018).

Decreases in battery cost allow manufacturers to increase the range of electric cars while setting lower prices for consumers. This would also enable more affordable vehicles' models in the market (The Ministry of Economic Affairs, 2017). In 2018, half the average Dutch fleet comprising lease had a catalogue price under EUR 24,000, close to the currently cheapest electric vehicle (van Gijlswijk et al., 2018). Scale expansion as well as improvements in battery management and production have led to a significant decrease in battery prices, which went from an average of EUR 800 in 2010 to approximately EUR 200 per kWh six years later. Battery cost is expected to further decrease in the following years thanks to technological developments (The Ministry of Economic Affairs, 2017).

The total cost of ownership (TCO), which incorporates both the cost of ownership and use of a car during the possession period, is a major determinant of when electric vehicles will succeed in markets. When the total cost of ownership for EV turns to be below that of internal combustion engines vehicles, drivers will divert towards them for financial motives (The ministry of Economic Affairs, 2017). The case of the Netherlands shows that second hand electric vehicles already have a significantly lower TCO than conventional automobiles due to lower energy, taxes, and maintenance costs per km. Moreover, research find that in the future electric vehicles will be cheaper for most customer groups, thus removing the elitist nature of the typical EV driver (Cuijpers, Staats, Hoekstra and Bakker, 2016).

The present thesis aims at providing a further focus on the effectiveness of policy incentives for EV adoption in Norway and the Netherlands by considering all the measures adopted by the two governments and their effect on the increase in electric vehicles registrations and their market share. The research builds on and differentiates from the previously cited ones by analyzing in depth the two countries' conditions and considering the overall effect of the policies implemented. From the analysis it will be possible to generalize the conclusions to the situation of other countries and define what are the preconditions to successfully extend the use of EV worldwide.

4. BEV and PHEV: how do they work?

The present master thesis focuses on two types of electric vehicles: battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV). The former consists in an electric motor powered by a battery instead of the typical internal combustion engine and the tank. Most BEV use lithium-ion batteries, which can be recharged before being completely drained without decreasing performance (Groupe Renault, 2020). The car must be connected to a charging spot when it is not in use. Among the many advantages of BEV there are high efficiency, they do not cause tailpipe pollution and can be plugged in overnight using low-cost electricity, possibly produced by renewables. Therefore, they do not create on-road greenhouse gas (GHG) exhalations or criteria air pollutants (i.e. ground-level ozone, particulate matter, carbon monoxide, lead, sulfur dioxide and nitrogen dioxide) (U.S. EPA, 2018). The upstream emissions they do cause can be significantly less grievous based on the source of electricity employed to recharge the battery (Samaras and Meisterling, 2008; Holdway, Williams and Inderwildi, 2010; Michalek et al., 2011). Moreover, as electricity can be created from several different technologies, this type of vehicle permits the diversification of transport energy sources. BEV still have not penetrated the market due to the expensiveness of electricity storage and the time-consuming charging of the battery (Björnsson and Karlsson, 2017).

PHEV are hybrid electric vehicles, meaning that they have two engines. Thus, they work both through internal combustion and through electricity by charging the battery plugging it into an external source of electric power. PHEV can substitute a significant part of fuel used with electricity, therefore also decreasing the operational energy cost. However, both types of vehicles require a high investment cost (Björnsson and Karlsson, 2017). Among the two powertrains, BEV are the only zero-emission vehicles (ZEV), which are transport means that do not release environmentally harmful pollutants in the air when used (Fedkin, 2020). PHEV produce less CO_2 emissions than internal combustion engines thanks to their dual motor, but cannot be considered ZEV as emissions are not null.

5. Methodology

This section explains the methods and indicators used to test the three hypotheses. To test the first hypothesis and evaluate the effectiveness of the policy instruments on the increase in EV adoption, the thesis considers the number of registered electric vehicles, EV sales and their market shares. EV market shares are determined by dividing the number of registered BEV and PHEV by the total number of car sales each year. The effectiveness of policy incentives is assumed to depend on their scope and timing. They are considered effective if they significantly increase the purchase of EV (Langbroek, Franklin and Susilo, 2016). This is measured by comparing the total number of electric vehicles bought before and after a policy incentive is implemented. If when an incentive is introduced the number of registered electric vehicles rises significantly, then we can claim that such growth is correlated with the policy. The statistical analysis is carried out using the software STATA. In the regressions, the annual change in the natural logarithms of the number of registered cars in the Netherlands are compared to those in Norway when the former country had PHEV incentives implemented and announced to terminate them at the end of 2013 and 2015. The data on registered vehicles is recorded on the 31st of December of each year.

To test the local impact of incentives, car registrations in each region are examined before and after the introduction of local EV policies. Comparing the values with the area's population characteristics in terms of size, income and education levels allows to understand the underneath needs necessary for EV adoption. Finally, data on road traffic volumes per fuel type shows the mileage travelled by drivers of petrol, diesel and EV cars. From this analysis it is possible to visualize the change in total traffic and the fuel type causing it before and after the introduction of incentives. The thesis reports the results obtained from regressing the natural logarithm of total mileage for other fuel type cars in the Netherlands compared to that of BEV in Norway when incentives were in introduced in the former country before 2015. A regression was also made using as dependent variable the change in kilometers travelled in the two countries keeping the independent variable constant. The years chosen for the analysis of the third hypothesis are the ones when most EV regulations were in place and thus allowing to test for the greatest possible effect on electric cars' mileage.

6. Background

6.1 The national contexts

Comparing Norway and the Netherlands to analyze the effect of EV incentives on the population provides valuable insights as the two countries are similar in various aspects. Both states are situated in the Northern part of Europe and have one of the highest GDP per capita in the continent, denoting a high standard of living and high incomes. Moreover, both governments invest significantly in the well being of the citizens, which is reflected in low unemployment rates and high investments in education (Central Intelligence Agency, 2020; The World Bank, 2020). Norway's population is approximately 5.5 million and has one of the lowest densities among European countries, with an urbanization rate of 83% and a moderate population growth rate of 0.85%. The Dutch population counts more than 17 million people, 92% of which live in urban areas, mainly in the Randstad area that is in between the largest cities. The population growth rate is 0.37%, denoting a slight percentage growth. The Dutch and Norwegian age structure are similar, and the highest percentage of people belongs to the working group. These factors significantly affect the transport sector in the two countries (Central Intelligence Agency, 2020). Norway is one of the richest countries worldwide, with a Gross Domestic Product per capita of USD 92,121.40 (ca. EUR 81,794.59) in 2018, which corresponds to 729% of the world's average (Trading Economics, 2020). On the other hand, the Netherlands is the sixth largest economy in the EU and its citizens have a high-income level. In 2019, the GDP per capita was approximately EUR 45,000 (The World Bank, 2020) and its nominal GDP is the 17th largest worldwide. Part of their wealth derives from their efficient governance and rich fossil fuels reserves, Norway having a more developed petroleum sector while the Netherlands has more natural gas available (Central Intelligence Agency, 2020).

Norway's rich reserves of oil and gas allowed the development of the petroleum sector, which has become the biggest industry in the country's economy and the main contributor to the funding of the welfare state (Norwegian Government, 2019). The sector accounts for approximately 9% of jobs, 12% of GDP, 13% of state's revenues and 37% of exports, making Norway one of the main petroleum exporters worldwide (Central Intelligence Agency, 2020). Apart from the big oil and natural gas reserves, the country is also rich in natural resources such as water and forests (Hobbs, 2009).

In the Netherlands, natural gas and oil reserves have been exploited since their discovery in the 1950s. The oil deposits account for 4% of total fossil fuel reserves in the country, while natural gas is still present in significant quantities, despite only less than 20% of the original amount is now available. The Groningen Gas Field is the largest one in Europe and in 2004 it produced half of the natural gas in the Netherlands. In the same year, the government decided to decrease extraction in the area as it was thought to be the cause of the increase in earthquakes and to reduce the country’s carbon footprint (Sawe, 2019; Statistics Netherlands, 2017). Rather than decreasing natural gas consumption, the measures implemented to reduce Groningen gas production and the lower production from small gas fields led to an increase in imports from Russia (Annual Report 2018, 2019).

Since the 2012 earthquake in proximity of Huizinge, where many houses were damaged, natural gas started to be seen negatively from the Dutch population. Big oil and gas firms were thought to seek profits at the expenses of the population wellness and people started to become more aware of the severity of climate change. The increasing demand for the government to take action to tackle environmental change led to the signing of the Paris Agreement in 2016. The exploration of small gas fields is expected to decline in the coming years and to stop in the next decade due to low gas prices and the absence of support from the government, which made drilling permits very difficult to obtain (van den Beukel, 2017). In 2018, the Netherlands turned into a net importer of natural gas, mainly from Russia (Annual Report 2018, 2019). This is financially and environmentally detrimental not only for the country, but for the whole European Union. Indeed, the scarce efficiency of the Russian tailpipes to transport gas from the country to the Netherlands and the longer transportation distance causes increases in CO_2 and methane emissions. Vergeer, Blom and Croezen (2015) estimated that total GHG emissions from Russian gas in terms of CO_2 equivalents are 20 to 25% greater than those from Dutch gas.

Natural gas has been the primary source of energy in the Netherlands in the last decades swinging around 40% of the total energy supply, followed by oil and coal. In 2018, total primary energy supply corresponded to 72 Mtoe. 90% of it was provided by fossil fuels. In particular, 30,696 ktoe (42.6%) came from natural gas, 25,616 ktoe (35.6%) by oil and 8,130 ktoe (11.3%) by coal. Considering more sustainable sources of energy production, biofuels and waste are at the forefront with 4,234 ktoe, corresponding to 5.9% of total primary energy supply, followed by wind and solar accounting for 1.9% and nuclear at 1.3%. Hydropower only produced 6 ktoe (IEA, 2019). The production of crude oil is low, corresponding to 1.1

Mt last year. 99% of it is imported, mostly by Russia and England (EMEA Refineries Dataset, 2020). In Norway the situation is highly different, as hydropower covers 95% of the Norwegian electricity production and the share corresponding to wind power production is 2.6% (Statistics Norway, 2019). Norway is the largest producer of hydropower, creating 125,765 gigawatt hours of electricity in 2019, and the first country in terms of installed hydropower capacity in Europe (Sönnichsen, 2020). While the cost of fossil fuel in the country is one of the highest in Europe, electricity is quite cheap with EUR 0.17 per Kilowatt-hour in the second semester of 2019 for household consumers, against a EU-27 average of EUR 0.22 per Kwh and EUR 0.21 in the Netherlands (Eurostat, 2020).

6.2 EV policies in Norway

Climate change and GHG emissions have been present on the Norwegian policy agenda since the 1980s. Today’s climate policy derives from the targets set in the Framework Convention on Climate Change, the Kyoto Protocol, and the Paris Agreement (Norwegian Government, 2018). In 2017, the Norwegian government developed the National Transport Plan 2018-2029, which outlines the policy priorities and measures to implement to guarantee a significant contribution from the transport sector to national environmental efforts. Among the priorities there are the implementation of incentives for zero- or low-emission transport means, the increased use of alternative fuels, public transport, cycling and walking in urban areas, a shift from road to sea and rail in freight transport and better capacity usage (National Transport Plan 2018-2029, 2016). Technological advancement is essential to increase the competitiveness of zero emission vehicles, turning away from conventional ones. Moreover, the government seeks lower emissions from transport infrastructures by preparing fossil-free construction sites. The targets for the reduction of CO_2 emissions set in the National Transport Plan include that by 2025 all new passenger cars, urban buses and light vans shall be zero-emitters. By 2030 the same must apply to all new heavy-duty vehicles, 75% of new long-distance buses and 50% of new trucks (National Transport Plan 2018-2029, 2016).

The Norwegian context make the country a perfect place for EV adoption. Norway has one of the highest GDP per capita worldwide, many households own more than one car, speed limits are low, thus allowing for a longer range, electricity prices are lower than the European average, and the grid is robust. However, cold temperatures may significantly decrease BEV’s range (Figenbaum, 2018). The reason for the success of electric vehicles in

Norway is to be found in the significant use of incentives by the Norwegian government, started in the 1990s, to encourage zero emissions means of transport in the market. The main instruments used by the Norwegian government to control CO_2 emissions from the transport sector are taxes and subsidies. The different tariffs show the desire to not only improve low-emission vehicles competitiveness, but also to make them significantly cheaper than conventional cars; thus leading people into making them their preferred choice. This is in accordance with the "polluter pays" principle (Norwegian Government, 2018).

The CO_2 tax rate on petrol in 2020 corresponds to NOK 1.26 per liter, which shows an increase with respect to previous years. The auto diesel petrol tax is NOK 4.91 per liter, which is NOK 1.29 over the oil tax on unmarked mineral oil (Mineral product tax, 2020). The road usage tax is also levied on petrol for road transport. From 2007, CO_2 emissions were introduced in the computation of the vehicle registration toll. The duty is progressive, increasing the cost of highly polluting bigger vehicles. Over the subsequent years, the weight of CO_2 and NOx emissions in the calculation increased, while the government chose to extend the tax exemptions for VAT and registration for electric vehicles until 2021, when they will be revised (Norwegian Government, 2018). Electric vehicles do not pay for road usage as electricity is not subject to that duty. They are also exempted from the 2018 road traffic insurance tax, which replaced the annual motor vehicle toll (Road traffic insurance car, 2020). In addition to the economic benefits, EV in some municipalities are allowed access to bus lanes, discounts on ferry rides and free access to public parking spots (Norwegian Government, 2018). Table 2 summarizes all the Norwegian government's EV incentives implemented over the years.

Table 2

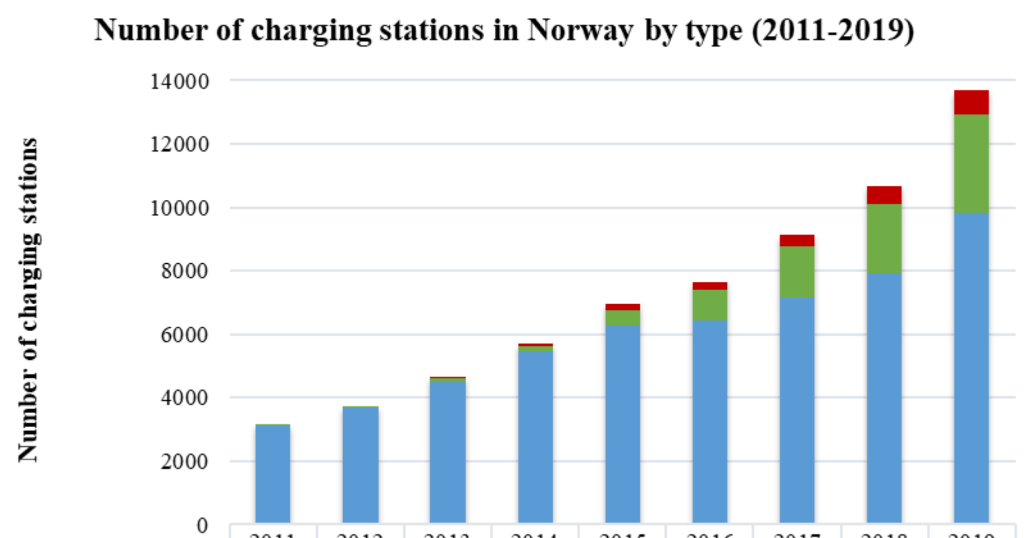
Year	Norwegian incentives & regulations benefitting Electric Vehicles
1990-	No registration or import taxes
1991-	CO_2 tax on petroleum production
1995	Foundation of the Norwegian Electric Vehicle Association to promote EV interests
1996-	BEV pay a lower annual road tax
2001-	BEV exemption from 25% VAT on purchase
1997-2017	No charges on roads or ferries' tolls

1999-2017	Free municipal parking
2000-2018	BEV used as company cars pay 50% less tax
2005-	BEV access to bus lanes nationwide
2007-	CO_2 emissions included in calculation of vehicle registration tax
2009	Norway invested EUR 6 million in charging stations installation
2015-	Exemption from 25% VAT on leasing
2016	New rules allow local authorities to limit bus lanes access to only include EV that carry one or more passengers
2018	Fiscal compensation for the scrapping of fossil vans when converting to a zero-emission van
2018-	Maximum 50% of the price for fossil fueled vehicles on ferry fares for EV
2018-	Parking fee for EV introduced locally with an upper limit of maximum 50% of the full price
2018-	Company car tax reduction decreased to 40%
2019	Allowing holders of driver license class B to drive electric vans class C1 (light lorries) up to 4250 kg
2019	Prohibition to charge more than 50% of the fossil fuelled cars' price on toll roads

Source: Norsk Elbilforening, 2019; Steinbacher, Goes and Jörling, 2018; Zeniewski, 2017

The national policy framework for incentivizing the adoption of electric vehicles encompasses the public both before and after the time of purchase. It contains political stimuli to significantly increase the presence on the Norwegian territory of charging stations, for carrying research, provide further information and marketing (Steinbacher, Goes and Jörling, 2018). The investments for the roll out of new public charging infrastructure nationwide started in 2009, with the EUR 6 million funding by Transnova. This state entity, now known as Enova, was created with the aim of decreasing GHG emissions from transport and was financed by the sale of oil and natural gas. National municipalities have also significantly contributed to the development of new charging infrastructures. In particular, Oslo's municipality invested EUR 2 million to set 400 charging stations between 2008 and 2011. The investments were supposed to lead to the creation of 2,500 new charging units over 2011 (Kvisle, 2012). At the end of the year, Norway had 3,105 standard charging stations and 18 fast-charging ones (Statista, 2019), with a total number of registered private cars, vans and motorcycles of 5,481 (Statistics Norway, 2019) over a population of slightly less than 5 million people (Statistics Norway, 2020). These numbers made Norway the country with the highest number of EVs in relation to population density at the time (Kvisle, 2012). Graph n. 2 shows the 70.8% increase in charging stations from 2011 to 2019 in Norway.

Graph n. 2



	2011	2012	2013	2014	2015	2016	2017	2018	2019
Tesla Supercharger	0	0	44	92	190	228	338	562	770
Fast charger 50 kW	18	58	87	157	508	993	1639	2190	3079
Standard	3105	3688	4511	5471	6253	6413	7141	7910	9829

Data source: Wagner, 2020

The regulations and EV incentives led Norway to achieve its average emissions from new cars target of below 85 g CO_2/km by 2020, which was even more ambitious than the one proposed by the European Union of 95 g CO_2/km (Norwegian Government, 2012). Norway reached its goal in 2017, with an average CO_2 emission of 82 g/km (Norwegian Government, 2018).

6.3 The European Union transport policies

In the European Union, politicians are increasingly committed to climate change and are implementing policies to counter it. As discussed in section 2.2, policies to reduce emissions in the transport sector depend on the individual binding objectives set by member states. Among the possible measures that countries can take in this respect are decreasing transport needs, incentives to use public transport and vehicles using renewable energy instead of fossil fuels. Procedures taken at the EU level, such as the introduction of CO_2 emissions standards for new vehicles, have the potential to decrease the whole area's pollution level deriving from the transport sector, which accounts for nearly a fifth of EU-27 GHG emissions and is the primary source of air pollution in cities (Climate Action Tracker, 2019).

On the 20th of July 2016, the European Commission adopted the European Strategy for Low-Emission Mobility, which represents a key component towards the move to a low-carbon, circular economy. Europe aims to limit emissions by shifting mobility towards the use of low and zero-emission vehicles. The goal is to reach a minimum 60% reduction of GHG externalities from transport by 2050, compared to the 1990 level, with the ultimate target to be climate neutral. The strategy will lead to better air quality and safety, as well as a decrease in noise levels by augmenting the efficiency of the transport network, investing in alternative energy for transport, accelerating their implementation and the shift to zero-emission vehicles. Local authorities have a key role in incentivizing the adoption of the strategy and raising awareness among citizens (European Commission, 2016). The strategy draws on several investment plans, such as the European Fund for Strategic Investment (EFSI) that fosters growth and competitiveness by funding transport infrastructure, services and research. The EFSI is open to firms, public sector entities, banks and customized investment platforms. The transport sector can also receive investments from EU grants for smart and low-emission vehicles. Some of the grants are Connecting Europe Facility, Horizon 2020, with a budget of EUR 6.3 million, and the European Structural and Investment Funds, with a budget of EUR 70 billion for the 2014-2020 time horizon (European Commission, 2016).

In addition to the previously stated strategy, on 17 April 2019, the European Parliament and the Council adopted Regulation (EU) 2019/631 setting CO_2 emission performance standards for new passenger cars and light commercial vehicles, which started to apply from 1 January 2020. From this date, Regulation (EU) 2019/631 defined an EU fleet objective of 95 g CO_2/km for the mean emissions of new passenger cars and of 147 g CO_2/km for those of new light commercial vehicles registered in the EU. Until the end of 2024, the regulation is accompanied by further measures accounting for a decrease of 10 g CO_2/km from the considered vehicles. The directive also sets out more ambitious targets starting in 2025 and 2030. It aims to reach its goals by motivating the automotive industry to invest in new technologies (European Parliament and Council of the EU, 2019). Moreover, the EU compels member states to supply consumers with all the relevant information, such as a label revealing a new passenger car's fuel efficiency and CO_2 emissions (European Parliament and Council of the EU, 1999). All states in the European Union except for Lithuania provide incentives or tax reductions for the adoption of electric cars. The Netherlands provides both purchase incentives and tax benefits (ACEA, 2020).

6.4 EV policies in the Netherlands

Being part of the European Union, the Netherlands has to implement all the measures stated in the regulations issued by the Union, which are legally binding across all member states. Moreover, it must freely devise actions to achieve the goals set in the EU directives (Regulations, Directives and other acts, 2020). Table 3 presents an overview of the Dutch EV incentives. Apart from BEV and PHEV, the Netherlands provides incentives for hybrid electric vehicles (HEV) and zero-emission vehicles (ZEV). The former are mainly petrol or diesel vehicles with an electric motor that operates through energy stored in batteries. Differently from plug-in electric vehicles, HEV cannot be charged by connecting the car to power points, rather they recharge through regenerative braking and by the internal combustion motor. The battery in hybrid electric cars results in improved fuel efficiency without decreasing performance, for example by powering auxiliary loads and limiting engine idling when the vehicle is at a stop. However, the environmental benefits compared to BEV and PHEV are minimal, as the battery in HEV is significantly smaller in size (How Do Hybrid Electric Cars Work?, 2020).

The Dutch national authority launched its first action plan on EV in 2009 to counter the increasing greenhouse gas emissions deriving from the transport sector (Dutch Government, 2009). The proposal suggested the institution of a task force focused on increasing EV success, investments in research and development activities, providing charging stations and financial stimuli for electric vehicles. Finally, the action plan set the goals of achieving 15,000 EV registrations by 2015, 200,000 by 2020 and 1,000,000 by 2025. Extended in 2011, the proposal terminated in 2015 (Tietge, Lutsey and Mock, 2016).

In 2010 the Dutch national government reduced PHEV registration costs, followed by a complete exemption from registration and circulation costs in 2011. While in the 2011-2013 period company-owned ZEV did not pay additions to taxable income, from 2014 they started to pay a 4% addition and a minimum 8% rate for cars with catalogue price below EUR

45,000 in 2020 (ACEA, 2010, 2011, 2012, 2013, 2014, 2020). PHEV owners first paid a 7% addition to taxable income, subsequently a 15% one in 2016 and 22% in 2017 (ACEA, 2012, 2013, 2016, 2017). Since late 2013, many municipalities have been providing subsidies of a value between EUR 2,500 and EUR 9,000 designated for buying zero emission vehicles or private charging points (Deuten, Gómez Vilchez and Thiel, 2020). An example is the municipality of the Hague that on 1 July 2016 made a EUR 3,000 and a EUR 5,000 subsidy available for buying respectively a fully electric secondhand car and a new one. Moreover, the municipality facilitated the installment of fast-charging infrastructures in the city centre (Netherlands Enterprise Agency, 2017).

Table 3

Year	Powertrain	Dutch incentives for Electric Vehicles
2007		CO_2 related vehicle taxation
2010	HEV/PHEV	Reduced registration costs
2010	BEV/PHEV	Subsidies for charging infrastructure: local application procedures for free public charging infrastructure
2011	ZEV	Exemption from registration and circulation costs
2011-2013	ZEV	No addition to taxable income for company-owned ZEV
2011-2013	HEV	Exemption from circulation taxes
2011-2014	PHEV	Exemption from registration costs
2011-2016	PHEV	Exemption from circulation taxes
2012	HEV	Company owned HEV reduced addition to taxable income
2012-2013	PHEV	No addition to taxable income for company owned PHEV
2013	PHEV/ZEV	Local purchase subsidies. ZEV purchase and charging points subsidies from 2,500 € to 9,000 € in many municipalities
2014	PHEV/ZEV	Reduced addition to taxable income for ZEV and PHEV
2014-2015	PHEV/BEV	No motor vehicle road use tax. For BEV continued after 2016
2015	PHEV	Reduced registration costs
2020-2025	BEV	Subsidy scheme (SEPP) for private cars’ purchase or leasing

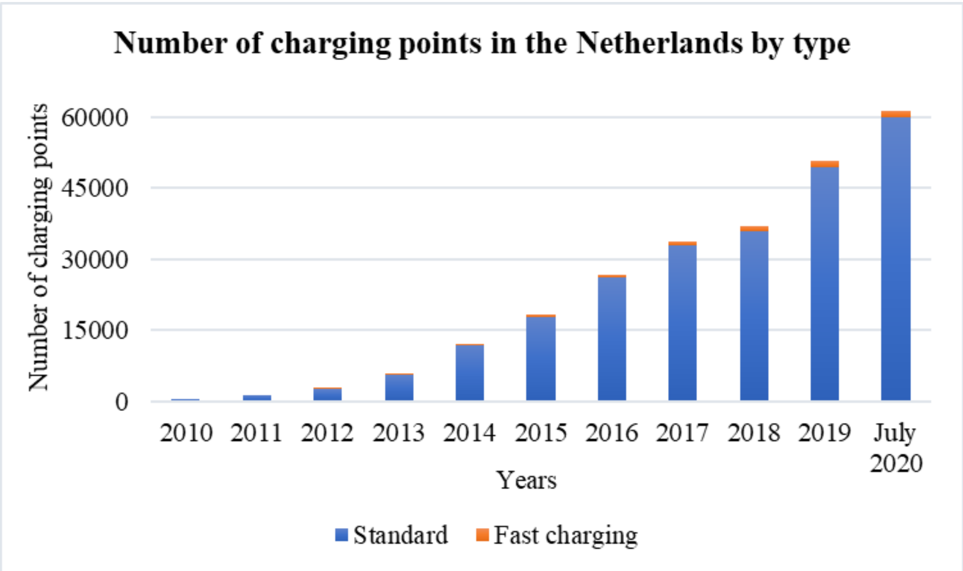
Source: Deuten, Gómez Vilchez and Thiel, 2020; ACEA, 2020

Starting on 4 June 2020, private individuals purchasing or leasing BEV are eligible for the SEPP subsidy. It is only possible to apply to it once and it is available until 1 July 2015, if the budget at disposal does not finish sooner (Subsidieregeling Elektrische Personenauto's Particulieren (SEPP), 2020). The Dutch government also provides an investment deduction (MIA) of 36% for BEV and fuel cell light commercial vehicles and BEV taxis to entrepreneurs investing in environmentally friendly techniques. Similarly, the Arbitrary depreciation of environmental investments scheme (Vamil) provides an investment deduction of 75% for entrepreneurs investing in fuel cell cars or taxis and BEV cars equipped with solar panels. The budget available in 2020 is EUR 124 million for MIA and EUR 25 million for Vamil. The minimum investment required to be eligible for the subsidy is EUR 2,500 (Mia en Vamil, 2020). Apart from national financial incentives, the Netherlands has also implemented measures at regional level, such as providing free parking spots with available charging points in Amsterdam and Rotterdam from 2009 to the first three months of 2012. Since April 2012, in Amsterdam it is possible to not pay parking while charging and to avoid waiting lists for obtaining electric vehicles' parking permits (Fluchs and Kasperk, 2017).

Therefore, in the Netherlands there are both direct consumer incentives, like vehicle taxation schemes, and indirect incentives, e.g. availability of charging infrastructure. Belonging to the former group are registration, circulation, and private use of company cars taxes. The first tax is progressive, increasing with the vehicle's level of CO_2 emissions and a supplement is imposed on diesel automobiles emitting over 70 g CO_2/km (Tietge, Lutsey and Mock, 2016). The circulation tax depends on the curb weight and powertrain type and differs across provinces. Since 1 January 2020, some diesel automobiles and lorries will pay a supplement for the emission of fine dust. As previously stated, BEV are excluded from registration and circulation taxes, while they have been reduced for PHEV (Belastingdienst, 2020). Because 92% of the total EV registrations at the end of 2014 were made by companies (Netherlands Enterprise Agency, 2016), the tax on the private use of company automobiles plays a key role in incentivizing EV acquisition. If an employee travels over 500 km annually with the company car, part of the automobile list price, i.e. the taxable benefit, is added to his/her yearly income throughout the first five years after the first registration (Tietge, Lutsey and Mock, 2016). The taxable benefit depends on the vehicle's CO_2 emissions and can be up to 25% of the list price (ACEA, 2015). The three taxes have risen over time, increasing the burden on high-emitting vehicles and further incentivizing the switch to zero-emission cars (Tietge, Lutsey and Mock, 2016).

Graph n. 3 highlights the increase in the number of charging stations in the Netherlands from 2010, when there were 400, to the approximately 60,000 in July 2020 (EAFO, 2020). The significant implementation of charging stations was a result of the effective subsidies introduced in 2010 as well as the efforts of the single municipalities. Most EV charger incentives were aimed at public stations. Among them there is the possibility available in most municipalities for residents to apply to the local authority for the installation of free charging points. The users will only need to pay for the electricity used (Wallbox, 2020). The Rotterdam municipality also offered a subsidy of up to EUR 1,450 for installing home chargers using smart energy (Fluchs and Kasperk, 2017). Smart charging implements innovative technologies allowing for EV optimum charging by balancing supply and demand in the grid. It permits fast movements of power across installations or over time so to have energy always available when required in an efficient way (The Ministry of Economic Affairs, 2017). It means that when a car is plugged in, charging will start at the most convenient time, for example when cheap renewable energy is available and the grid is not overtaxed. A survey by Hoekstra and Refa (2017) on Dutch EV owners found that the great majority of respondents supported the setting of default smart charging at home, but only if they could have the option to charge the car immediately if needed. The primary reason of their support for smart charging is the excitement in using more renewable energy.

Graph n. 3



Data source: EAFO, 2020

In 2019 there were 27% more public and semi-public charging points than in the previous year, while the increase from 2010 to July 2020 was of 99.3%. In July 2020, there were 59,935 standard charging points and only 1,462 fast charging ones. It means that the former were 41 times more than the latter. The number of private charging stations is significantly higher than those of public and semi-public infrastructures. In July 2020, private charging points were almost five times the sum of public standard and fast charging stations and 58% more than in 2015. The highest growth of private charging infrastructures took place between 2018 and 2019 and corresponded to 30%, reaching approximately 118,000 stations (Netherlands Enterprise Agency, 2018, 2020).

Fast charging needs a substantial quantity of power, which heavily relies on the grid. The higher the number of vehicles charging and the capacity utilized, the larger the demand from the grid. The requested energy and the costs lead to a collection of fast chargers in tactical areas (The Ministry of Economic Affairs, 2017). The survey on Dutch EV owners by Hoekstra and Refa (2017) found that over 70% of respondents viewed fast chargers as essential for BEV. However, they are all firmly against the idea that fast chargers can substitute standard ones. EV owners consider fast chargers as one of the best and cheapest methods to spur EV adoption. An interesting finding of the survey is that the majority of respondents had the opportunity to charge their vehicle at home and would have not considered buying an EV otherwise. This characteristic is worrisome for the success of EV adoption in the Netherlands as only 1/3 of households in the country has access to private parking allowing home charging (Hoekstra and Refa, 2017).

Currently, the municipalities with the highest number of regular public and semi-public charging stations are Amsterdam, with 5,510, Rotterdam, 3,615, the Hague, with 3,107, and Utrecht, at 2,083 (Netherlands Enterprise Agency, 2020). These are also the municipalities with the highest population in the Netherlands (Statistics Netherlands, 2020). While the cited municipalities have respectively one public and semi-public charging point every 158, 180, 175 and 172 citizens, many other Dutch municipalities have more stations available for users. An example is Lopik that has one charging infrastructure every 125 inhabitants (Netherlands Enterprise Agency, 2020; Statistics Netherlands, 2020).

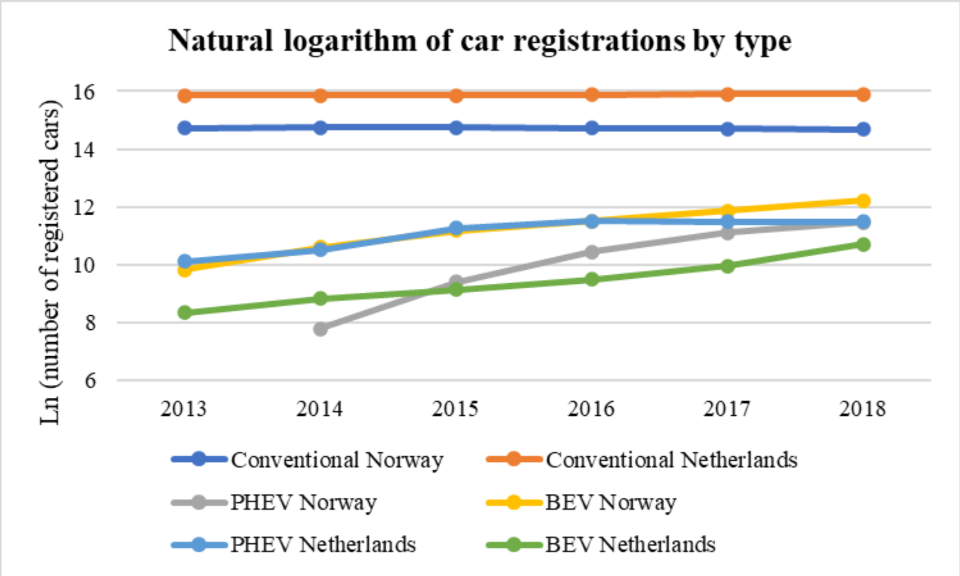
7. Empirical analysis and results

7.1 First hypothesis: policy incentives have a positive effect on EV adoption

Graph n. 4 shows the stock of conventional and electric registered passenger cars from 2013 to 2018 in Norway and the Netherlands. The number of cars in the latter country is significantly higher than in the former due to the larger population. In mid-2013, the number of diesel vehicles in Norway surpassed that of petrol. Instead, petrol is the most common combustion fuel used for cars in the Netherlands, followed by diesel. The natural logarithm of conventional registered cars in the two countries has slightly changed in the years considered, decreasing from 14,75 in 2015 to 14,68 in 2018 in the former and rising from 15,84 in 2013 to 15,90 in 2018 in the latter. The Norwegian adoption of EV has had a steady increase over time, but it is still significantly lower than the other two fuel combustion types. Indeed, in 2018 the number of registered battery electric cars was approximately $1/6^{th}$ of the diesel and $1/5^{th}$ of the petrol ones. The number of registered petrol and diesel automobiles were respectively almost 11 and 13 times that of PHEV. In 2019, Norwegian PHEV were less than half the number of registered BEV.

Also the number of registered EV in the Netherlands is minimal compared to that of conventional cars, with BEV being 151 and 28 times less the number of respectively petrol and diesel automobiles in 2018. While the number of petrol and battery electric vehicles have been increasing, that of diesel cars has been declining since 2015. Overall, the total number of passenger cars in the Netherlands has been constantly increasing since the beginning of the century, reaching 8,677,911 automobiles in 2020 (Knoema, 2020). Considering a population of approximately 17 million people, it corresponds to a car every two individuals, the same ratio as in Norway.

Graph n. 4



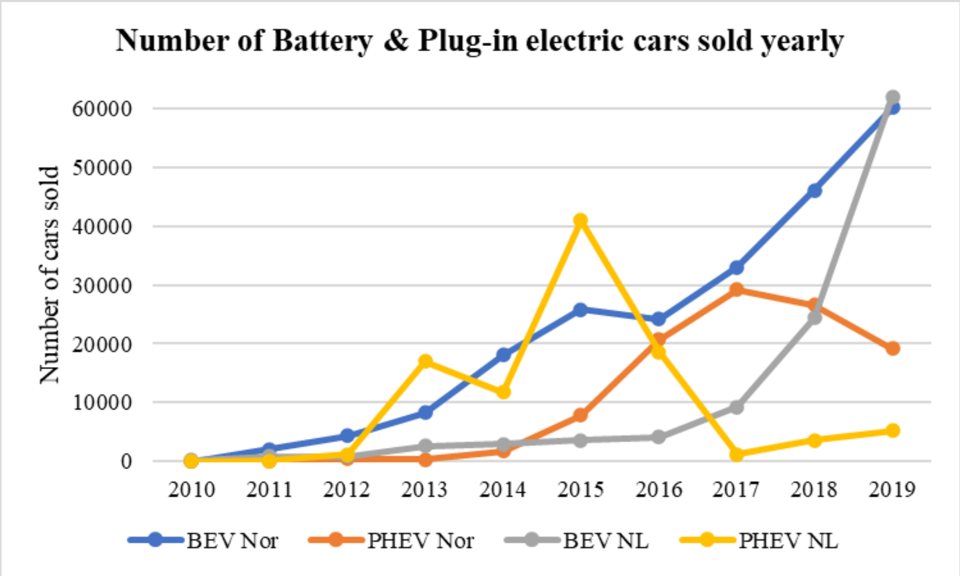
Data source: Netherlands Enterprise Agency 2016, 2020; Norsk Elbilforening, 2019; Statistics Norway, 2020; UNECE Statistical Database, 2020.

While in the Netherlands electric cars started to appear in 2011, in Norway they were already present before, thanks to the earlier incentives. Even if the relevant regulations date back to the 1990s, before 2008 the low number of electric vehicles in the Norwegian market was due to a shortage of them. The country in the first decade of the 21st century was characterized by almost only small producers and by the import of second-hand EV (Kvisle, 2012). Graph n. 5 shows that significant differences between the two countries started to arise after 2011, when more EV charging stations were installed across Norway. At the time, there were 3,105 standard charging points available and the number of Norwegian BEV rose to be four times that of the Dutch. Tesla superchargers were introduced in 2013 (see Graph n. 2).

Norway has always sold more BEV than in the Netherlands, even in absolute numbers, until 2019, when sales corresponded to 60,221 and 62,004 automobiles respectively. 2015 registered the biggest divergence in battery electric cars sold, with the former country selling 7 times more BEV than in the latter. Regarding the biggest difference in registered cars, it happened in 2016, when the number of Norwegian battery electric cars was almost eight times that of the Dutch. More precisely, there were 100,000 BEV in the former country and 13,105 in the latter. 2015 and 2016 were the first two years after 2007 when the Norwegian government introduced new EV incentives as reported in the Table below Graph n. 5. Specifically, the exemption from 25% VAT on leased vehicles and the possibility for local authorities to limit access to bus lanes to only include electric vehicles carrying one or more passengers. The increased passenger cars registration did not exclusively depend on the government’s incentives, but also on the availability of cheaper and more attractive EV options and greater population environmental and commercial awareness (Steinbacher, Goes and Jörling, 2018). While Norway has been progressively lowering its registrations growth speed, the Netherlands had more than doubled its electric car listings in 2018 and 2019. The similar path in BEV adoption of the two countries after the introduction of incentives suggests the importance of governments’ EV regulations in the success of their market uptake.

Regarding PHEV, the paths followed by the two countries are very different presumably because while most EV incentives were kept in place in Norway for the whole time considered, Dutch PHEV incentives started in 2010 and were reduced at the end of 2016. The number of plug-in electric cars sold in both countries was very low until 2012. Between 2011 and 2013 Dutch PHEV were excluded from registration and circulation costs and in 2013 local purchase subsidies were introduced in the Netherlands. PHEV sold registered two spikes in 2013 and 2015 in the country due to public discussion on the likely reduction of incentives for PHEV at the end of those years, which led numerous individuals to buy them to enjoy the available tax benefits (Thiel, Krause and Dilara, 2015). Afterwards, PHEV sales dropped to 1,130 in 2017 and have started to slowly rise again in recent years. The number of PHEV sold in Norway surpassed that in the Netherlands in 2016. Turning to the number of registered PHEV, whereas in Norway they have been growing since their introduction in 2014, in the Netherlands they rose until 2016 and then started to decrease until when, in 2019, Norway surpassed the Netherlands. Therefore, Graph n. 5 suggests that the two countries differences in PHEV sales are positively correlated to the timing of issuance of governments’ incentives for the powertrain. Moreover, it appears that policies take time to show a significant effect, as they need to be complemented by measures to raise public awareness (Thiel, Krause and Dilara, 2015).

Graph n. 5



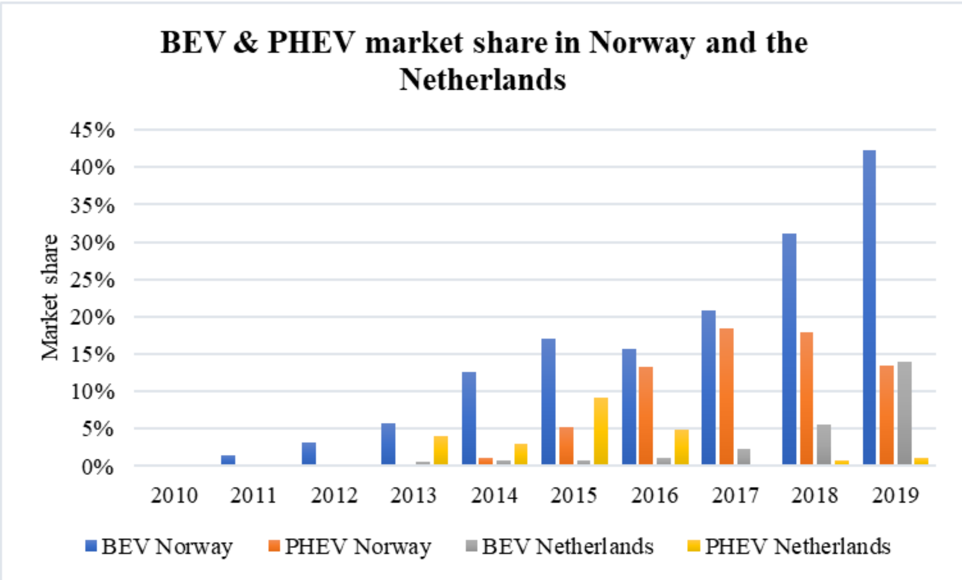
Data source: Netherlands Enterprise Agency 2016, 2020; Statistics Norway, 2020

	Norway		**Netherlands**
2009	EUR 6 million govern. investment in charging stations installation	**2010**	PHEV reduced registration costs and subsidies for charging points
2015	Exemption from 25% VAT on leasing	**2011**	BEV: no registration & circulation costs; no company-owned ZEV addition to taxable income(**until 2013**) PHEV: No registration costs (**until 2014**) & circulation tax (**until 2016**)
2016	Local authorities can limit bus lanes access to only include EV	**2012-2013**	No addition to taxable income for company owned PHEV. Reduced in 2014 for both BEV & PHEV
2018-	Max 50% of the price for fossil fueled vehicles on ferry fares and parking for EV; Company car tax reduction decreased to 40%	**2013**	Local purchase and charging points subsidies for PHEV and ZEV
		2014-2015	No motor vehicle road use tax. For BEV continued after 2016. In 2015 registration costs were reduced for PHEV.

To further investigate the effect of policy incentives on EV adoption, Graph n. 6 represents the market shares of battery and plug-in electric cars in Norway and the Netherlands from 2010 to 2019, calculated as the ratio of BEV and PHEV sales over the total car sales per year. The graph is accompanied by a summary of the main EV policies for the period considered. The market share of BEV and PHEV between 2008 and 2011 was close to 0% for both countries. In Norway, EV sales took off several years after the introduction of the first incentive. Once they took off, the EV market share grew steadily over time, starting from 0.22% in 2008 and reaching almost 50% over 10 years (Stoll, 2019). EV were able to cross the 25% threshold in 2016, when the percentages of BEV and PHEV were similar (15.7% and 13.4%), and the 50% share in 2019, mainly driven by BEV. The gradual progress is a result of all the regulations supporting electric vehicles introduced since the 1990s (see Table 2), whose benefits have been accumulating over time. It is interesting to notice that after the 2015 introduction of the EV exemption of 25% of VAT on leasing in Norway, in 2016 the market share of BEV declined by 1.4%, catching back up in 2017, when they accounted for 20.8% of the market. In the same time interval, the share of PHEV increased by 8.2%. After reaching a peak at 18.4% in 2017, PHEV had been decreasing until they accounted for 13.5% in 2019. From 2018 to 2019, the number of BEV sold increased by 11%, achieving its record score of 60,221 passenger cars sold. These numbers make Norway one of the leading EV markets worldwide and places the country on the right track to achieve its ambition of significantly decreasing its transport sector emissions (National Transport Plan 2018-2029, 2016).

While in Norway benefits have been mostly equal for BEV and PHEV, with an exception for driving in bus lanes, toll roads and ferry charges only available for the former powertrain technology, in the Netherlands there are greater cost benefits for BEV, reflecting their mission towards zero emission vehicles by 2030 (Electric Transport Green Deal 2016-2020, 2016). Regulations in the Netherlands mainly focused between 2010 and 2016. This is reflected in a higher market share growth within the timeframe and a subsequent fall back in 2017, which only reached a 2.5% market portion, the lowest since 2013. The Dutch market share of electric vehicles has varied significantly over the years, reaching two main peaks in 2015 and 2019. Before 2012, the portion of EV was below 0.4%. In 2013, the total number of BEV and PHEV rose by 90%, driven primarily by the increase in the latter due to the publicly discussed possibility of removing PHEV tax benefits by the end of the year (Thiel, Krause and Dilara, 2015). The very large increase in PHEV led the Netherlands to have the largest market share for EV in the European Union in 2013 (Thiel, Krause and Dilara, 2015). The same reason was behind the 2015 market share peak, when the Dutch automobile market share was composed by 9.1% PHEV, 0.8% BEV, 57.6% petrol-fueled and 28.9% diesel cars. Battery electric cars only surpassed the 1% share in 2016, year in which the number of diesel and PHEV significantly decreased in favor of petrol vehicles. The reduction of Dutch PHEV incentives at the end of 2016 was accompanied by a higher BEV market share, corresponding to 2.2% in 2017. Plug-in electric vehicles had a market share of 0.8% in 2018 and 1.2% the following year. Recently, Dutch battery electric cars have gained greater momentum and accounted for 13.9% in 2019, reducing the market penetration of conventional vehicles. Indeed, in 2019 fossil fuel driven passenger cars had a market share of 78.3%, the lowest they have had in ten years.

Graph n. 6



Data source: Demandt, 2020; EAFO, 2020; Knoema, 2020; Netherlands Enterprise Agency, 2020; Statista, 2015

	Norway		**Netherlands**
2009	EUR 6 million investment in charging stations installation	**2010**	PHEV reduced registration costs and subsidies for charging points
2015	Exemption from 25% VAT on leasing	**2011**	BEV: no registration & circulation costs; no addition to taxable income for company-owned ZEV (**until 2013**). PHEV: No registration costs (**until 2014**) & circ. tax (**until 2016**)
2016	Local authorities can limit access to only include EV	**2012-2013**	No addition to taxable income for company owned PHEV. Reduced in 2014 for both BEV & PHEV
2018-	Max 50% of fossil fueled vehicles' price on ferry & parking for EV; 40% company car tax reduction	**2013**	Local purchase and charging points subsidies for PHEV and ZEV
		2014-2015	No road use tax. For BEV continued after 2016. In 2015 registration costs were reduced for PHEV.

The EV market share in the Netherlands is still far below that of Norway but one of the highest in Europe. The analysis of the automobile industry registrations, sales and market share data suggests a positive relationship between national EV incentives and electric cars' adoption. Consumers are more prone to buy EV when there are economic benefits deriving from them. In particular, the threat of reducing tax benefits for PHEV in the Netherlands led to peaks in electric car purchases before the expected policy removal. The hypothesis is tested statistically for the most evident case arising from the graphs: the PHEV incentives available in 2012 and 2014 in the Netherlands compared to Norway and the announcement that they will be removed in the next year.

Table 4 reports the analysis of the regression using fixed effects of the yearly growth rate of the natural logarithm of registered cars after the announcement of reducing PHEV incentives in the Netherlands at the end of 2013 and 2015. The regression is performed on 41 observations, which correspond to the data on registered PHEV from 2013 to 2019 in Norway and from 2011 to 2019 in the Netherlands, data on BEV from 2011 to 2018 and data on conventional cars from 2011 to 2019 in Norway and from 2013 to 2018 in the Netherlands. Data on Norwegian PHEV before 2013 is not available as the powertrain was registered under the same category of petrol or diesel vehicles. The regression was performed using the number of registered cars because it was the most complete dataset. Two dummies were created: "dumNE", assuming value equal to 1 when the country is the Netherlands and 0 when it is Norway, and "PHE", equal to 1 when the type of car is PHEV and the years are 2012 or 2014. The effect of the incentives present in 2012 and 2014 in the Netherlands is positive and significant, having a p-value equal to 0.047 and a coefficient of 0.9. Instead, the coefficient of the impact of the 2012 and 2014 EV incentives on the number of electric cars is negative in line with the lack of new PHEV incentives in Norway in the period. In the absence of policies, the natural logarithm of the number of PHEV would be 1.5 units. The presence of incentives abolishing registration and circulation taxes on PHEV as well as the announcement that such taxes would have been reintroduced at the end of 2013 and 2015 have led to a number of Dutch registered plug-in electric cars 146% higher ($e^{0.9}$-1) than the number of BEV and conventional cars. In conclusion, the statistical analysis does not reject the first hypothesis that national EV incentives lead to an increase in the adoption of electric vehicles.

Table 4

```
. xtreg d.lcars PHE##dumNE i.year, fe
note: 1.dumNE omitted because of collinearity

Fixed-effects (within) regression               Number of obs     =         41
Group variable: ct                              Number of groups  =          6

R-sq:                                           Obs per group:
     within  = 0.4647                                         min =          5
     between = 0.0005                                         avg =        6.8
     overall = 0.2740                                         max =          8

                                                F(9,26)           =       2.51
corr(u_i, Xb)  = -0.0461                        Prob > F          =     0.0323
```

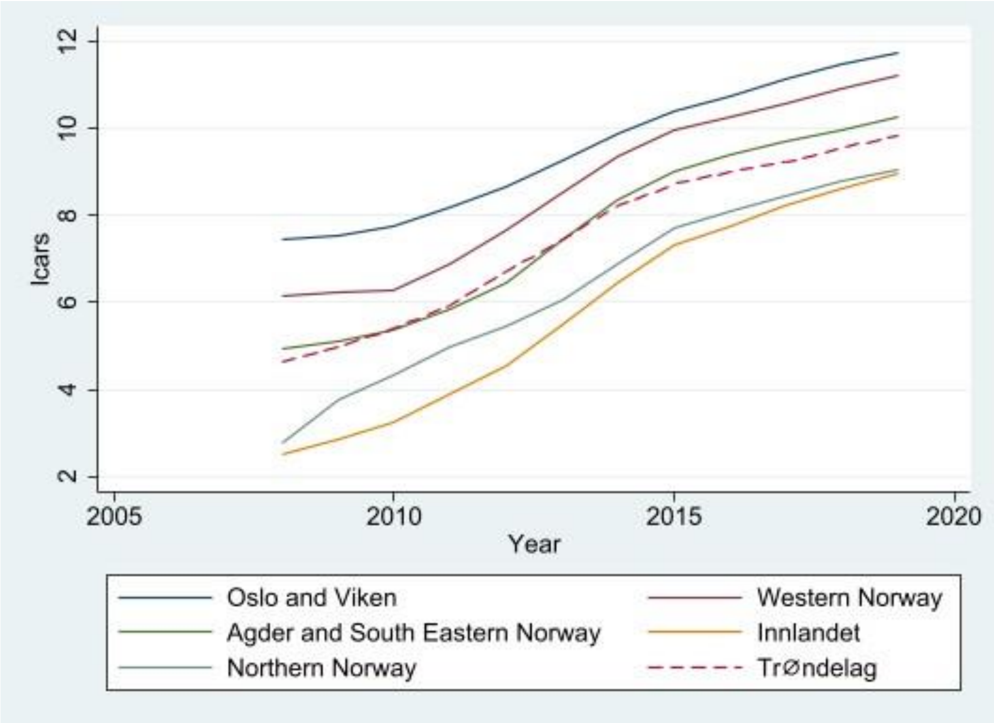
D.lcars	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.PHE	-.9932778	.5522407	-1.80	0.084	-2.128425	.1418691
1.dumNE	0	(omitted)				
PHE#dumNE						
1 1	.9083022	.4366295	2.08	0.047	.0107973	1.805807
year						
2013	-.6655746	.525296	-1.27	0.216	-1.745336	.4141867
2014	-1.076811	.4675562	-2.30	0.030	-2.037887	-.1157359
2015	-.9797006	.515602	-1.90	0.069	-2.039536	.0801345
2016	-1.202562	.515602	-2.33	0.028	-2.262397	-.142727
2017	-1.277526	.515602	-2.48	0.020	-2.337361	-.2176908
2018	-1.28718	.515602	-2.50	0.019	-2.347015	-.2273445
2019	-1.335097	.5206717	-2.56	0.016	-2.405353	-.264841
_cons	1.514184	.4976026	3.04	0.005	.491347	2.53702
sigma_u	.334984					
sigma_e	.33061213					
rho	.50656806	(fraction of variance due to u_i)				

```
F test that all u_i=0: F(5, 26) = 6.03                       Prob > F = 0.0008
```

7.2 Second hypothesis: local incentives lead to different regional EV adoption rates

To test the second hypothesis stating that the effect of local policy incentives is different for people that live in different areas, the regions’ data on registered automobiles is analyzed. Normally, most people think of EV as urban vehicles due to their range, their need for public charging stations and the presence of wealthy and environmentally conscious individuals (Ioannides and Wall-Reinius, 2015). Indeed, this is the case for both Norway and the Netherlands. As displayed in Graph n. 7, the Norwegian region with the highest number of registered electric private cars, vans and motorcycles is Oslo and Viken, with 130,332 vehicles (ln=11.78) in 2019. It is also the Norwegian area with the highest EV per capita (6.9%) and the one that invested the most for the rollout of EV charging points. It is followed by Western Norway with a per capita EV rate of 5.4%.

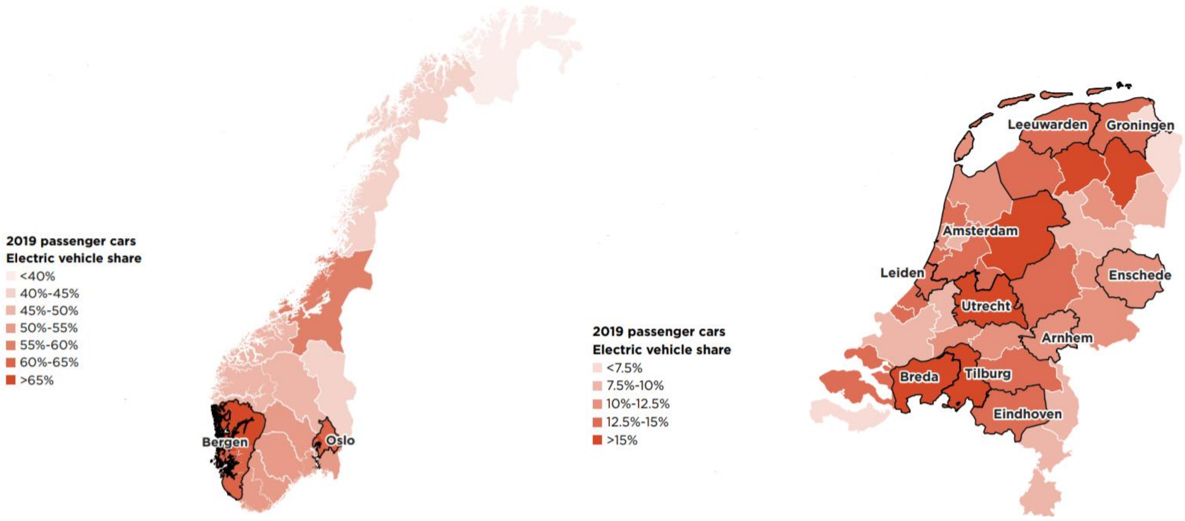
Graph n.7: Natural logarithm of registered EV by Norwegian region from 2008 to 2019



Data source: Statistics Norway, 2020

Considering the single cities highlighted in Figure 1, the two largest metropolitan areas, Oslo and Bergen, present the highest shares of registered electric passenger cars, respectively of 64% and 67% in 2019. The Trøndelag region follows with a share between 60% and 65%. Their car registrations numbers are above the national average. Electric cars have kept increasing in all regions over time. From 2008 to 2019, they all had a growth of above 99%, except for Oslo and Viken, which increase in registered EV was 98.7%. Innlandet and Northern Norway are the areas with the lowest EV share in the country, below 45%, but also the ones with the highest percentage growth in registered EV from 2018 to 2019, respectively of 31.7% and 25.5% (Statistics Norway, 2020; Lundetræ Jürgensen, 2020). In the case of the Netherlands, Amsterdam, Rotterdam, The Hague and Utrecht are the cities with the highest presence of electric cars, population and charging stations. They all have an EV market share above 15%.

Figure 1



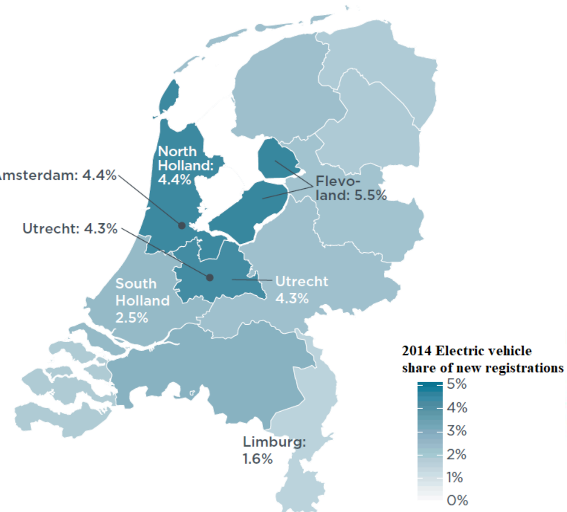
Source: Hall, Wappelhorst, Mock and Lutsey, 2020

To the author’s knowledge, extensive data on the number of electric cars by municipality since the introduction of EV incentives in the Netherlands has not been published. Therefore, only a comparison between the 2014 and 2019 data will be done. 2014 marked the end of PHEV exemption from registration costs as well as the start of BEV and PHEV exemption from motor vehicle road tax and reduced addition to taxable income (Deuten, Gomez Vilchez and Thiel, 2020). It also corresponded to a large reduction in PHEV new registrations due to a tightening in the Dutch tax scheme (Tietge, Lutsey and Mock, 2016). While Figure 2 shows the EV share of new registrations in Dutch provinces in 2014, Figure 3 represents the share of total registered passenger cars per area in 2019.

Figure 2 reveals that the highest share of new EV registrations in 2014 was in North Holland, Utrecht and Flevoland. The 2014 data may be biased due to car leasing as the vehicle can be registered in the province where the leasing office is based, where the firm leasing the car is placed, or where the employee driving the vehicle is from. Therefore, the place where registered cars are being used might be misrepresented. This could explain the disproportionately high number of company car registrations in Flevoland and Utrecht. It also justifies Flevoland’s scarcity of charging points despite it being the province with the highest new EV registrations shares (Tietge, Lutsey and Mock, 2016). The province of North Brabant, which include Breda, Tilburg and Eindhoven, was the third province with the highest EV new registration share, between 3 and 4%. For Friesland, Overijssel, Gelderland and South Holland the percentage was between 2 and 3%. Limburg, the southern province in the Netherlands, had the lowest share of electric vehicles. The white paper by Wappelhorst, Hall, Nicholas and Lutsey (2020) shows that also in 2018 the electric vehicle share of new registrations was high in Breda (7.9%), Amsterdam (7%), Utrecht (6%) and Rotterdam-The Hague (5.5%). The sales were mainly BEV rather than PHEV. The increase in new EV registrations since 2014 for the cited municipalities is in line with the data on total EV registrations in the Netherlands. Overall, the country had higher EV sale shares than in 2014 likely supported by the ongoing governmental incentives.

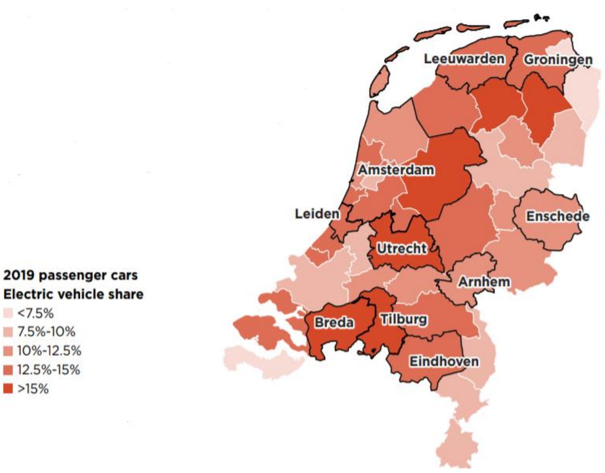
The distribution of EV share by province has changed over time. Flevoland and Utrecht have kept their high shares, above 15%, and were equaled by Breda, Tilburg, Friesland and Drenthe. In 2019, Breda had the highest EV share: 22%, followed by the city of Amsterdam, at approximately 18%, Tilburg and Utrecht. Despite Amsterdam had the highest absolute number of charging stations and of EV registrations, the electric passenger car share of its region, North Holland, was lower than in the previously cited areas, being between 12.5% and 15%. Leeuwarden (14.9%), Leiden (13%), the Hague, Groningen (13%), Eindhoven (14%) and the northern part of the Zeeland province were also in this range. In 2019, the western part of Groningen was the one with the lowest share of registered EV. Limburg still had one of the smallest shares of electric cars in the country.

Figure 2



Source: Tietge, Lutsey and Mock, 2016

Figure 3



Source: Hall, Wappelhorst, Mock and Lutsey, 2020

In 2014 there were, on average, 1.1 charging stations every 1,000 registered vehicles and were mainly in Amsterdam (North Holland), South Holland and Utrecht (Tietge, Lutsey and Mock, 2016). In 2020, the municipalities with the highest numbers of charging points are Amsterdam, Rotterdam, the Hague and Utrecht (Netherlands Enterprise Agency, 2018, 2020). These cities were the ones investing the most in local EV policies. In addition to local regulations for easier access to charging infrastructures and national policies, Amsterdam offered an EUR 5,000 subsidy for vehicles with an electric range of minimum 60 km (Netherlands Enterprise Agency, 2015). In 2016 it was substituted by a EUR 5,000 subsidy for company BEV with an annual mileage of at least 8,000 km within Amsterdam (Tietge, Lutsey and Mock, 2016). The municipality of the Hague has significantly improved its performance over the years, thanks to allowing easier access to the implementation of fast-charging stations in the city centre and the introduction of new subsidy schemes for BEV in 2016. The local authority provided EUR 3,000 for buying a second-hand car and EUR 5,000 for new cars. A budget of EUR 300,000 was available for passenger cars, taxis and delivery vans each. The municipality proposed to extend the scheme to the following year due to its positive result. The incentives resulted in an electric passenger cars share of over 12.5% in 2019. In the case of Rotterdam, situated in the Southern Holland region, and the Hague, their numerous subsidies and charging stations allowed them to achieve one of the highest EV sales in the country in 2018 (Wappelhorst, Hall, Nicholas and Lutsey, 2020).

An interesting case study is the local joint tender procedure launched by the provinces of North Brabant and Limburg in 2016 for the introduction of 2,500 smart charging stations. North Brabant planned to have 12,000 public or semi-public charging stations using local sustainable energy and smart technology by 2020. Already during the summer of 2016, 255 new smart charging points were located in 35 municipalities in the province (Netherlands Enterpirse Agency, 2017). While the Eastern part of North Brabant has significantly increased its electric car registrations, Limburg has remained one of the Dutch provinces with the lowest EV share. The underling reason is that the success of electric vehicles implementation depends on both local EV incentives and investments in infrastructures. From the municipal-level data, evidence in mixed. The municipalities that provided most subsidies and charging infrastructures to their residents are also the ones with the highest electric passenger car shares. However, in some cases, the local authority effort was not matched by an increase in the number of registered electric cars. The absence of complete panel data on Dutch EV shares by municipality does not allow to test the significance of this correlation.

Regressions were performed on Norwegian data using as dependent variable the yearly growth of the natural logarithm of registered cars in Norwegian regions and as independent variables the interaction between the EV incentives implemented in Oslo and Viken in 2011 (i.e. increase in charging infrastructures in Oslo), EV incentives in the same region in 2016 when the access to bus lanes was dependent on local authorities' decisions, and the effect of free ferry rides before 2017, year in which the incentive terminated, in Northern and Western Norway. Northern and Western Norway are the regions with the highest presence of islands in Norway. As ferries are often the only mean to move across places in the area, their inhabitants would highly benefit economically from free ferry rides (The ultimate EV tourist guide to Norway, 2020). The dummy assuming value equal to 1 when such incentives were in place is strongly significant across all regions. However, its interaction with the cited regions is insignificant, indicating that these incentives were not significant in EV adoption in the considered regions. The cited regressions were performed on the same dataset including 132 observations made of the number of conventional (sum of petrol and diesel) and electric cars for six regions, namely Oslo and Viken, Innlandet, Northern Norway, Western Norway, Trøndelag, and Agder and South Eastern Norway, from 2008 to 2019.

Table 5 shows the effect on EV adoption of the local incentives implemented in the Oslo and Viken region in 2011. The dummy variable "OandV" assumes value equal to 1 when the region is "Oslo and Viken" and zero in all other cases, while the dummy "EV" is equal to 1 when the year is 2011. This year corresponds to the introduction of 400 charging stations in Oslo but the dummy also includes the effect of all other EV policies active in the year. The EV incentives have a significant, positive impact on EV adoption. However, the relationship between EV incentives and adoption could be reversed: the increase in EV demand may be the one leading to an increased number of charging stations available. Further analysis on the topic may test the causal relationship among the two factors. The interaction between Oslo and Viken and electric vehicles' incentives in 2011 is not significant (p-value=0.668). In absence of the policy, the natural logarithm of the number of registered EV would be 0.24 units. The 2011 incentives increased the natural logarithm by 0.22 units. The overall R-squared indicates that the regression explains 15% of the variance in local EV adoption.

Table 5

```
. xtreg d.lcars EV##OandV i.year, fe
note: 1.OandV omitted because of collinearity

Fixed-effects (within) regression               Number of obs     =        132
Group variable: ct                              Number of groups  =         12

R-sq:                                           Obs per group:
     within  = 0.2832                                         min =         11
     between = 0.9426                                         avg =       11.0
     overall = 0.1578                                         max =         11

                                                F(12,108)         =       3.56
corr(u_i, Xb)  = 0.0790                         Prob > F          =     0.0002
```

D.lcars	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.EV	.2288205	.1355184	1.69	0.094	-.0398004	.4974415
1.OandV	0	(omitted)				
EV#OandV						
1 1	-.1053202	.245162	-0.43	0.668	-.5912737	.3806334
year						
2010	-.0833595	.0871145	-0.96	0.341	-.2560355	.0893166
2011	.0439842	.1084567	0.41	0.686	-.1709958	.2589642
2012	.1357915	.0871145	1.56	0.122	-.0368846	.3084675
2013	.208356	.0871145	2.39	0.018	.0356799	.3810321
2014	.1911129	.0871145	2.19	0.030	.0184368	.3637889
2015	.099463	.0871145	1.14	0.256	-.073213	.2721391
2016	-.0678402	.0871145	-0.78	0.438	-.2405163	.1048359
2017	-.0702623	.0871145	-0.81	0.422	-.2429384	.1024137
2018	-.0838876	.0871145	-0.96	0.338	-.2565636	.0887885
2019	-.0996802	.0871145	-1.14	0.255	-.2723562	.0729959
_cons	.2421691	.0615993	3.93	0.000	.1200687	.3642695
sigma_u	.28077493					

The reason that the impact of the 2011 increase in charging stations in Oslo on EV adoption in the region is not significant could be that the local policy only regarded the Norwegian capital, and not the whole region of Oslo and Viken. The unavailability of city-level panel data has not allowed to test the hypothesis on single cities. On the other hand, the regression on Northern and Western Norway demonstrates that the absence of charges on ferries are not a strong incentive for increasing EV uptake. The data on registered vehicles by fuel type in Northern Norway from 2008 to 2019 shows that the uptake of EV had a significant increase only from 2014, when registered cars were 57% more than the previous year. The data on Western Norway shows that the first relevant increase was in 2012, with a growth of 54% from 2011 (Data source: Statistics Norway, 2020). The 2017 Norwegian EV Associations' EV owners survey confirmed the belief among respondents that regulations decreasing the purchase price of BEV are the most effective, while those concerning free municipal parking, charging, or access to ferries are the less valued by consumers (Haugneland, Lorentzen, Bu, & Hauge, 2017). The result of these regressions is that the absence of tolls on ferries and policies incrementing the number of charging points at local level is not related to the increase in EV adoption in Norway. Therefore, the second hypothesis is rejected.

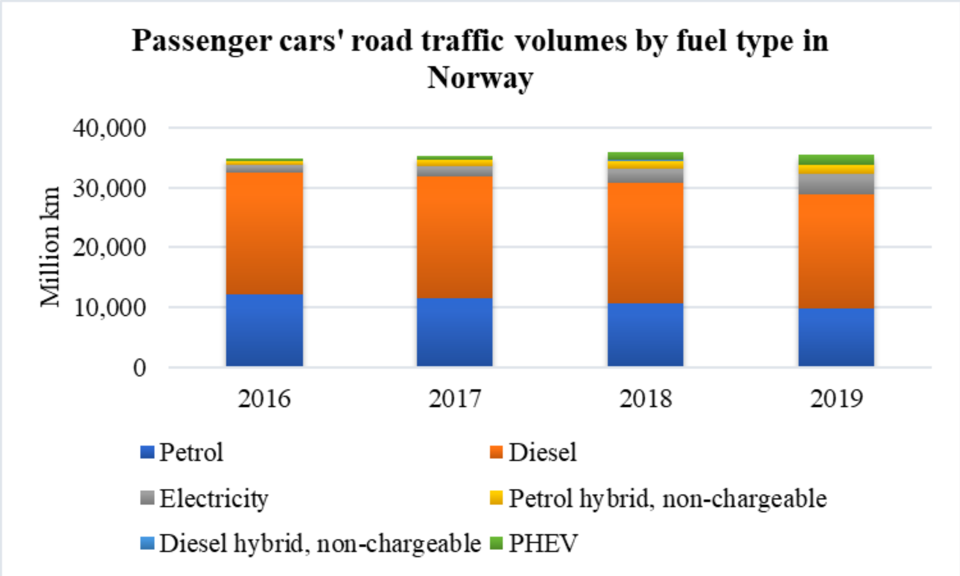
A possible factor influencing the uptake of electric cars at territorial level could be regional characteristics. Indeed, there appear to be a positive relationship between EV share and income and education. In both countries, the municipalities providing most subsidies and charging infrastructures to their residents are the ones with the highest electric passenger car shares. However, they are also the areas with the highest disposable incomes per capita: USD 27,125 (ca. EUR 23,084) in the Oslo region, USD 24,291 (approximately EUR 20,670) in Western Norway, USD 20,064 (ca. EUR 17,235) in North Holland, USD 19,608 (ca. EUR 16,844) in Utrecht, USD 18,577 (EUR 15,958) in South Holland and USD 18,480 (EUR 15,875) in North Brabant. All the regions are within the top 50% in income compared to all OECD countries. Hoekstra and Refa (2017) claimed that the positive correlation between Dutch drivers' wealth and their EV adoption is motivated by the tax benefits in the country favoring citizens paying high income taxes. Also in Norway the subsidies favour the rich: the more expensive the car, the larger the tax discounts (Steinbacher, Goes and Jörling, 2018). The cited regions are also the ones with the highest education level: Oslo and Western Norway are in the first two places for share of labor force with at least secondary education, while North Holland, Utrecht, South Holland and North Brabant are in the first six positions on a total of twelve, with Utrecht being at the top. On the other hand, Northern Norway and Innlandet, which present the lowest EV adoption and lowest population density, have also the lowest income and educational levels in the country. For the Netherlands, Limburg, with a disposable income per capita of USD 18,016 (ca. EUR 15,480) in 2018, is among the worst performing municipalities in terms of electric car share, income level and share of labor force with at least secondary education (OECD Regional Wellbeing, 2018). Therefore, the data analysis of the evolution of EV market shares in conjunction with the areas' income and education levels shows a positive relationship between the factors, as supported by the studies of Clery and Rhead (2013), Ferguson et al. (2018), Morton et al. (2018) and Zhuge and Shao (2019).

7.3 Third hypothesis: EV incentives increase road traffic

To test the third hypothesis, which assumes that EV incentives lead to greater road traffic, data on road traffic volumes, which measures the annual number of kilometers travelled by passenger cars, is used. In 2019, the Norwegian vehicle fleet consisted of approximately 2.8 million passenger cars driving on average almost 12,000 km per year. The average road traffic volumes per petrol and diesel vehicle were respectively 8,809 km (vs 11,878 km in 2008) and approximately 14,000 km (vs 19,024 km in 2008), while that of BEV was 12,361 km (vs 6,635 km). Many drivers have decided to switch to electric vehicles from conventional ones. Chargeable hybrids have a higher average mileage: 14,074 for petrol hybrid and 16,379 km for the diesel hybrid (Data source: Statistics Norway, 2020). Looking at Appendix n. 1 it is evident that as the average road traffic volumes per vehicle decreased for combustion fuels, they increased for BEV and PHEV. 2019 recorded the lowest average mileage per vehicle over a time frame of 15 years.

Graph n. 8 shows road traffic volumes for passenger cars by type of fuel in Norway from 2016 to 2019. The data for previous years is not reported in the graph because hybrids were registered as regular petrol and diesel vehicles up until 2015, thus not allowing to distinguish between them. The total volume of road traffic for all fuel types has been constant over time, especially in the last years, when it corresponded to approximately 35,4 million km on average. From 2005 to 2019 road traffic increased by 6,796 million km, which is explained by the increase in the number of households owning a car. From 2018 to 2019, the total passenger car kilometers travelled decreased by 1.3%, despite a 1.7% increase in registered private cars (Statistics Norway, 2020). The figures suggest that the increased purchases of electric vehicles did not increase road traffic. Instead, the rise in the use of BEV and PHEV corresponded to a decrease in the use of petrol, diesel and non-chargeable diesel hybrid cars.

Graph n. 8

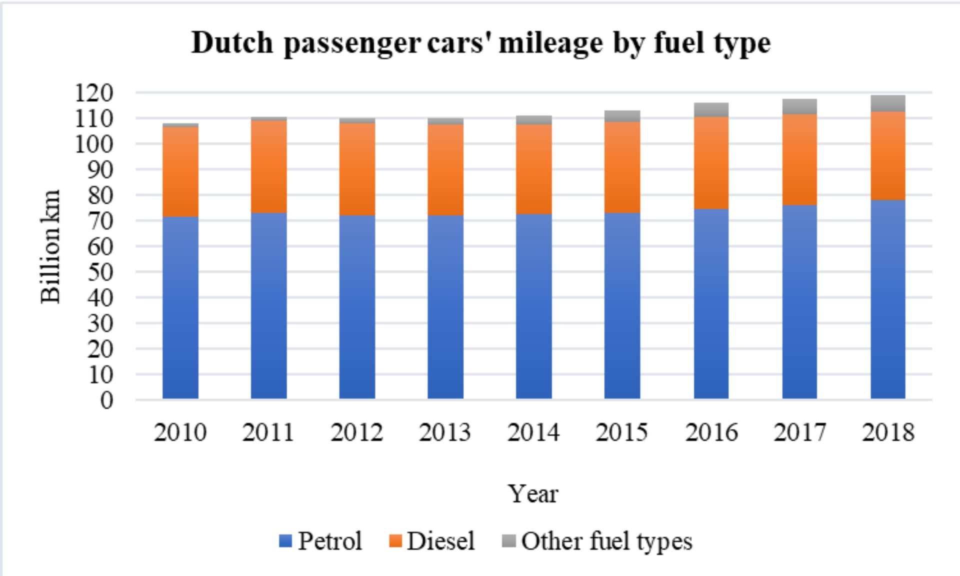


Data source: Statistics Norway, 2020

To test the third hypothesis in the case of the Netherlands, Graph n. 9 presents the total billion kilometers travelled by petrol, diesel, other fuel type vehicles, which includes compressed natural gas, BEV and PHEV, and their sum from 2010 to 2018. Specific data on Dutch EV kilometers covered was not available; therefore, it was necessary to consider the overall data on alternative fuel automobiles. Since 2012, electric vehicles had the highest number of passenger cars in the alternative fuel fleet (EAFO, 2020). Data before 2012, not dependent on EV, is reported to allow the reader to understand the mileage starting point in the category.

The mileage of other fuel type cars has been constantly rising since 2010 due to the increased adoption of less polluting vehicles, such as the battery and plug-in electric ones. Petrol cars had also increased their kilometers travelled since 2012 by 8.6%, reaching 78.4 billion km in 2018. The mileage of diesel vehicles has been relatively constant since 2009, being on average 35.5 billion km. It slightly decreased in 2018, reaching 34.3 billion km. The numbers are in line with those of total registered diesel vehicles: at the decrease in registered cars corresponds a reduction in total kilometers travelled. 2016 represents the only exception, as it registered almost 10,000 passenger cars less than in the previous year, but the car mileage increased by 1.1%. The same positive relationship between road travelled and number of registered vehicles is found for the other types of fuel examined. Indeed, petrol and other fuel cars have increased their mileage as well as their registration number over time. Despite a 0.5% decrease in mileage between 2011 and 2012, the total number of kilometers travelled has increased ever since, reaching 121,440.6 million km in 2018. The decrease in 2012 is not explained by the number of registered vehicles, which increased by 1.6%. The growth in petrol and other fuel type vehicles, the latter driven by electric vehicles (EAFO, 2020), has not been compensated by the decrease in diesel cars. Therefore, as vehicles augmented, so did the travelled kilometers. From 2010 to 2018, the mileage for other fuel type cars quintupled, that of petrol automobiles increased by 9.2%, while that of diesel vehicles decreased by 2.3%. In 2018, the total mileage of alternative fuel type cars was almost twelve times less that of petrol automobiles and five times less that of diesel vehicles.

Graph n. 9



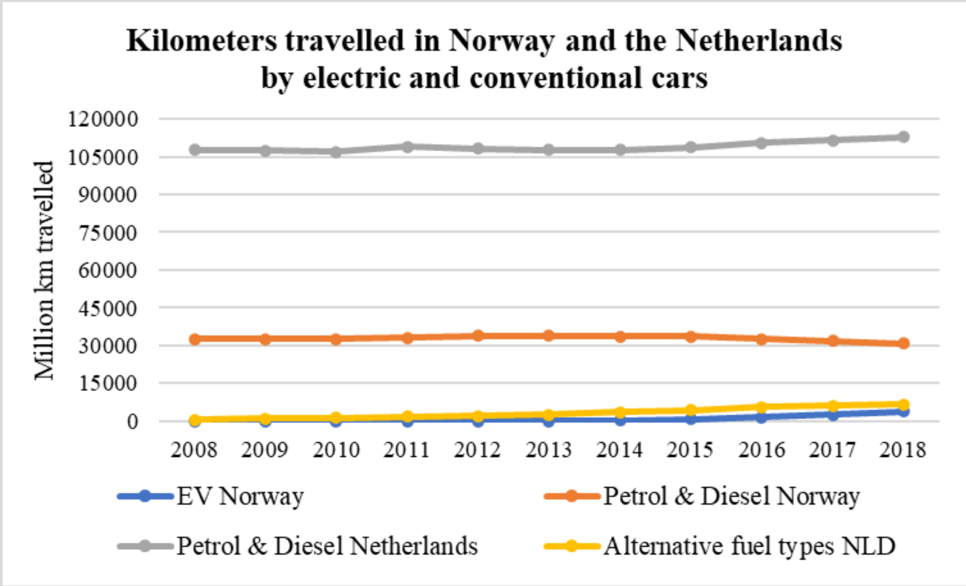
Data source: CBS, 2019; CBS Rwd, 2019

The average travelled kilometers per passenger car decreased from 14,807 km in 2011 to 14,503 in 2018. Both the average mileage per car and total mileage decreased from 2011, when the first EV incentives were introduced, to 2013. In this period, the number of petrol and diesel vehicles lost market shares, giving more space to alternative fuels. Since 2012, the total car mileage has kept increasing as did the number of registered petrol and electric cars. In 2016, the average mileage per passenger car reached a peak at 14,656 km, which was still below the 2011 level. It has been decreasing again in recent years. In conclusion, while the average mileage per vehicle has been decreasing recently, the total kilometers travelled have been rising since 2012 driven by petrol and other fuel type vehicles.

Graph n. 10 compares the trends of kilometers travelled by conventional cars with those of electric and alternative fuel type cars in Norway and the Netherlands respectively to visually see the mileage variation in relation to each fuel type and to EV incentives. While conventional cars in Norway decreased in number and in kilometers travelled, EV have increased their mileage. The total mileage remained constant thanks to a significant decrease in petrol automobiles usage, which compensated the increase in diesel and electric vehicles. The 6,796 million km travelled increase from 2005 to 2019 is explained by the rise in the number of households owning a car. 2006 and 2007 were the years in which mileage increased the most in absolute terms. They corresponded to the time when BEV were given access to bus lanes and CO_2 emissions were included in the calculation of the vehicles' registration tax. However, despite many incentives were introduced in 2018 and 2019, mileage decreased by 1.3% while passenger cars' registrations increased by 1.7%.

The rise in mileage in the Netherlands was caused by an increase in kilometers travelled by petrol and electric cars, while diesel automobiles have been constant at around 35.4 billion km travelled on average since 2007. Corresponding to the introduction of most ZEV and PHEV incentives in 2011, the mileage of fossil fuel combustion cars slightly decreased, while that of other fuel cars grew. With the publicly discussed reduction of EV incentives in 2016, kilometers travelled by petrol and diesel vehicles increased again, without a reduction in the mileage of other fuel types. Petrol and EV kilometers have been increasing ever since, while diesel mileage decreased in 2018, reaching 34.3 billion km. Both countries have seen their vehicles' mileages going up consequently to an increase in vehicles. In particular, since EV incentives were introduced in the countries, the kilometers travelled by low-emission cars have risen. Despite the number of registered cars increased more in Norway, the Netherlands showed a greater growth in mileage.

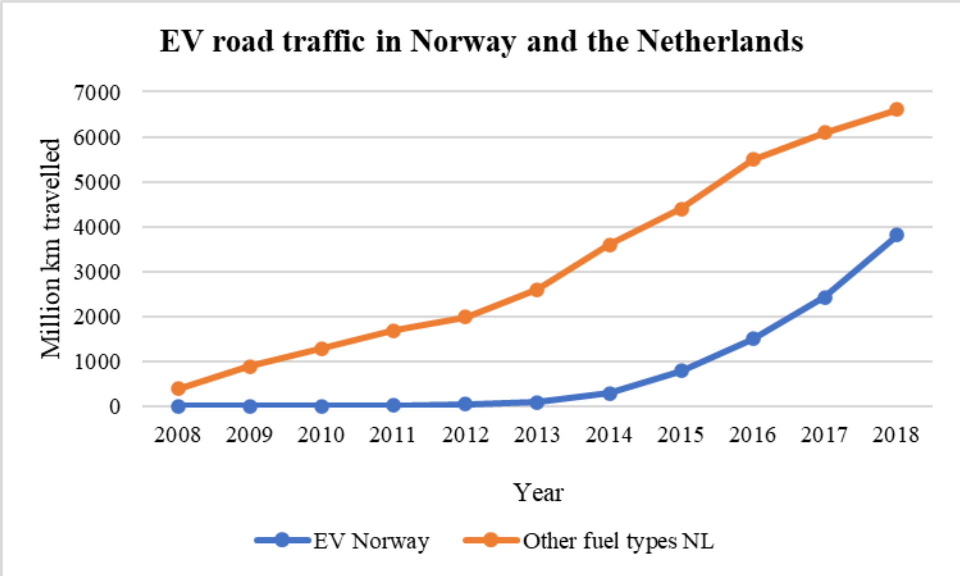
Graph n. 10



Data source: CBS, 2019; Statistics Norway, 2020

While Graph n. 10 has showed the number of kilometers travelled by the sum of BEV and PHEV in Norway and the mileage travelled by alternative fuel cars in the Netherlands in comparison to conventional cars, Graph n. 11 focuses on the mileage of the cited low-emission car types in the two countries to better detect variations across the years. In the Norwegian case, data from 2008 to 2015 only includes BEV because hybrids were registered as regular petrol and diesel cars. Kilometers travelled have been below 100 million km until 2013. Mileage started to increase at the end of 2013, reaching 3,817,200,000 km travelled in 2018. From 2013 to 2017, the total number of electric cars kept doubling from the previous year, while road traffic tripled in 2014 and 2015, and doubled in 2016 and 2017. In 2018 the number of electric cars was 1.4 times more than in 2017, while road traffic was 1.6 times higher. Regarding the Netherlands, the mileage for other fuel types started to rise at a faster rate after 2012, when the number of registered BEV and PHEV began to increase. In 2016 road traffic coming from other fuel types slowed down its growth speed.

Graph n. 11



Data source: CBS Rwd, 2019; Statistics Norway, 2020

In the regression reported in Table 6, the natural logarithms of car mileage of alternative fuel automobiles and battery electric cars respectively in the Netherlands and Norway are compared to the natural logarithm of the kilometers travelled by conventional automobiles when EV incentives were introduced before 2015, controlling for fixed effects. The regression on panel data uses as independent variable the dummy “dumEV”, which assumes value equal to 1 when the car type is electric and the years precede 2015. The model also considers the interaction with the dummy “dumNe” assuming value equal to 1 when the country is the Netherlands, happening 16 times. The objective is to analyze the development of car mileage in the two countries based on these years’ incentives. The model has 32 observations taken on four groups based on data on Dutch alternative fuel and conventional cars mileage from 2012 to 2019 as well as on Norwegian electric and standard cars kilometers travelled in each year from 2011 to 2019. Both the p-value of dumEV and the interaction between EV incentives and country are significant, being below 0.05, while the coefficient shows that the relationship between kilometers travelled and EV incentives is overall negative. This regression and the one carried out substituting ‘dumNe’ with ‘dumNor’, which assumes value equal to 1 when the country is Norway, confirm that the Netherlands is positively correlated with mileage while Norway is negatively correlated with it. In absence of zero-emission vehicles and PHEV incentives, the natural logarithm of car mileage is 8.66 units. The EV incentives previous to 2015 have led to a decrease of the natural logarithm of total kilometers travelled of 2.62 units compared to conventional cars. The R-squared shows that 68% of the variance in the natural logarithm of kilometers travelled in Norway and the Netherlands is explained by ZEV and PHEV incentives.

Table 6

```
. xtreg lmileage dumEV##dumNE i.year, fe
note: 1.dumNE omitted because of collinearity

Fixed-effects (within) regression               Number of obs     =         32
Group variable: ct                              Number of groups  =          4

R-sq:                                           Obs per group:
     within  = 0.8124                                         min =          7
     between = 0.9139                                         avg =        8.0
     overall = 0.6791                                         max =          9

                                                F(10,18)          =       7.79
corr(u_i, Xb)  = 0.5749                         Prob > F          =     0.0001

------------------------------------------------------------------------------
    lmileage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     1.dumEV |  -2.621949    .433655    -6.05   0.000    -3.533024   -1.710873
     1.dumNE |          0  (omitted)
             |
 dumEV#dumNE |
        1 1  |   1.751619   .5365531     3.26   0.004     .6243626    2.878875
             |
        year |
       2012  |   .5831506   .4579281     1.27   0.219    -.3789206    1.545222
       2013  |   .7721603   .4579281     1.69   0.109    -.1899109    1.734231
       2014  |   1.119842   .4579281     2.45   0.025     .1577711    2.081913
       2015  |   1.414009   .4579281     3.09   0.006      .451938     2.37608
       2016  |   .6897131   .4912968     1.40   0.177    -.3424632    1.721889
       2017  |   .8003181   .4912968     1.63   0.121    -.2318582    1.832494
       2018  |   .9075595   .4912968     1.85   0.081    -.1246168    1.939736
       2019  |   1.040994   .5565038     1.87   0.078    -.1281773    2.210165
             |
       _cons |   8.657326   .4175703    20.73   0.000     7.780044    9.534609
-------------+----------------------------------------------------------------
     sigma_u |  1.7591398
     sigma_e |  .51252546
         rho |  .92175682   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(3, 18) = 43.90                      Prob > F = 0.0000
```

When regressing the annual change in kilometers travelled by other fuel cars in the Netherlands, BEV in Norway and conventional cars in both countries when ZEV and PHEV incentives were introduced before 2015, the correlation is strongly significant both with ‘dumEV’ and for the interaction of the policies incentives in the Netherlands. Table 7 reports the results for the 28 observations analyzed in the regression model. The percentage of variance explained by this regression is higher than in the previous one, and accounts for 75%.

Table 7

```
. xtreg d.lmileage dumEV##dumNE i.year, fe
note: 1.dumNE omitted because of collinearity

Fixed-effects (within) regression               Number of obs     =         28
Group variable: ct                              Number of groups  =          4

R-sq:                                           Obs per group:
     within  = 0.7865                                         min =          6
     between = 0.9935                                         avg =        7.0
     overall = 0.7518                                         max =          8

                                                F(9,15)           =       6.14
corr(u_i, Xb)  = 0.5673                         Prob > F          =     0.0011

------------------------------------------------------------------------------
  D.lmileage |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     1.dumEV |   .4652079   .0907496     5.13   0.000     .2717798     .658636
     1.dumNE |          0  (omitted)
             |
 dumEV#dumNE |
        1 1  |  -.3462483   .1131846    -3.06   0.008    -.5874955   -.1050011
             |
        year |
       2013  |  -.1137777   .0913776    -1.25   0.232    -.3085444     .080989
       2014  |   .0448947   .0913776     0.49   0.630    -.1498721    .2396614
       2015  |  -.0086204   .0913776    -0.09   0.926    -.2033871    .1861463
       2016  |  -.0079719   .0986025    -0.08   0.937    -.2181381    .2021942
       2017  |  -.0461405   .0986025    -0.47   0.647    -.2563066    .1640257
       2018  |  -.0495041   .0986025    -0.50   0.623    -.2596702    .1606621
       2019  |  -.0779514    .111145    -0.70   0.494    -.3148515    .1589487
             |
       _cons |   .1643644   .0841427     1.95   0.070    -.0149815    .3437103
-------------+----------------------------------------------------------------
     sigma_u |  .17832175
     sigma_e |  .10146109
         rho |   .7554379   (fraction of variance due to u_i)
```

The analysis demonstrates a significant positive relationship between the annual increase in mileage and national EV incentives and a negative relationship between incentives and the natural logarithm of kilometers travelled. The former relationship is significant and negative for the Netherlands, meaning that, overall, the growth rate of road traffic has decreased after the introduction of EV incentives in the country. Meanwhile the relationship between the natural logarithm of mileage and EV incentives in Netherlands is positive. The reason for the rise in mileage by passenger cars can be connected to the constant population growth (The World Bank, 2020), which results in a greater number of vehicles used. EV incentives have motivated consumers to purchase them instead of more polluting options. However, the decrease in average mileage per car shows that drivers spend less time in their cars. In the case of Norway, the rise in the use of BEV and PHEV corresponds to a decrease in the use of petrol and diesel cars. Therefore, all factors considered, the hypothesis that incentivizing electric vehicles increases road traffic is rejected.

8. Limitations

Time and data constraints led to some assumptions and simplifications that may limit the analysis. This chapter aims to define the potential weaknesses and consider how they may affect the results.

The primary limitation is data availability. In the case of Norway, data on plug-in electric vehicles is only available since 2013. Before, the number of registered PHEV was incorporated to that of petrol and diesel vehicles. Due to this limitation it is not possible to have a more precise outline of the development of plug-in electric cars over time and the time series analysis could only be made on a limited number of years. Another limitation concerns the lack of car manufacturers in Norway before 2008. EV incentives were introduced in the country since the 1990s and stayed in place throughout the years. The lack of electric cars available does not allow to test for the effect of policies on the adoption of electric vehicles in the early years when incentives were launched. For testing the second hypothesis for Norwegian regions, city-level data rather than regional-level would have allowed for a more precise analysis of the effect of local policies.

Regarding the Netherlands, data was harder to find and more unprecise. The number of registered vehicles for all the Dutch provinces in each year is not available. Therefore, instead of being able to compare the number of registered cars before and after the introduction of incentives for each year, the comparison was only possible for EV market shares between 2014 and 2019. Moreover, the location where registered cars are being used might be misrepresented because of car leasing, as the vehicle can be registered in the province where the leasing office is based, where the firm leasing the car is placed, or where the employee driving the vehicle is from. For all these reasons, it was not possible to test this hypothesis statistically for the Netherlands. Another problem with Dutch data concerns the grouping of electric cars' mileage with that of all alternative fuel automobiles. Despite EV have the highest market shares among alternative fuel vehicles, the analysis of the third hypothesis for the Netherlands could be biased by the presence of compressed natural gas cars included in the other fuel types mileage data as we are not aware of the number of kilometers travelled by each type of automobile.

Finally, the regressions presented can be seen as descriptive, showing the correlation between the introduction of policies and the outcomes in question. A causal interepetation would require the consideration of unobserved factors and of the possible reverse causality between EV demand and incentives such as the introduction of more charging points in an area. The scope of this master thesis is to highlight the methods and impacts of the Norwegian and Dutch governmental decisions on the use of electric cars and can provide the starting point for subsequent causal analysis on the topic.

9. Conclusion

Norway and the Netherlands have a unique experience with incentives for the adoption of electric vehicles and are the two countries in Europe with the highest EV shares. The former country has started its EV policies earlier and hopes to achieve the sale of only zero-emission vehicles by 2025, before the other states and the Netherlands, which set the objective by 2030. Given their achievements in the share of electric vehicles in their fleet as well as the past and future commitments to the environmental cause, the two countries are of particular interest to analysis, and the findings arising from their experience, both positive and negative, can be used by other states in their paths towards the adoption of more environmentally friendly decisions in the transportation sector.

Three hypotheses were tested in the research: (1) Policy incentives have a positive effect on EV adoption; (2) Different local policy incentives lead to different EV adoption rates at regional level; (3) EV incentives lead to an increase in road traffic. The analysis was carried out by first providing a background in which the contexts and policy environment of the two countries are described. Subsequently, the analysis and results for the three hypotheses are presented. Data on the number of annual EV registrations, sales and market shares was studied to test the first hypothesis. To test the second and third hypotheses regional data on EV registrations and on kilometers travelled by vehicle fuel type was analyzed. For all three hypotheses, findings resulted by the comparison of data before and after the introduction of incentives, and by comparing Norway and the Netherlands. While the first hypothesis was not rejected, the second and third were.

In Norway, the first EV policies were introduced in the 1990s and most of them have been kept in place until the present day. The number of electric vehicles registrations has kept increasing over time, without fallbacks. In the Netherlands, EV incentives were introduced later and usually lasted for shorter periods of time. The number of electric cars registration was higher in the periods in which EV measures were present. Therefore, the adoption of electric vehicles was strongly and positively related to the presence of fiscal benefits introduced by the governments. Testing data on EV registrations at regional level has shown that local policies and EV adoption are not significantly related, thus rejecting the second hypothesis. Interestingly, the municipalities having the most electric cars were the wealthiest in the country and the ones with a higher percentage of education. Finally, the analysis of car mileage in the case of Norway has shown that road traffic has remained fairly constant over time and that electric vehicles have replaced the use of petrol, diesel and non-chargeable diesel hybrid cars. In the Netherlands, the decrease in average mileage per car and the negative and significant relationship between EV mileage and incentives have shown that Dutch drivers have been travelling less kilometers after 2015. Therefore, the hypothesis that EV incentives increase road traffic is rejected.

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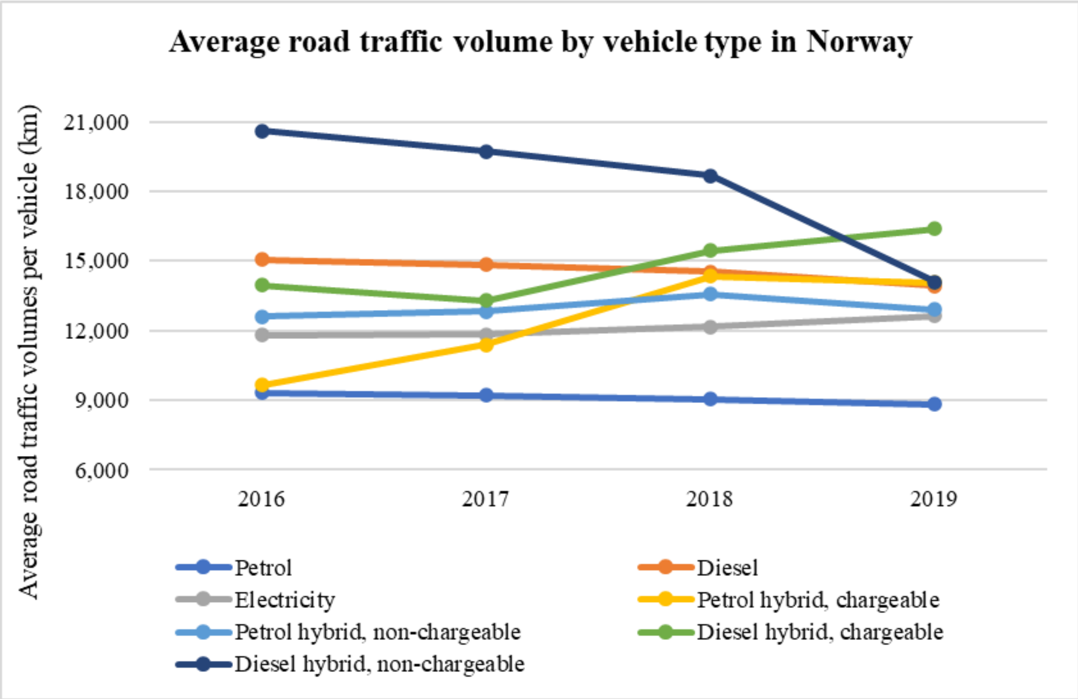
Appendix

Appendix n. 1



Data source: Statistics Norway, 2020