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UTILIZATION OF REGIONAL LINES AS ALTERNATIVE ROUTES FOR THE IMPROVEMENT OF THE RESILIENCE OF THE RAILWAY INFRASTRUCTURE IN CASE OF EMERGENCIES

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Abstract

For many companies and logistics centres, rail transport is a key aspect and an essential part of their business. End customers expect their goods to be transported by carriers in a fast, reliable, and efficient manner. However, in many cases, the efficiency and resilience of rail transportation is affected by emergencies such as natural disasters, accidents, and track maintenance. In such cases, situations can arise that make it difficult for carriers to meet their customers' expectations and can even significantly impact the entire transportation process. In an attempt to address these challenges, this paper analyses the impact of emergencies on the overall progress of rail freight transportation. The aim of the paper is to explore the possibilities of using regional lines as alternative routes in the event of an emergency on the corridors, and to describe the possible benefits for end users, but also for the carriers themselves, in case of using regional lines as alternative routes. The article also compares the strengths and weaknesses of regional lines in their use in rail freight transportation, with an emphasis on their ability to ensure reliable transportation of goods. The article compares and evaluates selected routes in the Czech Republic from an economic and operational point of view, which may help carriers react better and more efficiently to unexpected events that may occur on the railway infrastructure.

Keywords: regional lines, railway resilience, freight transport, alternative routes

1 Introduction

In recent years, railway systems have played a significant role in transportation systems due to the demand increase in conveying both cargo and passengers [1]. The transport system can be seen as a complex process involving transport services, which can be divided into passenger and freight transport systems, which are operated on railway corridors [2]. The rail transport system should be an important transport system which, based on its advantages (high transport capacity, safety, and environmental friendliness), should be the backbone transport system not only for passenger transport but also for freight transport, particularly over medium and long distances to be able to provide an adequate level of service over time [3]. Currently, transportation accounts for up to 25% of greenhouse gas emissions. Rail transport is perceived as an environmentally friendly mode of transport that can contribute to the environmentally friendly movement of goods and people. In order to increase the use of rail transport, its competitiveness and flexibility need to be improved [4]. The article focuses on the use of regional lines as alternative routes that can help achieve this. Unexpected closures, disruptions and emergencies can significantly affect the entire transportation process and result in the inability to move goods along the desired route.

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The paper compares a commonly used line that is part of a 2 corridors (I. and IV. tranzit corridors) with an alternative route that uses regional lines. The article compares the costs incurred in situations where the railway carriers cannot use the main corridors.

2 Status of freight transport in Czech Republic

National railway transportation is still important in the Czech Republic. The quality and safety of railway operations is one of the main priorities of Czech and European transport policy [5]. The importance of rail transport is also confirmed by the goals of the Green Deal, which contains several priority objectives. The document also includes the goal of transferring up to 75% of national transport in EU countries from road to rail by 2050 [6]. However, the figure 1 does not show an upward trend in national rail transport, and there is a decrease in rail transport of more than 19.2% in 2022 compared to 2015.

Figure 1 Volume of domestic freight transport in Czech Republic [7]

To achieve the binding goals, it is necessary to meet customer requirements, which will increase the reliability of rail transport and make it perceived by customers as a reliable and primary mode of transport. In order to increase the competitiveness of rail transport and improve its performance, several modernizations of the railway infrastructure in the Czech Republic took place in 2023. The infrastructure manager Sprava Železnice modernized up to 542 km of lines, which affected traffic on many sections. In many cases, intensive modernizations require a complete interruption of operations, which also affects the end customer and services provided by railway carrers [8]. Planned moderzniations as well as unexpected shutdowns require a quick response from carriers to get goods from the point of origin to the destination within the delivery time. In such cases, regional lines can be used as alternative routes, increasing the dispatchability of rail transportation.

3 Use of an alternative route

For the purposes of the article, the route between Beroun and Počerady was chosen, and the article compares the costs incurred by the carriers when using the “normal” route with an alternative route using regional lines. The choice of routes is shown in the figure 2, where the green line represents the normal route, along the corridor, and the red line represents the alternative route, which can be used in case of impossibility to use the normal route (for various reasons, such as emergencies, planned closures, etc.). Both routes have different specifics, as shown in the table1. The transport parameters for both routes are the same and are shown in Table 2.

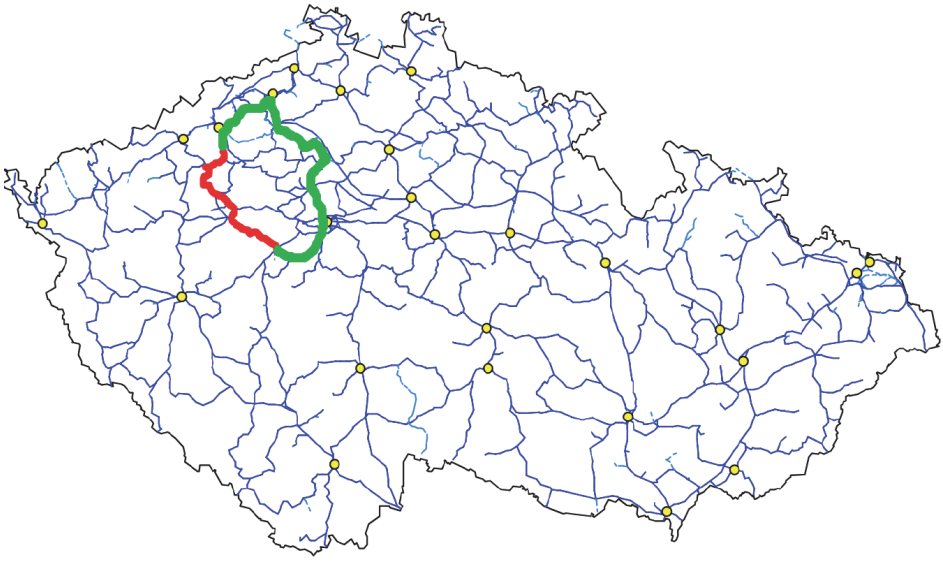

Figure 2 Selected routes for costs calculation [9]

Table 1 Line parameters

	Normal line	**Alternative line**
Length [km]	212.90	110.80
Transportation time [h]	4.77	5.67
Electrification	Yes	No
Number of locomotives	1 electrified locomotive	3 diesel locomotives

Table 2 Transport parameters

	Transport characteristics
Departure station	Beroun
Arrival station	Počerady
Wagon series	Fal(l)(n)s
Good volume [t]	1,100
Number of wagons	22
Owner of wagons	Customer – private wagons

4 Methodology of costs calculation

The article compares two options for transporting goods on the Beroun - Počerady route, using real rates provided by a carrier providing services in the Czech Republic to calculate the costs. As the data is sensitive, the calculations are compared on a percentage basis.
To the calculation the following formula was used, which consists of partial costs:

$$C_{ri} + C_{rc} + C_t + C_{rw} + C_l + C_{td} + C_{tc} + C_{lp} + C_{dm} + C_f = C_t \quad (1)$$

where:
C_t – total costs
C_{ri} – costs for railway infrastructure, these costs are calculated based on the document "Network Statement on Nationwide and Regional Railways", and it can be calculated according to Eq. (2).
C_{rc} – costs for rail capacity, these partial costs are also calculated based on the network statement, and it is possible to calculate using Eq. (3).
C_t – costs for traction (diesel of electricity)
C_{rw} – costs for railway wagons
C_l – costs for locomotives
C_{td} – costs for train driver
C_{tc} – costs for train crew

All these partial costs have been calculated as a multiple of train kilometres and individual partial rates. As the rates are subject to the commercial confidentiality of the carrier, it is not possible to publish them.
C_{lp} – local service cost represents the cost of manipulating the goods at the station of departure and station of arrival.
C_{dm} – Dispatch costs are calculated as a multiple of the train mileage and the dispatch control rate.

All the above costs are variable costs, i.e. they depend on the distance, the weight of the goods or the total weight of the train. Finally, the fixed costs must also be included in the calculation formula and are marked as a C_f and represents 19% of total variable costs.

$$C_{ri} = L \cdot P_1 \cdot W \cdot P_x \quad (2)$$

Where:
L – length of route
P_l – basic price for maintenance and repair of infrastructure [€/gross km], this price is available in Network Statement
W – total weight of train
P_x – value of the product factor, the product factor for freight train in Czech Republic is equal to 0,85

$$C_{rc} = R_P + R_{RA} \quad (3)$$

Where:
R_P – Rate for processing and planning, this rate depends on the type of the train and frequency of train running, for the case of our train this rate is approximately 3,92 €/train [10].

R_{RA} – Rate per day for train route allocation, this rate also depends on the type of the train and its frequency, in case of train calculated in this paper the rate is approximately 6,27€/train [10].

The cost of railway transportation is influenced by various factors, such as the distance of transportation, the category of the railway line, the technical condition of the railway line, the weight of the cargo. Since in our case we are comparing the same transport on both variants, the technical condition of the railway infrastructure will be the decisive factor in the cost calculation, which can significantly influence the total cost.

5 Results

Based on the formula shown above and the rates provided, the total costs were calculated, for both route alternatives. As shown in the figure 3, the normal route, which follows the main corridor, is significantly less costly compared to the alternative route. If the carrier had to use the alternative route, the cost would be up to 43% higher.

Figure 3 Comparison of total cost for selected routes

Traction costs represent the largest share of total costs for both variants. In the case of normal route, traction costs account for 27% of total costs, and in the case of alternative route, they account for 30% of total costs.
Therefore, the article is based on the customer's wagons, there is no cost to the carrier for the wagons, since they are private wagons, and carriers do not have to pay for their maintenance and repairs. Similarly, no train crew is assumed in this transportation (in the case calculated in the article, no train crew is needed), so both partial costs are zero (figure 4).
An overall comparison of the partial costs between the two options is shown in the figure 5. The largest difference between the costs is in locomotive costs (up to 209% increase in costs when using the alternative route), due to the need to use a bank engines where up to 3 diesel locomotives are required for a given traffic load. On the contrary, the costs of railway infrastructure, railway capacity and dispatch control are lower when using the alternative route, i.e. the route using regional lines.

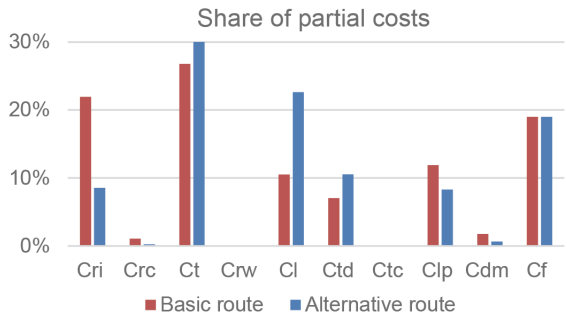

Figure 4 Share of partial costs in total costs for selected routes

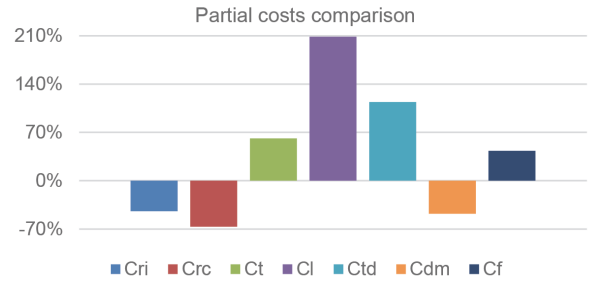

Figure 5 Comparison of partial costs between alternative route and normal route

6 Discussion and Conclusion

The paper found that regional routes can be used in achieving the Green Deal objectives. It is necessary that carriers are able to meet customer requirements and make the transport in the required time. Considering the above findings and analysis, we recommend that future research papers examine and evaluate in more detail specific regional routes that might be suitable for use as alternative routes in emergency situations. However, it should be noted that there are many such lines within the Czech Republic due to the dense railway infrastructure. Of course, it would also be useful to look at other countries with thinner rail infrastructure and explore the possibilities of using regional lines for those countries as well. These analyses should consider not only the economic and technical aspects, but also the environmental sustainability and societal benefits associated with the use of regional routes.

Overall, the use of regional routes as alternative routes for rail transport is an important step towards increasing the resilience and reliability of the whole rail infrastructure in times of emergency. Through this strategy, it is not only possible to improve the availability and efficiency of transport services, but also to contribute to a more sustainable and greener future for transport.

The paper found that despite the shorter alternative route (by 102.1 km), which would run on regional lines, the cost is 43% higher compared to the normal route. This is due to the poorer technical condition of the regional lines compared to the corridors. Significantly higher costs were incurred mainly in the cost of locomotives, due to the necessity of using the bank engines on the entire alternative route. Due to the poor technical condition of the regional lines, travel times are also significantly increased, resulting in significantly higher costs per driver. Modernisation of the regional lines, improvement of their technical condition or electrification could strengthen rail freight transport and increase the overall resilience of the railway transport in the event of unexpected and extraordinary emergencies.

Acknowledgement

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