REDUCING EXTERNALITIES OF LAST MILE DELIVERY THROUGH TAXATION

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Abstract. In today's society, with growing interest in environmental sustainability and climate responsibility, the European Union has an ambitious goal - to achieve climate neutrality by 2050. This strategic plan, known as the European Green Deal, expresses a strong desire not only to address current environmental problems, but also to create a sustainable, green future for its citizens. However, only from these paths, the tax policy as one of the most important instruments of government influence can be both an obstacle and a tool in achieving the set goals. In this paper the tax policy of the European Union is analyzed in relation to its "green" ambitions. The aim of the research is to find out to what extent the current green tax system corresponds to the strategy of the European course and what changes are necessary to make the most of its potential for ensuring environmental sustainability. This study focuses specifically on the transport sector, which is one of the biggest sources of pollution in many countries. In the organization of the supply chain, it is important to achieve the least negative impact on the environment right in the last mile, when the goods are delivered to the end consumer in an urban city environment, where large population is concentrated. Therefore, one of the hypotheses of the study is to differentiate the tax policy depending on the use of alternative transport in a specific environment, that is, to apply tax discounts to alternative transport for passengers and trucks only in cities, while in the other stages of the supply chain to stimulate other forms of transport, such as rail transport.

Keywords: taxation, last mile, sustainability, mobility, transport, green deal.

Introduction

In this research, we assess the readiness of the European Union (EU) to realize the ambitious goals outlined in the European Green Deal. It focuses on the role of electric vehicles as well as the problem of urban air pollution.

Despite a noticeable increase in the number of electric vehicle registrations in recent years, the total number of electric vehicles is still relatively low. Even with this positive trend, the problem of urban air pollution remains acute.

In the study, we recognize the limitations of applying solely tax incentives to stimulate the adoption of electric vehicles. Alternatively, a number of alternative solutions are proposed such as:

1. Differential taxation: Introducing lower taxes for electric vehicles predominantly used in urban settings (especially for last-mile delivery) where pollution is most significant.
2. Mileage-based tax: Charging electric vehicle owners based on distance traveled to account for infrastructure use and generate funds for maintenance.
3. Investment incentives: Supporting technological advances in batteries, chargers, and other electric vehicle components through targeted incentives.

These suggestions are highlighted by the literature review, which notes the difficulty in predicting the growth rate of the electric vehicle (EV) market and the effectiveness of public policy measures to stimulate it. Government support such as tax credits and incentives can increase consumer confidence and boost EV sales but can be costly in the long run. Targeted subsidies for low-income buyers may be most effective. Focusing only on reducing emissions through electric vehicles can lead to ignoring other environmental concerns and economic factors. Successful promotion of electric vehicles requires a multifaceted approach that includes technological advances, cost-effective incentives, infrastructure investments, and awareness campaigns.

Materials and methods

It is difficult to predict the e-car market; it depends on several factors, including technological development. The electric vehicle market, which refers to the demand for electric vehicles, is undoubtedly a complex and dynamic industry that presents challenges in terms of accurate prediction. Predicting its trajectory relies on many factors, with technological development being one of the pivotal aspects shaping its future [1].

The successful development of the electric vehicle market requires a complex approach. Government support and incentives increase confidence in the e-car market. Technology development, sustainability of accumulators and other factors increase confidence. However, their relative disadvantages must be compensated for by incentives, at least during the initial marketing phase. Moreover, it is also necessary to raise awareness among citizens [2].

Various socio-economic factors (e.g. consumer preferences, income, environmental awareness, number of electric vehicle charging stations, travel demand and maximum electric vehicle range) have a significant impact on electric vehicle consumption. Fixed-effect controls are used to determine the impact of tax incentives on electric vehicle sales. According to the analysis, the share of electric vehicle sales increases when tax incentives increase. This implies the sample average price elasticity for electric vehicles. The estimated benefits of tax incentives for electric vehicle sales are smaller than for hybrid electric vehicle sales. Despite the progress made, the use of tax incentives to reduce emissions and other environmental externalities through electrification of transport remains costly. A more effective strategy could be to offer incentives for battery and vehicle technology development rather than consumer behaviour [3].

Since battery electric vehicles are the fleet of the future, it is impossible to overlook how they will affect the government revenue, CO2 emissions, vehicle miles traveled, and traffic congestion. Mileage charging should be implemented first in order to "contain" some of these negative externalities. One of Australia newest proposed policies is a distance traveled charge for electric cars. Governments may use road pricing as a first step toward implementing a more comprehensive transportation policy. The primary finding indicates that a 5s/km distance fee for electric vehicles would bring the government revenue back to the level of gasoline excise duty after 2040, when there will be a significant shift to electric vehicles [4].

A more effective approach to raising sales of electric vehicles, particularly among those who do not currently possess one, will be to increase the infrastructure for charging them as well as customer interest and engagement programs. Currently, not enough is being done to dispel the majority of consumer ignorance, indifference, or animosity toward electric automobiles. The credence to the notion that initiatives to expand the installation of public charging infrastructure should prioritize more comprehensive consumer engagement tactics targeted at convincing prospective buyers to purchase electric vehicles in addition to evaluating the efficacy of charging electric vehicles [5].

A targeted rise in electric vehicle fees would be inefficient, impeding the promotion of adoption initiatives. Nonetheless, declining revenue collection from electric vehicles is a minor but developing issue that should be addressed in future initiatives to enhance revenue for transportation infrastructure investment [6].

One step towards sustainability in transport could be one of taxing electric vehicles to offset the revenue generated by the tax policy benefits for alternative products or the use of alternative transport. However, it is necessary to evaluate the impact of these measures on the economy and the possible alternative approach [7].

A substantial decrease in the price per extra electric car might be attained by increasing the low-income user subsidy and doing away with it for the high-income user. This would allow for a greater rate of electric vehicle adoption with the same funding. This strategy makes it possible to allocate resources more effectively, guaranteeing that money is given to the people who need it the most. Ultimately, this strategy can lead to a higher adoption rate of electric vehicles within a given budget, as it maximizes the impact of subsidies by targeting those who face more significant barriers to adoption [8].

It is generally anticipated that supportive policy on electric vehicles will lead to less energy consumption from fossil fuels and a decrease in local pollution and noise issues. Regretfully, things are more complex. High-income families are encouraged to buy a second automobile by Norway current electric vehicle policy incentives, which is one of the most concerning parts of the program. Two-car households are currently in the minority. The prevalence of two cars per household poses several environmental problems. It suggests that the policy promoting electric vehicles to lower greenhouse gas emissions is wholly ineffectual. The Norwegian government may buy emission rights worth the same amount on the allowance market and keep them unused, reducing the supply of allowances rather than

supporting owners of electric vehicles. As a result, permit costs would have increased, and technology would have developed differently [9].

There is a noticeable disparity between the social cost of carbon and the government emission targets, as seen by the enormous welfare costs associated with large-scale reductions in CO2 emissions in the transportation sector. This discrepancy illustrates the conflict between achieving aggressive emission targets and optimizing overall well-being. While addressing climate change is vital, it is also critical to understand that concentrating only on emissions could ignore other flaws in the market and possibly have unexpected effects on the transportation industry [10].

Encouraging the use of electric vehicles requires users' interest in promoting more and changing their scepticism. It may have a multiplier effect if some users inspire others. The management of companies and organizations must lead by example in choosing electric vehicles also in the business environment. This will increase the percentage of positive opinions among users and ultimately lead to more positive support [11].

According to the findings, the government incentives, as they currently exist, are expensive. However, policymakers can reduce costs by tailoring incentives to people's income, where they live, how much they used to own a car, or how many miles they travelled. Under some conditions, such designs could more than quadruple the cost-effectiveness of policies (assuming full consumer pass-through of subsidies, like an upfront refund). These economic strategies involve subsidising those with lower incomes, whose purchases are more likely to be supplemental. Because of their progressive nature, tailored subsidies may also be politically acceptable in addition to being less expensive [12]. An analysis of the statistics shows that the EU is not yet ready for the implementation of the Green Deal, as both the use of electric vehicles and the use of alternative fuels are critically low. In addition, pollution in cities remains relatively high.

Additional administrative solutions are needed to reduce the pollution of harmful emissions in cities, i.e. in the delivery of goods in the last mile.

The number of electric cars in Europe has increased significantly in recent years. Since 2013, the share of both battery and electric cars connected to the mains in the automotive market has been gradually increasing. Especially rapid growth began in 2019, when the share of electric cars in total sales exceeded 2%. In turn, in 2020 and 2021, this growth became impressive, and the share of electric vehicles was 10.7% and 18.0%, respectively (Table 1).

Table 1

New registrations of electric cars, EU-27

Year	Electric cars with battery	Plug-in electric cars	Total number of cars	Share of electric cars
2013	21454	31079	9573937	0.5
2014	31197	60370	10075476	0.9
2015	46857	84115	11150601	1.2
2016	54065	65011	12027051	1.0
2017	83491	88334	12574590	1.4
2018	132377	106502	12753440	1.9
2019	242966	137632	12991283	2.9
2020	536186	525311	9924123	10.7
2021	878092	862569	9694858	18.0

Source: European Environment Agency

Data: https://www.eea.europa.eu/en/analysis/indicators/new-registrations-of-electric-vehicles#:~:text = There%20has%20been%20a%20steady,registered%20passenger%20cars%20were%20electric

The growing interest of consumers in electric cars is also evidenced by the trend of significant growth in the share of electric cars in the global passenger car market from 2013 to 2021. The largest increase was observed from 2018 to 2021, when the share of electric vehicles increased more than fourfold (Figure 1).

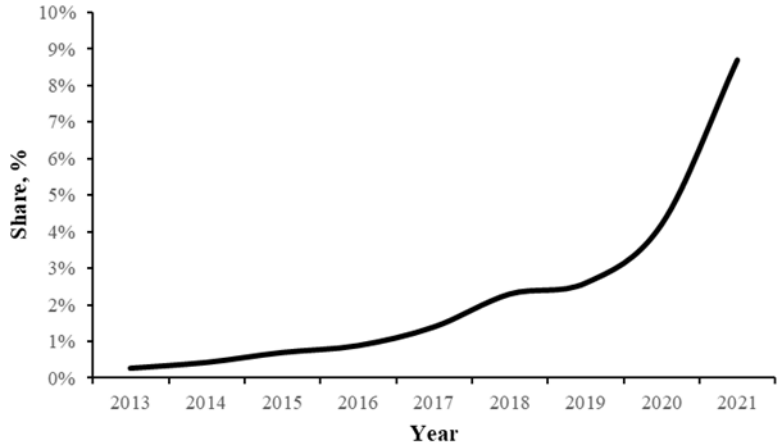

Fig. 1. **Global market share of electric vehicles within passenger car sales** (https://www.statista.com/statistics/1371599/global-ev-market-share/)

Between 2015 and 2021, the number of publicly available electric car charging stations in European countries has increased significantly. However, despite this increase, the findings also point to a lack of the charging station infrastructure, in particular for fast charging stations. For example, in 2021, there were only 49 fast charging stations compared to 307 slow charging stations (Table 2).

Table 2

Fast and slow publicly available chargers in Europe, thousand

Year	Fast publicly available chargers	Slow publicly available chargers
2015	6	61
2016	9	113
2017	11	122
2018	16	136
2019	25	187
2020	38	236
2021	49	307

Source: International Energy Agency

Data: https://www.iea.org/reports/global-ev-outlook-2022/trends-in-charging-infrastructure

Between 2013 and 2016, the average CO2 emissions per kilometre of new passenger cars fell in European countries. This trend towards a reduction in emissions shows a gradual improvement in the environmental performance of cars. While the following years (2017-2018) have seen a temporary increase in emissions, there has been a significant decrease in 2021 (Figure 2).

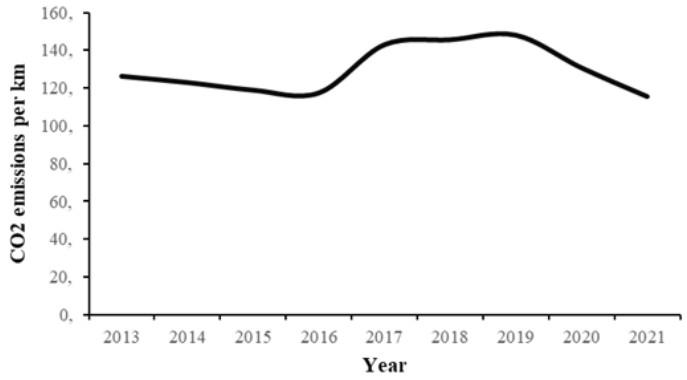

Fig. 2. **Average CO2 emissions per km from new passenger cars** (https://ec.europa.eu/eurostat/databrowser/view/sdg_12_30/default/table?lang = en)

The aim of the research is to find out to what extent the current green tax system corresponds to the strategy of the European course and what changes are necessary to make the most of its potential for ensuring environmental sustainability.

The tasks of the research are to analyse data on alternative vehicles and fuels, assess the impact of taxes on pollution reductions in EU countries, develop solutions for tax differentiation so that pollution in supply chains can be reduced directly in the last mile sections of cities.

The research uses econometric research methods by applying the nonlinear regression function in the impact assessment of the performance indicator. Data on different types of vehicles were collected and analysed to assess the impact of taxes on the use of e-cars in cities and outside cities. These data include information on e-car sales, frequency of use of e-cars, demographic indicators of e-car users and others. In addition, several external factors have been used that influence the use of e-cars, including the economic situation in the country, purchasing power, consumer attitudes and others. Finally, taxes on vehicles and e-cars are also taken as variables. These data include information on VAT, customs duty, fuel tax, and road tax. When applying nonlinear regression, a statistical analysis was carried out; it was determined whether there are regularities between taxes and the use of e-cars. Thus, a model was created that predicts the use of e-cars based on the tax data.

The validation of the model confirms the relevance of the variables and their impact on the performance indicator. The model can be used for further analysis. However, it is necessary to take into account other factors that may affect the use of e-cars, such as the infrastructure, technological developments, political decisions, etc.

Assessing the feasibility of alternative fuels as a substitute for existing fuels, fiscal aspects need to be considered. While the development of alternative fuel types and transportation should be supported, the government also needs revenue for infrastructure development and many other needs, which means that taxes will eventually have to be paid for electric vehicles because the budget requires funds. However, taxes could be differentiated by applying a discount in urban areas (last mile) where the highest pollution logically occurs, so it would be better to have e-vehicles in cities. Conversely, outside the city, no discounts would be necessary.

The formula (1) for the tax could be based on the average mileage of electric vehicles in the city (C) divided by the total mileage (T). Average indicators could be applicable until there are technologies that accurately determine the mileage of each vehicle based on the territory it operates in.

$$R = \frac{C}{T}, \tag{1}$$

where R – correction factor for the tax rate;
C – average mileage of a specific electric vehicle in the city, km;
T – total mileage of a specific electric vehicle, km.

Results and discussion

A non-linear multivariate regression provides a detailed analysis to account for the observed variations in transportation emissions. Specific components were chosen: the number of passengers cars with petroleum product engines; number of electric cars; transport tax revenues and as a depended component, CO2 emissions from newly registered cars. The regression analysis findings in several EU member states for variation factors between 2013 and 2021 are displayed in Table 3. The findings indicate that selected components in several EU member states have a strong correlation as well as a very tiny regression standard error (Table 3).

In order to assess in even more detail the impact of tax initiatives, it would be necessary to analyze in detail the data on mileage in different territories. It should be noted that the movement of persons was significantly affected by the recent COVID-19 crisis, which also rapidly changed the movement habits [13].

Although the market for electric vehicles is developing and their sales are also increasing, it is intolerable to study other influencing factors, not only the price and taxes, but also the effectiveness of technological solutions and the available infrastructure. For example, what are the charging options,

capacity, performance, availability and competitiveness. Charging speeds and other modern technologies could further incentivise a change in user habits more than tax credits.

Table 3

Non-linear multivariate regression results: emissions, type of cars and transport taxes

Country	Multiple R	Standard Error
Latvia	0.6212	0.0646
Lithuania	0.6308	0.0827
Estonia	0.7142	0.0603
Germany	0.8906	0.0648
Sweden	0.9367	0.0731
Finland	0.8938	0.0663

Source: calculation by the authors

Data: Eurostat. (2024). Passenger cars, by type of motor energy. Available: https://ec.europa.eu/eurostat/databrowser/product/page/road_eqs_carpda__custom_10222226; Eurostat. (2024). Energy taxes. Available: https://ec.europa.eu/eurostat/databrowser/view/env_ac_taxind2/default/table?lang = en; Eurostat. (2024). Average CO2 emissions per km from new passenger cars. Available: https://ec.europa.eu/eurostat/databrowser/view/sdg_12_30/default/table?lang = en

Government policies can be chosen not only in the form of economic instruments, but in the form of administrative restrictions, for example, as is the case in many countries when designating low emission zones [14].

In order to change the users' behaviour, it is necessary to change their attitude, including that users understand all the costs associated with using the chosen transport. By raising public awareness of electric cars as a practical thing that also saves money, it could spur the demand for electric cars. Consequently, campaigns to raise public awareness should be envisaged and developed to encourage people to make greater use of electric vehicles as an integral part of their daily lives.

It is also necessary to assess socio-economic factors, namely, the standard of living, income, purchasing power, differentiating government subsidies according to the necessary support. Transport and movement specifically to go to available workplaces is the main direction in which support or alternative solutions should be provided for the provision of public transport or in the form of support for a particular entrepreneur (employers of shared cars).

Our findings on the impact of tax incentives on EV adoption are consistent with the previous research [6] and [7]. However, as noted by [10], there is a risk of diminishing rewards as the market matures. According to [10], tax incentives may become less effective after a critical mass of early adopters is reached. This emphasizes the necessity for a multifaceted approach that moves away from depending primarily on the tax benefits and toward embracing additional tactics as the EV market matures.

Our research expands on current information. We agree with [3] and [6] that tax incentives have a favourable impact on EV sales. However, we offer a novel solution: a tax differentiation formula (1) based on the mileage within metropolitan regions ("last mile"). This strategy directly addresses the concerns highlighted by [4] about potential negative externalities, such as greater travel as a result of decreased operating costs for electric vehicles. Furthermore, our focus on user behaviour and public awareness campaigns is consistent with [11] and [14], which emphasize their importance in fostering EV adoption.

Conclusions

1. A complex approach is needed for the electric vehicle market to develop with sufficient success, which includes measures from both government support and incentives for technological development, as well as other sustainability measures, including the necessary public awareness measures. In order to be able to promote the widespread deployment of electric vehicles for sustainable and environmentally friendly transport, it is necessary to analyse various factors and develop a comprehensive strategy.

2. If the existing tax policy provides for a tax waiver for the use and stimulation of electric cars, then a new problem that needs to be addressed is reduction in government revenues. Therefore, future initiatives should seek a new specific targeted approach, such as differentiating the tax according to where such electric cars are used, for example, only in cities, in last-mile deliveries and in places with the highest pollution respectively. It is necessary to create an approach that provides sustainable finance for investments in the transport infrastructure, while taking into account the unique characteristics of electric vehicles.
3. Tax incentives have a positive impact on the sale of electric vehicles, but the high costs of relying solely on tax incentives to reduce emissions should be considered as alternative solutions that could be an even more effective strategy. For example, incentives should be offered for technological solutions, the development of accumulators, chargers, and other technical investments. So, cost reduction or the use of effective resources could be an alternative to tax credits on final products.
4. Another novelty could be an approach based on the application of a tax depending on the amount traveled. So, it could be a charge for the use of the infrastructure depending on the intensity of use. By developing a variety of diversified approaches that support the transition to an alternative transport, it would simultaneously address the issues of fundraising for the maintenance and development of the infrastructure.

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Author contributions

The contribution of each author: Conceptualization, M.J.; methodology, M.J.; validation, B.Š-R.; formal analysis, B.Š-R.; data curation, I.Ņ.; writing – original draft preparation, I.Ņ.; writing – review and editing, B.Š-R. and M.J.; visualization, I.Ņ.; funding acquisition, M.J. All authors have read and agreed to the published version of the manuscript.

References

[1] Aiazzi C. "E-cars: a multi-perspective analysis to future scenarios for the Italian market," 2018.
[2] Figenbaum E. et al., "Increasing the competitiveness of e-vehicles in Europe," Eur. Transp. Res. Rev., vol. 7, 2015, pp. 1-14.
[3] Yan S. "The economic and environmental impacts of tax incentives for battery electric vehicles in Europe," Energy Policy, vol. 123, 2018, pp. 53-63.
[4] Hensher D. A., Wei E., Liu W. "Battery electric vehicles in cities: Measurement of some impacts on traffic and government revenue recovery," J. Transp. Geogr., vol. 94, 2021, p. 103121.
[5] Hoogland K., Kurani K. S., Hardman S., Chakraborty D. "If you build it, will they notice? public charging density, charging infrastructure awareness, and consideration to purchase an electric vehicle," Transp. Res. Interdiscip. Perspect., vol. 23, 2024, p. 101007.
[6] Jenn A., Azevedo I. L., Fischbeck P. "How will we fund our roads? A case of decreasing revenue from electric vehicles," Transp. Res. Part A Policy Pract., vol. 74, 2015, pp. 136-147.
[7] Konstantinou T., Labi S., Gkritza K. "Assessing highway revenue impacts of electric vehicles using a case study," Res. Transp. Econ., vol. 100, 2023, p. 101248.
[8] Sheldon T. L., Dua R. "Effectiveness of China's plug-in electric vehicle subsidy," Energy Econ., vol. 88, 2020, p. 104773.
[9] Holtsmark B., Skonhoft A. "The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries?," Environ. Sci. Policy, vol. 42, 2014, pp. 160-168.
[10] Wangsness P. B. "How to road price in a world with electric vehicles and government budget constraints," Transp. Res. Part D Transp. Environ., vol. 65, 2018, pp. 635-657.
[11] Li J., Jiao J., Tang Y. "Analysis of the impact of policies intervention on electric vehicles adoption considering information transmission – based on consumer network model," Energy Policy, vol. 144, 2020, p. 111560.

[12] Xing J., Leard B., Li S. “What does an electric vehicle replace?,” J. Environ. Econ. Manage., vol. 107, 2021, p. 102432.
[13] Brizga J., Jurušs M., “Covid-19 and energy crises induced mobility changes: a case study of Latvia,” in Transforming Consumption-Production Systems Toward Just and Sustainable Futures, 2023.
[14] Morfeld P., Groneberg D. A., Spallek M. F. “Effectiveness of low emission zones: large scale analysis of changes in environmental NO2, NO and NOx concentrations in 17 German cities,” PLoS One, vol. 9, no. 8, 2014, p. e102999.