

Analysis of Carbon Dioxide Emissions for Cars in Europe

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Abstract. *This article addresses the interconnection between macroeconomics and microeconomics, emphasizing the importance of a responsible approach that identifies dysfunctions and conflicts in these areas. The analysis of micro-macroeconomic convergence focuses on the relationship between economic performance and energy consumption, highlighting the need for efficiency in the use of resources, especially in the transport sector in the European Union, between 2007 and 2023. The study uses the regression method to process the collected data, which suggests a quantitative approach in environmental impact assessment. The paper focuses on the relationship between carbon dioxide emissions determined by transport, respectively automobiles in the context of the growth of economic activity, highlighting their impact on the environment. Although the use of renewable energy is a goal of sustainable development, the analysis suggests that it does not significantly improve economic performance. The study proposes a two-dimensional approach, mediating the conflict between economic profitability and environmental constraints, examining both microeconomic and macroeconomic aspects. These contributions are essential for underpinning energy and environmental policies.*

Keywords: *carbon dioxide, automobiles, electric cars, sustainable development, Europe.*

Introduction

The increase in the number of automobiles has had a predictable result: internal combustion engines burning fossil fuels such as diesel and gasoline have led to increased emissions of greenhouse gases, including CO₂ (carbon dioxide). Attention to the negative effects of automobiles has increased with the amplification of the effects of pollution, such as global warming, ozone depletion, and the impact on human health (Alandejani & Al-Shaer, 2023).

In response, new technologies and regulations have emerged to reduce these emissions, helping to lessen the impact that modern cars have on the environment and public health. Among the current solutions are the introduction of cars with filters for harmful particles, hybrid systems that reduce the use of the heat engine, downsizing and supercharging of turbine engines (Seow, 2024).

Regulations are becoming more stringent around internal combustion cars, and the promise

DOI: 10.2478/picbe-2025-0109

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of a zero-emission future is starting to take shape by imposing strict rules on car manufacturers, who are forced to implement solutions to comply with the emission limits imposed. Car owners are also encouraged to use environmentally friendly vehicles through tax incentives and are charged extra for cars with large, inefficient engines that use fossil fuels (Kong et al., 2023).

Automobiles are an essential means of transportation for people and goods. Daily activities such as commuting to work, shopping or traveling would be much more difficult without the use of public or personal automobiles in areas of interest, where we need or want to get to. World population growth, facilitated by favorable living conditions and technological advancement, has led to a significant increase in the number of automobiles in use (Martiny et al., 2024).

Literature review

Climate change is having an increasingly frequent and severe impact on the lifestyles of the global population (Mogos et al., 2021). Over the past ten years, Europe has witnessed many extreme weather events, such as prolonged droughts, wildfires, torrential rains and floods (Kartal& Pata, 2023). These phenomena not only disrupt daily activities, but also generate significant economic losses and endanger human lives (Angheluta et al., 2019). The consequences of climate change vary according to the entities affected and can be classified into various subcategories, thus highlighting the complexity and extent of these changes on society and the environment. (Aydoğmuş, Gülay& Ergun, 2022).

The evolution of nature at the level of fauna and flora is affected, the loss of natural habitats and the increase in the number of pests being problematic (Radulescu et al., 2023). Agricultural yields decrease and droughts, fires and floods can even destroy entire crops (Buzoianu, et al., 2024). In Europe, the tendency is to increase floods and adjacent storms, which produce, increase in river flows, landslides resulting in damage to the integrity of citizens and considerable financial losses (El Khoury, Nasrallah& Alareeni, 2023).

The greenhouse effect is a natural phenomenon essential to life on Earth, involving a layer of gases that reflects the sun's rays back into the atmosphere. This layer of gases makes it difficult to separate and analyze their flow by source, whether natural or human (Dewaelheyns et al., 2023).

The study by Bekaert, G et al. (2023) analyze the correlation between economic growth and renewable energy consumption in the context of the European Green Deal. They explore the link between gross domestic product, the global competitiveness index and the use of renewable energy. It highlights how the development of European states stimulates the use of renewable energy, having positive effects on energy security and sustainable economic growth (Radulescu, Bran et al., 2020). Focusing on the transport sector, the study aims to investigate the impact of renewable resources on economic performance in this field.

The study by Feng, G.F. et al. (2022) focus on evaluating alternatives to fossil fuel systems and quantifying their potential to facilitate the transition to a fully renewable transport sector.

Sarbu, R. et al (2020) examines the intersection of geopolitics and renewable resources, highlighting their impact on international relations. Thus, a complex context is emerging in which the transition to renewable energy not only influences economic performance, but also has significant geopolitical implications.

Tuna et al., (2023) formulated the paradox of energy, stating that an increase in energy efficiency can lead to greater consumption, suggesting that the solution to environmental problems lies not in increased efficiency but in reduced consumption.

In this context, the Joint Research Center proposes a set of tools to evaluate the measures adopted in the implementation of EU policies in the transport sector. These tools focus on

increasing the efficiency of the transport system, through techno-economic analyzes of emerging technologies, assessing the impact on transport demand, costs, emissions, congestion, accessibility and economic impact (Yang, 2022).

The aim of these assessments is to strengthen the competitiveness of European industry, promote innovation in transport and reduce CO2 emissions and other externalities, underlining the importance of an integrated approach to managing environmental and economic challenges

Methodology

The study aims to present the influences of various variables on the increase in CO2 emissions from the transport sector in Romania. The analyzed data are processed and correlated using various sources: the database of the National Institute of Statistics of Romania for information on the number of the resident population, the Eurostat database for information on the number of cars registered in Romania and the database on emissions for atmospheric research (EDGAR) for information related to CO2 emissions from the transport sector. Thus, interdependencies between the analyzed data can be observed. The form of the multiple regression equation used to analyze these factors and interpret the relationship between the four variables is:

$$Y = b_0 + b_1 * X_1 + b_2 * X_2 + E_i, \text{ where:}$$

b_0, b_1, b_2, b_3 – coefficients of the regression equation; Y – the endogenous or dependent variable; X_1, X_2, X_3 – exogenous or independent variables; E_i – the errors of the model or the value of the residual variable.

To use the regression equation correctly, it is essential to understand what the coefficients represent and how they can be interpreted. Within this equation, b_0 is the coefficient of the free term, which has no direct economic relevance. It represents the estimated value of the dependent variable (Y) when the independent variable (X) is zero or absent, thus indicating the baseline level of the dependent variable in the absence of the influence of the independent variables. Considering the aspects found in the literature as well as our own expectations, the following hypotheses will be tested:

- H1: There is a positive link between economic performance and CO2 emissions.
- H2: There is a dependency between carbon dioxide emissions and the total number of cars at European level

Results and discussions

The Covid-19 pandemic, which began in 2020, has had a significant impact on carbon dioxide emissions, due to restrictions on the movement of people, transport and vehicles. Various economic sectors, including tourism, were affected. In 2020, global CO2 emissions fell by 5.3% compared to 2019, as a result of reduced fossil fuel use.

However, the resumption of economic activities and the end of quarantine periods led to a return of emissions to pre-pandemic levels, so that in 2021 there was an increase in CO2 emissions of 5.3% compared to 2020, which is equivalent to a reduction of just 0.36% between 2019 and 2021.

In the transport sector, emissions remained lower, with a 7% reduction in 2021 compared to 2019. Per capita global CO2 emissions increased by 13% between 1990-2021.13% (1990-2021) (EDGAR, 2022), (JRC, 2022)

In the European Union, carbon dioxide emissions increased by 7.3% from 1990 to 2021. The pandemic caused a decrease in CO2 emissions by 10.8% between 2019 and 2020, resulting in an effective reduction of 5% in period 2019-2021.

Germany is responsible for the largest share of emissions (24%), followed by Poland and Italy with shares of 11.6% and 11.5% respectively. The only sector in which the European Union registered an increase in emissions is that of transport, with an advance of 16% between 1990 and 2021, while emissions from all sectors fell by 27%. (EDGAR, 2022), (JRC , 2022)

According to the European Automobile Manufacturing Institute (ACEA), in 2022, cars were classified according to the type of fuel used, resulting in seven distinct categories: petrol, diesel, natural gas, electric hybrids, plug-in hybrids, battery electric and other fuel types (ACEA, 2023).

Diesel cars accounted for 19% of total sales in the European Union in 2021, falling to 16.4% in 2022. These vehicles are preferred in commercial and passenger transport due to their low urban and extra-urban fuel consumption and torque superior compared to gasoline cars. The main disadvantage of diesel engines is the emission of noxes, including particulate matter (PM) and nitrogen oxides (NOx). The implementation of European emission standards required the use of particulate filters and additional additives to reduce these emissions.

Hybrid electric vehicles (HEVs) saw a growth in purchases in 2021, accounting for 19.8% of total sales, and will rise to 22.6% in 2022. This growth is due to the continued refinement of alternative propulsion technology, which has become more and more accessible, without additional efforts for recharging.

However, the sales growth of this type of vehicle is slower compared to that of fully electric cars. HEVs have a heat engine used when the vehicle requires maximum power or to charge the electric battery. An electric motor uses the energy stored in the batteries to operate the vehicle when stationary or at low speeds.

Analysis of the environmental impact of cars in Europe

The lack of regulations surrounding the advent of cars has had a significant impact on Europe's climate and, by extension, the global climate. Currently, research, regulation, development and implementation of new emission reduction technologies have reduced the individual impact of motor vehicles. Thanks to technological advances, modern cars have evolved and use alternative propulsion, such as hybrid-gasoline engines, or zero-emission technologies, such as electric vehicles.

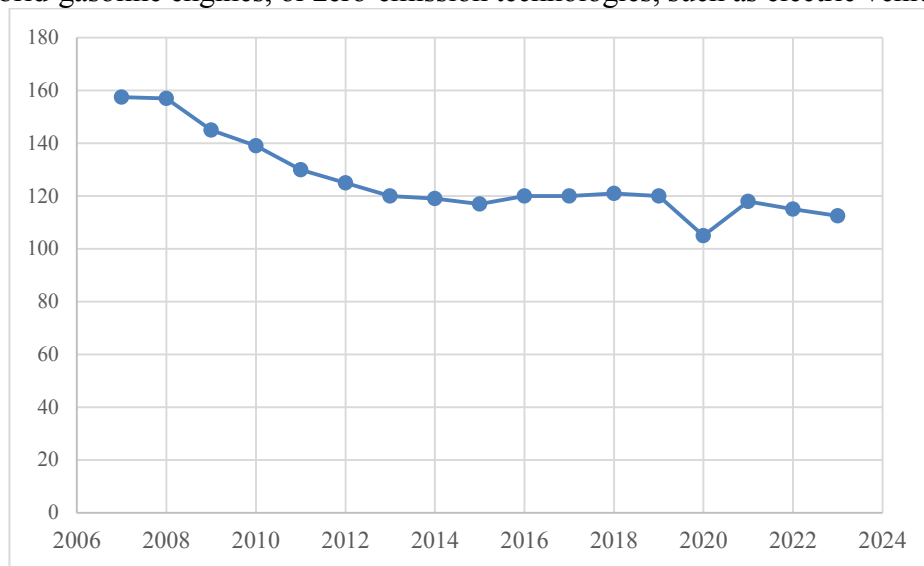


Figure 1. Evolution of average g/CO2 emissions per kilometer of new passenger cars in the European Union in the period 2007-2023

Source: European Environment Agency.

During the analyzed period, the volume of g/CO₂ emissions per kilometer of new passenger cars in the European Union decreased from 157.5 g/CO₂ per kilometer in 2007 to 112.5 g/CO₂ per kilometer in 2022. the analyzed period, the average volume of emissions of new passenger cars in the EU was 127.83. The average year-on-year decrease was 3 g/CO₂, - 2.21%.

Thermal engines have low emissions and are more efficient due to lower fuel consumption and smaller engine sizes. They generate more power through mechanisms that optimize the introduction of air into the engine (such as turbines and compressors). In addition, the possibility of reducing the number of engine pistons to minimize greenhouse gas emissions is being explored.

The results obtained The regression equation obtained after analyzing the data is of the form $Y = 3094.7 - (0.002) \cdot X$. Thus we can observe the following: the coefficient $a = 3094.7$ is represented by the value of the variable Y in the absence of the variable X .

To make the decision of the test, we will look at the value of "Significance F" and if it is less than 0.05, the model is statistically correctly identified or valid. As we can see above, the value obtained is Significance F= 0.003 which is lower than 0.05 which means that the analyzed model is correctly identified from a statistical point of view, therefore it is valid.

To be able to analyze whether the coefficients of the regression equation of the analyzed model are statistically significant, the "P-value" must be less than 0.05. Next we can analyze the coefficient of determination (R Square), its value being 81.6 so we can see that there is a strong and direct connection between the variables.

The model could be improved if it had more input data for dependent and independent variables as well as more variables for which to apply the econometric regression model.

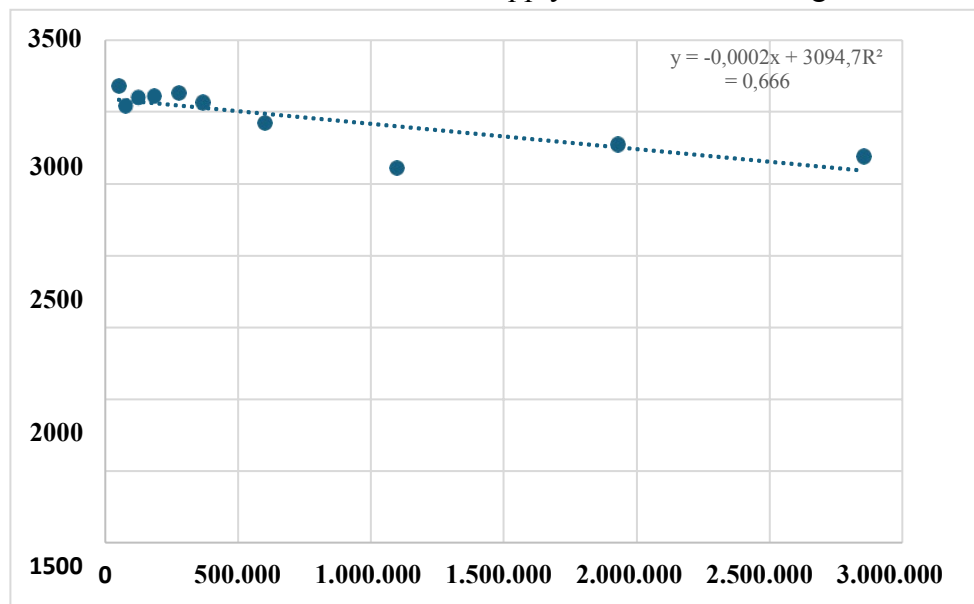


Figure 2. The dependence of carbon dioxide emissions on the total number of cars in the period 2013-2022

Source: own processing.

Conclusion

Environmental legislative packages and directives have had a significant impact on reducing emissions. The Euro emission norms, applied to all vehicles, have had a major effect since the beginning of the 21st century until now, eliminating in proportions 90-99% the values of compounds such as sulfur oxides and lead. The European Union has set itself the goal of achieving zero emissions by 2035 for new cars and by 2050 for all vehicles in circulation, an ambitious target that is particularly challenging for those who use diesel cars and work in factories with significant emissions.

From 1990 to the present, microeconomic and macroeconomic data have been collected and analyzed on emissions from coal, oil, and natural gas combustion in industrial processes and automobile use.

These economic and geopolitical efforts have materialized in the allocation of funds for the research, development and implementation of new technologies. These include both complementary technologies to existing devices and cars, such as adding particulate filters to internal combustion engines, and completely new product development, such as electric cars, when emission reductions are no longer possible with current technologies.

The impact of natural calamities such as deforestation and fires is also analyzed, with human involvement largely responsible for these. Efforts to reduce emissions of CO₂ and other compounds have been successful, and the European Union is considered an example to follow for other regions or states that have not yet assumed the financial and moral need to reduce emissions, although they ultimately affect health and quality of life on Earth.

The reduction of carbon dioxide emissions in Europe has been possible thanks to the awareness of anthropogenic impact and the implementation of effective policies and technologies. The European Union serves as a model for other regions, demonstrating that taking financial and moral responsibility for reducing emissions is essential to protecting global health and well-being.

References

- Alandejani, M., & Al-Shaer, H., (2023). Macro uncertainty impacts on ESG performance and carbon emission reduction targets. *Sustainability*, 15(5), 4249
- Angheluta, S.P.; Mitrita, M.; Burlacu, S.; Gole, I.; Badea, C.G. (2019). Climate Change and Renewable Resources in the European Union, 34th International-Business-Information-Management-Association (IBIMA) Conference, ISBN978-0-9998551-3-3 Page1324-1336
- Aydoğmuş, M., Gülay, G., & Ergun, K., (2022). Impact of ESG performance on firm value and profitability. *Borsa Istanbul Review*, 22, S119–S127
- Bekaert, G., Rothenberg, R., & Nogue, M., (2023). Sustainable investment-Exploring the linkage between alpha, ESG, and SDGs. *Sustainable Development*, 31(5), 3831–3842
- Buzoianu, O. A. C., Iacob, O., Mateescu, V. M., & Burlacu, S. (2024). Balancing Economic, Environmental, and Technological Systems for Sustainable Agricultural Development in Romania. *European Journal of Sustainable Development*, 13(4), 153-153.
- Dewaelheyns, N., Schoubben, F., Struyfs, K., & Van Hulle, C., (2023). The influence of carbon risk on firm value: Evidence from the European Union emission trading scheme. *Journal of Environmental Management*, 344, 118293.
- El Khoury, R., Nasrallah, N., & Alareeni, B., (2023). The determinants of ESG in the banking sector of MENA region: A trend or necessity? *Competitiveness Review: an International Business Journal*, 33(1), 7–29

- Feng, G. F., Long, H., Wang, H. J., & Chang, C.P., (2022). Environmental, social and governance, corporate social responsibility, and stock returns: What are the short-and long-run relationships? *Corporate Social Responsibility and Environmental Management*, 29(5), 1884–1895
- Kartal, M.T., & Pata, U.K. (2023). Impacts of renewable energy, trade globalization, and technological innovation on environmental development in China: Evidence from various environmental indicators and novel quantile methods. *Environmental Development*, 48, 100923
- Kong, Y., Agyemang, A., Alessa, N., & Kongkuah, M., (2023). The moderating role of technological innovation on environment, social, and governance (ESG) performance and firm value: Evidence from developing and least-developed countries. *Sustainability*, 15(19), 14240.
- Martiny, A., Testa, F., Taglialatela, J., & Iraldo, F., (2024). Determinants of environmental social and governance (ESG) performance: A systematic literature review. *Journal of Cleaner Production*, 456, 142213.
- Mogos, R. I., Negescu–Oancea, M. D., Burlacu, S., & Troaca, V. A. (2021). Climate Change and Health Protection in European Union. *European Journal of Sustainable Development* (2021), 10, 3, 97-108 ISSN: 2239-5938 Doi: 10.14207/ejsd.2021.v10n3p97
- Rădulescu, C. V., Bran, F., Burlacu, S., Dobrea, C. R., & Diaconu, S. (2020). Challenges Regarding Food Resources in the Context of Globalization and Population Growth. In *Proceedings of the International Conference on Economics and Social Sciences* (pp. 1041-1052). Sciendo.
- Radulescu, C. V., Deac, I. G., Burlacu, S., Petrescu, I. E., & Gombos, C. C. (2023). Enhancing Resilience And Sustainability: Transforming The Agri-Food Sector In Romania'S Mountainous Regions. In *Proceedings of the INTERNATIONAL MANAGEMENT CONFERENCE* (Vol. 17, No. 1, pp. 158-167). Faculty of Management, Academy of Economic Studies, Bucharest, Romania.
- Sarbu, R., Niculescu, A. M., Buzoianu, O.A.C., & Gombos, S.P., (2020). Economic-Ecological Analysis of Sustainable Development in Romania. *European` Journal of Sustainable Development*, 9(4), 161
- Seow, R. Y. C. (2024). Determinants of environmental, social, and governance disclosure: A systematic literature review. *Business Strategy and the Environment*, 33(3), 2314–2330.
- Tuna, G., Türkay, K., Çiftyildiz, S.S., & Çelik, H., (2023). The impact of financial tools in environmental degradation management: The relationship between CO₂ emission and ESG funds. *Environment, Development and Sustainability*, 26, 14941-14956
- Yang, Q., Du, Q., Razzaq, A., & Shang, Y., (2022). How volatility in green financing, clean energy, and green economic practices derive sustainable performance through ESG indicators? A sectoral study of G7 countries. *Resources Policy*, 75, 102526.