

THE IMPACT OF TRANSPORT INVESTMENTS ON SOCIETAL WELL-BEING

Abstract: This study focuses on evaluating the impact of selected transport investments on societal well-being. The aim of the study is to assess how selected forms of transport investment may influence the quality of life of the population and contribute to a broader understanding of societal well-being. The analytical part is based on three case studies. The first part evaluates the modernization of the Czech Railways rolling stock using the Net Promoter Score (NPS) as a subjective indicator of service quality. The second part focuses on the effectiveness of noise mitigation measures near densely populated areas, while the third part compares the emission intensity of rail and road freight transport. The results show that rolling stock modernization may increase the subjectively perceived quality of public transport, that noise mitigation measures contribute to reducing noise exposure in the vicinity of transport infrastructure, and that electric rail traction has significantly lower emission intensity than road freight transport.

Keywords: transport investments, societal well-being, noise mitigation measures, transport infrastructure

Matěj Daněček¹

¹ Faculty of Operation and Economics of Transport and Communications University of Žilina, Univerzitná 8215/1, 010 26 Žilina; +421/41 513 3434; danecek@stud.uniza.sk

Introduction

Societal well-being in the context of transport represents a set of economic, social and environmental benefits that are reflected in the overall quality of life of the population. Transport, as one of the key infrastructure systems, affects the level of well-being primarily by ensuring access to employment opportunities, services, education and health care, while at the same time reducing mobility barriers and supporting the spatial and social integration of territories. In this context, well-being cannot be associated solely with the economic effects of transport, but also with social and environmental impacts that significantly shape the living conditions of the population. An important role is also played by the modernization of means of transport and infrastructure, including the use of alternative energy sources and the introduction of more environmentally friendly forms of propulsion. These changes may contribute to reducing emission burdens, noise and the consumption of non-renewable resources, and thereby to improving public health, environmental quality and the overall standard of living of society.

Societal well-being is a multilayered concept that goes beyond traditional economic indicators. Its definition requires consideration of economic, social and environmental factors that jointly influence the quality of life of the population. Well-being therefore includes not only material wealth, but also broader aspects of living conditions and societal satisfaction (Zbranková, 2014). Subjective well-being is defined as a combination of a high level of life satisfaction, frequent positive emotions and a low frequency of negative emotions. This concept emphasizes the individual assessment of the quality of one's own life (Večerník, 2012).

development and increasing societal well-being. Well-planned transport systems improve access to employment opportunities, services and markets, thereby supporting the mobility of the population as well as the more efficient movement of goods. Transport infrastructure affects not only the physical mobility of people and the flow of goods, but also the broader socio-economic opportunities of territories, as it influences access to work, services, economic activities and the overall competitiveness of regions (Lee, 2021). Investments in transport infrastructure may also include measures aimed at mitigating the negative externalities of transport, particularly noise exposure. Noise barriers represent one of the technical measures applied along transport corridors in order to limit the propagation of noise from road or rail transport into the surrounding residential environment (Barros et al., 2024).

- The modernization of transport routes represents one of the important areas of transport investment, which may influence not only the technical level of the transport system but also the quality of life of the population. In practice, it may include, for example, increasing line speeds, reconstructing technically inadequate sections, building higher-capacity transport connections, or constructing bypasses and motorway sections that contribute to shorter travel times and improved territorial accessibility (Chan et al., 2024).
- Noise mitigation measures make it possible to reduce the negative impacts of transport noise on the population living or working in the vicinity of transport infrastructure. From the perspective of technical design, these measures may focus on the noise source itself, the condition of the transport infrastructure, or limiting the propagation of noise into inhabited areas. In road transport, for example, low-noise road surfaces are used, while in rail transport, measures applied to both vehicles and infrastructure may be implemented, such as modifications to braking systems, rail grinding and damping, or noise barriers (Heutschi et al., 2016).

1 Transport Investments and Their Impact on the Well-Being of the Population

Investments in transport infrastructure represent an important instrument for supporting economic

- The development of transport hubs and related infrastructure represents an important area of investment that supports better interconnection between individual modes of transport and increases the accessibility of the public transport system. In practice, it may include the modernization of transfer terminals, stops and stations, the construction of P+R and B+R parking facilities, the improvement of pedestrian and cycling connections, barrier-free access, waiting areas and higher-quality information systems for passengers. In the context of the well-being of the population, the importance of these investments lies primarily in reducing barriers to the use of public transport, improving transfer comfort and strengthening the accessibility of the transport system for different user groups (Bell, 2019).
- Investments in digitalization increase the user-oriented quality of public transport by providing passengers with more accurate and up-to-date operational information. They mainly include mobile applications, vehicle location tracking systems, real-time information on service arrivals, and alerts about operational disruptions. In the context of the well-being of the population, these systems may contribute to reducing uncertainty during travel, improving time planning and increasing passenger satisfaction. However, their effectiveness also depends on the regularity and reliability of the transport service itself (Henriquez-Jara et al., 2025).

Investments in transport vehicles represent an important component of transport investments, as they influence the technical level of the vehicle fleet, the energy intensity of operation and the environmental impacts of transport. Fleet renewal may include the replacement of outdated vehicles, the modernization of propulsion systems and the transition to vehicles with lower operational emissions, such as hybrid or electric vehicles. In the context of the well-being of the population, the importance of these investments is associated primarily with the possibility of reducing local emission burdens, limiting the negative environmental impacts of transport and supporting more sustainable public transport operation. However, the actual benefits of these measures must be assessed not only according to direct emissions from vehicle operation, but also according to indirect emissions related to energy production and supply (Konečný et al., 2020).

- Investments in the modernization of propulsion units and technical vehicle systems represent one of the possibilities for reducing the energy intensity and selected environmental impacts of transport. For diesel locomotives, it has been demonstrated that the modernization of the fuel system can lead to a reduction in specific fuel consumption and, at the same time, to a significant reduction in nitrogen oxide emissions. In the context of the well-being of the population, the importance of these measures is associated primarily with reducing fuel consumption and lowering part of the emission burden generated

during the operation of transport vehicles, or potentially with reducing noise emissions (Plotnikov et al., 2021). The modernization of existing vehicles may represent a suitable way to increase the quality of transport services without the need for complete fleet renewal. Comfort is considered one of the qualitative characteristics that may support the preference for public transport over individual car transport. From the perspective of the well-being of the population, vehicle modernization can therefore be associated with increasing the attractiveness of public transport, improving the travel experience and better adapting vehicles to passengers' needs (Moerman et al., 2022).

- Investments in fleet renewal may significantly influence the attractiveness of public transport, especially when they are focused not only on the technical condition of vehicles, but also on the quality of the passenger environment. Important parameters for passengers include, in particular, interior layout, capacity, spatial flexibility and the level of travel comfort. Comfort represents one of the factors that may influence passengers' willingness to prefer public transport over individual car transport. In the context of the well-being of the population, fleet renewal can therefore be understood not only as a technical investment, but also as a means of improving the quality of everyday mobility and the attractiveness of public transport (Moerman et al., 2022).
- Investments in the implementation of safety and signalling systems in rail transport are mainly associated with the introduction of train protection and traffic management systems, such as ERTMS. These systems support the safe management of train movements, the interoperability of railway operations and the transition towards more modern traffic management systems. From the perspective of the well-being of the population, their importance is associated primarily with increasing the safety of rail transport, protecting the life and health of passengers and strengthening trust in public transport as a safe and reliable mode of mobility (Smith et al., 2012). In road transport, the function of safety systems is fulfilled by advanced driver assistance systems, referred to as ADAS. These include, for example, automatic emergency braking, lane keeping assistance, adaptive cruise control and systems supporting the monitoring of surrounding traffic. These technologies may contribute to reducing the frequency of road accidents, as they assist drivers in recognizing risk situations and limit the effects of human error (Masello et al., 2022).

Investments in alternative energy sources in transport are becoming an important instrument for reducing the negative environmental impacts of transport, especially in urban and suburban environments. Their use in public transport may contribute to improving air quality, reducing local emission burdens and also reducing traffic noise.

These benefits are directly linked to the quality of life of the population, as traffic noise and air pollution are among the factors that negatively affect health, sleep and overall well-being (Tsoi et al., 2023).

- Electricity used in transport represents one of the main options for reducing local emissions, especially when it is generated from low-emission or renewable sources. Electric vehicles do not produce direct exhaust emissions, which may contribute to improving air quality in urban environments and reducing health risks associated with transport-related pollution. The importance of transport electrification for the well-being of the population lies primarily in reducing local emission burdens, supporting a cleaner urban environment and providing potential health benefits (Mousavinezhad et al., 2024).
- Hydrogen is among the most widely researched and discussed alternative fuels in contemporary transport. The transition to hydrogen fuel in transport and industry may contribute to reducing greenhouse gas emissions, which leads to improved air quality and, subsequently, to improved public health. The environmental impact and energy efficiency of hydrogen depend on the method of its production, namely whether it is produced from renewable sources such as solar energy, wind energy or biogas, or by using fossil fuels (MPO ČR, 2021).
- Biofuels in public transport offer the potential to reduce greenhouse gas emissions and contribute to greater energy independence. However, the production of crop-based biofuels may increase competition for agricultural land and create pressure on food security, particularly when agricultural land that could be used for food production is allocated to biofuel production, which may lead to higher food prices and reduced food availability. This may have negative social impacts, especially on low-income population groups. The production and distribution of these fuels are largely dependent on state support and subsidies, which may create an economic burden for taxpayers (ECA, 2023).
- Natural gas is used in transport primarily in the form of compressed natural gas (CNG), especially in urban buses. Compared with conventional diesel vehicles, it may represent a transitional alternative in urban public transport, as CNG buses show better results for selected pollutants and lower particulate matter emissions. However, their actual environmental benefit depends on specific operating conditions, the driving cycle, the technical design of the vehicle and fuel consumption; therefore, the use of CNG in transport should rather be assessed as a partial and transitional measure for reducing local emission burdens in urban environments (Prati et al., 2022).

2 Analysis of the Impact of Transport Investments

To verify the impact of transport investments on the well-being of the population, specific examples were selected for which their relationship to quality of life, the environment and the accessibility of the transport system was assessed. The analysis focuses primarily on changes in emission and noise burdens or transport accessibility. Based on these examples, it is possible to interpret how selected transport investments are reflected in the economic, social and environmental aspects of the well-being of the population.

2.1 Investments in Transport Vehicles

Investments in transport vehicles represent one of the most visible forms of transport investment from the perspective of the travelling public. Fleet modernization is reflected not only in the technical improvement of operation, but also in increased comfort, safety, accessibility and the overall attractiveness of public transport. In the context of societal well-being, the importance of these investments is associated primarily with improving access to mobility. Higher-quality public transport enables the population to have more comfortable and reliable access to employment, schools, health care facilities, services and cultural centers. At the same time, it may reduce dependence on individual car transport, thereby contributing to the reduction of negative transport externalities, such as congestion, emissions or noise.

As a case study example, Czech Railways, a.s. can be used, as in 2025 it accounted for more than 79.76% of passenger rail transport performance on the SŽ network and was the dominant operator within public passenger transport in the Czech Republic (SŽ, 2026). Given this share, the renewal of its rolling stock represents a significant intervention in the quality of passenger rail transport in the Czech Republic. Since 2022, approximately CZK 60 billion has been directed towards the renewal and modernization of the Czech Railways rolling stock. During the same period, the carrier acquired approximately 700 new vehicles, whereas in the period 2011–2021 this involved only approximately 140 vehicles, indicating an acceleration of fleet renewal. At the same time, the average age of the rolling stock decreased from 34 years in 2022 to 31 years in 2025 (zdopravy.cz, 2026).

In parallel with fleet renewal, ČD introduced a new passenger evaluation system. According to a press release by the Ministry of Transport and Czech Railways, the average passenger satisfaction rating for the journey reached 4.21 out of 5 points in 2025, compared with 4.10 points in 2023. Since the introduction of the system, more than 834 thousand evaluations have been submitted. This statistic forms part of the subjective assessment of well-being from the passenger's perspective, to which modern and high-quality transport contributes (MD ČR, 2026).

For assessing the social dimension of the impacts of investments in rolling stock, NPS was selected as the main output indicator. This indicator expresses the level of customer loyalty and willingness to recommend the service to other users. In the case of Czech Railways,

NPS is based on the question of whether a customer would recommend the company's services to people in their surroundings. Responses are recorded on a scale from 0 to 10, with scores of 9–10 representing promoters of the service and scores of 0–6 representing detractors. The resulting NPS value is determined by the difference between the proportions of these two groups. The survey results are presented in the following graph.

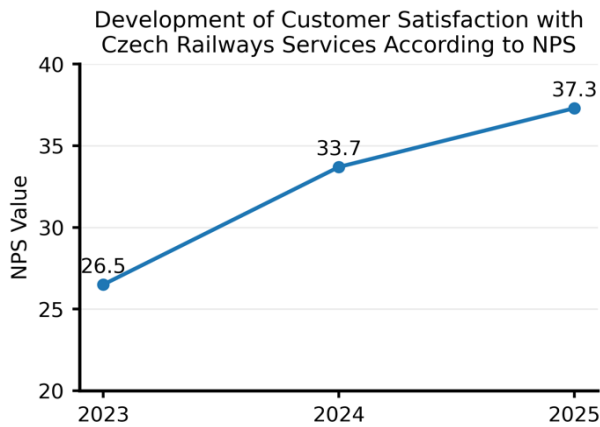


Fig 1. Development of customer satisfaction with Czech Railways services according to NPS (ČD, 2025; ČD, 2026)

The increase in NPS values indicates an improvement in the subjectively perceived quality of passenger rail transport services. Czech Railways relates this development, among other factors, to the modernization of its rolling stock and the deployment of new units. In the context of the well-being of the population, the NPS indicator is used as a subjective social indicator of the quality of the transport service, as it captures passengers' evaluations in relation to everyday mobility and their willingness to recommend the service further.

2.2 Investments in transport infrastructure

Investments in transport infrastructure cannot be understood solely as the construction of new roads or railway lines; the quality of their operation, maintenance and related protective elements is also important. On the one hand, transport infrastructure improves mobility, access to services and the economic activity of territories; on the other hand, it may also generate negative environmental impacts, particularly noise exposure affecting residents living in its vicinity. For this reason, measures aimed at reducing noise at its source or along its propagation path should also be considered part of infrastructure investment. In rail transport, such measures may include, for example, rail grinding, modifications to the railway superstructure, rail absorbers or noise barriers, while in road transport they may include low-noise road surfaces or noise barriers. Transport noise negatively affects the well-being of the population, especially in urban areas. It has adverse effects on the mental and physical health of residents, increases the risk of disease and reduces quality of life. A partial solution is provided

by the installation of noise barriers along transport infrastructure, which may lead to a significant reduction in noise levels. A conventional noise barrier with a height of 4 m achieves an attenuation of approximately 22 dB at the location immediately behind the barrier (Křivánek et al., 2022).

The practical impact of investments in noise mitigation measures for transport infrastructure can be demonstrated by the study of Lomoz et al. (2021), which evaluated the effectiveness of noise mitigation measures near the Praha–Sedlec railway stop. The monitored location is situated on the double-track electrified railway line Praha – Ústí nad Labem – Děčín, with dense residential development in its surroundings. The measurements were carried out in four measurement campaigns, following the gradual implementation of individual noise mitigation measures, and focused on evaluating the noise emitted by the passages of individual train categories. Category C included regional trains, category R included express and EuroCity trains, and category N included freight trains. The measurements were carried out in accordance with the ČSN EN ISO 3095 standard, Railway applications — Acoustics — Measurement of noise emitted by railbound vehicles. The results were expressed using the L_{AE} indicator, i.e., the A-weighted sound exposure level. The initial measurement was carried out before the installation of noise mitigation measures, the second measurement 51 days after rail grinding, the third measurement after the installation of rail absorbers, and the fourth measurement after the construction of noise barriers (Lomoz et al., 2021). The measurement results are presented in Figure 2.

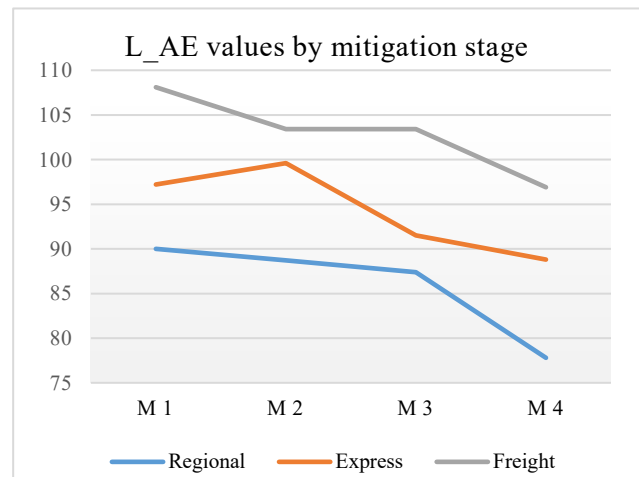


Fig 2. Development of L_{AE} values during the implementation of noise mitigation measures by train category (Lomoz et al., 2021).

The results shown in Figure 2 indicate a reduction in L_{AE} values across all monitored categories of train sets. For regional trains, the value decreased from 90.0 dB to 77.8 dB between the first and fourth measurements; for express and EuroCity trains, it decreased from 97.2 dB to 88.8 dB; and for freight trains, it decreased from 108.1 dB to 96.9 dB. The highest values were recorded for freight

trains in all measurements, confirming their significant contribution to the noise burden of rail transport.

The comparison shows that the gradual implementation of noise mitigation measures was associated with a reduction in the noise burden in the studied location. The results therefore support the importance of investments in protective elements of transport infrastructure, especially in areas with residential development near railway lines. In the context of societal well-being, these measures can be understood as investments that contribute to improving the quality of the residential environment, reducing negative transport externalities and protecting residents from excessive noise.

2.3 Investments in alternative energy sources

Investments in alternative energy sources and low-emission forms of propulsion represent one of the important options for reducing the negative environmental impacts of transport. In rail transport, the development of electric traction is of particular importance in this respect, as it makes it possible to reduce dependence on the combustion of fossil fuels directly at the place of operation. From the perspective of impacts on the population, the importance of electric traction is associated primarily with reducing emission burdens and improving air quality in the vicinity of transport corridors. Electric rail transport does not produce direct exhaust emissions at the place of operation, which is particularly important in densely populated areas, around railway hubs and on lines with high traffic intensity. However, the benefits of electrification cannot be assessed solely on the basis of zero local emissions; emissions generated during electricity production must also be taken into account. Even under this more conservative approach, however, electric traction shows significantly more favorable results compared with diesel rail traction and road freight transport.

The practical impact of electric traction can be demonstrated by comparing the emission intensity of freight transport on the monitored section, where rail and road transport were evaluated under comparable transport conditions. The comparison included electric locomotives of classes 193, 183 and 189, a class 753.7 diesel locomotive, and MAN TGX and Renault Trucks K road freight combinations. The results are expressed using two indicators: grams of CO₂e per gross tonne-kilometre, i.e., in relation to the total weight of the transported train or vehicle combination, and grams of CO₂e per net tonne-kilometre, i.e., in relation to the weight of the transported cargo itself.

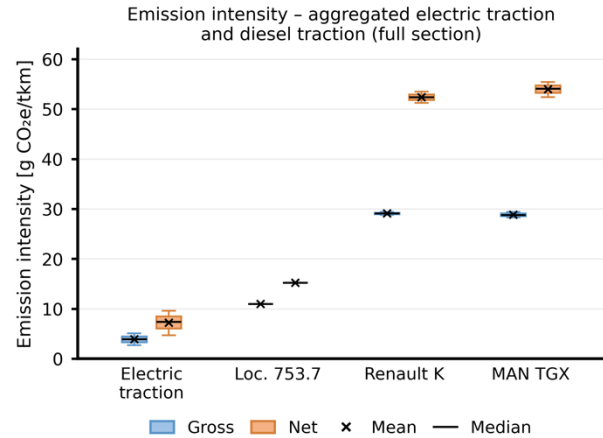


Fig 3. CO₂e emission intensity of rail and road freight, full section (own source).

The results shown in Figure 3 confirm the substantially lower emission intensity of rail freight transport compared with road transport. Electric traction is presented in the graph as a range of values achieved by the assessed electric locomotives. In terms of gross tonne-kilometres, electric traction reaches values of approximately 2.7–5.1 g CO₂e/gtkm. The class 753.7 diesel locomotive reaches approximately 11.0 g CO₂e/gtkm, which is roughly two to four times higher than the values for electric traction. The Renault K and MAN TGX road freight combinations reach values of approximately 28.8–29.4 g CO₂e/gtkm, placing them considerably above both assessed forms of rail transport. Even more pronounced differences are evident when calculated per net tonne-kilometre, i.e., in relation to the weight of the transported cargo itself. Electric traction reaches values of approximately 4.7–9.6 g CO₂e/ntkm, the class 753.7 diesel locomotive approximately 15.2 g CO₂e/ntkm, while road freight combinations reach approximately 52.4–54.1 g CO₂e/ntkm.

The comparison shows that electric rail traction achieves the most favorable results in terms of greenhouse gas emissions. At the same time, it is evident that diesel rail traction has a significantly lower emission intensity than road freight transport. The results therefore support the importance of investments in the electrification of railway lines and in the development of rail freight transport as instruments for reducing environmental burdens. In the context of societal well-being, these investments can be understood as measures that contribute to reducing emissions, supporting a more sustainable functioning of the transport system and, in the long term, improving environmental quality.

Conclusion

The results of this study confirm that transport investments may contribute to societal well-being through several interconnected dimensions. Fleet modernization may improve the perceived quality and attractiveness of public transport; investments in transport infrastructure, particularly noise mitigation measures, may reduce

negative externalities and improve the quality of the residential environment near transport infrastructure; and investments in alternative energy sources show clear potential for reducing emission intensity and thereby improving the environment.

Overall, the results indicate that the benefits of transport investments should not be assessed solely through technical or economic indicators, as their broader contribution also lies in improving the accessibility of the transport system itself, reducing environmental burdens and supporting a more sustainable and user-oriented transport system. From the perspective of societal well-being, transport investments therefore represent an important instrument for improving quality of life.

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