EXTERNALITIES OF RAIL FREIGHT TRANSPORT IN THE LIGHT OF ENVIRONMENTALLY CONSCIOUS TRANSPORT

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Abstract: *The issue of transport as a primary environmental burden is of prime importance when making economic policy decisions in developed countries. To what extent do the external effects of transport, especially rail freight transport, burden the total national income of a country, what impact do they have on economic development, how much do they damage the present and influence the livable conditions of the future, these are the questions that are partially or completely waiting to be answered. The work is based on literature data and data from Hungarian railway transport companies. Companies interested in rail freight transport are making significant efforts, primarily in the field of mass goods transport, to increase the share of their performance.*

Keywords*: logistics, rail transportation, environment, externality, economic development*

INTRODUCTION

The effects of globalization affecting our planet appear as an exponential factor in the field of transport, the result of which is that the level of pollution has also increased significantly. The Earth's "tolerance" is decreasing; we receive signals almost daily from biodiversity, the atmosphere, and other actors of the living world that this cannot go on like this. The issue of transportation as a primary environmental burden is of prime importance when making economic policy decisions in developed countries, although everyday experiences do not always support these propositions. It should be very decisive in the life of a country to what extent it allows its environment to be burdened even more strongly, how much it can make the population aware of the respect and protection of the environment, and how suitable and effective the areas of legal regulation are. To what extent do the external effects of transport burden the total national income of a country, what effect do they have on economic development, how much do they damage the present and influence the livable conditions of the future, these are the questions that are partially or completely waiting to be answered.

According to the classic definition of transport - an economic service activity that regularly transports people and goods using various technical means. The transport system is a complex of interrelated elements that operates under specific laws. The characteristic of the system is that it has a goal and a task, its elements cooperate to achieve the goal or to solve the task [2].

Today, you can only see a steam locomotive connected to a nostalgia train or in a museum. One of the most common types of modern traction vehicles is the diesel locomotive, which pollutes the air to a great extent. Electric traction vehicles do not emit pollutants into the atmosphere, but the thermal power plants that produce the largest proportion of electricity pollute the air by emitting SO_2, CO_2 and solid pollutants. The pollution caused by thermal power plants can be reduced by pretreatment of the combustion product and technologies that result in more perfect combustion. The spread of the electric traction system is an aspiration due to its environmentally friendly nature and many other properties (high efficiency, low noise level), but Hungary still faces large-scale electrification tasks. In Hungary, 2,630 km of the 7,473 km long, standard-gauge rail network have been electrified, which represents 35% of the entire network. This value is more favorable than the proportion of electric lines in the world, which is 25.6%, but it is

still below the European average, which is 45.5% [4]. When examining these data, it is also necessary to mention that about 80% of the transport of goods - including the transport of dangerous goods - takes place on electrified lines.

In general, transport, as a consumer of energy from fossil fuels (oil, coal, etc.) and as a user of land, is closely related to the problem of natural resources, and as one of the most important sources of air and noise pollution, to the problem of environmental damage.

The most important social costs of transport arise in the areas: traffic safety (personal injuries), air pollution, noise pollution, area use, energy and raw material consumption.

Among the above, personal injuries require a lot of attention, followed by air and noise pollution as a serious element of environmental damage. Among the above, personal injuries require a lot of attention, followed by air pollution as a serious environmental damage element. A clear alternative to mitigating serious damage and losses caused by road transport is to increase the share of railways. According to accident statistics, the railway is twenty-four times safer than road transport. For the same performance, the railway pollutes the air 30 times less compared to the truck. Assuming the same performance, the railway makes a quarter as much noise as road traffic. However, by now it has become clear that it is worth transporting large quantities of goods over long distances, on land, most economically by rail [5].

Externalities, whether positively or negatively affecting the economic situation and well-being of those concerned, are definitely harmful phenomena from the point of view of society, as they cause a social loss relevant decision. If, for example, the treatment of health problems arising from environmental pollution costs more than the potential additional costs of industrial companies related to the control of pollution, then society suffers a loss due to the external phenomenon. And in the same way, if the cause of the positive external effect does not perceive the additional benefit that it provides to society "for free" in the form of an external effect, then its activity will be less intense than it would be desirable [8,9].

Noise pollution is an environmental pollution whose effect can only be felt directly for a short time, but in the long term it causes health problems and worsens the quality of life. Fortunately, protection against this is a very well developed area of environmental protection. There are several ways to reduce the noise level: we eliminate the noise source itself, or we replace our old, loud devices with modern, low-noise equipment. Sound insulation, increasing the distance from the noise source, or, for example, planting plants that absorb harmful noises can also be solutions. The creation of noise ordinances can also have a very beneficial effect on noise reduction [6].

By the beginning of the 21st century, the decline in traffic has stopped in many countries, although the overall picture is decreasing, but some growth can also be detected in some places. In response to these processes, three distinctive, opposing views emerged on the future of the railway:

1. The first is that we have reached an era in the history of transport where, in the process of the current transport technology change, the railway and similar mass transport methods based on them lose their primary character, giving way to other forms, primarily to cars, which are much more flexible in space and time [3]. Due to the limitations arising from its system properties, the fixed track train system can no longer meet the increased demands.

2. According to the other view, the unexpectedly rapid collapse of rail transport has serious traffic distribution and environmental consequences. Therefore, the further decline of the railway's role within transport as a whole must be prevented, or at least reduced to a minimum by modernizing the infrastructure, vehicles and traffic management, increasing services and the interaction of passenger experience and satisfaction.

3. However, according to some views, the decline in the role of the railway as a form of transport is only a temporary phenomenon. After all, there is an urgent need for interaction

and cooperation between transport options and forms, the backbone of which must undeniably be represented by the railway, in terms of its ability to overcome huge distances. In order to achieve full high-level transport, cooperation can be developed by exploiting both water and air transport, but on land, split cooperation can be used. Such is the railway with a fixed-track system, which is the perfect means of covering long distances, while road transport is responsible for shorter distances.

In terms of GHG emissions, taking into account the CO_2 emissions of transport modes, rail transport occupies a favorable position (Figure 1). At the same time, the countries of the world are not uniform in terms of CO_2 emissions. In the countries of South-Eastern Europe, for example, compared to other countries in Europe, the growth of greenhouse gases, i.e. carbon dioxide emissions, was mostly higher in the last twenty years [1].

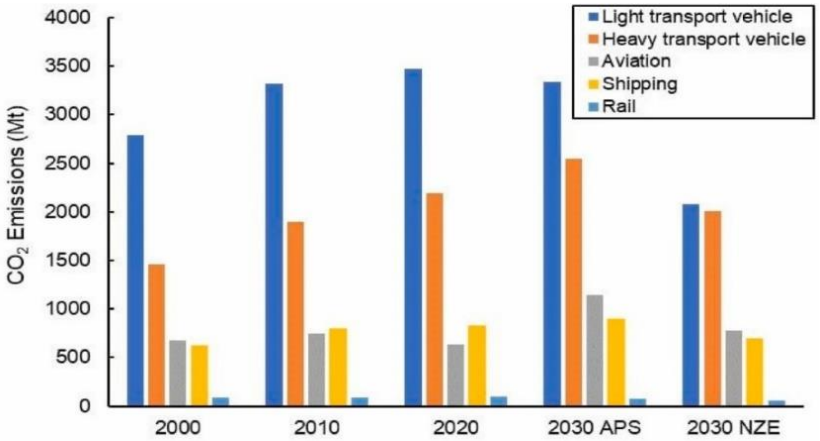

Figure 1. Global CO_2 emissions of various sub-sectors of the transportation sector from 2000 to 2030

Source: (APS - Announced Pledges Scenario, NZE - Net Zero Emissions) [16]

Transport is considered one of the most serious sources of CO_2 pollution, yet many companies operating in the transport and logistics sector seem to lack environmental protection measures. This behavior can be traced back to two main reasons. On the one hand, the company's environmental behavior is influenced by its position in the supply chain. Companies in direct contact with end users started to implement and communicate sustainable behavior a long time ago. However, companies in the transport and logistics sector are now beginning to realize that sustainability is not always a "necessary evil" but can result in long-term added value [10]. On the other hand, in addition to a few multinational companies, the transport sector is usually characterized by SMEs, which often do not have sufficient resources (e.g., capital and know-how) to deal with environmental challenges.

The technical condition and the environmental condition of the railway track are two separate concepts, and although they are connected by many threads, it is important to know the differences. The technical condition of the railway track is influenced by:

- track structure,
- its geometrical state,
- the quality of the materials used,
- the loads passing through and passing through the track,
- weather conditions. [7]

The construction of the railway can also cause further, temporary habitat deterioration due to temporary use. The environmental effects of the transport of various materials used for construction (sand, gravel, earth, etc.) occur along the entire length of the transport routes. The affected routes are characterized by an increased traffic load, resulting

in an increase in noise and vibration load, as well as air pollution. The environmental effects of the transport of construction materials are of a temporary nature and will disappear after the completion of the railway construction. Transport routes and landfills for construction materials can occupy a significant area, destroying and polluting natural habitats [15].

From the point of view of railway construction and maintenance, even a completely new bed can be contaminated if many fine-grained components are included (e.g., due to substructure defects), so we are talking about mechanical contamination. The bedding that has been lying in the track for a long time can also be contaminated from an environmental point of view, in which case chemical and biological contaminations also occur [7].

It is relatively rare to talk about the electromagnetic field that develops near the high-voltage wires needed for traction. Since the end of the nineteenth century (the development of direct current (Edison) and alternating current (Westinghouse) systems), there has been a debate about the electromagnetic fields created by them, which affect the human body, including the nervous system, circulation, etc. As sources of accidents, these wires are also dangerous for both humans and animals [12].

As a result of all this, an environmental impact assessment (EIA) is inevitable already in the planning stages of railway investments in order to explore the possible environmental consequences of railway construction and the often very unfavorable effects on the habitats of humans and wild animals, as well as on biodiversity [14].

MATERIALS AND METHODS

The material of the study was compiled based on the processing of literature sources, data of the Central Statistical Office (KSH) and information from interviews with the managers of enterprises dealing with Hungarian rail freight transport.

RESEARCH RESULTS

In the global economy, the growth of transport has many shortcomings, such as delays resulting from congestion, increased noise and stress for traffic users, environmental pollution due to harmful emissions, etc. Determining and quantifying these factors is the first step for the subsequent internalization of external costs. It is well known that the costs of transport do not only include the consideration of the transport service, which is paid by the state or the users, but also cover much wider expenses [11]. In Nikolova's (2015) study, average external costs are calculated for the following main cost categories:

1. Traffic-related accidents – including health care costs, lost productivity and loss of life.
2. Air pollution – including health/medical costs, loss of production, property damage, etc.
3. Climate change – including the costs of prevention to reduce the risk of climate change and the costs of damage from rising average ambient temperatures.
4. Noise pollution - including disturbance and health costs.
5. Congestion and delay - including lost time and additional operating costs; delay costs resulting from non-scheduled delivery.

In addition to the above cost categories, other important cost categories were formed:

6. Costs of upstream and downstream processes - including air pollution costs of GHG emissions from energy consumption. The focus is on the production and use of energy resources;
7. Costs related to nature and landscape - including costs such as conservation and restoration costs (detection, restoration of the original state, green bridges, etc.);
8. Loss of biodiversity resulting from air pollution - including biodiversity restoration costs; and

9. The costs of soil and water pollution - including the costs of removing and disposing of soil and water pollutants, with particular regard to heavy metal and hydrocarbon pollution from traffic.

In 2020, Hungary achieved the following achievements in terms of all (domestic + international) freight transport compared to the base year, expressed in terms of freight tonne-kilometers. Projected on the total transport of goods, the increase was only 1.0% and thus approached 56 billion km. Within this, rail freight transport shows a decrease of around 2% compared to an increase of almost 2% by road. For the past three years, the performance of rail freight has accounted for nearly 18% of the entire transport sector and is increasingly separated from the 68% by road (Figure 2).

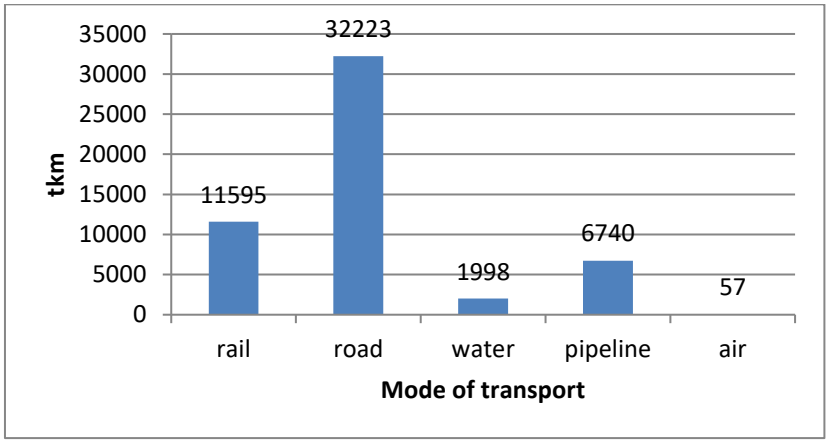

Figure 2. Distribution of transport performances by means of goods transport (tonne-km of goods) in domestic and international terms [17]

It is interesting to examine in what proportion the total transport performance is divided between domestic and international transport modes, highlighting rail and road freight modes. Examining the performance data, we can conclude that in 2020 the share of domestic rail freight transport was 13% compared to the 74% share of road traffic, while examining all of this in international traffic, the result is slightly more favorable for railways at 19% compared to 67%. The data speak for themselves, it can be seen that the share of rail transport within the goods transport systems is constantly losing ground compared to the share of road transport.

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We will now perform the above analysis based on the performance indicator of the delivered ton of goods. Based on the statistical data, we can see that the total (domestic+international) delivered power in tons shows a similar distribution result as the one projected per ton-kilometer of goods. We can see this in Figure 3.

In relation to the base, it can be concluded that the performance of all modes of goods transportation barely changed in 2020 with regard to all (domestic + international) transported tons of goods.

Examining the methods of goods transport in a comparison between rail and road, we can make the following conclusions. In 2015, domestic transport accounted for 29% of all rail freight transport, while the international share accounted for 71%.

Now let's look at all of this in terms of road freight transport. In 2020, the distribution of all road freight tons moved is as follows, 80% domestic and the remaining 20% international. It is clear from the analysis that the international share of rail freight transport is very high compared to the share of domestic freight (71-81.5%), both in terms of moved freight tons and freight ton-kilometers.

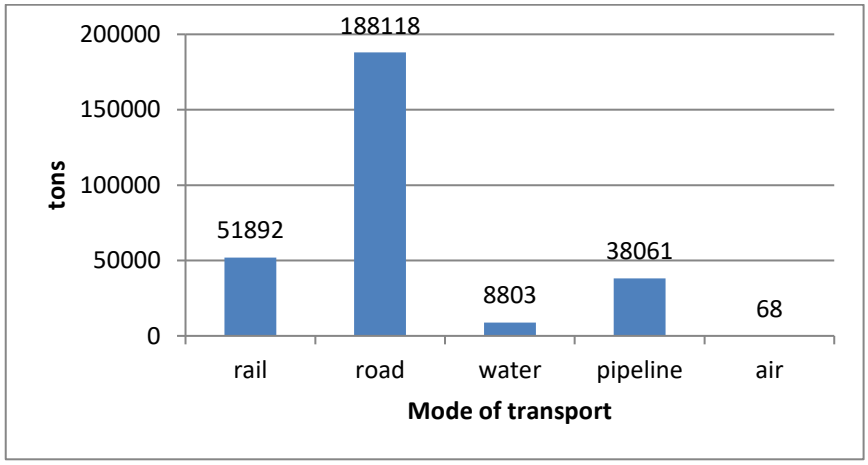

Figure 3. Distribution of delivery performance according to goods delivery methods in domestic and international terms [17]

Applying this finding to road freight transport, we get an inverse ratio measured in terms of the performance indicator of tonne of goods moved, i.e. the domestic share is 80% and only 20% is international. Projected per tonne-kilometer of road freight, the ratio is of course reversed here: 27% domestic and 73% international.

From the above comparative analysis, the great importance and role of rail freight in long-distance transport is clearly evident, which is further induced by the rise of environmentally conscious European thinking, namely to choose the railway instead of the road for long-distance transport.

In 2020, nearly 150,000 freight trains traveled in Hungary, covering 16.5 million kilometers, which is also very significant in a daily breakdown, 411 freight trains and 45,205 kilometers, which is an average of 110 km per train per 24 hours. This number of trains runs on 80% of the main Hungarian railway network.

The volume of international rail freight in our country shows a slightly fluctuating trend even in the average of one or two years in the light of the numbers, which is also significantly influenced by the current international economic and political balance of power. With regard to our neighboring railways, we can state that our traffic in Ukraine, Croatia and Serbia is decreasing, while in Romania, Slovakia and Slovenia the numbers show a slight increase, and in relation to Austria the traffic increase is significant.

The division of the Hungarian rail freight market is well illustrated by the fact that MÁV Cargo, the business branch of MÁV that was bought out by the Austrian state in 2008, still had an advantage of more than 90% in terms of market share. In 2010, RCH (Rail Cargo Hungaria Zrt.), converted to the Austrian model, still had a 78% share of the Hungarian freight market in terms of performance per ton of goods moved. This value continuously decreased during the following years and barely reached 65% in 2015. The figure clearly shows that the remaining 35% is shared by another 7-10 predominantly private railways, of which the most significant GySEV Cargo has a share of just under 8%. Examining the

additional results of the previously analyzed railway companies, it can be concluded that the established ratios are valid when comparing market shares, as well as when comparing sales revenue. The Hungarian railway market has not been able to grow overall in the last ten years, but the number of rail freight operators has increased due to liberalization, and a serious competition between the market operators has started. The privately owned railway companies in Hungary that were founded at that time primarily targeted closed train traffic in their market strategy, which entailed little risk but provided a high specific income. In the construction of closed systems, the newly established railway companies gained an advantage over RCH with a relatively difficult reaction time, of course, they achieved all this with their low cost, favorable transport prices and accuracy. In the market segment of bulk goods (stone, gravel), they were able to acquire a significant share in a short time and in order to increase their turnover, they minimized the prices. These smaller private companies primarily solve their transport tasks with rented towing and towed vehicles, thereby reducing unnecessary costs such as maintenance, periodic overhaul, etc.

Developments at RCH in terms of compliance with environmental regulations are focused on the following [5]:

- streamlining the use of energy and fuel is a continuous activity, because economics also requires it. More and more electric locomotives, mainly from Austria, are used, the braking devices of which are equipped with energy recovery equipment, and the train drivers are further trained in the economical operation of the trains, all of which also has a favorable effect on CO_2 emissions;
- during the repair and maintenance of the vehicle fleet, the use of environmental pollutants and the generation of hazardous waste were reduced;
- during the repair of wheels and rolling parts, the bearings are replaced with less maintenance-requiring ones, which significantly reduce the use of machine grease, and generally also reduce the use of graphite grease, for example, by replacing friction parts with special plastics where possible.
- As a result of the above, the noise emissions of locomotives and freight cars have been significantly reduced.
- Only solvent-free (water-based) coating systems are permitted for surface treatment of vehicles.
- Environmentally friendly methods are used to wash and disinfect freight wagons.

The implementation of all modes of transport requires a skilled workforce, and it is no different in rail freight transport. There is currently a labor shortage in the field of freight transport, whether it is the reduction of training capacities in the railway system, the unfavorable age composition of the workers and the aging workforce among drivers. It is difficult to encourage young people, to go for these jobs. The Romanian state, for example, gives scholarships to these young people on the one hand, and gives various subsidies to the companies that employ these young people on the other hand [13].

CONCLUSIONS

In the Hungarian freight transport market, the established rail freight companies are trying to gain as much share as possible at the expense of other modes of transport. Their aspirations are not very spectacular for the time being, but in the long term, their goals seem realistic due to the negative external effects of road transport, among other things. At the same time, railway carriers also have to solve a series of tasks arising from increasingly strict environmental protection regulations. As a consequence, the total collapse of the railway will not occur even decades from now, because society and the economy will take advantage of the changing opportunities arising from its technical/traffic system properties, but we can

hardly speak of a real renaissance, because it has to make do with a more modest position than possible in the transport sub-sector structure. — especially withdraws from rural areas, leaving the territorial task of transport to service systems that are more flexible in terms of time and space. The process is complicated by the fact that the renovation of some international main lines and the decline in the importance of certain peripheral lines are taking place in the country at the same time. The continuation of the research is both timely and justified from a logistical, economic and environmental point of view.

REFERENCES

[1]. BESKOVNIK B., TWRDY E., 2012, Green logistics strategy for South East Europe: to improve intermodality and establish green transport corridors, Transport, 27 (1), 25-33. doi:10.3846/16484142.2012.663731

[2]. BODNAR B., 2021, Az intermodális közlekedési rendszerek és közösségi központok optimális város- és közlekedésfejlesztő hatása. PhD. Thesis, University of Debrecen, Debrecen, Hungary, https://dea.lib.unideb.hu/server/api/core/bitstreams/49a89bdb-5e95-4e6c-a229-58cd4da38a7f/content (access: 2023. 09. 13.)

[3]. ERDŐSI F., 2009, Összeomlás vagy reneszánsz? A hagyományos vasúti közlekedés állapota és kilátásai Kelet-Európában, Tér és Társadalom, 23(2), 1-23. DOI: https://doi.org/10.17649/TET.23.2.1232

[4]. HORVÁTH H., KÁTAI-URBÁN L., 2016, A vasúti áruszállítás környezetbiztonsági aspektusainak értékelése. I. Rész, Hadtudomány, 2016 évi elektronikus lapszám, 51-58. DOI 10.17047/HADTUD.2016.26.E.51

[5]. JERNEY Z., ZENTAI, N. NEUSCHL SZ., BODNAR K., 2022, Main elements of the Rail Cargo Hungaria Zrt's environmental concept, Gradus, 9 (2), 1-6. https://doi.org/10.47833/2022.2.ECO.001

[6]. KEREKES S., 1998, A környezetgazdaságtan alapjai, Aula, Budapest, 72-73.

[7]. KOREN E., 2005, Vasúti pályák környezeti állapotának elemzése, PhD. Thesis, Nyugat-magyarországi Egyetem, Sopron

[8]. LENGYEL I., MOZSÁR F., 2002, A külső gazdasági hatások (externáliák) térbelisége, Tér és Társadalom 16(2), 1-20.

[9]. NIKOLOVA C., 2015, Evaluating average external costs of inland freight transport in South-Eastern European countries - Policy implications, Economic Alternatives, 3 (10), 64-81.

[10]. OBERHOFER P., DIEPLINGER M., 2014, Sustainability in the transport and logistics sector: Lacking environmental measures, Business Strategy and the Environment, 23, 236–253. DOI: 10.1002/bse.1769

[11]. PETROVIC N., JOVANOVIC V., NIKOLIC B., PAVLOVIC J., MIHAJLOVIC J., 2022, A comparative analysis of road and rail freight transport through the Republic of Serbia from the aspect of external cost, Acta Technica Jaurinensis, 15(3), 130-137. DOI: https://doi.org/10.14513/actatechjaur.00655

[12]. PLAMADEALA V., SLOBODEANIUC S., 2019, Negative impact of railway transport on the ambient environment, Journal of Engineering Science, 26 (1), 83-90. DOI: 10.5281/zenodo.2640044

[13]. SCARIŞOREANU D.I., GHICULESCU L.D., 2023, Study of the multimodal freight transport sector in Romania: Analysis of the external and internal environment, Broad Research in Artificial Intelligence and Neuroscience, 14(4), 571-595. doi.org/10.18662/brain/14.1/436

[14]. STABAK R., 2023, Ecological consequences of railway infrastructure development: A case study of the Belgrade-Novi Sad Corridor, Opportunities and Challenges in Sustainability, 2 (3), 116-129. https://doi.org/10.56578/ocs020301
[15]. *** **ANONYMOUS,** 2021, Budapest-Belgrád vasútvonal hazai szakaszának fejlesztése, Környezeti Hatástanulmány, (access: 2023. 09. 13.) https://soroksar.hu/wp-content/uploads/2022/08/22/013752f2-6179-4702-8c1e-d02ab6d57656.pdf
[16]. *** **IEA**, 2021, Global CO_2 emissions from transport by subsector, 2000-2030. International Energy Agency; 2021, Updated November 4, https://Www.Iea.Org/Data-and-Statistics/Charts/Global-Co2-Emissions-from-Transport-by-Subsector-2000-2030/. (access: 2022. 10. 10.)
[17]. *** **KSH**, 2020, Data of Central Statistical Office, Budapest, Hungary https://www.ksh.hu/stadat_eves_4_6