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ENVIRONMENTAL EFFICIENCY IN LOGISTICS: A SUSTAINABLE DRIVING MODEL TO REDUCE EMISSIONS

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Abstract. In leading countries around the world, sustainable driving (eco-driving) is used as a tool, method, or strategy for achieving environmental efficiency in transport and logistics. The development of the concept of eco-driving is driven by stricter environmental regulations at the national level and the need for companies to reduce energy consumption costs and comply with environmental requirements. The purpose of the article was to clarify the concept and idea of sustainable driving, the model of sustainable driving as a way to achieve environmental efficiency in logistics, taking into account the Ukrainian experience. The study uses general scientific methods of analysis and synthesis to combine qualitative and quantitative data that characterize trends in achieving environmental logistics efficiency as a result of integrating the sustainable driving model. The article clarifies the concept of sustainable driving as a tool for achieving fuel economy as a result of changes in driver behaviour on different types of routes, adjusting speed, choosing a route depending on weather conditions and other determinants of fuel use or behavioural determinants that ultimately affect the reduction of carbon emissions into the atmosphere. The study identifies the main concepts of sustainable driving: economic effects from reduced fuel consumption and fuel costs, social effects as a result of behavioural factors and changes in driver behaviour on routes, and additional environmental effects from reduced carbon emissions as a result of reduced fossil fuel consumption. Based on an analysis of Ukrainian practice, the main drivers and constraints for the development of eco-driving have been identified, which are related to the growth of the electric vehicle market as a result of rising fuel prices, improvements in the technical characteristics of electric vehicles, the low quality of the country's transport network, which requires the development of efficient logistics and route optimization, and the introduction of mandatory environmental standards for the registration of new cars. Ukrainian practice in achieving environmental efficiency in logistics demonstrates compliance with global trends in the implementation of the eco-driving model.

Keywords: logistics, transport industry, environmental efficiency, sustainable logistics, green logistics, sustainable driving, eco-driving.

JEL Classification: L91, Q53, Q56, R41

1. Introduction

Traditionally, logistics has created added value for the economy and contributed to GDP growth. However, it is also considered a high-carbon emissions sector (Su et al., 2022). Over the past decades, the growth in multimodal freight and passenger transport as a result of increased global trade and tourism has significantly increased the transport and logistics sector's anthropogenic impact on the environment. Logistics, which has traditionally focused on optimising transportation costs, delivery speed and reliability, is increasingly required to integrate environmental criteria into its planning and management processes. According to the European Commission, in 2023, the transport sector consumed 32.0% of total energy consumption, with road transport accounting for 73.4% of total consumption of all modes of transport (European Commission, n.d.). Carbon emissions from transport in the EU exhibited an upward trend from 1990 to 2024, with a slight slowdown during the 2020 coronavirus pandemic, reaching 117.1 million tons in 2023, with the transport sector accounting for 14.4% of emissions (European Environment Agency, 2025; Eurostat, n.d.). Consequently, enhancing the environmental

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efficiency of logistics has emerged as a pivotal endeavour in ensuring the sustainable growth of the transport and logistics sector on a global scale (Bai et al., 2022).

From 2015 to 2025, literature considered the sustainable driving model (eco-driving) to be one of the most promising tools for ensuring environmental efficiency (Fafoutellis et al., 2021; Zhou et al., 2016). The main elements of the eco-driving model include behavioural factors and the technological characteristics of the vehicle at a micro level. At the macro level, factors affecting fuel consumption and carbon emissions into the atmosphere, such as regulatory requirements and infrastructure conditions in the country, are considered in the development of sustainable driving. In the most developed countries, the practice of sustainable driving has contributed to the transition to "green logistics", in which the latest technologies built into vehicles allow for fuel savings. The practice of eco-driving has been demonstrated to contribute to a reduction in vehicle operating costs, and at the macro level, energy efficiency in logistics is achieved. Despite the growing interest in the sustainable driving model, its practical effectiveness is contingent on the drivers of development at the country level, as well as at the level of the logistics industry.

In this context, the article aimed to clarify the concept of sustainable driving and present it as a model for achieving environmental efficiency in logistics, based on Ukrainian experience. The study focuses on sustainable driving and the factors influencing the development of eco-driving in Ukraine.

2. Literature Review

In academic literature, the environmental performance of the logistics sector is assessed as the amount of carbon emissions from the logistics sector, which are classified as "undesirable outcomes" (Su et al., 2022). The environmental performance of logistics is influenced by a number of factors, including the industrial structure of the country, the level of urbanisation, the level of technological innovation, environmental regulation, the level of energy intensity, and the energy structure in the country (Bai et al., 2022). Consequently, within the EU, the implementation of novel regulatory frameworks could facilitate a reduction in carbon emissions from road transport as early as 2025. Nevertheless, this trajectory of growth in environmental efficiency is contingent upon the preservation of standards and the mitigation of existing risks of their weakening (Scott, 2025). According to the European Commission, carbon emissions from the transport sector in the EU fell by 2.9% in the first quarter of 2025, although this reduction occurred in only seven countries against the backdrop of declining production volumes (European Commission, 2025). Fuel consumption by vehicles is one of the factors with the most negative impact on the environmental performance of logistics, resulting in high carbon emissions (Zhou et al., 2016). One method of achieving fuel economy is eco-driving, which, according to the results of empirical research, can reduce emissions by 15–25% (Zhou et al., 2016). A study in Colombia found that an eco-driving campaign (training) reduced driver errors and fuel consumption per ton of freight transported (Díaz-Ramirez et al., 2017). To evaluate eco-driving algorithms, the following appropriate fuel consumption and emission models are being developed: the VT-Micro microscopic model (which determines fuel consumption values using static or machine learning methods) (Fafoutellis et al., 2021); the Polly model; and the power-based fuel consumption model (Zhou et al., 2016). Classifying these models into five main subtypes enables us to distinguish between the following categories: modelling based on the scale of input variables; modelling based on a formulation approach; modelling based on the type of explanatory variables; modelling based on state variable values; and modelling based on the number of measurements (Zhou et al., 2016). At the same time, the concept of eco-driving needs to be clarified in order to promote carbon emission reduction and improve environmental efficiency in logistics. It is also necessary to discuss the possibility of applying these models to evaluate new eco-driving systems and the influence of various factors on fuel consumption. The Ukrainian experience of sustainable driving and the development of eco-driving remains understudied.

3. Summary of the Main Provisions

In the narrowest sense, eco-driving is considered a means of reducing fuel consumption. However, a more comprehensive approach defines sustainable driving as a multidimensional, holistic concept that combines behavioural factors and other determinants of fuel consumption. Behavioural concepts involve the driver's choices regarding different types of routes, speeds and weather conditions. This ultimately results in reduced fuel consumption and lower carbon emissions. Other influencing factors include fuel quality, the presence of air conditioning and the vehicle's other technical characteristics. Increased traffic also affects resource consumption (Fafoutellis et al., 2021).

In the transport and warehousing sector, eco-driving is defined as a strategy for reducing fuel consumption. This is achieved by reducing the cost of fuel purchases. The environmental benefit of sustainable driving is reduced carbon dioxide emissions (Lin & Wang, 2022). In the context of digitalisation, technologies are employed to connect vehicles to the internet and GPS navigation systems in order to monitor fuel consumption. This reduces logistics operational costs and enables remote route management. As a result, economic effects are achieved alongside environmental efficiency in logistics. Against the backdrop of environmental regulations being introduced to promote sustainable economic development, the concept of sustainable driving has become increasingly important at a micro level. This concept encompasses economic efficiency (reducing fuel consumption and operating costs), environmental efficiency (minimising harmful emissions) and social efficiency (changing driver behaviour on the roads).

To ensure economic and environmental efficiency in logistics, eco-driving is becoming more commonplace. This approach combines behavioural factors and the technical characteristics of vehicles to reduce fuel consumption. Research on eco-driving practices in Spain shows that improving routes on roads with greater traffic capacity reduces fuel consumption. The environmental efficiency of different eco-driving models depends on various factors, such as vehicle traffic intensity, road type and route type. Overall, implementing this practice can reduce carbon emissions by between 0.2% and 10% (Coloma et al., 2021). For comparison, Fafoutellis et al. (2021) found that eco-driving led to a reduction in fuel consumption of 15–25%, as well as a minimum reduction in greenhouse gas emissions of 30%. Total fuel savings for vehicles with the latest technologies are estimated at 10–12%.

Developed countries are implementing measures to encourage sustainable driving as part of their transport sector management policies. In various countries, governments are utilising incentives to encourage the procurement of technologies that serve to reduce carbon emissions within urban areas. Local authorities are establishing legal frameworks with the aim of promoting sustainable driving as part of sustainable transport development. Municipalities are utilising a range of methodologies to accomplish environmental objectives. Concurrently, the efficacy of diverse methodologies can be realised through collaborative endeavours with the logistics sector. The prevalence of eco-driving in the transport sector is influenced by market drivers for sustainable driving. It is incumbent upon the public to demonstrate their support for the government's environmental policy by ensuring compliance with legally established traffic rules. The private sector exerts a significant influence on the environmental performance of logistics by employing digital tools to manage routes and regulate fuel consumption. Research on eco-driving has highlighted the practical aspects of achieving environmental effects at the city or regional level (Fafoutellis et al., 2021). A number of publications have examined the challenges of ensuring efficiency at the level of logistics companies (Coloma et al., 2021).

The Ukrainian experience demonstrates the existence of driving factors for sustainable driving development, primarily the growth of the electric vehicle market (Automotive Market Research Institute, 2025), in the context of the country's energy risks and increased diesel fuel costs. Other factors include the poor quality of various road networks (international, national and regional), which affect traffic efficiency and speed, and the introduction of mandatory environmental standards for registering new Euro 6 cars from January 1, 2025. Standard driving rules and environmental standards for carbon emissions also play a role. As a result of rising fuel costs and improved technical characteristics of electric vehicles, the electric vehicle market in Ukraine amounted to 12,100 vehicles in September 2025, which is 89.2% higher than in September 2024 (Automotive Market Research Institute, 2025). Experience from other countries shows that electric vehicle drivers are more familiar with the concept of eco-driving than drivers of internal combustion engine vehicles (Lin & Wang, 2022). The impact of various factors on reducing pollutant and carbon dioxide emissions in Ukraine, especially the impact of eco-driving, has been little studied. This is because eco-driving is a relatively new concept and strategy for Ukrainian businesses. Nevertheless, between 2010 and 2021, emissions from road transport decreased by an average of 4.1%, reaching 1,546,800 tonnes in 2021 – significantly less than in European countries (latest available data). The proportion of emissions from road transport in the total emissions increased from 36% in 2010 to 41% in 2021 (State Statistics Service of Ukraine, n.d.-a).

The significant environmental risks posed by the existing vehicle fleet (used cars) and the absence of formal regulations for eco-driving, in conjunction with the projected growth in passenger and freight traffic during the 2024-2025 period, are factors impeding the advancement of sustainable driving practices. The presence of a high volume of passenger and freight traffic results in the occurrence of uneven vehicular movement, thereby hindering the ability to maintain optimal speed on the roads and to change routes. This, in turn, has the effect of increasing fuel consumption. In 2024, the average growth rate of passenger traffic was 116.7%, freight traffic was 117.8%, and road traffic was 118.8% and 107.1%, respectively (State Statistics Service of Ukraine, n.d.-c) (Table 1).

In the context of Ukraine, the transportation, warehousing, postal, and courier services sector is experiencing a period of heightened importance. This is due to the destruction and threats to transport infrastructure, as well as the changes in the supply chain. The sector's share in the national economy in terms of product sales amounted to 692.28 billion UAH in 2024, which is higher than the pre-war level of 654.50 billion UAH in 2021. Concurrently, since the onset of the invasion, there has been a precipitous decline in the proportion of product sales, which reached 3.3% in 2024, in comparison to 11.3% in 2021. Within the industry, the predominant share in terms of sales of services is held by freight transport and warehousing, with sales volumes of 168.44 billion UAH (24%) and 284.28 billion UAH (41%) in 2024, respectively. The observed growth in sales volumes in these two sectors over the 2020–2024 period is indicative of an increase in the importance of logistics in the Ukrainian economy. The average annual growth of 5% in the added value of the transport, warehousing, postal, and courier services sector in Ukraine in 2020-2024 indicates an increase in the overall productivity of the industry. The largest companies in the logistics market include Switzerland's Kuehne + Nagel, Denmark's DSV Logistics, France's FM Logistics, the Netherlands' Raben, Turkey's Ekol, Ukraine's Zammler Ukraine, and others, which primarily provide container contract, project, warehousing, distribution, and other services. One of the largest logistics companies, Kuehne + Nagel, which specialises in integrated logistics solutions, has announced its intention to reduce its carbon emissions to zero by 2030.

There are significant opportunities for the private sector to implement sustainable driving practices. These include introducing GPS vehicle monitoring and driving control systems to monitor fuel consumption and costs, as well as planning fleet maintenance and insuring the fleet against property damage risks. Companies can reduce fuel costs by controlling and monitoring routes. GPS-based monitoring in logistics controls the movement of vehicles and ensures drivers adhere to the specified route. Displaying vehicle movements in real time reduces the risk of route deviations and fleet downtime. As a result, fuel savings are achieved, which has an economic effect. Companies can reduce their operating costs by up to 30% by using these route management methods. Thanks to information transferred from

Table 1
Drivers and barriers to the development of sustainable driving in Ukraine

Driving forces	Restraining factors
Growth of the electric vehicle market and driver awareness of eco-standards	Significant environmental risks of the existing vehicle fleet
Increase in the cost of diesel fuel	No formal rules for eco-driving with passenger and freight traffic growth in 2024-2025
The poor quality of roads, especially regional and local roads, affects traffic speed.	Absence of environmental standards and requirements for the private sector (enterprises) with large vehicle fleets
Introduction of mandatory Euro 6 environmental standards for the registration of new cars	Lack of promotion of sustainable driving practices at the national level

GPS navigation systems to information systems, companies can track fuel costs and analyse the economic and environmental efficiency of logistics. The main incentive for companies to reduce fuel consumption is cutting internal costs. In 2024, capital investments by companies in Ukraine in air pollution control measures for transport, warehousing, and postal and courier services accounted for only 2% of companies' costs in all types of economic activity (25.516 million UAH). There has been a general trend towards a reduction in capital investments in these measures in Ukraine between 2021 and 2024 (State Statistics Service of Ukraine, n.d.-b).

By comparison, households are less aware of ethical, sustainable driving rules and are guided solely by traffic regulations or environmental requirements approved at a national level. City authorities can influence driver behaviour by introducing city fees, such as parking taxes (up to 0.075% of the minimum wage per square metre of space), or penalties for parking violations.

4. Discussion

Ukraine's experience in achieving environmental efficiency in logistics through the implementation of sustainable driving practices demonstrates similarities with global trends. Transportation in Ukraine is identified as a primary contributor to carbon emissions, while the transportation, warehousing, postal, and courier sectors demonstrate a negligible commitment to air pollution control measures through capital investments. In the context of domestic logistics, the primary objective is to curtail fuel expenditures in the face of escalating fuel costs. To this end, control activities employing monitoring systems are implemented to monitor fuel expenditures at the company level. A consequence of this process is a reduction in carbon emissions. Conversely, the general market trends towards growth in the electric vehicle market amid rising fuel prices and the introduction of European environmental standards will stimulate eco-driving.

Research on American practices indicates that the transport sector has become the primary source of carbon emissions, accounting for an estimated 18% in 2018. This trend is driven by significant demand for passenger cars among the population, with a high proportion of SUV purchases and use (Lin & Wang, 2022). The American experience highlights the pivotal role of market drivers in the development of eco-driving. In light of the increasing demand for such modes of transport in the US, it is imperative to advocate for the advancement of infrastructure to facilitate the expansion of the road network. This will serve to reduce the risks of reduced economic and environmental efficiency in the field of logistics. It is anticipated that there will be an increase in the consumption of fossil fuels in the transport sector, due to the rising demand for vehicles powered by such fuels. Notwithstanding considerable advances in the utilisation of alternative low-carbon energy sources to enhance the environmental efficiency of logistics, fossil fuel-powered vehicles continue to predominate in the United States (Lin & Wang, 2022). The integration of technology into logistics has also not contributed to solving the problem of improving the environmental efficiency of transport. The experience of Ukraine in this regard, with its significant anthropogenic impact on the environment by the transport sector, underscores the necessity for the introduction of sustainable driving practices. However, in the absence of environmental standards, eco-driving as a strategy for reducing carbon emissions has not become widespread. The sluggish rate of carbon emission reduction indicates the necessity for substantial investments in environmental protection measures in the imminent future. Conversely, the transport sector allocates a negligible amount of financial resources to the promotion of the reduction of carbon dioxide emissions into the atmosphere.

5. Conclusions

The purpose of the article was to clarify the concept and idea of sustainable driving, the model of sustainable driving as a way to achieve environmental efficiency in logistics, taking into account Ukrainian experience. The notion of eco-driving is regarded as a mechanism for attaining fuel economy by modifying driver behaviour across diverse route types, adjusting speed, and selecting routes contingent on meteorological conditions, along with other factors that influence fuel utilisation or conduct, consequently resulting in a diminution of carbon emissions into the atmosphere. The study identifies the main concepts of sustainable driving, namely the economic effects of reduced fuel consumption and fuel costs, the social effects resulting from behavioural factors and changes in driver behaviour on routes, and the additional environmental effects of reduced carbon emissions resulting from reduced fossil fuel consumption. The Ukrainian experience demonstrates that the primary factors contributing to the development of eco-driving are associated with the expansion of the electric vehicle market, consequent to rising fuel prices, advancements in the technical capabilities of electric vehicles, and the substandard quality of the nation's transport infrastructure. This necessitates the implementation of efficient logistics and route optimisation, as well as the introduction of mandatory environmental standards for the registration of new vehicles. The Ukrainian practice of achieving environmental efficiency in logistics is in line with global trends. According to these trends, the transport sector remains one of the main sources of fuel consumption and carbon emissions. There is low investment in environmental protection measures, and there is a tendency to increase the share of carbon emissions from the automotive sector in the total emissions of various sectors of the economy. The adoption of sustainable driving practices remains limited in Ukraine, with domestic companies implementing fleet monitoring systems as a strategy to reduce fuel expenditure, thereby indirectly contributing to a decrease in carbon emissions. In this context, the introduction of regulatory requirements and improvements in road infrastructure will have a significant positive impact on the environment by reducing transport carbon emissions.

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