

Policy-Efficiency Trade-Offs in Sustainable Freight Transport

Lan Di

*Faculty of Arts, Society and Business, University of Wollongong, Wollongong, Australia
ld1818888@gmail.com*

Abstract. Freight transport is a necessary part of the economy and supply chains. With the aim of reducing carbon emissions from the freight sector, governments and enterprises have begun to advance several measures to promote decarbonisation. However, it is not known how much the above-mentioned measures will affect the daily work of freight transport. This paper provides an introduction to studies that have investigated the effect of sustainability policies on operating performance, how efficiency trade-offs need to be made to promote sustainable development, various types of responses to decarbonisation policies, and deviations between the aims of policies and their business results. According to the above results, although the sustainable development plan will strengthen environmental protection, it may lower production efficiency and other business indicators. Rail and intermodal transport have better environmental performance; at the same time, road freight is more flexible in operation. Based on the above analysis, this paper will present some difficulties and advantages of sustainable freight transport and propose some suggestions for the future development of this area in terms of research and policies.

Keywords: Freight transport, sustainability, operational efficiency, decarbonization, modal shift

1. Introduction

To promote the economy, support the global supply chain and enable regional and international trade, freight transport is required. This area is also one of the reasons for increased greenhouse gas emissions and energy consumption in the whole city, so it will be included in the plan for reducing emissions [1, 2]. With the goal of achieving carbon neutrality and fulfilling the obligations of sustainable development for more countries in the world, governments are gradually addressing this issue in their transport and environmental policies [3].

In light of the problems posed by freight transport to the environment, many sustainable development activities have been introduced around the world. Investments have been made in rail freight, intermodal transport systems, low-emission zones, electrification, alternative fuels and digital logistics technology, etc. [4-6]. Based on the above research, it is hoped that the measures will reduce environmental pollution and help achieve the goal of carbon neutrality in the long run [7, 8]. Nevertheless, unlike many other industries, the improvement of the environment for freight

transport must not be at the expense of other reasons such as service quality, reliability, timeliness, cost, etc. In other words, the decisions that affect the environment and operation must be taken at all times, but this is quite difficult. Finally, it will be possible to build a high-quality and sustainable freight transport system that is good for both the environment and the economy.

Although the research on sustainable freight transport has expanded, some problems still exist in the literature. A problem in the previous research is that the effects of sustainability on operations have not been studied together. For instance, in many studies on modal shift and emission reduction for rail freight, the goal is to demonstrate the environmental benefits; generally speaking, most general research on logistics efficiency and operation and management aims to increase productivity and reduce costs [1, 2]. Therefore, relatively little research has been conducted on how the new sustainability policy will impact on the company's operations.

The second problem is that most of the current research has focused on only a few technologies, modes or policy tools, such as electric road systems, zero-emission trucks, digital solutions for freight and improvements in rail freight. The above studies have offered some references, but not enough to understand the whole situation of sustainability transition in freight transport systems.

The third issue is that there are disagreements among scholars in different areas about the connection between sustainability and economy. Some studies show that the environmental projects will boost the economy by making better use of resources and reorganising transportation [9, 10]. On the other hand, some research has found that the sustainability measures may be more expensive to implement because of increased costs and infrastructure construction, or they may even alter the mode of operation of the company [11, 12]. As a result, the exactness and scope of the trade-off between sustainability and economy for freight transport have yet to be agreed upon.

Based on the above deficiencies, the purpose of this paper is to investigate the following issues. What is the impact of the sustainable development policy on the operating capacity of freight transport systems? What is the loss of efficiency caused by carrying out the sustainable development plan for freight transport? How are the Different types of transport responding to the Green Deal? What are the differences between the goals of sustainable development policies and actual results in freight transport research?

The results of this review have enabled more people to understand the general situation and provided policymakers with some real-world ideas for the design of sustainable development that are easy to implement and economically reasonable. Through the study of various links in the system, policymakers can devise policies that support the ecological economy and promote the continuous development of enterprises.

2. Findings

2.1. Effects of sustainability policies on operational performance

According to the above research, the direction of change in freight transport systems is being driven by sustainable development policies. Many places around the world have introduced various policies to reduce greenhouse gas emissions and improve the environmental situation of enterprises, such as carbon pricing, low-emission zones (LEZs), rail-support programmes, fuel taxes, etc., as well as subsidies for zero-emission vehicles. Sustainability policies have had some good and some bad effects on the company's operations.

Many studies have shown good results of sustainable development goals. For example, taxes on energy and the use of biodiesel have helped to increase the efficiency of freight transport and reduce

harm to the environment [9]. In the same way, measures to support rail transport, such as construction of railway sidings and intermodal terminals, have been shown to promote the transition to more sustainable modes of transport and improve the overall sustainability of transport networks [13]. Research on urban freight has shown that the combination of low-emission zones and rail freight can reduce emission pollution from transport significantly and meet the demands of the market at the same time [14].

At the same time, there are various issues with the implementation of sustainable development policies. Electrification policies are generally about building a lot of charging stations and other facilities; modal-shift policies mainly require strong network coverage and good cooperation. According to the above research, although the sustainable development policies are expected to create a better ecological environment, there will still be some problems in the short run, such as operating expenses increasing. Therefore, the effectiveness of policies will be constrained by their high-level aspirations and how well they can be implemented in practice.

2.2. Efficiency trade-offs associated with sustainability initiatives

All along, a problem in the research has been how to balance the goals of sustainability and operational efficiency. Many of the sustainable projects have reduced emissions, but there may be an increase in operating costs, reduced flexibility of delivery plans, slower transport speeds, and so on.

The most common trade-off is modal shift. Research shows that the Environmentally Friendly Performance of Rail and Intermodal Transport is relatively good compared with road freight [7, 8]. Generally speaking, in exchange for this, people have more constraints in life, increased mobility burdens and reliance on infrastructure. Electrification can help reduce emissions, but at present, the cost of new cars, the construction of charging facilities, and insufficient range and load capacity are still problems [4, 5].

Therefore, it is not necessarily true that sustainability and efficiency are always in harmony. In fact, the companies that transport goods often have to choose between presenting an environmental advantage and keeping their normal operations going smoothly and maintaining profits due to economic reasons. This idea of a trade-off is to consider what can be done for the good of the planet in light of the necessity of maintaining business operations, and this consistent view has been found in many studies.

2.3. Differences across freight modes

Research shows that the various types of transport for goods have different responses to the green revolution.

Most countries are still using road freight to transport goods and have drawn much research attention. Most research has been focused on improving the energy efficiency of vehicles, introducing alternative fuels, digitalisation of operations, ESG initiatives, etc. [15, 16]. Although the above measures promote the long-term development of rail freight, it is still the most polluting mode of land-based transport. It is a problem that needs to be solved because road freight constitutes a relatively high proportion of the transportation system in many countries.

Rail freight is often considered an alternative to road freight and the best way to reduce carbon emissions for transporting goods. Research in Europe, Asia and Australia has found that the emission per tonne-kilometre for rail transport is considerably lower than that of road transport [2, 17]. However, there are some problems that have limited the widespread use of rail freight, such as

inadequate infrastructure, limited transport capacity and poor service reliability. The above problems have restricted the development of rail freight, although it is a relatively clean way to transport goods.

Due to changes in the environment and business, an intermodal and synchromodal system will be established. By combining the advantages of many types of transport, intermodal systems can reduce harmful emissions and still meet the needs of service quality [6, 10]. Nevertheless, the successful construction of an intermodal system requires coordination by all parties and relevant departments, and good terminal operation for all modes of transport must be realised. Therefore, a system that is good for the environment and can help the company achieve its objectives will be realized.

Inland waterways and coastal shipping are not well-researched but have good environmental performance. According to the analysis above, water-based transport will be more economical and environmentally friendly in a good environment. However, there are some drawbacks to note; that is, the travel time is relatively long, and specific facilities are also required, so it may not be convenient for all people to use [18].

Generally speaking, the literature does not propose one specific type of freight mode. Therefore, the sustainability results of the transport system will be better when using several kinds of transport.

2.4. Gaps between policy objectives and operational outcomes

Freight decarbonisation has drawn the attention of policy makers, but it is not being realised in practice.

The first problem is that people hope for a considerable shift in mode of consumption. Although many policy systems promote rail and intermodal transport, some studies have shown that, in reality, there are many problems with the infrastructure, it lacks coverage in certain areas, and the entire system is too complex; therefore, it is difficult to achieve significant improvements, as indicated by some studies [13, 17].

The second gap is a problem of the application of technology. The government has introduced many new electric and zero-emission trucks to reduce emissions. However, the pace of adoption is limited by funding problems, insufficient construction of necessary facilities, etc. [11, 12].

The third gap is the problem of measurement and assessment of sustainability. All the above indicators have been used in the previous research to measure the sustainability of enterprises. The problem is that there is no standard way to measure these indicators, so it is difficult to compare results from different studies and obstructs policy assessment [1].

Finally, there is a methodological problem in literature. Most studies focus on the environmental results or business operations of a company, but rarely both. Therefore, the relationship between the sustainable development goals and the efficiency of the enterprise is unknown. Freight companies will choose to do so based on both the environment and the economy.

In short, based on the above results, research should not only concentrate on a single index but also construct a combined system covering the environment, operation and economy. This will give them a general sense of the freight system.

The results show that the sustainability policies are generally beneficial for the environment, but their actual effects vary among different modes of transport and in various places. To achieve freight decarbonisation, the environmental goals should be in line with economic development. This is a difficult trade-off that will be further discussed in the following section.

3. Discussion

3.1. Sustainability policy and operational performance

The policies of sustainability are effective, but not always in a simple and direct manner. In light of the above policies, a carbon tax will be introduced, support will be provided for the railway industry, a low-emission zone and other incentives to promote clean cars. How these policies will actually be implemented in life is not straightforward. Some research has found that the above policies can lower emissions and improve the operational efficiency of vehicle fleets; at the same time, others have pointed out that there may be an increase in short-term costs due to additional coordination and construction of necessary facilities before the anticipated benefits are realised [7, 9, 13]. Freight operators are not very conscious of the environmental problems associated with freight. Cost, service reliability and network flexibility are also factors that will be considered in the choice. That is to say, the existing studies have not supported the idea that a greener policy will automatically improve freight performance. It is suggested that policies will work better if the actual problems in operations are taken into account and they are put into effect with good infrastructure and market demand.

3.2. Trade-offs across freight modes

The response of the freight mode to the greening of China will also vary. A Rail and Intermodal Transport System will be built to reduce the carbon emissions of the long-distance corridor and containerisation. However, the same literature also explains why road freight is still the main way: it is more flexible, has wider coverage, and is easier to handle goods that are dispersed [8, 17]. This is an unfortunate situation. Trains are good for the environment, but trucks are faster; they can go to more places and are more convenient to operate. Intermodal transport uses multiple types of transport, so it is often considered a compromise, but only when the terminals are efficient, everyone involved cooperates, and the transfer points are reliable will it be effective [6, 10]. That is to say, the change in modes of transport is not only about choosing between roads and railways.

It would be better to consider it as an incremental process where various modes of transport are employed together to make full use of their respective advantages, and the policy should be to promote integration among these modes rather than substituting one type for another. Not only does one need to choose an environmentally friendly option, but it is also necessary to consider all kinds of transport and use it to the best advantage. One can take a train in the long run, a truck for short distances, and intermodal transport for goods that need to be transferred in different modes. Policies can take many forms to help build an all-weather transportation network in stages. Finally, people hope to lower the carbon footprint of transporting goods and promote green development. Therefore, freight enterprises should think flexibly about how to combine various modes of transport rather than choosing one to replace the others. In this way, they will build a more efficient, practical and ecological transportation system for all people.

3.3. Implications for transition strategy and research

Research on the decarbonisation of freight is not only about technology; it is also a problem of governance, infrastructure and behaviour. New ideas such as electrification, digitalisation of documents, automation and blockchain technology are all very promising, but they still need adequate funds, trust and rules to get off the ground [5, 12]. Therefore, to promote the greening of

freight transportation, it is necessary to have both good ideas and practical measures. Freight operators have been focusing on technology and may have overlooked how people actually use the system or what the design needs are. And if they are only focused on making things more efficient, they will not make the necessary changes. Therefore, future research should focus on how the results of the environment, economy and operations are linked. It can help the government form better policies and learn why some sustainability projects are successful while others are not. Therefore, a solid foundation for decision-making will be laid, and more sustainable projects will be able to succeed over the long run.

4. Conclusion

Based on research, it is to be found that the direction of freight company operation has changed with the promotion of sustainability. To this end, some basic research questions will be answered, such as how sustainable development plans will be realized in normal freight transportation, what adjustments are necessary for different categories of transport services under this new plan, and why there are still problems despite the hope that the policies can achieve sustainable development goals. The research has found that the shift towards a more sustainable freight system is not simple or even. The first goal of both the government and the freight sector is now to reduce carbon emissions, but in practice, this policy will have many problems.

According to the results of this review, in general, the sustainability policies are associated with reduced emissions and better environmental results, but they have different impacts on the operation of different enterprises. Model change, electrification and the low-emission policy are generally good for the environment, but there are still some problems in reality, such as high costs, lack of essential facilities, low flexibility in operation and service, etc. Rather than being in opposition, sustainability and operating efficiency can also be carried out together according to the characteristics of the freight system, the institutional environment and the implementation of policies.

It should be noted that none of the freight transport modes can achieve decarbonisation and at the same time maintain operational performance independently. Rail and intermodal transport have had relatively good environmental performance in recent years; at the same time, road freight is more convenient for people to use and more flexible. Therefore, based on the above evidence, it is more likely that the future development will not be driven by replacing one mode of transport with another, but rather by strengthening the integration of all modes of transport. At the same time, technological development is advancing the construction of an environmentally friendly transport system in the country. Without good support facilities, a stable policy environment and an organisation that can implement the new ideas well, the advantages of the new ideas will not be realized.

It will also add some new ideas to the existing research in this field. First, it collects the scattered studies on sustainability, freight operations and transport policy into one type of analysis to show how they are related. Second, it also points out that there is often a trade-off between environmental goals and production efficiency, and this problem has not been solved yet by policymakers and enterprises. Third, the review finds that there is still a gap in literature; most studies assess environmental and operational results independently and do not consider how they work together in reality. In the future, more integrated ways should be used to assess the combined situation of the environment, economy and operation. The above work can provide stronger support for the design

of green freight transport strategies and be used economically and conveniently for a long time to come.

References

- [1] Collaço, F. M. A., Teixeira, A. C. R., Machado, P. G., Borges, R. R., Brito, T. L. F., & Mouette, D. (2022). Road freight transport literature and the achievements of the sustainable development goals—a systematic review. *Sustainability*, 14.
- [2] Gandhi, N., Kant, R., & Thakkar, J. (2022). A systematic scientometric review of sustainable rail freight transportation. *Environmental Science and Pollution Research*, 30. <https://doi.org/10.1007/s11356-022-22811-5>
- [3] International Transport Forum. (2023). ITF transport outlook 2023. Organisation for Economic Co-operation and Development Publishing.
- [4] Flores-Gandur, J., Vassallo, J. M., & Sobrino, N. (2025). Assessing the socioeconomic impacts of an inductive electric road system for decarbonizing freight transport: A case study for the TEN-T corridor AP-7 in Spain. *Sustainability*, 17.
- [5] Linke, R., Öztürk, Ö., & Kassens-Noor, E. (2024). Analysis of technical and operational requirements of alternative drive systems by transport companies: The case of the overhead contact line truck. *Sustainability*, 16.
- [6] Zhang, Y., Tan, X., Gan, M., Liu, X., & Atasoy, B. (2025). Operational synchromodal transport planning methodologies: Review and roadmap. *Transportation Research Part E: Logistics and Transportation Review*, 193.
- [7] Ahmed, M., Mehdi, M., Baig, M. A., & Arsalan, M. (2022). The assessment of sustainability of freight transportation in Pakistan. *Innovative Infrastructure Solutions*, 7.
- [8] Wirotthitayawong, S., Champahom, T., & Pholwatchana, S. (2025). Activity-based CO₂ emission analysis of rail container Transport: Lat Krabang Inland Container Depot–Laemchabang Port Corridor Route. *Infrastructures*, 10.
- [9] Kot, S., & Ojinji, A. (2023). Environmental sustainability and freight transport performance in the EU – An autoregressive conditional heteroscedasticity (ARCH) model analysis. *Promet–Traffic & Transportation*, 35.
- [10] Okyere, S., Yang, J., & Adams, C. A. (2022). Optimizing the sustainable multimodal freight transport and logistics system based on the genetic Algorithm. *Sustainability*, 14.
- [11] Aryanpur, V., & Rogan, F. (2024). Decarbonising road freight transport: The role of zero-emission trucks and intangible costs. *Scientific Reports*, 14.
- [12] Popat, A. (2025). Decarbonising Australian freight and logistics: A stakeholder perspective analysis. *Australian Geographer*.
- [13] Cerná, L., & Mašek, J. (2025). Model of public support for railway sidings as a component of the sustainable development of rail freight transport. *Sustainability*, 17.
- [14] Ampong, G., Švadlenka, L., Molková, T., & Bauer, M. (2026). Simulation-based evaluation of low emission zone–rail impacts on emissions and logistics efficiency: Case study of Rotterdam, The Netherlands. *Case Studies on Transport Policy*.
- [15] Nkesah, C. T. (2023). Making road freight transport more sustainable: Insights from a systematic literature review. *Transportation Research Interdisciplinary Perspectives*, 20.
- [16] Reis, J., Puglieri, F. N., & Piekarski, C. M. (2026). A roadmap approach to enhancing ESG and operational performance in road freight logistics. *Logistics*, 10.
- [17] Bošnjaković, M., Santa, R., & Culetić Condrić, M. (2026). The role and significance of rail transport in the decarbonisation of the EU transport sector. *Smart Cities*, 9.
- [18] Nazemian, A., Boulougouris, E., & Aung, M. Z. (2025). Modal transportation shifting from road to coastal-waterways in the UK: Finding optimal capacity for sustainable freight transport through swarming of zero-emission barge fleets. *Journal of Marine Science and Engineering*, 13.