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Assessment of Implementing Green Logistics Principles in Railway Transport: The Case of Lithuania

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Abstract: Today, green transport is a growing trend in terms of transport costs, CO_2 emissions and satisfaction with logistics services. Green logistics is an environmentally friendly and sustainable logistics system that encompasses activities affecting logistics functions and processes, promoting the environment and the development of a circular economy. Rail transport is considered to be one of the least polluting modes of transport, but the fact that only electrified rail represents the concept of green logistics has been underemphasised, as the fleet consisting of diesel trains is a major challenge. This article aims to investigate the implementation of green logistics in railway transport in the case of Lithuania. The scientific literature, SWOT analysis, expert evaluation and parameter correlation methods were used to achieve this goal. An analysis of the internal and external factors of Lithuanian Railways in terms of green logistics has identified the main strengths of rail transport. These are environmental friendliness, electric trains reducing CO_2 emissions, a strong focus on circular economy and others. The main weaknesses include the more extensive use of diesel trains, competition, etc. The external factors of the company show that the main opportunities are the reduction in net CO_2 emissions to zero, the acquisition of more electric locomotives and others, while the main threats include an increase in energy costs or the complexity of implementing new technologies. An analysis of these factors has led to the construction of a SWOT matrix, which shows that the company's strategy in the field of green logistics is quite strong, with more strengths than weaknesses. The results made it possible to identify the links between the individual implementation principles of green logistics in railway transport and provide strategic guidelines for the successful integration of green logistic principles into railway transport in Lithuania.

Keywords: green logistics; sustainability; railway transport; parameter correlation

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1. Introduction

Transport and logistics are an integral part of the economy and society. With the intensive movement of goods, information, capital, technology and people between countries around the world, the flow of orders is increasing, stimulating the development of logistics services. In the face of technological advancements, e-commerce has become increasingly popular and was particularly relevant during the pandemic. E-commerce increases the volume of shipments, which, in turn, results in greater environmental pollution, more frequent traffic accidents and higher CO_2 emissions. For these reasons, measures are being sought to tackle environmental problems. A system that would allow the promotion of European economic progress, competitiveness and the provision of high-quality services to ensure mobility while using resources much more efficiently is a key objective of the European transport policy identified in the White Paper [1]. Green solutions are applied

to reduce CO_2 emissions, which are mainly generated by the transport and logistics sector. Green logistics is a form of logistics that is linked to environmental objectives and promotes the sustainable development of the transport sector, a reduction in CO_2 emissions, congestion, noise and accidents and the improvement of air quality. Transport and logistics companies encourage their employees to contribute to reducing environmental pollution by participating in environmental clean-up actions or waste sorting, but it is essential to identify problems and solutions in company processes, such as replacing vehicles that pollute the environment, promoting and optimising green processes, etc. In passenger transport companies, it is important to pay attention to passenger reactions and feedback to green logistics solutions and to encourage the choice of less environmentally damaging vehicles.

The COVID-19 pandemic has severely affected rail passenger transport in the European Union [2]. The EU has seen significant interruptions in rail passenger transit as a result of the COVID-19 pandemic, which is principally attributed to the implementation of rigorous lockdown measures and travel restrictions designed to mitigate the transmission of the virus. The significant decrease in both commuter and tourist travel exacerbates the aforementioned effect, signalling a major shift in mobility trends and posing significant economic challenges for the industry.

However, it is important to remember that rail transport plays a crucial role in sustainable development, especially in the context of a greener economy and transport [3].

Scientific articles usually focus on green logistics in road transport, highlighting its importance and challenges. They provide a conceptual model that emphasises green vehicles, efficient systems and advanced technologies, despite challenges, such as funding and cooperation [4] and explore the practice of green logistics aiming to reduce transport pollution, proposing such strategies as a modal shift, hybrid fuel technology, route optimisation, proper network design, reverse logistics and green transport procurement, which are effective in reducing environmental impacts [5], while also looking for such alternatives for intermodal transport, etc.

The development of rail transport is linked to its coherence and integrity, which creates a competitive advantage, enabling new technologies, long-term economic performance, sustainable transport, professional competencies and continuous improvement in service quality [6].

Therefore, green logistics should be seen as a growing trend in supply chain management, incorporating green elements into global strategies. Southeast Europe faces challenges in implementing green concepts due to inadequate infrastructure. The proposed models include unique intermodal networks, simplified procedures and the increased use of rail and recycling initiatives [7].

Sustainable development is crucial for supply chain management, and the implementation of a green transport strategy in logistics companies can help to achieve this. Increased social awareness can lead to environmental protection and the development of green transport [8].

A Green Cargo Train (HCT for railways) aims to improve transport systems by focusing on high-capacity trains, reducing energy consumption and emissions [9].

In light of the fact that railway transport is more often considered a part of intermodal transport in scientific articles, the case of Lithuanian Railways was chosen in this article to analyse the topic of green logistics implementation in railway transport. This choice was determined by the fact that there is still a significant number of lines that have not been electrified, and this has become one of the main challenges in complying with the principles of green logistics. It is also important to assess what factors are hindering/allowing the development of green logistics principles in rail transport and what are the synergies between these principles (which have not been investigated in other scientific articles on green logistics in rail transport).

The structure of the paper is as follows: an analysis of the concept of green logistics, the determinants of its implementation and its application in rail transport are presented

on the basis of the scientific literature; a description of the research method used, chapters on the results obtained and a discussion also are concluded with general conclusions and recommendations for further research.

2. Literature Analysis

Nowadays, climate change is a challenge not only for today's society but also for tomorrow's generations. It is a worrying phenomenon for many individuals, and as the logistics sector develops and expands, it is becoming more difficult to manage congestion, accidents, CO_2 emissions, etc. The publication of the first paper on environmental issues in the scientific journal *Transport and Logistics* marked the start of the research and interest in green logistics. In 1950, the first scientific papers on the environmental impact of freight transport were published [10]. Green logistics encompasses all attempts to reduce the environmental impact of traffic systems, human mobility and transport in regional and global supply chains, including the reverse flow of products and materials [11]. Green logistics is not only a scientific theory or a business concept but also the next stage in the development of the logistics concept. The application of this form of logistics in a transport company is a targeted competitive advantage as it is an evolving and dynamic concept [12]. Green logistics has a positive impact not only on the company but also on society. Sustainable logistics aims to address the problem of reducing the impact of transport emissions on air pollution [13]. Various definitions of green logistics can be found in the scientific literature, and they are listed in the table below (Table 1).

Table 1. Analysis of concepts of green logistics.

Year	Author	Explanation of the Concept
2018	[14]	Green logistics is an activity aimed at reducing the adverse environmental impacts of logistics operations, such as greenhouse gas emissions, noise and waste, in order to achieve sustainable economic, social and environmental development.
2019	[15]	Green logistics (GL) is a major trend in the development of modern logistics, an integral prerequisite for the development of the circular economy (CE) and the main system. Green logistics is a concept that links resources and products, goods and consumers.
2019	[16]	Green logistics is an environmentally friendly logistics system that encompasses logistics processes, including transport, warehousing, distribution, promoting environmental friendliness and green reverse logistics recycling, such as waste processing and disposal.
2020	[17]	Green logistics is a development of traditional logistics that emphasises the performance of logistics activities in an environmentally friendly manner in order to realise logistics and economic development in a way that conserves resources and protects the environment.
2020	[18]	Green logistics is a logistics concept that takes into account the impact of the transport and environmental sectors on the overall logistics process.
2020	[18]	Green logistics is a sector that influences logistics functions and supply chains, including transport, delivery and storage through resource saving, recycling, the use of environmentally friendly substitutes and a reduction in waste and emissions.
2020	[19]	Green logistics is one of the current trends that logistics companies are applying to their logistics operations in their pursuit of addressing issues within economic efficiency while at the same time ensuring environmental friendliness and socially responsible activities.

Source: compiled by the authors.

The authors list different concepts of green logistics in Table 1 and highlight their different features. Some authors state that logistics is a traditional development of activities [17], while other authors define it as a modern/current trend [15,19].

Green logistics is also defined as a logistics activity, a process, a system or the performance of logistics activities. These aspects have been mentioned by some researchers who want to emphasise that green logistics is an activity that affects the logistics functions and

performance as well as the overall logistics process of companies that aim to implement economic efficiency and ensure social responsibility [16–19].

The authors of some scientific papers have identified in their definitions of green logistics the following logistics processes that promote environmental performance: resource-saving, environmentally friendly recycling and using environmentally friendly substitutes and a reduction in waste and emissions [14,16,18]. The importance of ecology, which green logistics ensures, was also emphasised by other researchers [17,19]. Green logistics has also been identified by some researchers as an environmentally friendly logistics system [16].

Researchers have also been looking for different solutions to the development of the green logistics concept, for example, the optimisation of freight flows using Guanxi principles [20] and logistics cost management throughout the product life cycle [21].

Finally, some researchers revealed that green logistics is an integral condition for the development of a circular economy, which implies the implementation of a closed loop of material flowing in the economic system and the main system, as green logistics links resources and products, goods and consumers [15].

The application of green logistics in companies is important for various reasons. As mentioned above, the authors of various scientific articles emphasise that green logistics promotes environmental friendliness in logistics processes through such steps as the recycling and disposal of waste, the conservation of resources, the use of environmentally friendly substitutes and economic rebalancing, which help to reduce greenhouse gas emissions and waste and to achieve economic efficiency.

The implementation of green logistics in a transport company requires knowledge and a variety of approaches and methods. There is still a lack of knowledge about green logistics and how to apply it in a company, which can lead to an inappropriate choice of tools and methods for its implementation. Some researchers argue that the lack of knowledge about sustainability is a problem that prevents the improvement of supply chain efficiency [22,23]. Other authors also emphasise that the lack of technology involves both a lack of knowledge and understanding of sustainable technologies, practices and methods among partners [23].

Researchers emphasise the importance of green logistics in support and regulatory policies, as the government's consideration of the objective and the overall approach would allow emissions, pollution and consumption to be reduced, setting environmental targets, engaging in the environmental monitoring of the green logistics production process, and a strict limitation of noise that has a negative impact [16]. The application of green logistics has a highly positive impact on the environment, but the use of environmentally friendly resources requires funds to be allocated for labour, machinery and materials, and this affects the development of green logistics in transport companies.

One researcher distinguished four factors that affect green decisions as follows: the company, policy, customers and society [15]. The opinion of customers is particularly important in the development of green logistics, as consumers now demand goods to be delivered by a green means of transport to be environmentally friendly, and the supplier, i.e., the company, is therefore forced to opt for green solutions. Home delivery has the greatest impact on the development of green logistics, as customers are direct users of this service. Customers also expect a convenient road system to reach a supermarket, staying away from transport emitting additional amounts of environmentally harmful pollutants to reach a parking space. The public may also demand green products, environmentally friendly vehicles and home delivery instead of going to a supermarket. This author named politics as the strongest factor in the development of green logistics. Customers and the public elect members of political organisations, while companies have to respond to the needs of consumers and the public.

Some researchers identify the legal, social, ecological and technological factors for the implementation of green logistics measures and emphasise that they are equally important [4]. Also, based on the study carried out by these authors, and given that the aim of this study was to identify the risks involved in the implementation of green transport logistics measures and the reasons for their avoidance, financial, time-related, failure-related and

psychological factors have been identified as the main drivers that lead to the risks involved in the implementation of green transport logistics measures. This source, which included a survey of Lithuanian transport companies and interviews with foreign transport enterprises, revealed that funding, a lack of state support and low technology transferability are the main factors preventing transport companies from implementing green logistics measures [4].

Having identified the factors determining the implementation of green logistics measures, the application of this type of logistics in rail transport needs to be examined.

It is important to keep in mind that goods are transported, especially over longer distances, in the supply chain using more environmentally friendly modes of transport (rail and waterborne transport). Rail transport is generally associated with the long-distance carriage of large volumes of goods, where logistics companies have their own rail access roads. Intermodal transport, e.g., a containerised freight, is particularly convenient nowadays. It can reduce the negative environmental impact, as CO_2 emissions in rail transport are several times lower than in road transport [24].

Some researchers state in their research papers that the majority of people are in favour of transport infrastructure being provided mainly by the state [25]. This is an opportunity to substantially improve the sustainability of transport and logistics, where the burden of the large investments required for green public infrastructure becomes the basis for the greener transport and logistics sub-systems used in everyday activities.

The above-mentioned authors also argue that one of the forms of public provision of green transport services could be the state creating the infrastructure of the rail network for the provision of rail transport services, i.e., by allocating funds for the development of the rail network, etc. Actions could be implemented sustainably, e.g., by the state generating and supplying renewable energy for electrified railway tracks [26]. This should be performed using market expenses, as they can stimulate investment in the renewable energy sector, e.g., in the face of increasing the price of conventional energy sources, renewable energy technologies become more competitive, which can encourage investors and consumers to turn to renewable energy sources to save money and reduce emissions while also promoting sustainability development. Sponsorship funds could also be used to promote the shift from road to rail transport and sustainable energy consumption.

The International Union of Railways (UIC) represents the rail sector, promotes rail transport and states that the efficient development of rail transport is aimed at making railways greener, quieter and more energy efficient in terms of energy use [26]. As the cleanest and most environmentally friendly large-scale transport, the railway plays an important role in the development of sustainable lifestyles and economies [26]. The UIC also argues that today's challenges can only be overcome by using rail as the basis for a seamlessly connected sustainable mobility system. Rail transport is a key pillar for achieving transformative climate action in the field of transport. It is the fastest and most cost-effective way to improve the global situation by reducing emissions of environmentally damaging atmospheric gases, i.e., carbon dioxide, in the daily movement of people and in logistics chains. Like the UIC, the Community of European Railways (CERs) refers to the sustainability of railways as being embodied in environmental friendliness, energy saving and high efficiency [27]. The community also identifies two other factors that contribute to railway sustainability: transport efficiency and integration [28].

In summary, the use of rail transport can be said to reduce environmental impacts and promote environmental friendliness, while the use of renewable energy in rail transport promotes green logistics, helps to save money, uses energy more efficiently, etc. Given that rail transport is analysed as, e.g., by carbon footprint, the use of a sustainable multimodal transport or part of an intermodal transport system from an ecological point of view and other technological parameters [29–34], this article aims to exclusively evaluate rail transport and the application of green logistics processes in it.

3. Methods and Methodology

The methodology is presented in the following sequence in this chapter: firstly, the need for SWOT analysis to describe the methodological approach, followed by a brief presentation of the methodologies used to carry out the expert evaluation and the correlation are highlighted, providing the basic concept and references from the main sources, where these methodologies are presented in greater detail (in order to avoid double citation).

3.1. Research Methodology

All companies engage in strategic planning because it helps them to identify their strengths and weaknesses; analyse the organisation's performance; review a company's business opportunities; and identify the measures that could help to achieve productivity, the efficient use of available resources and the desired results. Some organisations use SWOT analysis for strategy planning, which is historically attributed to Albert Humphrey, a management consultant at the Stanford Research Institute in the 1960s, but this attribution is still controversial, and there is no universally recognised originator of SWOT.

SWOT analysis is a strategy planning tool used to analyse a company's strengths and weaknesses as internal factors and its opportunities and threats as external factors. Its purpose is to help the company create options for choosing a strategy and to assess future courses of action [34]. It is also defined as a tool for the strategic management of the company to identify internal and external factors and to use it to help the business to act from a position of identified strengths [35]. This corporate strategy planning tool encourages owners and management to assess the internal and external environment of the organisation in order to gain a clear picture of the company's resources and opportunities for growth, as well as threats from external sources and their avoidance. This analysis will help to identify the objectives or obstacles to be overcome. If weaknesses are transformed into strengths and threats into opportunities, these two factors, which have a positive impact on the company's performance, should be optimised in light of the company's potential.

Strengths are internal capabilities and positive factors of businesses that are important for companies to achieve their goals and serve customers effectively [36]. Organisational strengths are the qualities or traits that enable managers to effectively carry out the institution's mission. These can include both tangible and intangible attributes, such as experienced management, assets (physical, human or intangible), competitive advantage and other aspects of the organisation that are important in conducting activities and ensuring long-term success.

Weaknesses are internal factors or limitations that may hinder or impede the performance results of the organisation [36]. These are the risks of the internal factors of the organisation that can disrupt the achievement of successful performance. Weaknesses can negatively impact an organisation's success and growth. These internal factors do not meet the established standards and must be controlled, reduced or eliminated. The weaknesses of the institution may be related to insufficient facilities, a lack of staff and teachers, etc.

Opportunities are external factors or characteristics that can facilitate relationships between business entities outside of the organisation [36]. They are related to external factors that can help the organisation achieve its goals in the business environment. This means that an organisation can use its environment to plan and implement strategies that help it become more profitable. Exploiting opportunities can give an organisation a competitive advantage. Organisational vigilance is important to be able to spot and exploit opportunities as they arise. Opportunities may include the best prospects of competitive advantage and be aligned with the offers of the organisation.

Threats are related to the negative external factors of the company that can hinder or delay the goals to be achieved [36]. These are external factors that can harm the success and profitability of the organisation. They are unpredictable and uncontrollable. Threats can be related to environmental changes, competition, regulation, etc. These external factors increase the vulnerability of the organisation and can lead to volatility. Meanwhile, the

organisation can take measures to reduce the impact of threats, such as developing crisis management strategies or searching for new markets and opportunities [37].

Having conducted an analysis of the company's strengths, weaknesses, opportunities and threats, a SWOT matrix was created (Table 2), which included the previously mentioned four elements of the strategy: internal factors, based on the organisational approach, i.e., strengths and weaknesses and external factors, i.e., opportunities and threats, based on inter-correlation.

Table 2. SWOT matrix.

	Positive	**Negative**
Internal	S	S
External	G	G

Source: compiled by the authors according to [38].

In the SWOT matrix, the first row represents the internal factors, i.e., weaknesses and strengths, and the second represents the external factors, i.e., opportunities and threats. The first column reveals the positive side of the company, i.e., its strengths and opportunities, and the second represents the negative factors, i.e., its weaknesses and threats.

Thus, SWOT analysis is a method of business strategy analysis that can be applied both in small and large companies as it allows an assessment of the internal and external factors of the organisation. SWOT is an acronym that stands for an organisation's strengths, weaknesses, opportunities and threats. This analysis can help identify strengths within the organisation to capitalise on and weaknesses that need to be addressed. Also, the analysis helps to identify factors in the business environment, i.e., the opportunities that can help achieve the set goals and predict threats that need to be avoided because they can harm the organisation's activities.

3.2. Expert Evaluation and Correlation Methodology

After evaluating the internal and external factors, it is important to arrange them in the order of priority. Thus, an expert evaluation is conducted for this purpose, which allows the sequence of the elements of each of the SWOT groups to be identified, while the correlation allows the synergy of interaction between these elements to be determined.

After the expert survey, the data received were processed to obtain summarised data and new information contained in the expert evaluation form. Based on the processing results, a solution to the problem was formulated. The calculated concordance coefficient shows the level of concordance of the expert group if the number of experts is greater than two.

The calculated sum of squares for the deviations of rankings for all criteria from the mean, S, shows whether the experts' evaluation differs significantly from the overall mean of the evaluations. Therefore, the reliability of an expert evaluation can be expressed by the concordance coefficient of expert opinions, W, which shows the degree of closeness of individual opinions [39–41].

When conducting an expert evaluation, experts were asked to assign importance estimates to the objects based on their knowledge, experience and intuition. The obtained criteria were coded, where a group of experts, n, evaluated the objects, m, in terms of quantity. The evaluations formed a matrix of n rows and m columns [41].

It should be noted that ranking is a procedure where the most important indicator is given a rank equal to one, the second indicator is given the rank of two and the last indicator is given the rank m (*m* is the number of comparative indicators). With the experts' indicators, the concordance of their opinions is determined by calculating Kendall's rank concordance coefficient W.

The concordance coefficient can be applied in practice if its limit value, when expert opinions are concordant, is established. If there are more than seven criteria, the significance

of the concordance coefficient can be determined using the $\mathcal{X}^2$ Pearson criterion, and if its value is greater than $\mathcal{X}^2_{kr}$, it shows that the experts' evaluations are concordant. Having made sure that the experts' opinions are concordant, the order of importance of the evaluated criteria can be established.

Importance indicators were determined as follows: the average rank of each criterion of the object was divided by the fixed value for all object criteria—the sum of the ranks—thus calculating q. The sum of q estimates calculated accordingly is equal to one. The most important criterion is the one with the lowest calculated value. For each criterion, the inverse of q is calculated. The sum of the calculated estimates D is equal to $n - 1$.

Finally, the criteria importance indicators, Q, are calculated, the sum of which are equal to one. Also, the importance of the criteria of an object when evaluated by experts can be determined by equating their sum to one and calculating the importance indicator, Q, of each criterion.

After assessing the order of priority of the criteria, the evaluation of their mutual interaction according to the importance is carried out according to the Pearson correlation coefficient in the following sequence of actions:

Pearson's product-moment correlation coefficient measures linear relationships between two variables (1) [42].

Interval data are obtained from paired observations and when the variables are normally distributed (2) [43]. However, it is important to ensure that there are no extreme values in the data that could affect the result.

Assuming that a pair of variables follows a normal distribution of two variables, a correlation between the two variables can be analysed using ellipses (3) [44].

4. Results

4.1. Internal and External Factors of the Strategy of Lithuanian Railways in the Implementation of Green Logistics

There are internal and external factors in every company that indicates the appropriateness and effectiveness of the organisation's strategy. These factors can also indicate whether green logistics are important for companies and whether they are effectively aiming to reduce their negative impact on the environment and use resources more efficiently. As environmental requirements become more stringent and consumer awareness of environmental sustainability increases, it becomes even more important for companies to implement green logistics principles in their operations.

One of the internal strengths of Lithuanian Railways is the fact that railway transport is one of the most environmentally friendly types of transport. It is a much less polluting alternative to road transport, as it uses up to 10 times less fuel for transporting goods and passengers (Figure 1). The continuous improvement and financial support of the European Union legislation facilitate the development and improvement of the railway transport business, especially in order to improve interactions with other modes of transport.

Figure 1 illustrates that rail transport accounted for a very low share of transport CO_2 emissions compared to other transport modes in both 2009 and 2019. Also, according to the statistics presented, CO_2 emissions were 4.2% in 2009 and 2.7% in 2019, which represents a decrease of 1.9%. These two aspects allow us to conclude that rail transport is one of the greenest modes of transport.

Another strength of Lithuanian Railways is that transport by electric train leaves less CO_2 emissions per passenger seat than transport by bus or car. For example, according to the Lithuanian Statistics Department, trains accounted for a mere 2.7% of the total greenhouse gas emissions from transport in Lithuania in 2019, even though more than 67% of freight was transported by rail. Furthermore, when comparing CO_2 emissions per passenger seat, an electric Vilnius–Kaunas train emits 0 kg of CO_2 as it runs on electricity generated from renewable energy sources, while a bus has CO_2 emissions of 1.57 kg, and a car has 3.49 kg of CO_2 emissions. Thus, rail transport is one of the most efficient and least polluting modes of transport, especially for carrying freight.

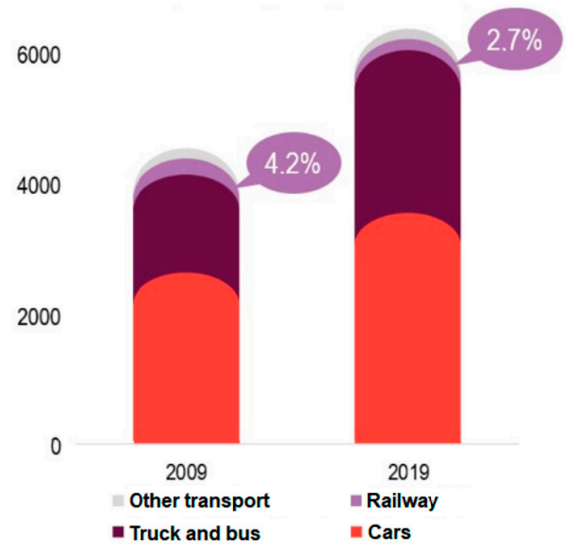

Figure 1. Transport CO_2 emissions in thousand tons. Source: [45].

Another strength of the company is its electrification activities, which help to reduce emissions and ensure climate change mitigation and energy efficiency. The use of electric energy in vehicles is less polluting than the use of fuel, resulting in increased energy efficiency and reduced emissions. According to the data from 2018, the length of railways in operation was 1910.7 km, of which 152.4 km were electrified [46]. In 2021, 3464.6 km of railways were in operation, and the length of electrified tracks is shown in the table below (Table 3) [45].

Table 3. Length of electrified railway lines and electrified tracks.

Indicators for the Implementation of Specific Commitments Agreed with the Controller of Appropriations (the Ministry of Transport and Communications)	Unit of Measure	2021
Proportion of electrified tracks in relation to total railway lines	%	8%
Length of electrified tracks	km	317.5

Source: [45].

The statistics presented show that the length of electrified tracks was 317.5 km in 2021, which is 165.1 km more compared to 2018, indicating that emission reductions and other climate change mitigation measures are being implemented. The electrification project has been underway since 2018, lasting for 48 months, with a value of EUR 411.26 million, a maximum speed of 160 km/h on this section and a length of 731 km. Thus, the aim is to have the total length of electrified railway tracks account for 35% in Lithuania, which means that the share of electrified railways, which has been increasing so far, will continue to increase in the future [47].

A strong focus on the circular economy is yet another strength of the company. The circular economy aims to keep natural resources in use for as long as possible, to improve waste sorting and recycling, and to reduce waste and environmental pollution. The Lithuanian Railways Group is committed to preserving the environment and adopting a sustainable approach to its operations. Therefore, in order to reduce waste and increase recycling efficiency, the company uses sustainable practices, such as reusing wooden and reinforced concrete sleepers, road ballasts and sorting and collecting packaging, plastic and paper waste separately, which is then passed on to waste handlers for reuse or recycling. In addition, staff received training in 2021 to enable them to better understand the waste management process and to make a conscious contribution to the problem. The company is also working with various waste management specialists to find new ways to manage

waste more efficiently. The Lithuanian Railways Group achieved excellent results in 2021, having increased the amount of recyclable, and energy-recoverable waste from 90% to 99% in the last two years [45].

Another major advantage is that the company's documents are digital, signed by electronic signature only, without using paper. A digital document management system helps to reduce the bureaucracy and administrative burden, improves the efficiency of information use and reduces environmental pollution associated with paper production and consumption. Electronic signatures allow for the fast and reliable signing of documents and reduce the time and costs associated with printing, delivery and storage. The figure below (Figure 2) shows the quantity and type of documents in the organisation between 2018 and 2021.

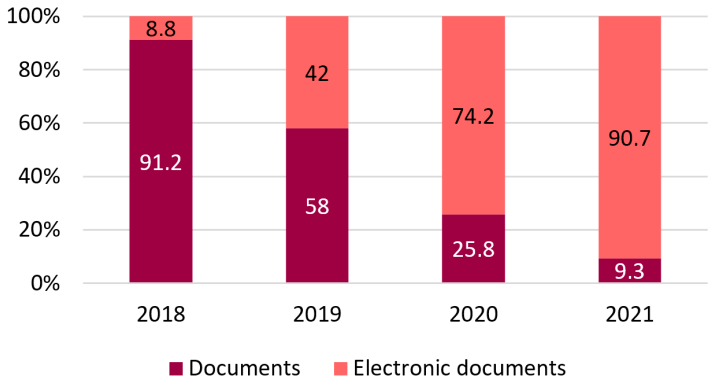

Figure 2. Document dynamics in LTG group, %. Source: [45].

Thus, the statistics reveal that digital document management has been evolving year after year, while paper documents have been declining, accounting for a mere 9.3% in 2021, which is a strength in the green logistics environment.

The Sustainable Travel Club, where passengers can accumulate club membership points and redeem them for discounts on train trips to reduce CO_2, is yet another great initiative. Trains are one of the most efficient means of passenger transport in the EU as they emit only a fraction of greenhouse gases per kilometre travelled compared to other modes of transport [48] (Figure 3). It promotes sustainable travel practices and reduces the environmental impact of travelling while supporting people who have chosen a sustainable alternative. This could encourage more people to choose sustainable travel alternatives and increase the use of public transport [49].

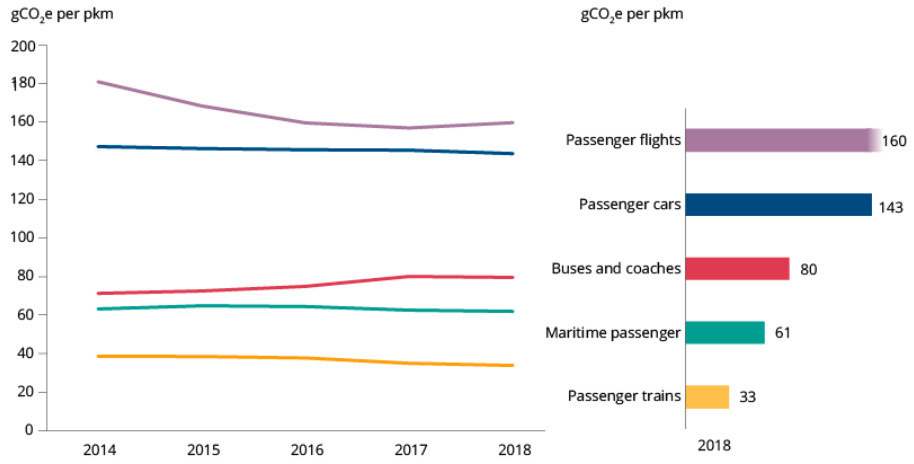

Figure 3. Average GHG emissions by type of motorised passenger transport, EU-27, in 2014–2018. Source: [48].

Thus, these data highlight that rail transport is a reliable and efficient mode of passenger transport in the EU, with significantly lower greenhouse gas (GHG) emissions per kilometre than other modes. Passenger trains emit 79% less CO_2 than passenger planes and 77% less CO_2 than passenger cars, which means that rail is not only the most economical but also the most environmentally friendly mode of transport. In 2014–2018, the efficiency of rail passenger transport increased by 13%, which was achieved as a result of the electrification of the rail network and the reduction in the intensity of and use of electricity in the EU [48].

One of the weaknesses of the Lithuanian Railways is that freight and passenger transport is mainly diesel-powered, emitting GHG and causing environmental pollution. Diesel trains are a major source of pollution, and pollution is a major problem not only from the environment but also from a health point of view. Therefore, electric transport, which is significantly cleaner and more efficient and reduces emissions and climate change, has a major role to play in the development of sustainable transport systems. According to data from 2018, there were 17 electric trains and 28 diesel trains, while in 2021, there were 14 electric trains and 28 diesel trains. In 2018, there were 56 electric rolling stock and 92 diesel units, and in 2021, there were 42 electric rolling stock and 92 diesel units [50]. Thus, the number of electric trains and rolling stock has decreased over the past 3 years, while the number of diesel trains and rolling stock has remained the same, which is a weakness for green logistics.

Another weakness is competition, as there is a lot of competition in the green logistics sector, which means that other providers of these services may have more experience, more efficient technology and more extensive resources. Green logistics services are provided by various Lithuanian companies, which may be competitors of Lithuanian Railways.

Also, a higher price of travel on electric trains and green logistics services compared to traditional logistics is unappealing to customers. Green logistics services are more expensive due to investments in new technologies, vehicles, special and environmentally friendly equipment and infrastructure. For example, a trip from Klaipėda to Vilnius in a second-class diesel train costs EUR 18.5, and a second-class electric train costs EUR 22.5. Due to this price difference, some customers may find the aspect of green logistics services less important than the price, which may reduce the demand. This means that selling green logistics services is more difficult, which is another weakness of the company.

Another weakness is the shortening or cancellation of train services on various routes due to ongoing electrification works, which causes inconvenience to passengers. For example, in 2023, a large number of trains on the Vilnius–Klaipėda–Vilnius routes were cancelled due to ongoing electrification works, and on some weekdays, only one journey time was left, or trains did not run on the Vilnius–Klaipėda route altogether. This may cause inconvenience for users, leading to lower passenger interest in this mode of transport.

Having analysed the company's strengths and weaknesses, the next step is to look at external factors.

As mentioned above, the appropriateness of a company's strategy is determined by internal and external factors. These factors can also indicate whether the application of green logistics methods, a reduction in negative environmental impacts and other environmental measures are important to the company's activities.

The success of companies applying green logistics principles is affected not only by internal but also by external factors such as more stringent environmental requirements, changing consumer demands and other circumstances.

The first option is to reduce net CO_2 emissions to zero. Green logistics operations can reduce emissions and help companies to achieve their sustainability goals. The Lithuanian Railway Group (LTG) is contributing to the implementation of the European Green Deal and the Paris Agreement by committing to reduce net CO_2 emissions to zero by 2050 [45]. The plan is to progressively reduce CO_2 and particulate matter emissions in rail transport, with the target set for reducing total CO_2 emissions by 30% and specific CO_2 emissions by 50% for freight and passenger transport by 2030 compared to 2005. In addition, in line

with its strategic objectives and its priority of sustainability management, the LTG aims to actively contribute to the implementation of the Sustainable Development Goals set by the United Nations. One of the objectives is Goal 13: Mitigation of climate change, which is linked to the above-mentioned Paris Agreement, as these goals both include the mitigation of climate change through a reduction in greenhouse gas emissions.

Another option is the purchase of more electric traction freight locomotives and passenger rolling stock. This would reduce emissions and contribute to sustainable transport. In addition, these vehicles tend to be more efficient, which results in energy savings and lower operating costs. As previously mentioned, LTG is committed to a net reduction in CO_2 emissions to zero, which means that the implementation of clean energy transport solutions, such as the purchase of more electric locomotives, will be possible.

Obtaining 100% of electricity from renewable energy sources is another option for Lithuanian Railways. Electricity from renewable energy sources is clean and sustainable as it comes from nature and is dependent on natural phenomena, so using such energy could make rail transport even more sustainable. It would also lead to a reduction in emissions and represent a commitment to environmental protection. Thus, 100% renewable electricity remains an option for Lithuanian Railways, while other companies have already achieved this.

More noise barriers would be a sustainable way to reduce noise and improve quality of life. Noise from trains can be a major disruptive factor to those living and working close to the railway. Noise abatement can help to improve the quality of the environment and life in these areas. Walls can be built as a long-term investment in infrastructure as they can last for many years. This solution is also in line with the principles of sustainability, as it is less damaging to the environment than many other noise abatement methods and can be linked to renewable energy sources in order to reduce reliance on fossil fuels. In 2021, the length of these walls was only 2.7 km, so installing more of these noise barriers could be an excellent option to achieve an effective outcome and improve quality of life [45].

When it comes to threats, the first is an increase in energy costs due to the use of green transport infrastructure and innovative technologies. High energy consumption is mostly associated with the transport and logistics sector, and the costs of these sectors are often highly dependent on the price of energy used [51]. Supplying electricity to consumers is an expensive process, consisting of several different types of costs that are all collectively referred to as electric energy costs. Capital costs, load hours, fuel costs and lifetime are assessed, while most polluting plants, which use cheap but highly polluting fossil fuels, are at the forefront of this type of cost analysis. For example, rail transport is an efficient and environmentally friendly way to move large volumes of freight, but most trains are still diesel-powered. Electrification is one way to make rail transport more efficient and reduce emissions. It is a green logistics operation that requires new infrastructure elements directly linked to the railway infrastructure, such as power stations and energy supply networks, which can provide electricity to railway lines. The development and use of these elements can increase the cost of operations, as the introduction of new elements and technologies requires more energy, which means an increase in the total energy costs.

Another threat is the complexity of implementing new technologies. New technologies such as electric vehicles can lead to high implementation costs and the complexity of such a process. Sustainable transport requires appropriate green infrastructure, such as freight terminals with loading and unloading stations that can handle vehicles such as electric trains. Companies starting to implement green logistics in their business operations may face financial or technical difficulties due to a shortage of appropriate infrastructure, which may imply investments in new infrastructure. These investments may affect their competitiveness and ability to make a profit, implement new technologies and reduce environmental pollution.

A lack of funding for electrification is also a threat. Electrification is one of the main ways to reduce vehicle pollution. Unless a company is able to obtain the necessary financial support, it may face difficulties in modernising its fleet and adapting to green logistics

requirements. Technological progress and the emergence of new alternative energy sources have a major impact on the energy sector. This may lead to changes in national priorities and project allocation. For example, the European Union's strategic objective is to increase the use of renewable energies in order to reach an energy efficiency level of at least 32% by 2030. This means that more investment may be made in alternative energy sources and infrastructure than in the traditional energy generation sector, which may also affect investment in the modernisation of electric trains and railways.

Customers may be dissatisfied with the company if short-haul train journeys are cancelled. This may be due to electrification and other technical works and may affect the use of polluting road vehicles. For example, on the 6–28 February 2023 and on the 1–16 March 2023, trains were not running on the Vilnius–Šiauliai and Kaunas–Šiauliai routes from Monday to Saturday and on the 17–29 March 2023, trains were not in operation on the Radviliškis–Klaipėda route for all days of the week [52]. If a company cannot provide a stable and reliable service, customers may lose confidence and turn to other companies that offer traditional transport solutions and faster and more reliable services. Moreover, cancellations or delays in transport can have a negative impact on customers' business and their costs.

Having reviewed the company's external factors, a net reduction in CO_2 emissions to zero, the acquisition of more electric locomotives, 100% renewable electricity and more noise barrier walls were identified as the main opportunities. An increase in energy costs, the complexity of implementing new technologies, a lack of funding for electrification and customer dissatisfaction were distinguished as the main threats.

4.2. SWOT Analysis of Lithuanian Railways from the Perspective of Green Logistics and Its Results

The assessment of the internal and external factors of the strategy of Lithuanian Railways from the perspective of green logistics allows a SWOT analysis of the strategy to be conducted (Table 4).

Table 4. SWOT analysis of the Lithuanian Railways strategy in terms of green logistics.

Strengths	**Weaknesses**
Rail transport is one of the greenest modes of transport; Zero CO_2 emissions from electric trains; Increasing the share of electrified rail; Strong focus on the circular economy; Digitised document system; Sustainable Travel Club.	Diesel trains account for the major share of trains in this service; Competition; Higher cost of travelling on electric trains; Reduction or cancellation of routes as a result of electrification works.
Opportunities	**Threats**
Reduction in net CO_2 emissions to zero; Purchasing more electric locomotives; 100% of electricity from renewable energy sources; Noise barrier walls.	Increase in energy costs; Complexity of the implementation of new technologies; Shortage of funding for electrification; Customer dissatisfaction.

Source: compiled by the authors.

Based on the analysed internal and external factors of the company's strategy, the company's green logistics strategy can be concluded to have more strengths than other factors. It also has four weaknesses, opportunities and threats. However, more strengths than weaknesses were found, suggesting that Lithuanian Railways is quite strong in the area of green logistics. When it comes to external factors, an equal number of opportunities and threats were found, suggesting that there are opportunities for Lithuanian Railways that can be implemented in order to achieve greater sustainability, but there are also threats that may make this more difficult. However, it should also be noted that when assessing the synergies between these factors, assessing their mutual interaction is important.

5. Discussion

5.1. Assessment of the Correlation Parameters of SWOT Matrix Elements

Sixteen experts with many years of experience in rail transport took part in the expert evaluation. For the factors identified in the SWOT analysis, the experts were asked to assess their impact in the context of the implementation of green logistics; on the basis of the results obtained, the synergies between the factors in each group were assessed. The first group for evaluation was the strengths identified in the SWOT analysis. The experts were, therefore, asked to indicate which of the strengths they considered to be the most influential in terms of the implementation of green logistics in rail transport (Figure 4).

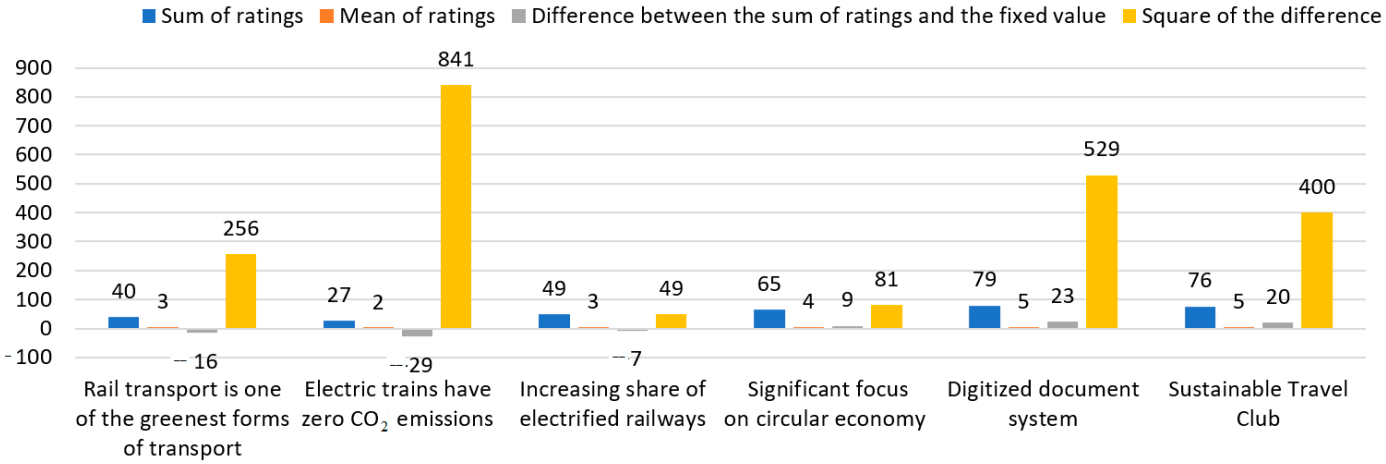

Figure 4. Expert evaluation ranking the strengths of the Lithuanian rail transport that have the greatest impact on the implementation of green logistics principles.

In the absence of correlated ranks, Kendall's concordance coefficient W = 0.6417 was calculated. The significance of the concordance coefficient can be determined using the $\mathcal{X}^2$ Pearson criterion with a value of 51.3333, which is significantly higher than the value of $\mathcal{X}^2_{kr} = 1.063623$, which shows that experts' evaluations are concordant. This is also confirmed by the lowest value of the concordance coefficient W_{min}, which is 0.0133.

The results received allowed the ranking to determine the importance of the criteria (Figure 5).

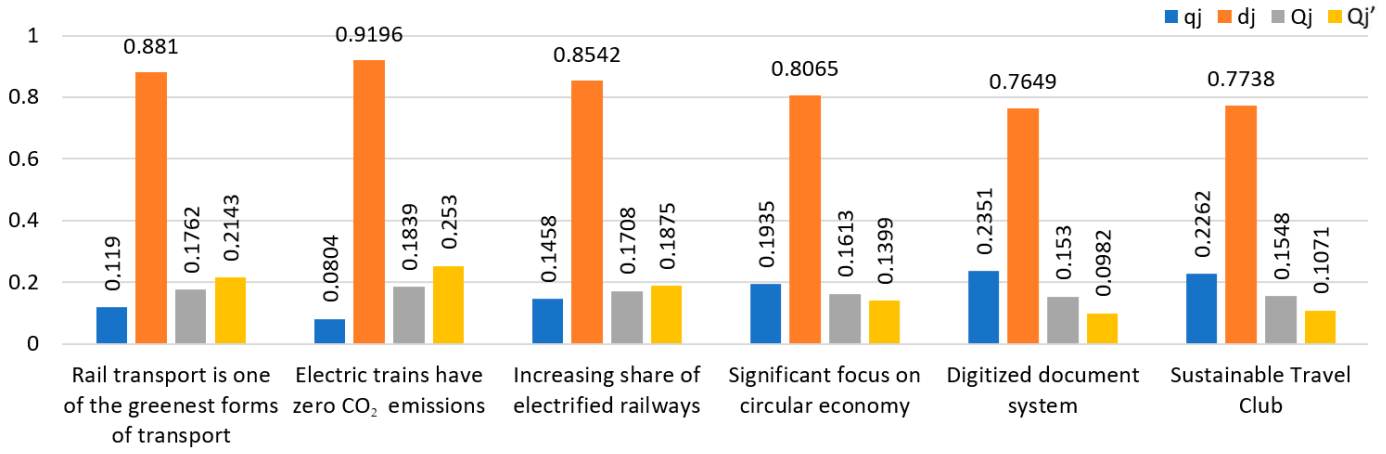

Figure 5. Indicators of the most influential principles of green logistics in Lithuanian rail transport.

The received results show that the key strength that has the greatest impact on the implementation of green logistics principles in rail transport is the fact that, by increasing the level of electrification, the CO_2 emissions of electric trains lead to zero environmental

impact. The Sustainable Travel Club and the digitised document system are somewhat less relevant. In light of the data obtained, it is important to assess how these factors interact with each other and which of them have the greatest synergies (Table 5).

Table 5. Pearson's coefficient values assessing the strengths of the SWOT analysis.

		Rail Transport Is One of the Greenest Forms of Transport	Electric Trains Have Zero CO_2 Emissions	Increasing the Share of Electrified Railways	Significant Focus on Circular Economy	Digitised Document System	Sustainable Travel Club
Rail transport is one of the greenest forms of transport	Pearson Corr.	1	0.99697	0.99821	0.98415	0.95702	0.96416
	Sig.	-	0.00303	0.00179	0.01585	0.04298	0.03584
Electric trains have zero CO_2 emissions	Pearson Corr.	0.99697	1	0.99053	0.96736	0.93154	0.94058
	Sig.	0.00303	-	0.00947	0.03264	0.06846	0.05942
Increasing the share of electrified railways	Pearson Corr.	0.99821	0.99053	1	0.99299	0.97264	0.97829
	Sig.	0.00179	0.00947	-	0.00701	0.02736	0.02171
Significant focus on circular economy	Pearson Corr.	0.98415	0.96736	0.99299	1	0.99328	0.99593
	Sig.	0.01585	0.03264	0.00701	-	0.00672	0.00407
Digitised document system	Pearson Corr.	0.95702	0.93154	0.97264	0.99328	1	0.99967
	Sig.	0.04298	0.06846	0.02736	0.00672	-	3.30359×10^{-4}
Sustainable Travel Club	Pearson Corr.	0.96416	0.94058	0.97829	0.99593	0.99967	1
	Sig.	0.03584	0.05942	0.02171	0.00407	3.30359×10^{-4}	-

The rail sector is the greenest mode of transport if electrified railways are taken into account. This is illustrated by a nearly linear correlation between it and the CO_2 generated by electric trains (0.997), as well as increasing levels of electrification (0.998). Document digitisation (0.957) and the Sustainable Travel Club (0.964) also have a very strong correlation. The last two segments have an almost linear correlation with the development of the circular economy (0.993 and 0.996, respectively). This suggests that the level of the circular economy is directly influenced by digitisation and Sustainable Travel Clubs. These parameters can be ensured by the use of "green" modes of transport such as electric trains.

Another group of experts focused on the weaknesses distinguished; thus, the expert evaluation aimed to find out which of the weaknesses identified in the study were the most important barriers to the implementation of green logistics in rail transport (Figure 6).

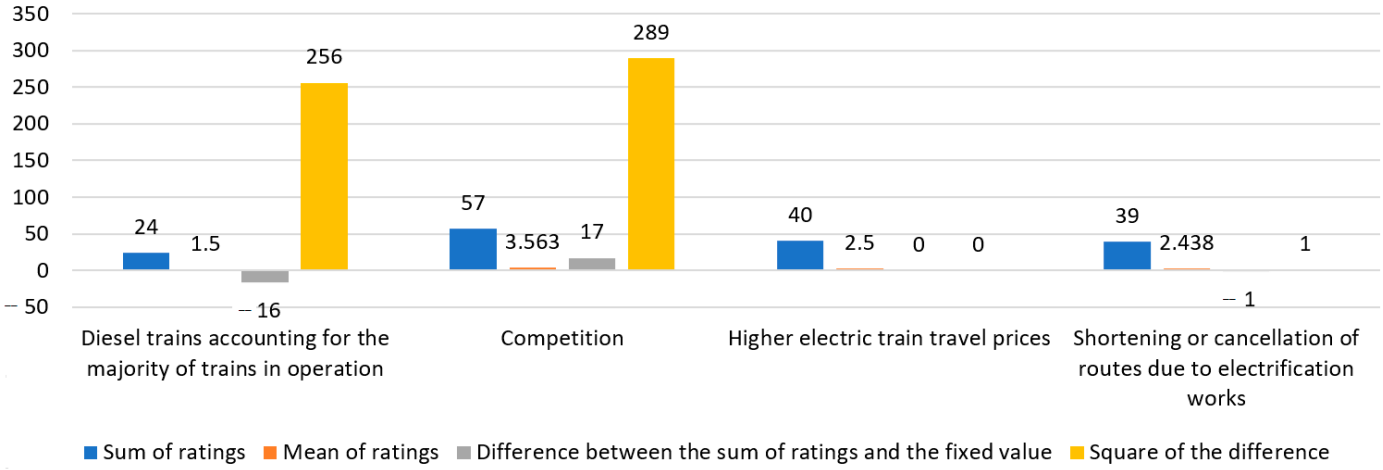

Figure 6. Expert evaluation the ranking the weaknesses of the Lithuanian rail transport that are the greatest obstacles to the implementation of green logistics in rail transport.

In the absence of correlated ranks, Kendall's concordance coefficient $W = 0.5688$ was calculated. The significance of the concordance coefficient can be determined using the $\mathcal{X}^2$ Pearson criterion with a value of 27.3000, which is much lower than $\mathcal{X}^2_{kr} = 0.584375$ and

shows that experts' evaluations are concordant. This is also confirmed by the lowest value of the concordance coefficient W_{min} which is 0.0122.

The results received allowed the ranking to determine the importance of the criteria (Figure 7).

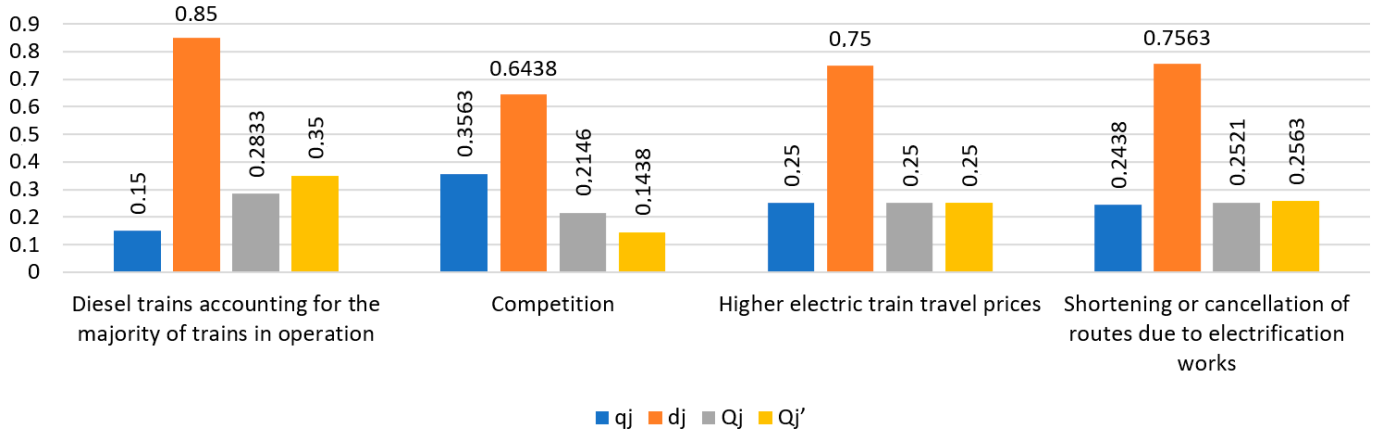

Figure 7. Indicators of the weaknesses of the Lithuanian rail transport that are the main obstacles to the implementation of green logistics in rail transport.

According to the received results, the fact that diesel trains still make up the majority of trains in this service is the biggest obstacle to the implementation of green logistics, while competition has the least impact on the process. It was, therefore, important to assess how these weaknesses interact (Table 6).

Table 6. Pearson's coefficient values assessing the weaknesses of the SWOT analysis.

		Diesel Trains Accounting for the Majority of Trains in Operation	Competition	Higher Electric Train Travel Prices	Shortening or Cancellation of Routes Due to Electrification Works
Diesel trains accounting for the majority of trains in operation	Pearson Corr.	1	0.77373	0.96237	0.96775
	Sig.	-	0.22627	0.03763	0.03225
Competition	Pearson Corr.	0.77373	1	0.91677	0.90837
	Sig.	0.22627	-	0.08323	0.09163
Higher electric train travel prices	Pearson Corr.	0.96237	0.91677	1	0.99979
	Sig.	0.03763	0.08323	-	2.11011×10^{-4}
Shortening or cancellation of routes due to electrification works	Pearson Corr.	0.96775	0.90837	0.99979	1
	Sig.	0.03225	0.09163	2.11011×10^{-4}	-

The market dominance of diesel trains has a direct impact on areas such as competition and the development of electric trains. This dominance of diesel trains shows a very strong correlation (0.962) and does not allow for shortening or cancelling shorter routes due to electrification works. This directly leads (as Pearson's correlation coefficient was very strong at 0.968) to higher electric train trip prices as a result of relatively poorly developed electrification infrastructure. This is also reflected in the competition between diesel and electric trains, where the dominance of diesel trains has a strong correlation (0.773). On the economic side, there is a very strong correlation between competition and both the shortening or cancellation of journeys as a result of the development of the electrification infrastructure (0.908) and the higher price of travelling on electric trains (0.916). This shows

that having increased competition and adjusted infrastructure development directions, a successful and sustainable development of electrified rail could be achieved. After all, the correlation between the cost of electrified rail travel and the planning of its routes is almost linear (0.999).

After assessing the internal factors, the external factors of Lithuanian Railways must be analysed as well. Therefore, experts were asked to assess which of the identified factors would contribute to the implementation of green logistics principles in rail transport the most (Figure 8).

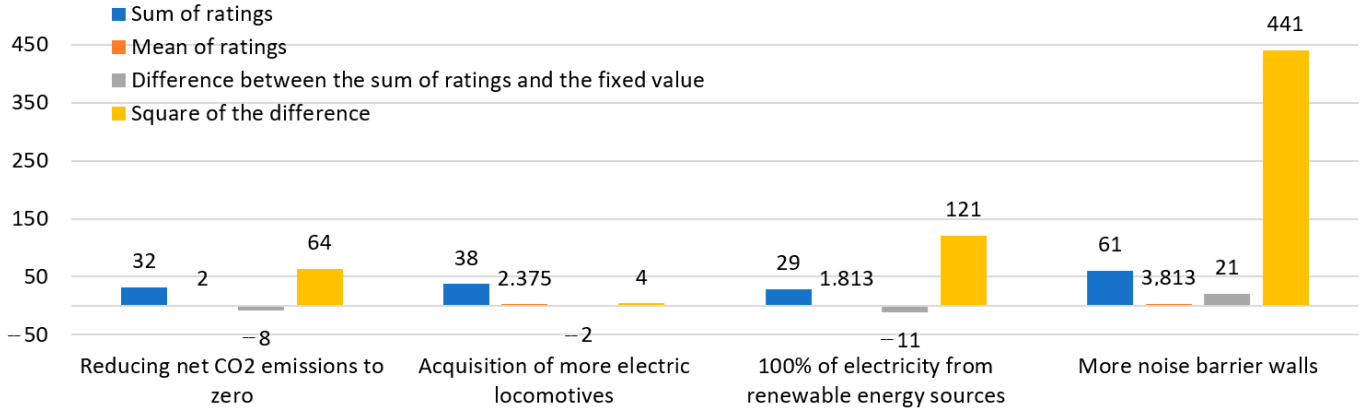

Figure 8. Expert evaluation ranking the capabilities of Lithuanian Railways that contribute to the implementation of green logistics principles.

In the absence of correlated ranks, Kendall's concordance coefficient $W = 0.6563$ was calculated. The significance of the concordance coefficient can be determined using the $\mathcal{X}^2$ Pearson criterion with a value of 31.5000, which is significantly higher than the value of $\mathcal{X}^2_{kr} = 0.584375$, which shows that the experts' evaluations are concordant. This is also confirmed by the lowest value of the concordance coefficient W_{min}, which is 0.0122.

The results received allow the ranking of importance to be determined for the criteria (Figure 9).

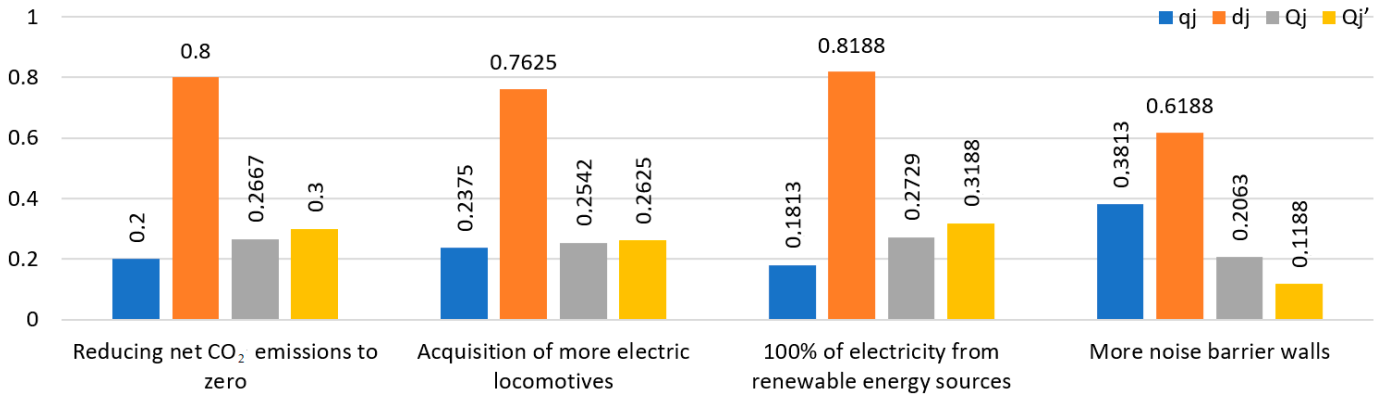

Figure 9. Indicators of the factors of Lithuanian railways that are the main obstacles to the implementation of green logistics in rail transport.

The results show that obtaining 100% of electricity from renewable energy sources is the most important factor, while a greater number of noise barrier walls installed is less important. This suggests that electrified trains emit significantly less noise than diesel trains, which led to experts ranking noise barrier walls as a less important option. The results of the synergy assessment between the identified options are presented in Table 7.

Table 7. Pearson's coefficient values assessing the opportunities of SWOT analysis.

		Reducing Net CO_2 Emissions to Zero	Acquisition of More Electric Locomotives	100% of Electricity from Renewable Energy Sources	More Noise Barrier Walls
Reducing net CO_2 emissions to zero	Pearson Corr.	1	0.99386	0.99878	0.78434
	Sig.	-	0.00614	0.00122	0.21566
Acquisition of more electric locomotives	Pearson Corr.	0.99386	1	0.98718	0.84818
	Sig.	0.000614	-	0.01282	0.15182
100% of electricity from renewable energy sources	Pearson Corr.	0.99878	0.98718	1	0.75274
	Sig.	0.00122	0.01282	-	0.24726
More noise barrier walls	Pearson Corr.	0.78434	0.84818	0.75274	1
	Sig.	0.21566	0.15182	0.24726	-

When assessing the pollution parameters of the electrification of railways, two key parameters can be distinguished. The development of renewable energy in railways is a very important factor for the EU, both in terms of energy and the environment. Therefore, when compared to a reduction in the CO_2 footprint (where coal-based fuels are no longer used) and the increase in the electric locomotive fleet, a nearly linear correlation is shown (0.999 and 0.993, respectively). Clearly, the same trend is observed when the increase in the electric locomotive fleet and the reduction in CO_2 emissions are compared with each other—the trend is similar and almost linear (0.988). Sound insulation is another important parameter, but considering the noise pollution of electric trains (which is much lower compared to diesel trains), there is a strong correlation in all the parameters compared (reduction in CO_2 emissions—0.784; increase in the electric train fleet—0.848; and use of 100% renewable energy—0.753). Thus, sound insulation infrastructure is not as important for rail electrification as for diesel trains.

The last group of SWOT factors presented in the experts' evaluation was threats. Here, the experts had to indicate which of the threats would have the greatest impact on the implementation of green logistics principles in rail transport (Figure 10).

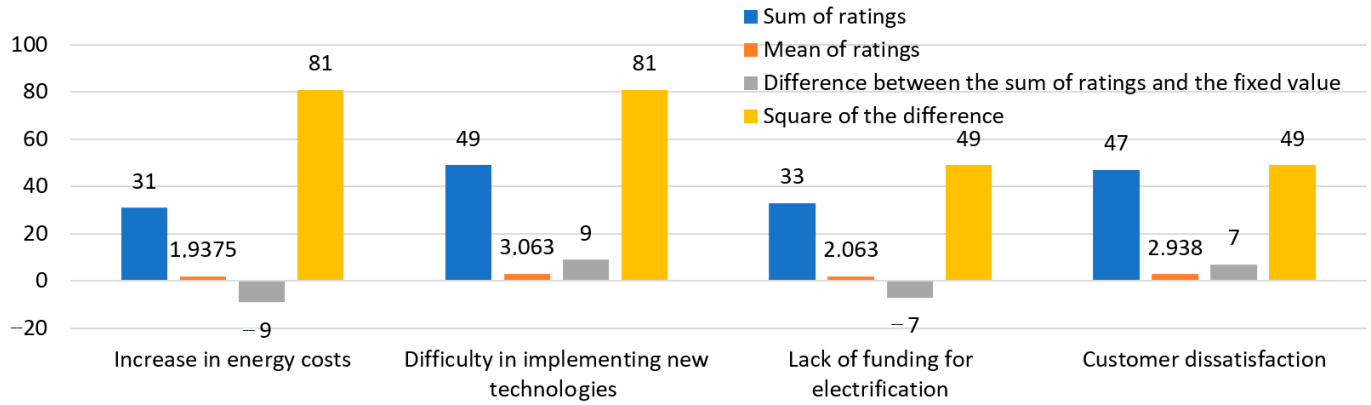

Figure 10. Expert evaluation ranking the aspects of Lithuanian Railways that contribute to the implementation of green logistics principles.

In the absence of correlated ranks, Kendall's concordance coefficient $W = 0.2708$ was calculated. The significance of the concordance coefficient can be determined using the $\mathcal{X}^2$ Pearson criterion with a value of 13.0000, which is significantly higher than $\mathcal{X}^2_{kr} = 0.584375$, and shows that the expert evaluations are concordant. This is also confirmed by the lowest value of the concordance coefficient, W_{min}, which is 0.0122.

The results received allow the ranking to be determined for the importance of the criteria (Figure 11).

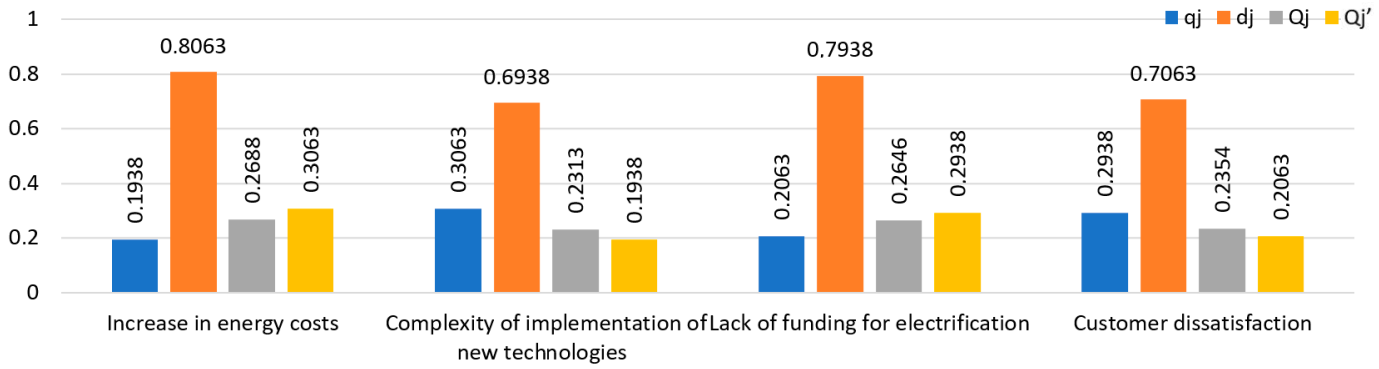

Figure 11. Indicators of the threats of Lithuanian Railways that would have the greatest impact on the implementation of green logistics principles.

The received results show that an increase in energy costs is the greatest threat, and the complexity of the implementation of new technologies is the smallest threat. Assessing the interaction between different threats was important based on the results received (Table 8).

Table 8. Pearson's coefficient values assessing the threats of SWOT analysis.

		Increase in Energy Costs	Complexity of Implementation of New Technologies	Lack of Funding for Electrification	Customer Dissatisfaction
Increase in energy costs	Pearson Corr.	1	0.93109	0.99941	0.94766
	Sig.	-	0.06891	5.8750×10^{-4}	0.05234
Complexity of implementation of new technologies	Pearson Corr.	0.93109	1	0.94304	0.99883
	Sig.	0.06891	-	0.05696	0.00117
Lack of funding for electrification	Pearson Corr.	0.00041	0.94301	1	0.95805
	Sig.	5.8750×10^{-4}	0.05696	-	0.04195
Customer dissatisfaction	Pearson Corr.	0.94766	0.99883	0.95805	1
	Sig.	0.05234	0.00117	0.04195	-

Table 8 reveals two correlated trends, which are nearly linear between the increase in energy costs and the lack of funding for electrification (0.999) and between the complexity of implementing new technologies and customer dissatisfaction. In the first case, the increase in costs always comes with a lack of funding. Additional cost diversification and the prioritisation of payment for the works are needed. When it comes to the introduction of technology and consumer satisfaction, consumers seek to obtain the newest and most modern product possible, which further increases their expectations. Otherwise, there is a very strong correlation, which is dependent on the financing of the electrification of the railways, whether this is related to the introduction of new technologies (0.943) or to the level of consumer satisfaction (0.958).

5.2. Problem-Solving Methods

The performed analysis and calculations made it possible to predict ways of solving the problem, i.e., how to eliminate weaknesses and avoid possible threats.

The acquisition of electric trains, which are less polluting and more efficient, is the main challenge and opportunity of today—to make Europe the first climate-neutral continent, to

ensure that by 2050, greenhouse gas (GHG) emissions are at net zero and decouple economic growth from the use of natural resources [53] The European Commission has launched the European Green Deal, which is the most ambitious set of measures to enable European citizens and businesses to reap the benefits of a sustainable transition to a green economy. Lithuanian Railways is also aiming for 2050 to become a climate-neutral organisation, and one of its projects is the purchase of electric trains, the implementation of which, according to the company's 2021 annual report, is planned until 2025. It is also mentioned that the goal of the project is to replace diesel trains with modern, more environmentally friendly electric rolling stock, which reduces pollution emissions, as their energy and maintenance costs are about 40 percent lower than that of railcars, ensuring compliance with passenger rights regulations, as well as improving customer satisfaction [45] All new trains will be adapted for passengers with individual needs, including the elderly, families with young children or people with disabilities. The value of the public procurement of rolling stock is more than EUR 200 million, and 30 new electric trains are to be purchased [54]. It is estimated that the annual carbon dioxide (CO_2) emissions will be reduced by 69 percent after the renewal of the train fleet. Although the company wishes to purchase new electric trains by 2025, it may take time due to public procurement because in order for this to happen smoothly, a company must appear that meets all the requirements stipulated in the contract and which offers a modern, high-comfort level on ecological trains. The implementation of this project would help to eliminate one of the weaknesses that most of the trains in operation are diesel; i.e., in 2018, according to the data, there were 17 electric trains and 28 diesel trains, and in 2021, according to the data, there were 14 electric trains and 28 diesel ones [50]. Also, with a larger number of electric trains, there would be an opportunity to reduce the prices of travel on these trains.

Another weakness mentioned in the analysis was the higher prices of electric train travel. This problem can be addressed by finding and investing in alternative energy sources and technologies that can increase the efficiency of energy production and reduce costs, such as solar or wind energy technologies. The company claims that since 1990 until 2016, the railway sector has reduced energy consumption and is increasingly using renewable energy sources [54]. If there was a switch to trains that are 100% powered from electricity obtained from renewable energy sources, the costs would decrease even more, which would allow for a reduction in ticket prices for electric train travel as well. Different financial instruments, such as subsidies or incentives, can also be used to increase the availability of electric trains and reduce the cost of travelling on these trains. Regarding the latter method of solving the problem, in the SWOT analysis, among the strengths identified, the Sustainable Travel Club created by Lithuanian Railways was mentioned, which promotes one of the most sustainable and least CO_2-emitting train trips, and by accumulating points from these trips, they can be exchanged for discounts. This tool allows customers to buy tickets cheaper and, at the same time, travel without polluting the environment, so choosing such solutions helps to attract more consumers for whom sustainability is an important aspect of train travel.

As mentioned in the SWOT analysis, one of the weaknesses is competition, which can be turned into a strength by becoming a distinctive and unique company. This weakness can be overcome by providing customers with services that other companies cannot provide. As mentioned earlier, the acquisition and increase in the number of electric trains provide a unique opportunity for people to travel by train without polluting the environment. One of the criteria when choosing a mode of transport for a trip is time, so a higher speed would shorten the travel time. The current electrification works would ensure not only sustainable journeys for customers but also shorter journey times, as the maximum speed on the stretch would reach 160 km/h, which means that this mode of transport would become more attractive [52].

One of the weaknesses is the shortening or cancellation of routes due to electrification works, which can lead to threats such as customer dissatisfaction. This problem can be solved by communicating with passengers so that they are properly informed about

cancelled or shortened trains, their reasons behind this and alternative options of transport. Social networks, messaging systems, information departments and other communication channels can be used for this purpose. It is especially important to start planning and organising the work in time in order to minimise their impact on passengers. Also, it is possible to pre-schedule tickets for cancelled days or schedule the work to be carried out in the evenings or at night when there are fewer passengers using the transport. Another method is to shorten the period of the electrification works so that fewer routes are cancelled or shortened. This can be undertaken by increasing the number of employees to work at an accelerated pace or by using new technologies that allow work to be performed faster.

One of the threats mentioned was the complexity of implementing new technologies that can be turned into an opportunity. Properly trained company employees would have sufficient knowledge and competencies to successfully implement new technologies. Proper training would increase productivity, improve the quality of work and reduce the chance of making mistakes. Cooperation with specialists can solve the complexity of implementing new technologies because it is useful to consult with specialists who have experience and knowledge in this field. They can help identify problems, provide solutions and help implement new technologies, thereby preventing the aforementioned threat.

Such a threat as the increase in energy costs can be avoided using more efficient technologies that save energy and reduce costs. The use of alternative energy sources, such as solar, wind or hydropower, which can be cheaper than traditional energy sources, has already been mentioned. The company claims that during the implementation of the aforementioned project for the purchase of new electric trains, all-electric trains can be powered by electricity produced from renewable energy sources, so the new rolling stock runs completely ecologically [54]. Another way to avoid this threat is energy management, using automated systems to optimise energy use, such as turning off lights or other electrical appliances when not in use.

Threats such as a lack of funding for electrification implementation can be avoided by optimising costs to generate more funds for electrification implementation. Other methods can also be found to reduce costs, such as purchasing less expensive components or saving energy. It is also possible to collaborate with other companies or government institutions to split funding between several sources or look for public funds and subsidies from the state to help finance the project.

6. Conclusions

In summary, the implementation of green logistics measures is influenced by many factors, such as a lack of knowledge, politics, customers and society, with politics being one of the key factors, as a government's consideration of the objective and the overall approach could make the development of green logistics more effective. Rail transport is one of the areas where green logistics is being applied because it reduces negative environmental impacts and promotes environmental friendliness, energy is used more efficiently, etc. In research works, rail transport is usually considered as a part of intermodal transport, while as a separate element, it is analysed from an engineering or economic perspective.

An analysis of the internal and external factors of Lithuanian Railways in terms of green logistics has identified the main strengths of rail transport. These are environmental friendliness; electric trains reducing CO_2 emissions; a strong focus on a circular economy; and others. The main weaknesses include the more extensive use of diesel trains, competition, etc. The external factors of the company show that the main opportunities are a reduction in net CO_2 emissions to zero, the acquisition of more electric locomotives and others, while the main threats include an increase in energy costs or the complexity of implementing new technologies. The analysis of these factors has led to the construction of a SWOT matrix, which shows that the company's strategy in the field of green logistics is quite strong, with more strengths than weaknesses. The analysis of the external factors reveals that the number of opportunities and threats are equal, which means that there are opportunities to further increase sustainability, but there are also threats that need to be

avoided through the implementation of opportunities. Thus, the company has weaknesses and threats that can be replaced by strengths and opportunities, but this requires the right solutions and instruments.

The EU rail industry can achieve carbon neutrality and improve sustainable mobility by strategically adopting electric trains and investing in renewable energy sources. The initiative aims to create a climate-neutral Europe by replacing diesel trains with electric ones and utilising solar or wind energy. This not only aligns with the objectives of the European Green Deal but also effectively reduces greenhouse gas emissions and operational expenses. As a result, rail travel can become more accessible and attractive to environmentally conscious consumers.

Overall, there are various ways to solve the problem. Weaknesses related to the implementation of green logistics in the company's strategy can be eliminated by replacing diesel trains with electric ones; investing in alternative energy sources and technologies; implementing electrification to ensure more sustainable and faster journeys; and organising electrification works in the evenings or at night so that there is no need to shorten or cancel some routes and to ensure customer satisfaction with the services. In order to avoid the possible threats that may arise during the implementation of green logistics, the proper training of employees and cooperation with specialists should be taken care of so that the implementation of new technologies is not complicated; alternative energy sources are used in order to reduce energy costs and travel prices by electric trains; and, finally, cooperation with other companies or state institutions should be undertaken in order to prevent a lack of funding for electrification works.

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