External Costs of Inland Transport

Subjects: Others | Economics
Contributor: Florian Hofbauer

Sustainable transport, such as using inland waterway transport (IWT), represents a major pillar of the European Green Deal to reduce global warming. To evaluate the different inland transport modes (road, rail, IWT), it is crucial to know the external costs of these modes.

Keywords: external costs ; transport emissions ; sustainability ; sustainable freight transport ; external cost calculation methods ; Inland waterway transport

1. Introduction

Sustainability is a major goal of the European Climate Policy, with the aim of limiting the effects of global warming and climate change. In December 2019, the "Green Deal" was announced by the European Commission, aiming at a 90% reduction of emissions by 2050 in the transport sector[1]. Developing the vision of sustainable transport systems from abstract ideas to actual implementation constitutes a major challenge for many logistics, supply chain management and transport stakeholders. A modal shift towards sustainable transport modes, such as railway or inland waterway (IWT), is a major part of the Green Deal[1] and has the potential to reduce the negative side effects caused by road transport, including external costs from emissions, noise and congestion[2]. Railway and IWT are the inland transport modes with the lowest emissions and external costs compared to road and air transport[3][4].

2. External Costs

"External costs, also known as externalities, arise when the social or economic activities of one (group of) person(s) have an impact on another (group of) person(s) and when that impact is not fully accounted, or compensated for, by the first (group of) person(s). In other words, external costs of transport are generally not borne by the transport user and hence not taken into account when they make a transport decision."[3]

External costs can be divided into seven categories: accident, noise, congestion, habitat damage, air pollution, climate change and well-to-tank emissions. Table 1 explains the seven external cost categories.

Table 1. Explanation of external cost categories.

Accident costs	Material damage or immaterial damage resulting from accidents that are not covered by insurance payments (e.g., human costs, medical costs, administrative costs, loss of production)
Noise costs	Costs from unwanted noise of varying duration, intensity or other quality that causes physical or psychological harm to humans
Congestion costs	Congestion costs are the delay costs and welfare loss associated with the congestion.
Costs of habitat damage	Costs resulting from negative impacts of transport on nature and landscape: loss of habitats (ecosystems), fragmentation of habitat, habitat degradation through emissions
Air pollution costs	External costs from the following four types of impacts caused by the emission of transport-related air pollutants: health effects, crop failures, material and construction damage, loss of biodiversity

Climate change costs	The costs of climate change are defined as the costs associated with all the effects of global warming: sea level rise, crop failures, health costs, damage to buildings and materials (weather damage), loss of biodiversity and problems with water supply.
Cost of well-to-tank emissions	The cost of well-to-tank emissions (= cost of energy production) includes the production of all types of energy sources, which leads to emissions and other externalities. This includes the extraction of energy sources, processing (e.g., refining or electricity generation), transport and transmission, construction of energy plants and other infrastructure

Adapted from Schroten et al. [3]

3. External Costs of Transport

In this section, the calculation methods of the external cost categories from Schroten et al.[3] & PLANCO[5] are compared. The focus is on the general description of the calculation factors followed by an overview of average external costs of freight transport.

3.1. Accident costs

In the PLANCO study[5], the external accident costs result from the calculation of human costs and material damage in accidents in which a freight vehicle was involved. For the calculation of human costs, the number of casualties per mode of transport is divided into different levels of injury and multiplied by the corresponding cost factor. The cost factors for human costs and material damage were taken from calculations by the German Federal Highway Research Institute[6]. For rail transport and IWT, separate cost factors for material damage were calculated based on the damage estimates of evaluated accident reports. The resulting total external accident costs were related to the transport performance in tonne-kilometers by the respective mode of transport.

Schroten et al.[3] deal with significantly more subcategories of external accident costs and distinguish between human costs, loss of production, medical costs, administrative costs and property damage in the case of external accident costs. Due to insurance payments, only a certain percentage of these cost categories are considered external costs. For example, it is assumed that 100% of material damage is covered by insurance and therefore does not have to be taken into account in the calculation of external accident costs. In addition, the study uses correction factors for the number of accidents to compensate for the problem of unreported accidents[7][8][9]. This concerns mainly road transport, as it is very unlikely that accidents in rail transport and IWT go unnoticed. In the case of accidents involving different modes of transport, the accident costs are allocated to the mode of transport that caused the accident. Within a mode of transport, the accident costs are assigned according to the damage potential of the vehicles involved[10][11].

3.2. Noise costs

Noise costs are calculated using the same methodology in both studies. The number of people and the extent of noise pollution is determined by interviewing the affected population. The cost factors for noise result from the willingness of the affected people to pay for the reduction of environmental noise levels. In addition, treatment costs for cardiovascular diseases resulting from increased noise pollution are taken into account[12][13].

3.3. Congestion costs

Congestion costs are not addressed in the PLANCO study[5], since they can be neglected for IWT. The calculations of congestion costs by Schroten et al.[3] focus on road freight transport, as they are highly relevant for this sector. Congestion costs result from the calculation of delay costs and welfare loss. The calculation of these costs depends on numerous factors, such as speed-flow functions, demand curves [14][15], value of time[9][16][17] as well as the social costs in terms of welfare loss. The costs are calculated using simulation tools for the European area[18].

For rail transport, congestion costs are generally not relevant due to the fixed train schedules. However, in the case of highly used networks, train delays can cause congestion even for scheduled services. Schroten et al.[3] also consider the future calculation of scarcity costs in the event that the means of transport of regular services strongly compete with each other in terms of time slots. However, such a calculation requires a great deal of information and is highly contextspecific[3]. For IWT, congestion costs are considered similar to those of rail transport and therefore not relevant. An idea for further critical evaluation is the analysis of congestion situations in ports or at bottlenecks such as locks, which might be relevant for inland navigation and may cause considerable congestion costs[19][20].

3.4. Costs of habitat damage

PLANCO[5] refers to the cost rates of a study by INFRAS[21] which are intended to show the costs of the renaturation of sealed surfaces along transport routes. However, due to the uncertainties in the delimitation of impaired areas, the study refrains from using these cost rates and from monetizing habitat damage. Schroten et al.[3] calculate the costs of habitat damage based on the length (or area) of the infrastructure network of the transport modes and the derived annual cost factors for habitat loss and habitat fragmentation per kilometer based on a study by INFRAS/Ecoplan[22].

3.5. Costs of air pollution, climate change and well-to-tank emissions

For the calculation of air pollution, climate change and well-to-tank emissions, the input values are vehicle performance data[23], emission factors per vehicle type and cost factors of air pollutants. Multiplying these values results in the external costs of air pollution, climate change and well-to-tank emissions. The cost factors for air pollutants refer to the health effects, crop losses, material and building damage and biodiversity loss caused by air pollutants. The cost factor for CO_2 equivalents corresponds to the avoidance costs of one tonne of CO2e. Schroten et al.[3] use the cost factors of air pollutants from the Environmental Prices Handbook 2017[24] and a CO2e price of 100€/t based on the average of the values found in the literature. PLANCO[5] refers to the cost rates from the method convention of the German Federal Environment Agency from 2007[25] and uses a value of 70€/t as CO2e price.

3.6. Average external costs of freight transport

Table 2 lists the external cost factors of PLANCO[5] for the transport modes road, rail and inland waterways. The study provides the average external cost factors per tonne-kilometer for the cost categories accidents, noise, air pollution and climate change for Germany for the year 2005. The external cost factors per mode of transport are differentiated between bulk and container transport.

Table 2. Average external costs of freight transport (Germany, 2005) per transport mode.

External cost categories	Road €-cent/tkm		Rail €-cent/tkm		Inland Waterway €-cent/tkm	
	Bulk	**Container**	**Bulk**	**Container**	**Bulk**	**Container**
Accident costs	0.43	0.43	0.06	0.06	0.03	0.03
Noise costs	0.79	0.79	0.84	0.84	0.00	0.00
Air pollution costs	0.32	0.17	0.05	0.04	0.12	0.12
Climate change costs	0.47	0.26	0.18	0.16	0.12	0.11
Total	2.01	1.65	1.13	1.1	0.27	0.26

Adapted from PLANCO [5].

Table 3 shows the external cost categories of the “Handbook on External Costs of Transport” [3] for the transport modes road, rail and IWT. The study provides the external cost categories accidents, noise, congestion, habitat damage, air pollution, climate change and well-to-tank emissions for the EU-28 area for the year 2016. Moreover, costs for light commercial vehicles, heavy goods vehicles and electric and diesel trains are included.

Table 3. Total and average external costs of freight transport (EU-28, 2016) per transport mode.

External Cost Categories	Road		Rail		Inland Waterway	
	Total Costs (Billion €)	€-cent/tkm	Total Costs (Billion €)	€-cent/tkm	Total Costs (Billion €)	€-cent/tkm
Accident costs	42.8	6.0 (LCV) 1.3 (HGV)	0.3	0.1	0.1	0.1
Noise costs	14.5	1.6 (LCV) 0.5 (HGV)	2.5	0.6 (electric) 0.4 (diesel)	n.a.	n.a.
Congestion costs	70.1	16.8 (LCV) 0.8 (HGV)	n.a.	n.a.	n.a.	n.a.
Costs of habitat damage	8.0	1.35 (LCV) 0.2 (HGV)	1	0.2 (electric) 0.2 (diesel)	0.3	0.2
Air pollution costs	29.4	4.7 (LCV) 0.8 (HGV)	0.71	0.0 (electric) 0.7 (diesel)	1.9	1.3
Climate change costs	22.8	4.0 (LCV) 0.5 (HGV)	0.2	0.0 (electric) 0.2 (diesel)	0.4	0.3
Costs of well-to-tank emissions	7.5	1.15 (LCV) 0.2 (HGV)	0.6	0.2 (electric) 0.1 (diesel)	0.2	0.1
Total	195.1	35.6 (LCV) 4.2 (HGV)	5.4	1.1 (electric) 1.8 (diesel)	2.9	1.9

Adapted from Schroten et al.[3].

A comparison of the tables shows that the studies differ in the degree of breakdown into subcategories of external costs. PLANCO[5] offers a differentiation of the average external costs according to the type of cargo (bulk and container). Schroten et al.[3] also offer this differentiation, but only when listing marginal external costs. This differentiation is of great relevance, since the values can differ significantly depending on the type of cargo. Other categories such as car transport should be considered for future external cost calculations, as emission calculation studies such as the Global Emissions Council Framework[26] show that the difference in emissions due to the different weight and aerodynamics can be significant.

An essential distinction that is missing in both studies is the distinction between fuel types. Schroten et al.[3] offer a distinction between electricity and diesel for rail, and the significant differences in external costs underline the importance of this distinction. However, this distinction is missing for the other modes of transport. Alternative fuels are also essential in view of the European Green Deal[1] and therefore need to be considered for future calculations. Future studies on the specific emission values of alternative fuels, such as those of the Smart Freight Centre and Global Logistics Emissions Council Framework[27], should provide the basis for differentiated calculations with regard to external costs.

4. Further Research

Due to the omnipresent topic of climate change, the internalization of external costs will play a major role in the future when calculating and comparing transport scenarios. Research gaps need to be identified and adressed to ensure an accurate comparison of inland modes of transport with regard to external costs.

As an example, the following Table 4 shows the high potential for future research of external cost calculation methods of IWT. It shows the evaluation of IWT compared to road and rail for the external cost categories. Moreover, the future research column summarizes the major gaps in the existing literature concerning the calculation of each external cost category.

Table 4. External cost categories and future research for IWT.

External Cost Category	Evaluation of IWT	Future Research
Accident costs	very low accident costs	Evaluation of accidents and related costs in all relevant EU countries
Noise costs	very low noise costs	Evaluation of the noise of ships at anchor
Congestion costs	very low congestion costs	Evaluation of congestion situations in ports or at bottlenecks such as locks
Costs of habitat damage	very low cost of habitat damage	Evaluation of the multifunctionality (i.e., multi-use as recreational area, touristic area) of waterways
Costs of air pollution, climate change and well-to-tank	lower than road, similar to rail	Identification of ships older than 2003 Evaluation of used theoretical vs. practical values for energy consumption and its parameters (e.g., engine load factors)

Briefly summarized, the major recommendations for further research are:

- Measurement of energy consumption and related emissions of IWT needs to be qualitatively and quantitatively improved and brought up to the level of road transport, to ensure an accurate comparison of the related external costs with other modes of transport.
- Other external cost categories such as noise costs, congestion costs and costs of habitat damage should also be further researched, as these categories have the potential to demonstrate some advantages of sustainable transport modes such as rail and IWT, which could play a role in the future internalization of external costs.

Detailed information about the external cost calculation of IWT and recommended further research can be found in the study by Hofbauer and Putz.

References

1. The European Green Deal. COM (2019) 640 final . European Commission. Retrieved 2020-8-4

2. McKinnon, A.C. Green Logistics. In Improving the Environmental Sustainability of Logistics; McKinnon, A., Cullinane, S., Browne, M., Whiteing, A., Eds.; Kogan Page: London, UK, 2010; ISBN 0749456787.
3. Schroten, A.; van Essen, H.; van Wijngaarden, L.; Sutter, D.; Parolin, R.; Fiorello, D.; Brambilla, M.; Maffii, S.; El Beyrou ty, K.; Fermi, F.; et al. Handbook on the External Costs of Transport; Version 2019; European Union: Brussels, Belgium, 2019.
4. Otten, M.; 't Hoen, M.; den Boer, E. STREAM Freight Transport 2016. Emissions of Freight Transport Modes—Version 2. 2017. Available online: https://www.cedelft.eu/en/publications/download/2260 (accessed on 20 March 2020).
5. PLANCO Consulting GmbH. Verkehrswirtschaftlicher und Ökologischer Vergleich der Verkehrsträger Straße, Bahn und Wasserstraße. 2007. Available online: https://www.bafg.de/DE/08_Ref/U1/02_Projekte/05_Verkehrstraeger/verkehrstra eger_lang.pdf?__blob=publicationFile.
6. Federal Highway Research Institute. Volkswirtschaftliche Kosten Durch Straßenverkehrsunfälle in Deutschland. 2004. Available online: https://www.bast.de/BASt_2017/DE/Publikationen/Archiv/Infos/2007-2006/02-2006.html?nn=1824954.
7. Ecoplan. Unfallkosten im Strassen- und Schienenverkehr der Schweiz 1998. 2002. Available online: https://www.are.ad min.ch/dam/are/de/dokumente/verkehr/publikationen/unfallkosten-im-strassen-und-schienenverkehr-der-schweiz-1998.pdf.download.pdf/unfallkosten-im-strassen-und-schienenverkehr-der-schweiz-1998_d.pdf .
8. Ecoplan/Infras. Externe Effekte des Verkehrs 2010. Monetarisierung von Umwelt-, Unfall- und Gesundheitseffekten. 20 14. Available online: https://www.are.admin.ch/dam/are/de/dokumente/verkehr/publikationen/externe_effekte_desverke hrs2010.pdf.download.pdf/externe_effekte_desverkehrs2010.pdf .
9. Bickel, P.; Friedrich, R.; Burgess, A.; Fagiani, P.; Hunt, A.; De Jong, G.; Laird, J.; Lieb, C.; Lindberg, G.; Mackie, P.; et a l. Developing Harmonised European Approaches for Transport Costing and Project Assessment (HEATCO). Deliverabl e 5: Proposal for Harmonised Guidelines. 2006. Available online: https://www.putevi-srbije.rs/images/pdf/strategija/HEA TCO_D5_eng.pdf .
10. van Essen, H.; Schroten, A.; Otten, M.; Sutter, D.; Schreyer, C.; Zandonella, R.; Maibach, M.; Doll, C. External Costs of Transport in Europe. Update study for 2008. 2011. Available online: http://ecocalc-test.ecotransit.org/CE_Delft_4215_E xternal_Costs_of_Transport_in_Europe_def.pdf .
11. Vermeulen, J.; Boon, B.; van Essen, H.; den Boer, E.; Dings, J.; Bruinsma, F.; Koetse, M. The Price of Transport: Overv iew of the Social Costs of Transport 2004. Available online: https://www.ce.nl/en/publications/download/718 .
12. Defra. Environmental Noise: Valuing Impacts on: Sleep Disturbance, Annoyance, Hypertension, Productivity and Quiet. 2014. Available online: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/fi le/380852/environmental-noise-valuing-imapcts-PB14227.pdf .
13. WHO/JRC. Burden of Disease from Envionmental Noise: Quantification of Healthy Life Years Lost in Europe; WHO: Co penhagen, Denmark, 2011; ISBN 9789289002295.
14. Litman, T. Generated Traffic: Implications for transport planning. ITE J. 2001, 71, 38–47.
15. Oum, T.H.; Waters, W.G.; Yong, J.S. A Survey of Recent Estimates of Price Elasticities of Demand for Transport; World Bank: Washington, DC, USA, 1990.
16. Significance; VU Unversity Amsterdam; John Bates Services. Values of Time and Reliability in Passenger and Freight T ransport in the Netherlands. 2012. Available online: https://www.kimnet.nl/binaries/kimnet/documenten/rapporten/2013/ 11/18/values-of-time-and-reliability-in-passenger-and-freight-transport-in-the-netherlands/bijlage-value-of-time-and-relia bility-in-passenger-and-freight-transport-in-the-netherlands-reprint.pdf .
17. Comité National Routier. Comparative Study of Employment and Pay Conditions of International Lorry Drivers in Europ e. 2016. Available online: http://www.cnr.fr/en/CNR-Publications/2016-social-synthesis-of-CNR-s-European-studies .
18. TRT. TRUST—Transport European Simulation Tool. Available online: http://www.trt.it/en/tools/trust/ .
19. Osama Al Enezy; Edwin Van Hassel; Christa Sys; Thierry Vanelslander; Developing a cost calculation model for inland navigation. *Research in Transportation Business & Management* **2017**, *23*, 64-74, 10.1016/j.rtbm.2017.02.006.
20. Korzhenevych, A.; Dehnen, N.; Bröcker, J.; Holtkamp, M.; Meier, H.; Gibson, G.; Varma, A.; Cox, V. Update of the Hand book on External Costs of Transport. 2014. Available online: http://ec.europa.eu/transport/themes/sustainable/studies/d oc/2014-handbook-external-costs-transport.pdf .
21. Schreyer, C.; Maibach, M.; Sutter, D.; Doll, C.; Bickel, P. Externe Kosten des Verkehrs in Deutschland. Aufdatierung 20 05. 2007. Available online: https://www.allianz-pro-schiene.de/wp-content/uploads/2015/09/studie-externe-kosten-des-v erkehrs-in-deutschland.pdf .
22. Infras/Ecoplan. Externe Effekte des Verkehrs 2015. Aktualisierung der Berechnungen von Umwelt-, Unfall- und Gesund heitseffekten des Strassen-, Schienen-, Luft- und Schiffsverkehrs 2010 bis 2015. 2019. Available online: https://www.ar

e.admin.ch/dam/are/de/dokumente/verkehr/publikationen/externe-effekte-des-verkehrs-2015-schlussbericht.pdf.download.pdf/20180629%20Externe_Effekte_Verkehr_Aktualisierung_2015_Schlussbericht.pdf .

23. European Commission. EU transport in figures. Statistical pocketbook 2019; EU Transport in Figures. 2019. Available online: https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1 .
24. the Bruyn, S.; Bijleveld, M.; de Graaff, L.; Schep, E.; Schroten, A.; Vergeer, R.; Ahdour, S. Environmental Prices Handbook EU28 Version. Methods and Numbers for Valuation of Environmental Impacts. 2018. Available online: https://www.cedelft.eu/en/publications/download/2622 .
25. Umweltbundesamt. Ökonomische Bewertung von Umweltschäden: Methodenkonvention zur Schätzung externer Umweltkosten. Available online: https://digital.zlb.de/viewer/rest/image/33336965/3193.pdf/full/max/0/3193.pdf .
26. Greene, S.; Lewis, A. Global Logistics Emissions Council Framework for Logistics Emissions Accounting and Reporting; version 2.0; 2019. Available online: http://www.inlandwaterwaytransport.eu/wp-content/uploads/2019GLECFramework_Aug2019.pdf .
27. Smart Freight Centre. Low Emissions Fuels and Vehicles | Smart Freight Centre. Available online: https://www.smartfreightcentre.org/en/low-zero-emissions-fuels-and-vehicles/ .
