Scientific Journals
of the Maritime University of Szczecin

Zeszyty Naukowe
Politechniki Morskiej w Szczecinie

2024, 79 (151), 39–48
ISSN 2392-0378 (Online)
DOI: 10.17402/614

Received: 16.07.2024
Accepted: 02.08.2024
Published: 30.09.2024

Multi-criteria analysis of road transport service providers as a method to support decision-making within sustainable supply chains

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Keywords: urban logistics optimization methods, decision-making effectiveness, organization of transport flows in urban conditions, sustainable supply chains management, environmental efficiency, green supply chains

JEL Classification: L91, R4, R 41, R49

Abstract

The efficient use of transportation resources is the foundation of the management concept behind sustainable supply chains. The complexity of distribution supply chains requires the implementation of appropriate decision-making steps during modeling. This is due to the number of supply chain participants, the diversity of processes, and their flow. Thus, an appropriate way to assess the variety of control parameters that define the functionality of participants within sustainable supply chains is required. An extended multi-criteria analysis provides an opportunity to support the decision process of selecting appropriate supply chain elements, based on a scoring system that defines the relevance of the parameters. The developed method of multi-criteria evaluation of the attractiveness of carrier offers can be applied to urban logistics conditions. Due to limited access to data on carrier offers and their range of services under urban conditions, it seems appropriate to translate the experiences and conclusions from the consolidation of deliveries and the sharing of long-distance routes into urban transportation logistics. The effectiveness of the selection of supply-chain road-transportation service providers has been the subject of a comparative analysis of the types and parameters of the process within the research. The principles of the multi-criteria decision-making (MCDM) approach are considered, including identification of the process, determination of process requirements, establishment of objectives, consideration of alternative solutions, and identification of the operational framework. The variant approach proposed within this study allows us to verify the impact of road transportation conditions on overall efficiency. The performed analysis enables a choice between full truckload (FTL) and less-than-truckload (LTL) types of road transport. The results of this study support the decision-making process in the selection of road transport service providers. Conclusions are valuable also from the organization of city transportation models, as the logic behind efficiency assessment is comparable in both operational environments. A formulated set of recommendations can be implemented within the organization with a focus on optimizing the use of road transport solutions.

Introduction

The efficiency of supply chains (SC) depends on their proper modeling (Abdullah et al., 2018). There are a number of studies proving that the process flow has a significant impact on the overall efficiency of the supply chain (Caputo, Fratocchi & Pelagagge, 2006; Mouronte-López, 2021). Influencing transport efficiency refers to the basic control parameters of the utilization of available transport resources (Hagerer, 2019). Therefore, it is possible to transfer conclusions developed from one transport mode to another. City logistics, due to the availability of data, a different structure of transport operators, and dedicated transport services offered, may attempt to verify its efficiency using the experience of other transport modes, including long-haul full truckload (FTL) and less-than-truckload (LTL). Improvement within city logistics can be achieved via different approaches, i.e., the modeling of a design of an existing supply chain, by introducing new participants, or by defining a new functional scope. Introducing cross docs that support a merging of shipments establishes goods flow improvements within a supply chain (Boysen & Fliedner, 2010). It is observed, in both the literature and practice, that it is the fundamental nature of SC management to constantly search for improvements to the efficiency of the controlled processes. However, it can be achieved by incorporating dedicated performance indicators that support better process control and enable verification of its performance (Spengler, 2016). Efficiency measured against a specific type of loading unit, means of transport, and the identified participant within the logistics process allows for improved management of supply chain flows.

Selecting appropriate types of services dedicated to the defined good flows is one of the proposed solutions for obtaining organizational and cost improvements within the supply chain. Such a state for the process may be achieved by incorporating advanced digital solutions supporting collaborative logistics systems (CLS) among all the SC participants (Khayyat & Awasthi, 2016). It has been observed that transportation costs can reach up to 50 % of all logistics costs; hence, there is a strong market need for a search for improvements within this area (Nie, Xu & Zhan, 2006). Thus, a heuristic procedure has been proposed by Nie, Xu, and Zhan (2006), who provide research for supporting decision-making between LTL and FTL transportation service levels. There are a lot of enterprises that, due to security reasons, choose FTL services only. However, the concept of shared transport (LTL) is growing in popularity due to its potential for cost reductions (Reggiani, 2013). Simultaneously, the choice of LTL transport is mainly driven by the demand for optimal use of vehicle loading space (Korpinen, Aalto & Ranta, 2019). However, due to the complexity of modern transportation supply chains, it is not possible to provide a strict answer on which type of transport is more advantageous. Therefore, this study attempts to analyze the actual logistics operator offers for FTL and LTL services and provide valuable recommendations that may support the decision-making process while choosing between the transport levels of service. The conducted research steps allow us to outline specific conditions that determine the attractiveness of particular logistics solutions proposed by transport operators.

Literature review

As detailed in the methodology section below, a literature review has been carried out to investigate the effectiveness of different transport service models. It is observed that different levels of transport efficiency can be obtained using various vehicles that are characterized by different classes of gross vehicle mass (GVM). It is strictly connected with other parameters, such as the vehicle's capacity and the vehicle wear rate, which influence fuel consumption levels that increase with each year of the truck's service (Dubisz, Golinska-Dawson & Zawodny, 2022).

A similar study focusing on the indications of proper planning of road transport activities is presented by Caputo et al. (Caputo, Fratocchi & Pelagagge, 2006). The proposed approach for choosing among LTL and FTL service levels has a highly utilitarian nature. However, the proposed solution does not reflect the wide range of parameters presented by the offers from the logistics operators. Thus, in the multi-criteria decision-making part of this research, emissivity, fleet availability, and delivery lead-time parameters are considered.

It has been pointed out that various vehicle types are recommended for conducting different transportation tasks. Vehicles dedicated to last-mile distribution do not perform efficiently in linehaul transport. It is mainly related to the vehicle's capacity and its capability to carry various types of cargo units (Olsson, Hellström & Pålsson, 2019).

In another research topic, the fuel type used was reviewed for its impact on overall supply chain efficiency. The main fuel-type parameters of the fleet directly influence the emissivity of the transportation process and impact the cost-effectiveness perspective (Ehsani, Ahmadi & Fadai, 2016). It has been revealed that choosing the appropriate type of service is crucial when ensuring the overall efficiency of the logistics model (Abdulla & Musa, 2021). The FTL service level supports control of the entire transport and the routing process; it also has a positive impact on cargo security (Wang & Wang, 2021). In addition, the LTL service level supports cost optimization and has a positive impact on carbon footprint reduction from transport due to improved loading space utilization. However, in the case of LTL shipments, it is the responsibility of the logistics operator to strive to maximize the filling grade of its own means of transport in order to reduce the "cost per unit rate" (Rudi et al., 2016). Reducing the "cost per unit" rate in terms of FTL shipments is usually the sender's responsibility. However, lowering this rate might be difficult to conduct due to the lack of co-loading and the possibility of merging orders within one organization.

It has been verified that various setups of process flow based on the incorporation of cross docs may influence supply chain efficiency. Introducing cross docs enables a reduction in the overall fleet mileage and supports the consolidation of shipments. Hence, an improved environmental efficiency can be achieved within a whole SC (Boysen & Fliedner, 2010).

Based on the conducted literature review, we observe that various approaches for the optimization of transport arrangements are possible. A number of publications refer to different levels of services, such as LTL and FTL. However, none of these issues reflect the various parameters of services offered by transport operators. Hence, additional research based on actual market offers using a multi-criteria decision-making approach shows the potential for transport management process improvement.

Methodology

The methodology adopted for this study was based on a literature review aimed at identifying key parameters of transportation services. Simultaneously, the existing approaches present in the literature used to determine the principles of cooperation with transport operators were verified. Analyzing Yannis et al. (Analyzing Yannis et al., 2020), the research identifies the issues related to the choice of transportation service level that applies to all types of transport, regardless of their route and location. The methods developed for assessing the efficiency of transport operators can be implemented in various types of transportation chains, including those based on urban logistics transport. The logic for assessing the attractiveness of carriers' offers is similar in both long-distance and urban transport. However, the parameters may be relevant in each

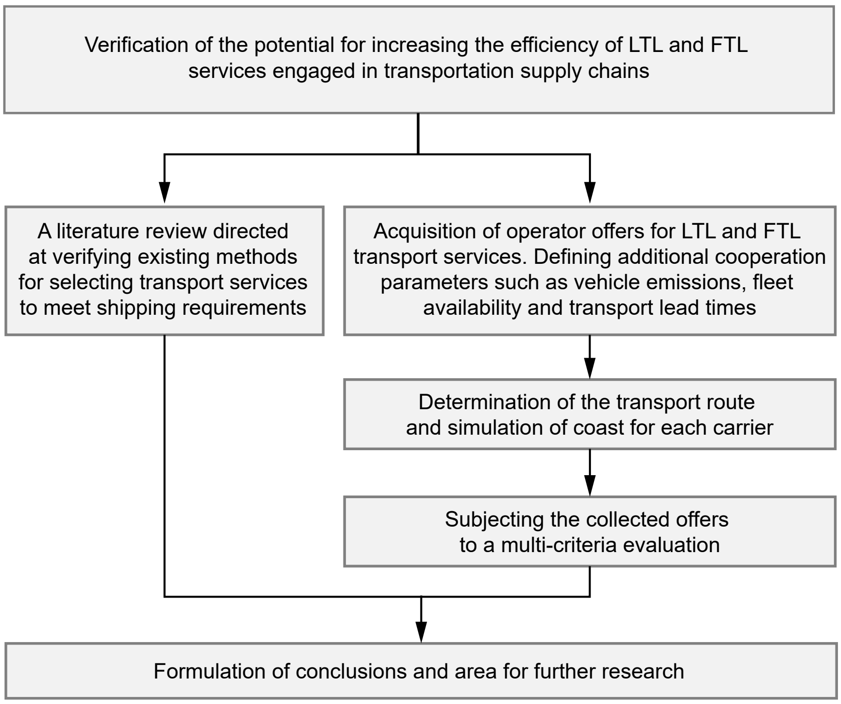

Figure 1. Methodology of the study

environment, but by being able to vary the number of parameters, the scale of weights, and the number of carriers being compared, the proposed multi-criteria evaluation method can be adapted to the urban logistics organization. The proposed multi-criteria evaluation approach is even more relevant as there is a lack of a sufficient number of carriers offering a range of different types of services in city logistics, so it is reasonable to attempt to transpose the experience gained in long-haul FTL and LTL logistics into the city logistics transportation models.

Research provided in this paper is conducted based on the actual carrier's offers and involves data collected from transport operators using FTL and LTL services. Offers were collected across four quarters (in 2023) among the transport operators present in the Polish market. According to the acquired offers, the differences in the levels of efficiency for both variants of LTL and FTL service are verified. Reference is also made to the other non-cost parameters of cooperation shown in the literature and present in the carriers' offers. In the next step, a multi-criteria analysis is conducted to identify the optimal transport solution. By assigning appropriate weights to the subsequent parameters, it is possible to identify the most attractive carrier, taking into account the non-cost parameters. Based on the conducted research, we refer to the results of the literature review so that conclusions can be formulated. The logic of the conducted research is presented in Figure 1.

Assessment of the transport operator's offer

Primary verification of the process efficiency directly refers to the cost perspective. It has been concluded during the literature review that organizational success is often determined by choosing the proper parameters for supply chain participants. To ensure the most effective supply chain configuration, the selection of the correct operator is also crucial. The selection of the correct offer should not only rely on the cost parameter but should depend on a number of other elements. An analysis of transport operator offers was carried out considering a number of non-cost parameters, i.e.:

- types of vehicles offered,
- vehicle weight in terms of its gross vehicle mass (GVM),
- availability (quantity) of means of transport,
- the average emissions of the means of transport within the fleet (unit used – kgCO_2e/km),
- unit transport costs,
- markets served,
- type of service level provided (LTL/FTL).

Figure 2. Planned transport route with additional unloading points

The assessment of attractiveness concerned ten offers submitted by transport operators that declared their ability to provide continuous services for the sender's transport orders. Each carrier was asked to submit price offers for FTL and LTL shipments. The loading and unloading points were identified by postal codes. To assess the attractiveness of the carriers' offers, an example route from Świecie to Rzeszów was selected. Additional unloading points were planned along the transport route. The route is shown in Figure 2.

Carrier's FTL and LTL offers

The received offers from the carriers had to be checked for consistency and completeness. This was undertaken by assessing the extent of freight information provided between the detailed postal codes of the location and country of departure and arrival. For each hauler, the gross vehicle weight (GVW) of the group of vehicles analyzed was assigned. The availability of the fleet declared in the offer was determined. Based on this, an estimate of vehicle emissions was determined using the vehicle emission matrices published by the UK Department for Environment, Food and Rural Affairs (DEFRA), and an average vehicle load factor was applied. The next step was to gather information about the markets served by the operator and the range of services it provided. It was found that not all operators offered FTL and LTL services. Other non-cost details of the submitted offers are shown in Table 1.

Analysis of the attractiveness of the offers

To assess the attractiveness of the offers, it was decided to carry out a cost simulation for a theoretical freight route between Świecie in the Kujawsko-Pomorskie Voivodeship, Poland, and Rzeszów in the Podkarpackie Voivodeship, Poland. An additional five unloading points were planned along the route. A visualization of the route is shown in Figure 2. The shortest route was adopted according to the available network of motorways, expressways, and national roads. The means of transport defined in Table 1 were engaged in the assessment. For the purpose of further simulation, Table 2 provides details of the locations of the subsequent delivery points. The order of the points along the route, the name of the town, and the number

Table 1. Summary of key performance parameters contained in the transport operators' offers

Carrier ID	Type of vehicle	GVM of vehicles	Fleet availability	Average emissions of fleet [kgCO2e/km]	Supported markets	Service level
Carrier 1	Up to CU33	40 tonnes	5	0.74	EN	FTL
Carrier 2	Up to CU33	32 tonnes	10	0.72	EN; EU	FTL
Carrier 3	Up to CU33	32 tonnes	12	0.75	EN; EU	FTL; LTL
Carrier 4	Up to CU33	32 tonnes	6	0.78	EU	FTL; LTL
Carrier 5	Up to CU33	32 tonnes	1	0.77	EN; EU	LTL
Carrier 6	Up to CU33	32 tonnes	6	0.74	EN;	LTL
Carrier 7	Up to CU33	40 tonnes	12	0.72	EN; EU	FTL
Carrier 8	Up to CU33	40 tonnes	5	0.71	EU	LTL
Carrier 9	Up to CU33	40 tonnes	8	0.74	EN; EU	FTL; LTL
Carrier 10	Up to CU33	40 tonnes	10	0.73	EU	LTL

Table 2. Routes involved in assessment

Route steps	Location	Postcode	Number [kms]	Number of pallets [pcs]
Start	Świecie	86-100	–	–
Additional delivery point 1	Włocławek	87-800	166	5
Additional delivery point 2	Łódź	90-024	273	12
Additional delivery point 3	Radom	26-600	438	1
Additional delivery point 4	Kielce	25-001	519	7
Additional delivery point 5	Tarnów	33-100	629	1
Stop	Rzeszów	35-001	716	7

of kilometers between locations are indicated. For each point, the number of load units to be unloaded was determined.

Simulation of FTL full truckload transport costs

Using the provided carrier's offers, an attempt was made to run a cost simulation for the defined route. Table 3 provides a cost simulation of the FTL route for each carrier. In addition to the basic freight rate, the entire freight cost has been included in the following estimated calculations, considering the costs associated with additional unloading points along the route.

Simulation of LTL transport costs

Based on the provided transport service offers, the costs of LTL pallet transport on the planned route were determined. Only four transport operators out of ten operate LTL transport services. The results of the simulation of LTL transport costs are shown in Table 3. When calculating the total LTL costs, actual offers considering extra rates related to the number of pallets transported were considered. Due to the nature of the LTL transport service, there is no single rate for a carriage. The total cost arises from adding up the sub-costs. The simulation results for LTL are presented in Table 4.

Table 3. Full truck load (FTL) transportation costs per carrier

Route steps	Costs							
	Carrier 1		Carrier 2		Carrier 3		Carrier 7	
	Extra unloading point costs	Main freight rate	Extra unloading point costs	Main freight rate	Extra unloading point costs	Main freight rate	Extra unloading point costs	Main freight rate
Start	–	–	–	–	–	–	–	–
Additional delivery point 1	€ 50.00		€ 50.00		€ 50.00		€ 50.00	
Additional delivery point 2	€ 50.00		€ 50.00		€ 50.00		€ 50.00	
Additional delivery point 3	€ 50.00		€ 50.00		€ 50.00		€ 50.00	
Additional delivery point 4	€ 50.00		€ 50.00		€ 50.00		€ 50.00	
Additional delivery point 5	€ 50.00		€ 50.00		€ 50.00		€ 50.00	
Stop	–	€ 268.39	–	€ 533.34	–	€ 573.34	–	€ 595.56
FTL total		**€ 518.39**		**€ 783.34**		**€ 823.34**		**€ 845.56**

Table 4. Less-than-truckload (LTL) transportation costs per carrier

Route steps	Location/ name	Number km	Number pallets	Costs							
				Carrier 3		Carrier 5		Carrier 6		Carrier 9	
				Rate per pallet	LTL cost	Rate per pallet	LTL cost	Rate per pallet	LTL cost	Rate per pallet	LTL cost
Start	Świecie	0		–	–	–	–	–	–	–	–
Additional delivery point 1	Włocławek	166	5	€ 21.89	€ 109.43	€ 24.52	€ 122.59	€ 20.48	€ 102.40	€ 22.65	€ 113.27
Additional delivery point 2	Łódź	273	12	€ 23.10	€ 277.22	€ 26.65	€ 133.25	€ 20.48	€ 102.40	€ 23.22	€ 116.11
Additional delivery point 3	Radom	438	1	€ 29.49	€ 29.49	€ 36.51	€ 182.56	€ 20.48	€ 102.40	€ 30.96	€ 154.80
Additional delivery point 4	Kielce	519	7	€ 31.22	€ 218.53	€ 34.65	€ 173.23	€ 20.48	€ 102.40	€ 32.74	€ 163.71
Additional delivery point 5	Tarnów	629	1	€ 31.31	€ 31.31	€ 37.31	€ 186.55	€ 20.48	€ 102.40	€ 35.87	€ 179.35
Stop	Rzeszów	716	7	€ 31.22	€ 218.53	€ 37.31	€ 186.55	€ 20.48	€ 102.40	€ 35.87	€ 179.35
Total [plts]/[costs]			**33**	–	**€ 884.52**	–	**€ 984.72**	–	**€ 614.40**	–	**€ 906.58**

The selection of the optimal solution for transport services from among those submitted by transport operators was based on a multi-criteria analysis. The proposed assessment model refers to various control parameters that influence the final result:

- transport costs,
- environmental vehicle emissivity parameters,
- availability of means of transport,
- delivery lead time.

A defined weight of each parameter was reflected in the assessment. Appropriate weight was assigned to the individual parameters presented in Tables 5 and 6. The results of the multi-criteria analysis of FTL carrier selection are presented in Table 5. The results of the multi-criteria analysis of LTL carrier selection are presented in Table 6. The scale for parameters assessment is 1–3. Here, 1 indicates the lowest parameter value, while 3 signifies the highest and most important parameter. The proposed parameters are based on the needs of the company, which is the basis on which the model for the multi-criteria evaluation of the carriers' offers was created. Referring to the selection of the parameters presented in the literature, such parameters should be correlated with the needs of the supply chain (Camargo Pérez, Carrillo & Montoya-Torres, 2015). In an urban transport chain, it is possible to extend the number of parameters and assign them appropriate weights. The number of parameters assessed was limited to only three due to the needs of the company on the basis of which the study was conducted. According to need, the number of parameters to be assessed can be modified, and the range of the scales can be changed. A scale that is too large to use in the model could adversely affect how a parameter influences the carrier's final result. The employed scales were proposed after consultation with a company and are the basis for the described research on the transport operators' offers.

Table 5. Results of the multi-criteria analysis for the selection of an FTL carrier

Carrier ID	Total cost [EUR]	No. of available vehicle [no.]	Delivery lead time [hrs]	Avg. emissivity of fleet vehicles [kgCO2e/km]	Value of parameter				Evaluation of parameter				Result
					Costs	Fleet availability	Delivery lead time	Environmental parameter	The cost parameter	The fleet availability parameter	The lead time parameter	The environmental parameter	
Recommended carrier 1	€ 518.39	5	24	0.74	3	2	3	2	1.00	0.42	1.0	0.67	8.17
Recommended carrier 2	€ 783.34	10	24	0.72	3	2	3	2	0.66	0.83	1.0	1.00	8.65
Recommended carrier 3	€ 823.34	12	48	0.75	3	2	3	2	0.63	1.00	0.5	0.50	6.39
Recommended carrier 7	€ 845.56	12	36	0.72	3	2	3	2	0.61	1.00	0.7	1.00	7.84

Table 6. Results of the multi-criteria analysis for LTL carrier selection

Carrier ID	Total cost [EUR]	No. of available vehicle [no.]	Delivery lead time [hrs]	Avg. emissivity of fleet vehicles [kgCO2e/km]	Value of parameter				Evaluation of parameter				Result
					Costs	Fleet availability	Delivery lead time	Environmental parameter	The cost parameter	The fleet availability parameter	The lead time parameter	The environmental parameter	
Recommended carrier 5	€ 984.72	1	24	600	3	2	3	2	0.62	0.08	1.0	0.50	6.04
Recommended carrier 6	€ 614.40	6	48	300	3	2	3	2	1.00	0.50	0.5	1.00	7.50
Recommended carrier 3	€ 884.52	12	24	300	3	2	3	2	0.69	1.00	1.0	1.00	9.08
Recommended carrier 9	€ 906.58	8	36	300	3	2	3	2	0.68	0.67	0.7	1.00	7.37

Impact of the application of the pallet service (LTL) on the change in the level of transport costs

To review the impact of the implementation of an LTL pallet service on the level of transport costs, both FTL and LTL transport costs were simulated for six, four, and two unloading points along the defined route (Figure 2). To conduct a valid simulation, a total transport of thirty-three pallets was assumed.

Due to the comparison of the FTL and LTL offers that were carried out, it was necessary to indicate changes to the route and update the number of kilometers. The proposed route changes on the basis of which further simulations were carried out are included in Table 7.

Table 7. Transport logistics parameters for the adopted unloading points

Route steps		Postcode	Number [km]	Number pallets [pcs]
Six unloading points				
Start	Świecie	86-100	–	–
Additional delivery point 1	Włocławek	87-800	166	5
Additional delivery point 2	Łódź	90-024	273	12
Additional delivery point 3	Radom	26-600	438	1
Additional delivery point 4	Kielce	25-001	519	7
Additional delivery point 5	Tarnów	33-100	629	1
Stop	Rzeszów	35-001	716	7
Four unloading points				
Start	Świecie	86-100	–	–
Additional delivery point 1	Włocławek	87-800	166	7
Additional delivery point 2	Łódź	90-024	273	14
Additional delivery point 3	Radom	26-600	438	3
Stop	Rzeszów	35-001	716	9
Two unloading points				
Start	Świecie	86-100	–	–
Additional delivery point 1	Włocławek	87-800	166	16
Stop	Rzeszów	35-001	716	17

Table 8. Simulation results of FTL versus LTL transport cost comparison for the assumed number of unloading points

Type of transport				FTL average costs	LTL average costs	Ratio
FTL		LTL				
Six unloading points						
Carrier 1	€ 518.39	€ 884.52	Carrier 3	€ 742.66	€ 847.56	14.12 %
Carrier 2	€ 783.34	€ 984.72	Carrier 5			
Carrier 3	€ 823.34	€ 614.40	Carrier 6			
Carrier 7	€ 845.56	€ 906.58	Carrier 9			
Four unloading points						
Carrier 1	€ 418.39	€ 849.03	Carrier 3	€ 642.66	€ 820.99	27.75 %
Carrier 2	€ 683.34	€ 926.19	Carrier 5			
Carrier 3	€ 723.34	€ 675.84	Carrier 6			
Carrier 7	€ 745.56	€ 832.91	Carrier 9			
Two unloading points						
Carrier 1	€ 318.39	€ 877.25	Carrier 3	€ 542.66	€ 837.91	54.41 %
Carrier 2	€ 583.34	€ 1 026.55	Carrier 5			
Carrier 3	€ 623.34	€ 675.84	Carrier 6			
Carrier 7	€ 645.56	€ 772.01	Carrier 9			

The results of the performed simulation, comparing FTL versus LTL transport costs for the assumed number of unloading points and kilometers, are shown in Table 8.

Conclusions

It was concluded that the costs of full truckload (FTL) services were comparable to less-than-truckload (LTL) services in the scenario based on six delivery points. As demonstrated in the Vega et al. (Vega et al., 2021) study, the efficiency of the use of individual service types depends on the parameters being assessed during the decision-making process. In the research described in this paper, FTL transport was cheaper in most cases. However, it should be considered that the result was achieved when the vehicle was fully loaded at the beginning of the route.

The performed research and the conclusions drawn can be applied to the organization of the urban logistics transportation model. The sharing economy is highly valuable, especially in an infrastructure-constrained urban area. The conclusions of the research carried out in the area of the long-distance national route can be applied to city logistics. The most favorable type of transport is full truckload transport, assuming full use of the loading space of the means of transport. The LTL service indicates a higher cost level; simultaneously, the proposed method also allows for the evaluation of non-cost parameters of the services and their modification. The conclusions of the research can be translated into the organization of city logistics. The consolidation of deliveries using urban infrastructure in one mode of transport and delivery to several recipients can have a very positive economic effect. The more delivery points there are, the lower the economic benefit of full-vehicle delivery. The results of such a comparison, conducted using the proposed multi-criteria assessment method for urban carrier services, may lead to the designation of an appropriate mode of transport. For future research, it is recommended that several delivery options using various modes of transport should be verified using the proposed multi-criteria assessment model.

In every scenario thereafter, where the number of unloading points was reduced, the costs of FTL transport were cheaper than LTL transport. In each of the cases analyzed, LTL transport was more expensive than FTL. With six delivery points, the same deliveries were 14.12 % more expensive in the LTL model; with four unloading points, LTL was 27.75 % more expensive, and with two unloading points, it was 54.41 % more expensive. Thus, research proved that a limited number of delivery points supports a reduction of the costs of FTL service. LTL may be more cost-effective in situations where there are a large number of drop points in one direction. The research indicates that there is no simple relation between the impact of the number of unloading points and the cost of LTL services in the case of the carriers involved in this research. It is important to assess each particular case on an individual basis, considering all aspects. When selecting a carrier, other factors should also be considered. As the multi-criteria analysis has shown, the cost of services does not have a direct influence on the choice of carrier. Other parameters, such as environmental impact, fleet availability, and lead time of delivery, have also been considered. The proposed design of Table 5 may be incorporated within existing supply chains to support the decision-making process that depends on various transport service parameters.

The presented model for assessing the efficiency of FTL and LTL transport in the described case is limited by the number of assessment criteria. By developing the model proposed in further studies, the number of control parameters can be increased depending on the specific characteristics and needs of a particular supply chain. The current model does not consider the volume of vehicles, their destination, etc. These elements could be included in future development work for the model. The control parameters proposed in this study are based on the needs of the company's examined supply chain.

A future study should be carried out with a more extensive range of carrier offers, including those from urban carriers. The perspective of transport routes within urbanized areas should also be examined. Further analyses could be extended to propose additional parameters to be evaluated in a multi-criteria analysis for selecting a transport operator.

Acknowledgments

Damian Dubisz would like to thank the Ministry of Education and Science for funding his research within the framework of the Applied Doctorate Program of the Ministry of Education and Science of Poland (Program Doktorat Wdrożeniowy Ministerstwa Edukacji i Nauki) implemented in years 2021–2025 (Contract No. DWD/5/0015/2021 dated 23/12/2021).

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Cite as: Zając, J., Dubisz, D., Koliński, A. (2024) Multi-criteria analysis of road transport service providers as a method to support decision-making within sustainable supply chains. S*cientific Journals of the Maritime University of Szczecin, Zeszyty Naukowe Politechniki Morskiej w Szczecinie* 79 (151), 39–48.