

Green, Greener, Super-Green Land Transport: Now or Never? Input-Output Analysis of Selected European Countries

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Abstract. Transport significantly contributes to emissions, waste, and pollution as being the dominant consumer of fossil fuels. Land transport greening is a primary focus for policymakers aiming for climate neutrality and emission goals, and for businesses facing increasing regulations and societal pressure to adopt greener practices. The aim of the research is to assess the economic interindustry impact of technological shifts in land transport (NACE H49) across various EU countries, by using input-output approach. The study examines 2020 and 2022 product-by-product input-output tables of selected EU countries. Modelling results suggest that a 20% reduction in fuel costs for land transport, achieved through the adoption of electricity, would have a neutral or slightly negative effect on the overall output. The effect of adoption of greener technologies is not conclusive. Policymakers at both the EU and national levels and businesses facing risks from the transition to green or greener solutions are advised to consider regional specifics, manufacturing dependencies, and import reliance in strategic planning.

Keywords: green transport, sustainable transport, sustainability, climate policy, input-output.

1. Introduction

Businesses are facing pressure to adopt greener practices. This pressure can emerge from various sources, including society and employees (Danish et al., 2024), competitors (Layaoen et al., 2024) and institutions. Transport in general – and road transport in

Received: 12/09/2025. **Accepted:** 01/06/2026

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particular – is key in ensuring the mobility and supply processes in Europe (Rabiega et al., 2021).

However, this sector still relies heavily on fossil fuels (Neagoe et al., 2024), and therefore significantly contributes to emissions, waste, and pollution (Brusselsaers et al., 2023). Although the transport sector in total and road transport in particular is key for economic development, the use of green fuels allows for decrease in emissions (Dai et al., 2023).

Moreover, transition towards green energy stimulates economic growth for developed countries and is essential for sustainable growth in developing countries (Elbargathi & Al-Assaf, 2024). Also, the mitigating effect of pollution using cleaner energy (Gara et al., 2024) must be considered.

In the EU and many countries in other regions, land transport is a primary focus for policymakers aiming for climate neutrality and emission goals and for businesses facing increasing national and international regulations along with pressure from society to adopt less polluting and hence expected to be greener practices (Majewski et al., 2023; Ren et al., 2020; Niftiyev & Bagirzadeh, 2024).

Several studies have analysed the impact of green transport. More emphasis is paid to the environmental impact of transport development (Rehman et al., 2025) and relationship of green transport with different socioeconomic, environmental, energy-related, and cultural indicators (Singh et al., 2023). Examining the greening of freight transport, the links between the countries' economic sustainability and the actual public policies have been investigated (Grigorescu & Ion, 2022). Less attention is paid to the impact of green transportation on the development of other industries. As the transport sector is one of the sectors that is related to most other sectors, it is important to understand how all industries are influenced by changes in the transportation sector in general and in land transport in particular.

The aim of the research is to assess the economic interindustry impact of technological shifts in land transport (NACE H49) across various EU countries, by using an input-output approach. The research aims to evaluate the potential economic effect to all economic activities (on 64 economic activities, according to the NACE classification) if current technologies are replaced with green, greener or cutting-edge (super green) technologies. The final technologies, which are currently more theoretical and not widely evidenced in economies, hence cannot be modelled for the application on an industry-wide scale.

The core research question is as follows: What is the economic impact of replacing current land transport technologies (NACE H49) with green, greener, and super-green technologies across the EU economies?

The research hypothesis (H) is raised:

H1: The shift to green and greener technologies in land transport will generally increase demand for sustainable inputs, positively affecting manufacturing and energy sectors; however, the magnitude of this effect will vary across EU countries depending on manufacturing dependencies and import reliance.

H2: Replacing current land transport technologies with green and greener technologies will have a moderate positive impact on overall economic output across EU countries,

but this effect will be uneven due to regional differences, technological adjustments and hence also labour market adjustments, and potential stranded assets in traditional transport activities.

The research has a main geographical focus on Latvia and Estonia, and also on Austria and Sweden. Selection of the countries is limited due to comparability of the data as the examined countries must have product-by-product approach for input-output data sets.

The rest of the paper is structured as follows. Section 2 provides a brief literature review. Section 3 continues with the description of the methodology and data used in this study. Section 4 provides the results and discussion. Section 5 presents conclusions and policy implications.

2. Literature Review

The *European Green Deal* (EGD) summarizes direction towards more sustainable practices in many sectors, including transport. Ozdemir et al. (2023) find that the Netherlands has performed best at implementing EGD, followed by Sweden. Financial support has made a significant impact towards climate protection. However, there is still challenge to be faced in supporting smaller firms and innovative technologies (Bakkar et al., 2025). Green funds are a significant element as they have been used to finance environmentally friendly projects such as sustainable transportation, energy efficiency, renewable energy, etc., resulting in positive environmental impacts by reducing carbon emissions and ensuring a more efficient use of natural resources (Karaş & Celikkol, 2025). Mohsin et al. (2023) provide empirical support for the theory that green financing positively impacts high-quality environmental sustainability in all three aspects – environmental, economic, and structural aspects – and hence green financing significantly impacts the quality of economic growth.

One option for ‘upgreening’ the transport is the substitution of conventional cars that consume fossil fuels to electric vehicles or other greener transport. However, there is often insufficient infrastructure available. For example, in Lithuania, the network of charging stations and the maximum available amount of electricity is not enough to facilitate the use of electric vehicles (Praneviciene et al., 2024). Poor infrastructure as a threat has also been highlighted in other studies (Klimecka-Tatar et al., 2021). Such a situation increases uncertainty, and, with this uncertainty, transportation and supply chain risks rise as well (Chodakowska et al., 2024). Also, the lack of funding and cooperation between the public and the private sectors are seen as an obstacle to greener transportation (Jarasuniene & Bazaras, 2023).

One of the reasons for deficient infrastructure may be the late development of local regulation. For example, in Spain, very few regulations related to climate and environment issues were adopted in 2000, whereas, a more active regulation process began after 2008. However, sustainable transport was not a part of the regulation until recently (Mora-Sanguinetti & Atienza-Maeso, 2023).

On the other hand, there are also research results indicating that green transition in the transport sector can be achieved according to the plans (Recka et al., 2023). Of course, many efforts and substantial finance are still needed to achieve that objective (Brzeziński & Kolinski, 2024; United Nations Economic Commission for Europe, 2021). Sweden is currently being considered as one of the leaders in global climate transition and thus can be perceived as a benchmarking country. However, even in this country, transport must compete with other sectors for government support (Niskanen et al., 2023).

Literature mentions several green logistics practices. Practices related to energy and emissions are most progressive (Osman, 2022); however, there is still substantial uncertainty related to the practical issues of using fossil-free fuels. Switching to electricity is more challenging for heavy-fleet vehicles, but other alternatives are also possible (Luxembourg et al., 2024). Many factors must be considered while choosing the most appropriate way to low-carbon development (Tian et al., 2023). Motivation for greening the transport can also be found in the investor behaviour – if companies base their investment decisions on ESG disclosures or other information showing, *inter alia*, the greenness of transport, it may facilitate the transition to a climate-neutral economy (Rogge & Ohnesorge, 2021).

One of the ways of greening the transport is by choosing more rail transport instead of road transport. Although rail transport is considered cheap and green, it lacks the flexibility and is constrained by a minimum transport quantity (Li et al., 2020). Other options include the use of hydrogen, especially green hydrogen (Włodarczyk & Kaleja, 2023) as a fuel, but green hydrogen generates carbon footprint (Majewski et al., 2023). There is a growing debate on the greenness and sustainability of green hydrogen and also electric vehicles. Nevertheless, currently, this type of infrastructure is even less developed than that for electricity-powered vehicles.

The concept of green and sustainable logistics has been examined by employing the science mapping approach (Ren et al., 2020) and green technologies employing bibliometric analysis (Niftiyev & Bagirzadeh, 2024) of a large number of existing research studies, revealing complexity and a high degree of diversity in definitions.

Input-output analysis is used as the core or one of the methods in numerous researches examining the green transition from fossil fuels and economic vulnerability related to availability of materials in the EU (Andersen et al., 2024), assessing the environmental load of urban and rural households and highlighting the importance of dependency on cars (Poom & Ahas, 2016), computing implementation of bioeconomy's footprints (Brizga et al., 2019), as well as performing the enhanced eco-efficiency assessment evaluating the direct production chain (Tenente et al., 2020).

There is little evidence on how greener technologies in the transportation sector would affect other sectors. Substantial research attention has been paid to technological, environmental issues and also to the policy-making perspective; however, direct and indirect economic impacts have been less covered.

3. Methodology and Data

In the research, *green* transport is the transport that applies technologies which meet the current requirements, that has already replaced existing fossil or polluting technologies and is assisting the transition to sustainable transport and economy in the long term. In this case, 20% of fuel costs in land transport are replaced through the adoption of electricity. At the same time, *greener* technologies *do* exist, and they are already being applied in other countries. In our study, we use Sweden as a benchmark of a country that is already using greener technologies.

Super green technologies are the so-called ideal or on-the-edge technologies, which include the technological progress and shifts that might be possible in the future. In this research, these technologies are regarded as the most optimistic and ideal scenario; however, it is not currently possible to model those due to their theoretical nature and lack of empirical evidence. However, the debate must be held open to stress the need to assess the effects of introduction of such technology, including economic, social, behaviour and other effects as well.

It is of importance to underline that the research is based on the application of economic mathematical modelling methods, and hence, purely technological and engineering aspects are outside of the scope of the research. Being aware of this limitation, the major assessment and computation focus is linked to the evaluation of the direct and indirect economic impact of technological shifts in land transport that are classified as *greener* in this research. Another limitation is related to the use of a static approach. That is, only the difference between the current state and greener technologies can be calculated without showing the transformation process to new technologies. Also, no further technological changes are incorporated. Knowing that technologies are developing rapidly, also, the implementation of greener technologies can be adjusted accordingly; thus, the application of the currently available greener technologies might not be fully representative of the way towards greener technologies sometime in the future.

In line with the aim of the paper, this research assesses the economic impact of land transport and employs the technological shift from the existing technology towards greener technology that is already being used in another country (hence ensuring that the modelling results correspond to potentially applicable technology, and not a purely theoretical iteration).

Land transport in this research according to the Eurostat classification is *Land transport and transport via pipelines* (NACE 2.rev. 2-digit level; code: H49).

The study examines selected EU countries with product-by-product IO tables available in the Eurostat database (Eurostat, 2025). The core of the dataset is formed of symmetric input-output tables of 2020 (product-by-product approach) in the current prices (an exception is Sweden, with the latest tables available being those of 2019, 2021, 2022; hence, the year 2022 is used) by 64 CPA/NACE elements representing technologies and intersectoral linkages.

As Latvia applies the product-by-product approach to input-output statistics, then, the countries that apply the same approach are analysed. Product-by-product approach is applied in Austria, Croatia, Cyprus, Czechia, Estonia, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Portugal, Slovakia, Slovenia, Spain, and Sweden (Eurostat, 2025). Other EU countries apply the industry-by-industry approach.

The applied input-output model (see also Auzina-Emsina, 2024, Auzina-Emsina & Ozolina, 2021 and Auzina-Emsina et al., 2020) executes the classic identities, where the total supply is identical to the total use.

The total supply of products consists of domestically produced (X_j) or imported (IM_i) products. Meanwhile, any demanded (or used) product is consumed in intermediate consumption (X_{ij}) or final demand (Y_i) domestically or exported minus imported (resulting in the net final demand). Each input structure of a product consists of costs for products of other industries (intermediate consumption expenses X_{ij}) and added value (see Formula (1)):

$$X_j = \sum X_{ij} + VA_j, \quad (1)$$

where X_j – j industry's output; X_{ij} – intermediate consumption of i products in j industry; VA_j – added value of j industry.

Direct input coefficients illustrate the input vector of a specific economic product, i.e., what and how many products of other sub-sectors and payments for labour, capital and other production resources are required to produce one unit of the specific sub-sector's products, representing the technological requirements (A_{ij}) (see Formula (2)):

$$A_{ij} = \frac{x_{ij}}{x_j} \quad (2)$$

On the other hand, any product produced in the economy, depending on various factors, may be used in the production of other products (as an intermediate product), consumed (as a final product), invested, or exported (as an export product) (see Formula (3)):

$$X_i = \sum X_{ij} + FD_i + I_i + EX_i - IM_i, \quad (3)$$

where FD_i – final consumption of households and government (including changes in stocks); I_i – investments (or gross capital formation); EX_i – export; IM_i – import.

Regardless of the aspect in which output is examined, the output is the same. This ensures the general equilibrium, and hence symmetric input-output tables are used instead of other approaches that are not able to meet this condition (see Formula (4)):

$$X_i = X_j \quad (4)$$

The economic effect of the application of greener land transport technology is modelled by substituting the existing A_j vector for land transport with the scenario's technology.

The study examines the selected EU member states with available symmetric product-by-product input-output tables and EU-27 aggregated symmetric product-by-product

tables. The technique and the method are applicable to other countries with the corresponding data sets.

The sequence of steps for assessment and modelling is as follows:

1. EU-27 symmetric product-by-product (total, domestic and imported) input-output data analysis to reveal the general trends.
2. Comparison of import dependency in EU-27.
3. Examination of available national symmetric input-output product-by-product data sets; selection of countries to be used in the further study. The selection of the benchmark country (Sweden in this research).
4. Input-output model (technological shift modelling; demand-driven approach) elaboration and calibration for 2020 and 2022 (if the data are available) for benchmark and other selected countries.
5. Modelling applying the scenario of green and greener technologies in land transport, while other direct input coefficients of 63 products are held constant (solitary land transport technology is changed), resulting in a sectoral impact on output and value-added. Modelling involves 2 directions: firstly, defining the greener technology scenario; secondly, application of green technology in Land transport. The results are computed in euros, current prices, as symmetric tables are developed in current prices. Subsequently, relative percentage changes are computed.
6. Bottom-up approach is applied, while aggregating values of 64 sectors into totals.
7. Examination and discussion of the results.
8. Comparison of the results and findings of modelling to other studies.

The main geographical focus of the study is on Latvia and Estonia. Austria is selected as a country to be compared, and Sweden as the benchmark country with already greener transport compared to many other EU countries, including the researched countries. Criteria for the EU country to be selected as a comparison country were as follows: the availability of symmetric product-by-product input-output tables in Eurostat (not all EU countries develop product-by-product tables; others use industry-by-industry tables), location outside the close region (neighbouring countries may show very similar results that cannot be generalized to other countries or regions) and a comparable size (notably larger countries were excluded). As a result, Austria was selected.

Robustness is assessed through a cross-country sensitivity comparison, as Austria being technologically closer to Sweden is used as a low-gap benchmark. By comparing the magnitude and sectoral distribution of impacts across Latvia, Estonia, and Austria under the same technological shock, the research tests the sensitivity of the results to differences in the initial technological conditions.

It is worth noting that Lithuania was selected as one of the core research countries (together with Latvia and Estonia due to geographical proximity, size comparability, comparable economic development and transitions expected); however, during the research, some data problems concerning the Lithuanian input-output data set were identified. Lithuania's data set contained some rows with 0 values (for petroleum products and pharmaceutical

products in the total flows input-output table, while, at the same time, it is evident that imported (non-domestic produced) petroleum products and pharmaceutical products were consumed). Therefore, Lithuania was excluded from further examinations and modelling.

4. Results and Discussion

General trends in EU-27

Land transport services are integral to all economic activities, with direct cost shares ranging from 11% to 0.1%, and accounting for 2.5% of the EU-27 economy. According to Eurostat, the transport sector accounted for 32.0% of the final energy consumption in the EU-27 in 2023, and road transport is the largest energy consumer (accounting for 73.4% of all energy consumption in transport).

Table 1. Economic activities with the largest direct costs share spent on land transport in the EU in 2022 (data source: Eurostat (authors' computations))

Product	Coefficient
Land transport services and transport services via pipelines	0.110
Warehousing and support services for transportation	0.098
Coke and refined petroleum products	0.082
Travel agency, tour operator and other reservation services and related services	0.053
Wholesale trade services, except of motor vehicles and motorcycles	0.046
Other non-metallic mineral products	0.045
Products of forestry, logging and related services	0.038
Paper and paper products	0.038
Basic metals	0.037
Wood and of products of wood	0.035

The largest sectoral direct cost share of land transport is caused by land transport, which means that transport companies, on average, spend 0.11 euros on land transport services offered by others to generate 1 euro output in 2022. Despite the strategic importance of ensuring deliveries, production of only a few products demand larger than 5% share of land transport on average in the EU (see Table 1), including warehousing services, petroleum products, travel agencies and related services.

The coefficient values of Mining (0.032), Agricultural products (0.011) and also services claimed to rely notably on transportation (such as Postal and courier services (0.030), Food, beverages and tobacco products (0.028), Retail trade services (0.023)) indicate that the actual share of land transport is relatively minor. Services involving a notably smaller share of land transport demand are: insurance, financial services, and real estate (see Table 2).

Table 2. Economic activities with the smallest direct costs share spent on land transport in the EU in 2022 (data source: Eurostat (authors' computations))

Product	Coefficient
Insurance, reinsurance and pension funding services	0.001
Financial services	0.001
Real estate services	0.002
Employment services	0.002
Services auxiliary to financial services and insurance services	0.003
Computer programming, consultancy and related services	0.004
Legal and accounting service; services of head offices	0.004
Creative, arts, entertainment, library, archive, museum, other cultural services	0.004
Telecommunications services	0.005
Residential care services	0.005

The largest absolute reduction of land transport share in direct costs in 2022 compared to 2020 in the EU was observed in travel agencies and related services, mining, water transport, air transport and publishing (see Table 3).

Table 3. Economic activities with the largest reduced share on land transport in the EU in 2022 compared to 2020 (data source: Eurostat (authors' computations))

Products and services	2022	2020	relative change (% of 2020)	absolute change
Travel agency, tour operator and other reservation services	0.053	0.074	-28%	-0.021
Mining and quarrying	0.032	0.034	-7%	-0.002
Water transport services	0.007	0.009	-15%	-0.001
Air transport services	0.006	0.007	-13%	-0.001
Publishing services	0.008	0.008	-5%	0.000

Land transport affects all economic activities in the economy, the direct costs shares spent on land transport significantly vary among activities, and the shares fluctuate over time; some economic activities reduced the land transport share in costs (such as travel agencies and tour operator activity, water transport, air transport, mining) by 28%–7% on average in the EU.

Comparison of import dependency in EU-27

The findings indicate that the import-dependence of land transport is varying amid products and services used, however, the overall import-dependence is relatively high due to its reliance on imported fuels and fossil products in the EU. In 2022, imported coke and refined petroleum products accounted for 18% of the land transport intermediate consumption costs. In total, 8% of the land transport intermediate consumption costs are on imported

products and services, but, for example, evidence on water transport (35%) and air transport (21%) claims a notably higher share of imported intermediate consumption in the EU.

Input-output model results of introducing green technologies in land transport

Modelling results of the economic impact of green transport or replacing the current technology achieved through the adoption of electricity claim that the demand for chemicals and chemical products would decrease by 9.5% in Latvia, 0.5% in Estonia, and 0.1% in Austria.

In Latvia, the direct input coefficient on refined petroleum is reduced by 20% (from 0.098 to 0.078), but, at the same time, the saved costs are added to the direct input coefficient on electricity (increased from 0.010 to 0.030). Definitely, the larger shift towards electric vehicles results in the altered overall technology, including spendings on repair services. However, at the moment, the evidence is limited on the effect of such sectoral distribution, hence, first-stage modelling reveals fuel shifts effects. If additional evidence gets available in future, this modelling stage also might be updated with more sophisticated assumptions also affecting other intermediate consumption positions and similarly value-added positions. The overall economic impact is estimated as an output decline of 0.1% in Latvia, whereas, the largest decrease is modelled for chemical products, rubber and plastic products, and services as legal, repair and advertising services (see Table 4).

Table 4. Modelling results on the largest declines estimated in Latvia (source: authors' computations)

Product or service	Change (%)
Chemicals and chemical products	-9.5%
Rubber and plastic products	-1.2%
Legal and accounting services; services of head offices	-1.0%
Repair and installation services of machinery and equipment	-0.8%
Advertising and market research services	-0.5%
TOTAL	-0.1%

However, the modelling results claim that some increase is expected for electricity and mining (see Table 5), and some positive impacts on wood products and forestry and water transport can be assumed.

Table 5. Modelling results on the largest increases estimated in Latvia (source: authors' computations)

Product or service	Change (%)
Electricity, gas, steam and air conditioning	4.2%
Mining and quarrying	1.8%
Wood and of products of wood and cork, except furniture	0.3%
Products of forestry, logging and related services	0.2%
Water transport services	0.1%
Electrical equipment	0.1%

In Estonia, the direct input coefficient on refined petroleum is reduced by 20% (from 0.097 to 0.077), but, at the same time, the saved costs are added to direct input coefficient on electricity (increased from 0.002 to 0.022). In Austria, the coefficient on refined petroleum changes from 0.033 to 0.026, and, on electricity, from 0.025 to 0.032. The data thus claim that land transport in Austria is already relying more on electricity than in Latvia and Estonia.

The modelling results on, Estonia argue that the largest decline is in the output of refined petroleum products, mining and basic metals (see Table 6).

Table 6. Modelling results on the largest declines estimated in Estonia (source: authors' computations)

Product or service	Change (%)
Coke and refined petroleum products	-9.8%
Mining and quarrying	-1.7%
Basic metals	-0.8%
Repair and installation services of machinery and equipment	-0.5%
Chemicals and chemical products	-0.5%
TOTAL	0.0%

The results on Estonia are close to those of Latvia, regarding the positively affected output of products (see Table 7).

Table 7. Modelling results on the largest increases estimated in Estonia (source: authors' computations)

Product or service	Change (%)
Electricity, gas, steam and air conditioning	3.4%
Wood and of products of wood and cork, except furniture; articles of straw and plaiting materials	0.1%
Products of forestry, logging and related services	0.1%
Electrical equipment	0.1%

In order to highlight the national specifics and the argument that the finding on one country has limited options to be generalized and applied directly to other, even alike, countries, Austria was included in the research. The modelling results reveal these differences along with, also, some similarities to the previously examined countries (see Tables 8 and 9). The most negatively and most positively affected production aspects are fluctuating notably amid countries.

Table 8. Modelling results on the largest declines estimated in Austria (source: authors' computations)

Product or service	Change (%)
Coke and refined petroleum products	-4.1%
Mining and quarrying	-3.7%
Water transport services	-0.7%
Chemicals and chemical products	-0.1%
TOTAL	0.0%

There are some common trends; however, there is no evidence to claim that the modelled effect is generalisable to other countries in the EU, such as Finland, Slovakia, the Czech Republic, or outside of the EU.

Table 9. Modelling results on the largest increases estimated in Austria (source: authors' computations)

Product or service	Change (%)
Electricity, gas, steam and air conditioning	0.9%
Sewerage services; sewage sludge; waste collection	0.1%
Products of forestry, logging and related services	0.1%

The comparison of modelling results on the direct input coefficient on refined petroleum is reduced by 20% for Latvia, Estonia, and Austria reveals no impact or a very relatively minor impact on overall economic performance (see Tables 4, 6, and 8). Also, a common positive effect is on Electricity, gas and steam production is detected (it varies between 0.9% and 4.2%).

Input-output model results of introducing greener technologies in land transport

The results of the modelling of the impact of applying greener technology already available in Sweden argue that in Latvia and Estonia the overall impact on sectoral output is different – notably, this is an increase of 1.2% in Latvia and a decrease by 0.1% in Estonia. It is mainly due to the value-added and intermediate consumption proportions in the cost structure.

Table 10. Modelling results on the largest increase estimated in Latvia if the land transport technology used in Sweden is introduced (source: authors' computations)

Product or service	Change (%)
Repair and installation services of machinery and equipment	28.0%
Chemicals and chemical products	18.0%
Employment services	12.8%
Water transport services	8.4%
Legal and accounting services; services of head offices; management consultancy services	7.6%

The results claim that some sectoral outputs are affected notably positively in services such as repair (+28.0% in Latvia), employment services (+12.8% in Latvia), and also on the production of chemical products (+18.0% in Latvia), refined petroleum products (+17.9% in Estonia) (see Table 10 and Table 11).

Evidence claims that Austria is closer to Sweden in green technology, and hence, the modelled positive (see Table 12) and negative effect (see Table 15) is notably smaller. If existing land transport technology from Sweden gets adopted and applied now in the modelled countries, then, this technological shift generates various positive effects but highly uneven sectoral output effects across countries, with the largest gains occurring in economies that are technologically more distant from Sweden.

Table 11. Modelling results on the largest increase estimated in Estonia if the land transport technology used in Sweden is introduced (source: authors' computations)

Product or service	Change (%)
Coke and refined petroleum products	17.9%
Mining and quarrying	6.0%
Land transport services and transport services via pipelines	5.0%
Repair and installation services of machinery and equipment	3.6%
Architectural and engineering services; technical testing and analysis services	3.3%
Postal and courier services	3.2%

Table 12. Modelling results on the largest increase estimated in Austria if the land transport technology used in Sweden is introduced (source: authors' computations)

Product or service	Change (%)
Land transport services and transport services via pipelines	3.6%
Chemicals and chemical products	2.5%
Architectural and engineering services; technical testing and analysis services	2.4%
Postal and courier services	2.4%
Warehousing and support services for transportation	2.0%

The modelling results claim that businesses in motor vehicles (-39.8% in Latvia; -28.5% in Estonia) are expected to experience the most severe decline, followed by basic metals (-27.1% and -4.8%) (see Table 13 and Table 14).

Table 13. Modelling results on the largest decrease estimated in Latvia if the land transport technology used in Sweden is introduced (source: authors' computations)

Product or service	Change (%)
Motor vehicles, trailers and semi-trailers	-39.8%
Basic metals	-27.1%
Other transport equipment	-7.8%
Rental and leasing services	-2.6%
Fabricated metal products, except machinery and equipment	-1.2%

Table 14. Modelling results on the largest decrease estimated in Estonia if the land transport technology used in Sweden is introduced (source: authors' computations)

Product or service	Change (%)
Motor vehicles, trailers and semi-trailers	-28.5%
Wholesale and retail trade and repair services of motor vehicles and motorcycles	-11.7%
Insurance, reinsurance and pension funding services, except compulsory social security	-6.1%
Warehousing and support services for transportation	-6.1%
Basic metals	-4.8%

Businesses in the service sector must also be ready for a decline as less insurance and rental services are demanded.

Evidence claims that Austria is closer to Sweden in green technology, and hence, the modelled negative effect is notably smaller (see Table 15).

Table 15. Modelling results on the largest decrease estimated in Austria if the land transport technology used in Sweden is introduced (source: authors' computations)

Product or service	Change (%)
Repair and installation services of machinery and equipment	-2.3%
Rental and leasing services	-2.2%
Electricity, gas, steam and air conditioning	-1.3%
Travel agency, tour operator and other reservation services and related services	-1.3%
Employment services	-0.8%
Insurance, reinsurance and pension funding services, except compulsory social security	-0.6%

Manufacturing, and particularly transport equipment and metal-intensive industries (such as Motor vehicles, trailers and semi-trailers, Other transport equipment, Fabricated metal products, except machinery and equipment), experiences the strongest negative output effects in Latvia. At the same time, in Estonia, manufacturing remains the most negatively affected sector, although the impact extends to trade (Wholesale and retail trade and repair services of motor vehicles and motorcycles), logistics and warehouses (Warehousing and support services for transportation), and financial services (Insurance, reinsurance and pension funding services, except for compulsory social security). But, in Austria, the negative impacts are limited and primarily service-oriented (such as Repair and installation services of machinery and equipment, Rental and leasing services, etc.), thus indicating Austria's closer technological contiguity to Sweden.

Discussion

The obtained results show that, indeed, the electricity, gas, steam and air conditioning sector gains most from the introduction of green technologies in land transport, thus confirming the first hypothesis, though this effect is less obvious for the introduction of greener technologies. In the latter case, more positive changes are related to repair and installation services of machinery and equipment and some other services, adding less to different manufacturing activities.

Contrary to the assumptions stated in the second hypothesis, the overall impact on the sectoral output in Latvia is negative and close to zero in Austria. Thus, the anticipated positive effect is not apparent in the results. The results of the greener technologies scenario show diversity – specifically, a moderate increase in Latvia and a slight decrease in Estonia, thereby confirming that the anticipated effect is uneven, as stated in the second hypothesis, and that only country-by-country analysis can provide more precise results.

The policy-makers' perspective must include the estimated results as the companies and, hence, labour resources are going to be affected by the shifts towards greener technologies, and, more so, if introduction of realistic green technologies is planned in the near future. A distinction has to be made between the private and the commercial sector, as argued by Illahi et al. (2024) as there are major differences between the needs of the two sectors.

The most affected sectors will provide larger labour resources to other sectors. Therefore, plans to improve the competencies must be in place to enable idle workers to be employed in other sectors. Celasun et al. (2023) show that there are differences in opportunities for redundant workers in different manufacturing sectors.

Businesses in the most affected sectoral activities are recommended to alter the future strategies and plans that the government and the EU require, which will result in planned and estimated changes rather than unexpected shocks for owners, managers and employees. The problem of stranded assets might be more serious for other forms of transport, e.g., maritime transport (Schwartz et al., 2024), but transport companies and other enterprises with own transport need to replace their fleet in a timely manner. Differences in adopting green technologies may also spur diversities in economic development of countries, which was already experienced after the Covid-19 crisis (Auzina-Emsina & Ozolina, 2025). The energy consumption pattern change definitely affects the economic growth and development (Khan & Kong, 2020), as it is linked with shifts and changes in the energy efficiency, and, in the euro area, the green transition is on the right track (Kėdaitienė & Klyvienė, 2020).

It is evident that the concept of super-green land transport technology is unrealistic. However, if more detailed information and hence rational and engineering-based assumptions are available, the modelling can be developed to estimate the extreme transitions and identify the most positively and negatively affected economic activities.

The limited sample of examined countries focusing on individual or few countries (as explored in (Grigorescu & Ion, 2022)) has both positive aspects as interpretable and traceable results for companies and policy makers, also, limitations are involved as the findings can offer limited applicability and scalability to clearly larger countries as Germany, France, and, notably, smaller countries, such as Malta or Cyprus.

Additionally, the economic impacts on individual industries and imports must be examined in relation to individual consumer choices as the study on decarbonization and the circular economy interaction in one EU country (Austria) argues that one benefit is the increased disposable income due to the reduced private car ownership (Haas et al., 2025). It leads to future research directions to include consumer behaviour and shifts in saving and spending patterns.

Further research options include dynamic analysis of transition to green, greener and super-green transport technologies that would show short-term adjustment mechanisms and longer-term developments that could show the benefits of green investments.

5. Conclusions and Policy Recommendations

Policymakers at both the EU and national levels are advised to consider regional specifics, manufacturing dependencies, and import reliance when planning the transition towards greener technologies in the transport sector. Moreover, not only production capacities and supply needs must be considered. Also, labour redundancies in one group of sectors and labour shortages in others can be a significant issue. The practical recommendations for policymakers are thus as follows:

- 1) Regional transition roadmaps – to develop region-specific transition plans that would account for manufacturing dependencies, import dependency, and labour market structures. This ensures that green technology adoption does not create disproportionate shocks in vulnerable regions or countries within the EU.
- 2) Labour reskilling programs – to establish EU- and national-level programs for reskilling and upskilling programs targeting employees from economic activities most affected by green technology adoption. This reduces unemployment risk and accelerates labour mobility.
- 3) Monitoring system of labour market – to implement sectoral monitoring tools to identify early signals of labour shortages or redundancies and adjust national policies dynamically.

Businesses facing risks from the transition to green or greener solutions should focus on local, regional, and national diversities in strategic decision-making. Stranded assets in transportation can become a problem. The practical recommendations for businesses are listed below:

- 1) Strategic asset management – companies are recommended to audit their transport assets and create plans for phased replacement in order to avoid stranded assets and financial shocks, postponing the beginning of replacement till legal deadlines.
- 2) Collaborative platforms and clusters – companies are recommended to engage in industry clusters or public-private partnerships to share best practices, reduce costs, and accelerate technology adoption, while identifying the import dependency and targeting to reduce the operational vulnerability due to high dependency of imported technologies and resources.

Although the introduction of super-green transport seems unrealistic in the near future, analysis of the potential impacts of smaller-scale changes helps shed light on the potential challenges which the countries and stakeholders can expect if and when that takes place.

Author contributions:

The authors contributed to the manuscript as follows:

Astra Auzina-Emsina was responsible for the conception and design of the research, data collection, computations, and contributed to the results, discussion, and conclusions.

Velga Ozolina: conducted the literature review and participated in the discussion of the results and conclusions.

Disclosure statement

The authors declare that there are no competing financial, professional, or personal interests involved that could have appeared to influence the work reported in this paper.

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