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Market and Regulatory Challenges of the EU Road Freight Transport Transformation towards Zero Emissions

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Abstract:

Purpose: *The main aim of the research is to identifying the key market and regulatory challenges the EU road freight haulers currently face as well as indicating the main barriers hampering their adapting to the restrictive requirements of the energy transformation.*
Design/Methodology/Approach: *At conducting this data-driven research, the following methods were applied: 1. critical literature analysis, 2. factor analysis, 3. Date mining and analysis, 4. market analysis and 5. comparative analysis.*
Findings: *The EU road freight transport playing key role in the internal land freight transport market, generats at the same time the largest amount of GHG in the total transport sector. Being under the restrict regulatory measures aimed at transforming it towards zero emission, streives to achieve the EC targets in the scheduled time through the accelerated development of electromobility. However, such a path towards decarbomization, is associated with huge upfront costs, the EU road freight transport companies need to bear. This capital-weak transport sector, characterized by low profitability and operating in highly competitive, atomized polypoly-type market, however, is not able to carry out the necessary replacement of the vehicle fleet driven by combustion engines by green electric trucks without sufficiently high financial state support. It applies mainly to the CEE countries, being strongly affected by the ongoing war in Ukraine.*
Practical Implications: *The current fast-track implementation of the EU road transport decarbonization strategy, focused almost exclusively on achieving ecological goals, should be revised. It should not only be extended in time, but also much more strongly than before, take into account the economic and social aspects resulting from its implementation. Otherwise, it may cause serious economic effects for all parties involwed in the road transport chains and the EU economy, as well.*
Originality/Value: *Without bridging the gap between the currently overemphasized environmental dimension and the economic and social ones of the sustainable mobility strategy, it will not be possible to proceed smoothly towards decarbonising the EU road freight transport.*

Keywords: *EU road freight transport, market slump, regulatory measures, decarbonization path.*

JEL classification: *D43, K23, L51, L91.*

Paper Type: *Research article.*

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1. Introduction

Energy transformation refers mostly to the transport sector being responsible for majority of the EU-27 GHG emissions, i.e., ca 30% and 26% of CO_2 emissions in the recent two years (EC, 2024; EEA, 2023). That's why the EU's main policy document, the European Green Deal (EGD), followed by the Sustainable & Smart Mobility Strategy (SSMS), together with numerous related regulations and directives creates serious energy transition challenges for transport and mainly for road transport which is the most burdensome for the environment, enforcing road haulers towards rapid decarbonization (EC, 2019b; EC, 2020b; Christen *et al*., 2021).

Such a strong regulatory preassure results both from the role played by this mode of transport in the total EU's freight transport market and from its high level of emissions generated by commonly used fossil fuels combustion engines of trucks, i.e., mainly heavy-duty vehicles (HDV).

Moreover, in the opinion of the EC as the regulatory entity, the energy consumption per km/ton of transported goods by roads is approximately six times higher than in inland waterway transport and more than three times higher than in rail transport, where hydrogen seems to be very promising alternative in relation to fossil fuels. That's why the EU regulator puts preassure on implementing an environment-friendly alternative in terms of both GHG emission reduction, energy consumption and noise emissions (Kaack *et al.*, 2018).

The new EU sustainable mobility strategy addressed to road transport tries to transform it to the use of new alternative green sources of propulsion. Elektomobility was recognised as the most promising path towards decarbonization of this mode of transport and establishing there zero-emission standards by 2050. However, the transition on green trucks, is associated with an increase in the costs of purchasing new vehicle fleet with electric drive. The costs of acquiring zero-emissions HDVs, depending on their type and model, are currently in the EU at least twice as high as traditional combustion models.

There is no doubt that it will be a serious burden for companies operating in the very competitive and sensitive to any economic disruptions road freight transport market. This will apply in particular to small and medium-sized companies (SME) operating in Central and Eastern European (CEE) countries, which may be affected the most. Therefore, the study also attempts to determine the potential effects resulting from the implementation of the EU's road freight transport decarbonisation strategy.

2. Methodology and Literature

In order to study in details the potential impact of the already adopted EU regulations, aimed at transforming the road freight transport sector on the path of sustainable and smart mobility, it was necessary, first of all, to use up-to-date

statistical data and credible reports and studies of reputable international organizations and institutes which periodically analyze such issues. In this case, mainly reliable, up-to-date and available sources were used, such as: reports, studies, policy statements and position papers of: 1. EEA (European Energy Agency), 2. EC (European Commission), 3. IRU (International Road Union), 4. ACEA (European Automobile Manufacturers Association), 5. ITF (International Transport Forum) as well as International Road Carriers Associations of the EU countries (e.g., ZMPD in Poland) and many other organizations as well as consulting and research institutes (T. Trans. EU, SpotData).

Data necessary for conducting analyses were obtained from statistical studies of the EU (Statistical Pocketbook, EU Transport in figures, DG Mobility and Transport) and Eurostat, Statista, as well as digital platforms for professionals, such as EUROACTIV, RailwayPro, Upply, T&E (Transport & Environment), Transporeon GmbH, TransportON and Timocon. Data and information from the websites of road carrier associations were also used.

In addition, some data and information were made available thanks to numerous interviews conducted with representatives of road carrier employers' organizations. Legal acts and sectoral regulations concerning the decarbonization of road freight transport being the subject of the analyses, were taken from the list of legislative actions concerning this transport sector undertaken by EU bodies. Legal commentaries and opinions regarding the analysed EU's road transport policy regulations were also taken into account.

The materials allowed obtaining basic data on all analyzed components, specifying at the same time existed relationships between them. It potentially made possible to examine the impact of the ongoing energy transformation in the road freight transport sector on the road haulers as well as the changes in the market structure - in its supply side and the competitiveness within the sector and with other providers of transport services in the EU transport market. Moreover, the collected and processed data as well as the obtained information and materials enabled the development of the methodological basis for the implementation of this research project.

In order to properly identify as well as evaluate the effects of imposing rigorous EU regulatory strategy addressed to this transport sector and examine its real impact on the the providers of road transport services as well as the EU freight transport market in medium and long term, a number of classic, both quantitative and qualitative research methods and techniques were used.

The following methods were mainly applied as part of the methodological triangulation formula: critical analysis of literature (CLA), factor analysis (FA), mining of data obtained mainly from Eurostat and other statistical sources, as well as market (MA) and comparative analysis (CA) (Shrestha, 2021).

3. The EU Road Freight Transport Development and its Economic and Environmental Effects: Stage I of the Research

Road freight transport holds the leading position in the EU transport market, determining to the great extent the efficient functioning and development of the European transport and logistics systems. Its dominant market share as compared to other modes of transport in the total movement of goods, measured in billions of tonne-kilometres [tkm], and the growing importance in smooth meeting of the soaring transport needs, creates strong incentives for further development of the EU. It has been the only transport mode that has not only maintained its dominant market position but also significantly strengthened it, reaching in 2022 ca. 54 % of the EU transport market share (Kurtulus and Cetin, 2020; Statista, 2024).

It is worth to mention that, analysing data concerning the EU's transport market development over the last 30 years, it due to its progressive openness and liberalization, the performance in each transport mode increased significantly.

However, only three transport modes absorbed the largest part of the growing demand for transport services in the period under review, i.e., road (as much as 65.6%), air transport (62.3%) as well as maritime transport (45.0%) (Eurostat, 2024; ITF, 2022; Grzelakowski, 2024). The long-term forecast to 2050 suggest that road freight transport will maintain its dominant position (IRU, 2024). Thus, providing favourable market conditions for the functioning of the sector, especially in the context of the smooth transport service supply, is probably a key element in maintaining efficient and competitive transport and logistics markets in Europe (Grzelakowski, 2024; CargoON, 2025).

This is possible because road freight carriers operating in the highly competitive transport market have not only a lofty adaptability to changing market conditions, but also a number of logistic and operational advantages, such as above-average flexibility and mobility.

They determine their competitive advantages over rail and inland waterway transport in terms of direct access to potential shippers. It is a consequence of the well developed competitive market of this transport sector and, as a result, its high adaptability to various kinds of supply chain disruptions that are a characteristic feature of the current period.

However, the EU road freight transport market is extremely fragmented. It reffers predominantly to the supply side but also to great extend the demand side. Such a characteristic feature for extremely competitive market structures (atomized markets of the polipol type), especially in times of economic recession, falling demand and, consequently, prices for carriers' services, usually seriously affect mainly small and medium sized road haulers, frequently limiting their operational rentability, making the possibilitiy of the costs covering in fact unrealistic.

Road transport haulers operate freight vehicles on behalf of shippers or logistics service providers, undertaking activities in the market that structure shows an overwhelming majority of 91% of small or micro enterprises with less than 10 employees in the land transport sector in the EU in 2022 (Transporeon, 2022). Such a supply side of the market indicates the vulnarability of road haulers on any market distortions caused by economic slump.

And so, the deep recession that hit the German economy in 2024 weighs heavily on the activity of almost all EU road haulers (Beguerie, 2025). However, the CEE; companies have been particularly hit hard by the significantly weakened demand. By turning to other EU's road markets, they have sparked fierce competition which impacted on transport prices in 2023-2024.

Falling prices were reflected by the Upply Road Freight Rate Index for Europe, which stands at 122.4 points in the third quarter of 2024 on the spot market, falling by 4.4 points compared to the previous quarter and by 6.1 points year-on-year (Beguerie, 2024). Meanwhile, the road freight rate index on the contract market remained stable quarter-on-quarterat 127.2, but fell by 2.2 points year-on-year (TIMOCON, 2024).

The analysis indicates that road transport haulers are actually the market price takers with marginal revenues (MR) which do not always cover the level of marginal costs incurred (MC). Relatively low barriers to entry into the market and a homogeneous product (high substitutability) limit the possibilities of maintaining financial surplus in the long term (Ragon and Rodriquez, 2022; Schröder *et al*., 2023).

As a result, their financial ressources and, consequently, investments potential is currently very limited. Therefore, their current level of readiness to meet the restrictive requirements of the energy transformation and to bear, in particular the high uptake costs of purchasing new electric vehicles meeting the EC targets concerning zero-emissions, are very limited (T&E, 2023).

The potential, unavoidable costs of structural market changes in the EU road transport sector, caused by the ongoing processes of its adaptation to zero emission requirements, have to be compared with the expected direct and indirect effects that EU community and economies can obtain from the energy transformation of this freight transport sector. They concern primarily the reduction of CO_2 , but also noise, accidents and congestion and will manifest themselves in the reduction of total external costs (Ragon and Rodrigues, 2021; EC, 2019a).

When examining the impact of the EU land transport sector on the level of external costs it generates, it is necessary at first to determine its role in the consumption of energy obtained from all sources. It accounted for 279,9 Mtoe in 2022 as compared to 220,7 in 1990 and 281,6 Mtoe in 2005 (EC, 2024). It should be pointed out that since 2005 it has been much higher than in the industry and also in houlseholds

sector since 2000. Land transport has therefore contributed on average 31% to energy consumption in the EU over the last three years, and the share of road transport as much as 29% (EC, 2020a). In comparison, rail transport and domestic aviation consume 1% each of the total energy consumed in the EU transport.

The countries where the energy intensity of transport activities is the highest include Germany, France, Spain and Poland, while in the total road transport segment the highest energy consumption is shown by countries such as, Germany, France, Spain, Italy and Poland. As a result of the high energy intensity of EU transport, the GHG emissions from this sector, including international bunkers, have been increased significantly, amounting to 1043.7 million tonnes CO_2 equivalent in 2022.

It was 25.9 % higher than in 1990 and 16.2 % higher than in 2020. The highest levels were recorded in Germany, France, Spain, Italy and Poland. The share of GHG emissions from transport in total emissions measured in CO_2 equivalent in EU-27 accounted for 26.2 % (EC, 2024; EUROACTIV, 2024). This means that currently the level of GHG emissions in the EU-27 transport sector is much lower than its share in energy consumption (31 % land transport).

Road haulage is the largest contributor to GHG emissions in EU-27 total transport. In 2022, its share was 73.2% and in fact it has not changed significantly since 1990 (74.8 %). The largest share in total GHG and CO_2 emissions from road transport is held by by heavy-duty trucks (HDV) and buses as well as l;ight-duty trucks (LDT). These two road transport means generate ca.5 0% of the total greenhouse gas emissions from the EU road transport sector.

However, taking into account the fact that the share of both road freight transport means in the total transport performance in tonne-kilometres (tkm) in the EU has been gradually increased since 2005, the GHG and CO_2 emission rate per 1 tkm performed is actually decreasing. Despite this, external costs are still very high.

According to official data published by the EC, it can be assumed that the total amount of external costs for HDV and LC(D)V in EU were calculated at the level of EUR 125 billion per year (2016-2019), with HDV generating € 62.9 bil.and LCV € 62.1 bil. (CE Delft, 2020; Transporeaon, 2022; Pfoser, 2021). This represented 17.5% of the total external costs from the EU-27 transport sector (EC, 2024). Only seagoing ships and passenger cars (+ motorcycles) produce a higher level of external costs in terms of tkm and pkm than separately treated HDV and LD(C)V.

In this period, the average external costs per tonne-kilometre (tkm) accounted for 3.5 eurocents for HDV and 13.1 eurocents per vehicle-kolometer (vkm) for LCV. Therefore, the main problem is the form of full internalization of external costs, i.e., who will actually bear the total external costs generated by these means of transport. Despite the fact that nowadays most users of motorised transport in EU already pay taxes and charges such as, energy taxes, taxes for purchasing or owning a vehicle,

VAT and excise duty on fuel purchases, the revenues from this sources do not cover the external costs at all. Some EU countries have additional charges such as distance-based tolls, time-based vignettes or urban road pricing systems and parking fees.

However, when comparing all revenues taxes and charges with all external costs and infrastructure costs for road passenger as well as freight transport, only 48 percent of the costs are covered in EU-27 (Antolini, 2024; EIB, 2024). What is more, this cost factor significantly varies among the countries, from 17% in Luxemburg to 99% in Denmark due to e.g. different tax rates (Takman and Gonzales-Aregual, 2024; ITF, 2023). In these conditions, the EU decided to choose a faster path to road freight transport's decarbonisation, based on the formula of its accelerated energy transformation.

4. Legal Requirements and Regulatory Challenges of the Energy Transformation of the EU Road Transport Sector: Stage II of the Research

The lack of real, visible effects of expected significant reduction of CO_2 and GHG in road freight sector, especially in the face of the adopted goals of the Paris Agreement, forced EC to take more decisive action towards its decarbonization The key document setting out the new strategy for achieving zero emissions was the New Green Deal (NGD) adopted by the EC in 2019. This policy document assumed the reduction of net GHG emissions by 2030 at least 55% less compared to 1990. The 90% reduction of GHG emissions in transport sector was targeted by 2050 (EC, 2019b).

Based on the defined NGD's goals, in 2020 EC developed the Sustainable & Smart Mobility Strategy which was set out a roadmap for putting EU transport firmly on the right track for its decarbonizing (EC, 2020b). By identifying 10 flagship areas with an action plan, the EC presented the scenarios common to those supporting the 2030 climate target plan, demonstrating that they can deliver a 90% GHG reduction in the transport sector's emissions by 2050 (EC, 2020a).

According to the assumptions of the Strategy until 2030 at least 30 million zero-emission vehicles will be in operation on EU roads and 2050 nearly all cars, vans, as well as new HDVs will be zero-emission.

In 2021 the EU package Fit for 55 was adopted (EP, 2021). It was oriented on wider and more accelerated greening of the transport sector, supporting the EGD process by several detailed regulations. According to its assumptions, the percentage of greenhouse gas reduction by 2030 should be 55%. However, this was only the first climate goal of the implemented by EU Fit for 55 package (EP, 2022). By 2035, combustion vehicles are to disappear from the market, and they will be replaced

primarily by electric trucks. Thanks to this, the EU transport sector is planned to achieve zero emissions in 2050.

On the basis of above mentioned EU key guiding documents regarding the implementation of the sustainable mobility strategy, based on the need to decarbonise transport sector by 2050, a number of detailed legal acts have been issued which directly concern the road freight transport (Antolini, 2023). The first one, i.e. Regulation EU 2019/1242, aimed at accelerating the decarbonisation of the HDV fleet and monitor GHG emissions from HDVs was released already in 2019 (EC, 2023a).

In accordance with its provisions, CO_2 emissions from new HGVs are to be reduced by 15% by 2025 and by 30% by 2030 compared to 2019 levels. However, to make also the HDVs segment contributing to the EGD's target with GHG emission reduction, the EC presented in 2023 the proposal on the revision of the Regulation EU 2019/1242 (EC, 2023; EU, 2024), aiming at tightening these targets.

According to it the average CO2 emissions of HDVs would have to decrease by 45% from 2030, by 65% from 2035, and by 90% from 2040 onwards, compared to 2019 levels (Antolini, 2024). To achieve these stricter CO_2 emission reduction targets, the adopted by EP proposal (COM (2023) 88 final) keeps an interesting technology-open approach, to make manufacturers decide freely on the propulsion technologies e.g., electrification, hydrogen fuel cells or hydrogen with internal combustion that could be able to achieve the new GHG emission targets (EC, 2023a).

After ratifying the trilogue agreement by EP in 2024, the EC adopted the agreement and completed the legislative process, establishing currently one of the most ambitious greenhouse gas standards for the HDV's sector globally (EU, 2024).

Another important regulatory challenge for the EU road freight transport is the s.c. ETS 2 system (EU, 2023a). The ETS2 for road transport is a new extension of the EU's emissions trading system, covering the road transport and construction sectors, from 2027. Its main objective is to reduce greenhouse gas emissions by 43% by 2030 compared to 2005. The system requires companies to report their emissions and buy the appropriate number of CO2 emission allowances.

The linear reduction factor is 5.1% per year from 2024 and will continue to increase. The ETS2 system also introduces strict monitoring and enforcement rules, ensuring that those who fail to comply face legal consequences. For example, road transport companies could be subject to penalties for failing to surrender the appropriate number of allowances. One of the key aspects of ETS2 is the auctioning of allowances, which will be reduced by approximately 5.38 percent annually from 2028. A new regulatory instrument, promoting the EU's road freight transport transformation towards zero emissions, creates also the Eurovignette Directive, amended in 2022 (EU, 2022).

It updates the rules for collecting road charges, encouraging the use of low- and zero-emission vehicles, to which the charge does not apply or is relatively low. One of its key elements is the introduction of road charges based on the CO2 emissions of a given vehicle. The actions aimed at decarbonising the EU road freight transport are also strengthened by the Alternative Fuels Infrastructure Regulation (AFIR), which came into force in April 2024, establishing binding targets for the development of zero-emission vehicle charging and refuelling infrastructure.

The main goals of the AFIR include creating a network of electric charging and hydrogen refuelling points along the main transport corridors (motorways) in each EU country. In the case of HGVs, countries are obliged to create charging points with a capacity of at least 350 kW at distances of no more than 60 km by 2025, and then increase the capacity to 700 kW by 2027, whereby full implementation should take place in 2030 (Antolini, 2024).

Moreover, there it is also worth mentioning the EU Regulation on Batteries and Waste Batteries (Antolini, 2023; EU, 2023b), which entered into force in 2024 and establishes a comprehensive framework for the production, use and recycling of batteries. The primary objective is to ensure sustainable battery production, increase recycling efficiency and introduce requirements regarding the carbon footprint of batteries.

The legislative actions undertaken by the EU indicate a comprehensive approach to the energy transformation of the road transport sector and a focus on issues related to the rapid reduction of GHG emissions in this pivotal from the economic and at the same time very sensitive from environmental point of view segment of road freight transport (T&A, 2022a; 2023b).

5. Research Results and Discussion

The EU restrictive regulatory activities and already implemented legislative measures aimed at pushing the road freight sector and mainly its HDVs segment for a transition to low or zero emissions, have already impacted both road freight companies and HDV manufacturing industry. The EU road freight transport industry is aware that GHG emissions from HDVs are difficult to reduce as still nearly all types of HDVs (94%) are diesel-powered and only a fraction of trucks on EU roads has a zero-emission propulsion system (Antolini, 2024).

Share of individual types of HDVs in annual sales in their core vehicle segments in the EU in 2023 accounted for: 1. heavy trucks (HT with axle configuration 6x2 and 4x2) – 65 %, 2. HT (6x4 and 8x4) – 1 % and 3. medium trucks (MT 4x2) – 13 %. The absolute majority of them were diesel powered. Share of vehicles powered by electric, hybrid or alternative energy (natural gas) in the total number of newly purchased HDVs (i.e., vehicles with GVW of 16 tonnes and more) registrations amounted to, 8% in France, 3% in Germany, 2% in Italy and only 1,1% in Poland in

2023 (ACEA, 2023; 2024). On average at the EU level it was only 3%. Meanwhile, the estimated share of these low and zero emission trucks' sales and thus their share in the total fleet of the EU road hauliers' fleet should be in 2025 – 7%, 2030 – 28%, 2035 – 49% and in 2040 – 78% (T&E, 2023; Beguerie, 2024). Achieving such indicators is necessary to meet CO_2 emission reduction targets in line with EU standards.

A factor that may accelerate the process of the stepwise introduction of stricter CO_2 emissions targets in the EU road freight transport, allowing at the same time the truck owners to gradually switch to zero emission trucks (ZET) is the average age of this type of vehicles (mainly in the HDV category) which is now over 12 years old (Beguerie, 2024; ACEA, 2024).

That is why EC in its Greening Freight Transport package in 2023 proposed the introduction of a methodological framework to give carriers the appropriate tools and means to calculate more accurately the carbon footprint of freight transport services and to support the uptake of ZET. The purchase of ZET is mainly depending on the s.c. total cost of ownership (TCO) and many other operational requirements. Therefore, the EU countries implemented several public financial incentives for bridging the investment gap between a diesel truck and a ZET.

They allow to compensate the investors up to 80% of the differences in purchase costs. Austria, Germany, and France have the most generous programs in place with 65% and 80% of the difference in vehicle price between a ZET compared to the diesel (T&E, 2022b). Regarding the supported drive train technologies, all countries offer aid for battery electric and hydrogen trucks (T&E, 2022b). Sweden is the only country that supports vehicles running on biofuels, while Germany is the only country that includes overhead-catenary systems in its program (CargoON, 2025; T&E 2022b). Few countries still invest in new fossil gas vehicles (T&E 2022b).

Nowadays almost all EU countries offer purchase grants for ZEVs for one or more vehicle configurations and are assumed to be phased out after 2024. es are included. However, according to the EC (EC, 2023), although purchase subsidies are being phased out, the stronger CO2 standards after 2025 will provide benefits for transport operators and users in the form of lower fuel costs and TCO of the ZET compared to fossil fuel trucks (Antolini, 2023). The EC assumes that TCO for first users of a new purchased HDV will be reduced significantly as a result of growing savings on average ca. 9,000 € for a vehicle purchased in 2030 and 41,000€ for a vehicle purchased in 2040 (Antolini, 2023; EC, 2023).

However, since still more than 95% of all HDVs in the EU have fossil fuel powered propulsion, the scope of the challenges that need to be overcome both on the EU and companies level to achieve the transition target and put into practice a necessary fleet of ZETs is vast (ACEA, 2023). Despite the efforts already taken by EC and member states, new barriers keep appearing to transition to zero-emission of the road

freight vehicles. There were identyfied by analysing the European Clean Trucking Alliance (ECTA)'s readiness to switch to ZETs (Ragon and Rodriguez, 2022).

However, they mainly concern small and medium sized road transport companies for which truck ownership is still important, as it usually constitutes their only asset. Therefore, among many limiting factors, this category of road freight carriers due to very small profit margins and unfavorable market conditions will not be able to cover the uptake costs of purchasing ZETs even in the nearest future (Ragon and Rodriguez, 2022; Globaldrivetozero, 2023).

This means that in this very vulnerable in economic terms segment of the EU road transport companies, one of the largest challenges towards ZETs deployment is still financing one, i.e., currently to high TCO (energy costs) and the initial investment costs.

Although it is considered optimistic that once a ZET alternative is cheaper to own and operate than its diesel counterpart, i.e., TCO parity has been reached due to deployment battery-electric trucks (BETs) and, as a consequence, the transition towards ZETs may happen swiftly, a two- to three-fold higher purchase price for ZET than for diesel trucks, due to the phasing out state subsidies from 2025 onwards, will be still longlasting major obstacle (Ragon and Rodriguez 2022; T&E 2022b; Globaldrivetozero, 2023).

The recently issued T&E's outlook pointed out that the uptake costs of battery-electric and fuel cell electric trucks are expected to decline below diesel trucks by the late 2020s. By 2035, 99.8% of new electric DHVs could be cheaper to own and run than diesel trucks, while carrying the same weight of goods over the same distance and journey time (T&E, 2022a; 2023). However, to achieve such targets, generous purchase premiums and other incentives granted by EU countries are still needed. Nevertheless, the uptake potential of ZETs by SMEs road transport companies is significantly to low, because already existing ZET subsidy schemes in the EU are often to difficult to get for them (T&E, 2022b; IRU, 2024).

With the absolute dominant share of SMEs in the total number of companies operating currently in the EU road freight transport, encountering the barriers in the form of significant cost differential between a diesel HDV and an electric one, as well as the erosion of profit margins in 2024, the market's adoption of these ZEVs has been considerable hampered.

As a result, the EU's global road freight market is being plummeting. Its decline can be seen in the falling number of truck registrations in EU which fell by 7.5% in the first three quarters of 2024, totalling 249,708 units (ACEA, 2025). Diesel remains largely predominant with 95.3% of registrations, or 237,937 vehicles (-7.3%). At the same time, the number of registrations of battery-electric trucks reached 5,510 units, down 6.6%. But there are significant disparities. Germany leads the way with 2,377

electric trucks registered in the first 9 months of 2024, representing a growth of 56.8% compared to the same period in 2023. France comes in second with 857 registrations, but this represents a decline of 58.4% year-on-year (Rodrigue, 2025).

This unfavorable trend has led to the introduction of new extra regulations in some EU countries, in form of aid measures for the acquisition of ZEVs. Among others, France has been put in place, where ADEME launched the E-TRANS energy saving program. It aims to provide financial support to road transport professionals and local authorities, encouraging them to electrify their fleets of DHVs, through purchasing assistance, long-term rental or retrofit of heavy goods vehicles (Rodrigue, 2024; 2025).

Meanwhile, the automotive industry is adapting very dynamically to the requirements of the energy transformation of the EU road transport sectore. HDVs manufacturing industry have announced to favour battery electric, fuel cell and hydrogen combustion technologies for the shift to producing ZET. However, under the pressure of regulatory bodies, aimed at rapid reducting the ecological impact of road freight transport, which generates high external costs, manufacturers have chosen to develop in particular battery-powered electric trucks.

Moreover, the first electric trucks suitable for long-distance transport are already on the market. According to the ACEA, at least 45 models of battery electric trucks areavailable today in different configurations (ACEA, 2024; 2025). Hydrogen-powered trucks (electric fuel cell and hydrogen combustion engine) is the second major zero-emission technology. However, the market is less developed, even though the first DHVs with such a drive are in service.

6. Conclusions

The conducted research indicates that the process of transformation of the EU road transport freight sector towards zero emission is very complex and difficult to implement within the time period specified by the regulator. It is also burdened with a number of risks.

They apply predominantly to the SME road haulers, suffering from both the lack of capital and, at the same time, a very limited acccess to credits and loans. Despite access to fairly limited state subsidies, any significant additional investment outlays related to the need to meet the requirements of still capital intensive and rapid energy transformation towards zero emissions, may mean bankruptcy or takeover by larger, capital-stronger operators of the road transport or dynamically supported international intermodal transport. This form of already ongoing, economically enforced consolidation of road transport, is already noticeable.

However, the serious crisis in EU road freight transport does not seem to activate a massive wave of consolidation at the moment, even if some large road transport

companies have made targeted acquisitions. Such a form of vertical and horizontal capital integration is mostly being played out at the level of large transport and multi-activity logistics groups since 2023. These mainly include the major maritime shipping carriers continued their purchases in land transport (Hapag Lloyd bought ATL, CMA CGM completed the acquisition of Bolloré Logistics, Sennder acquired CH Robinson's European Land Transport (EST) and finally DSV DB Schenker (Rodrigue, 2024).

However, if these processes intensifies, which may particularly concern the countries of CEE, mergers and acquisitions may increase significantly. It would lead to gradual oligopolization of the road as well as whole transport market with all the consequences for both shippers and consumers. Such a change on the supply side of the road transport market towards oligopoly would mean a significant weakening of its competitive position and could cause a substantial increase in logistics costs.

In order to eliminate or at least partially limit the negative economic effects of decarbonisation of the road freight transport, EC has taken up a number of solutions to support its development within the EU transport market. One of them was undoubtedly the proposal aimed at increasing the maximum authorised dimensions in national and international traffic and the maximum authorised weights for trucks with alternative fuels such as battery electric propulsion to accommodate the extra weight of batteries.

The standard 40 metric ton truck can see an additional 4 metric tons added to its maximum weight restriction while hydrogen-powered trucks would be longer (COM (2023) 445 final). Thereby, the transition to and the purchase of ZETs should be encouraged as disadvantages of heavier battery propulsion with the total weight of trucks would be eliminated and hydrogen-powered trucks could be longer.

By providing strong incentives in terms of additional loading capacity for zero-emission HDVs and for all types of vehicles involved in intermodal operations, the EU regulator intends to accelerate the uptake of ZETs and in such a way to promote the growth of intermodal transport as well (EFIP, 2022; EC, 2023).

However, such legal actions and solutions are addressed mainly to the large road transport companies being actually the frontrunners in adapting to EU zero emissions targets.

They are the ones who are most interested in purchasing ZETs, which comprise of two possible drive train technologies: battery electric (BET) and fuel cell electric trucks running on green hydrogen (FCET). That is why, ZETs are in high demand amongst first mover hauliers, and at least 44% of new truck sales could be zero emissions by 2030, although some manufacturers assessed that this indicator will be even 60% of ZET sales by then.

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