4i TRACTION
innovation · investment
infrastructure · integration

Railway development: lessons for the EU

Eoin, Quill; Climate Analytics

Andrzej, Ancygier; Climate Analytics

Olivia, Waterton; Climate Analytics

Sylvia, Schmidt; Climate Analytics

Mallika, Singh; Climate Analytics

July 2023

Suggested citation

E Quill, A Ancygier, O Waterton, S Schmidt, M Singh (2023) Railways development: lessons for the EU. Climate Analytics; Berlin

Acknowledgements

The authors would like to thank the participants in the workshops and interviews for their suggestions and comments. Different parts of the report have also been reviewed by experts in the respective areas. We would like to thank the reviewers for their constructive feedbacks.

Disclaimer

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 101003884.

This paper is based on the 4i-TRACTION Deliverable 3.4, 'What can the EU learn from non-EU countries on its path to climate neutrality?'

Content

1. Introduction

With the adoption of the European Green Deal and the European Climate Law, the European Union (EU) has set targets to reduce emissions by at least 55% below 1990 levels by 2030, and to achieve climate neutrality by 2050. With over 28% of the EU's emissions coming from the transport sector, railways are critical to decarbonising transport, especially for short and medium distances.

The decrease in transport emissions in 2020 due to the COVID-19 pandemic belies the sector's development in the EU over several years. In fact, the amount of goods transported by rail between 2012 and 2019 increased by almost 2% for the EU countries for which data is available, the number of passengers by 14%, goods transported by road by 8% and the number of air passengers by 40% (Eurostat, 2022a, 2022b, 2022c, 2022d). Likewise, the impact of the pandemic was unevenly distributed among the different modes, with rail experiencing larger decreases for both freight and passenger travel than road.

Facilitating the modal shift towards rail for both passenger and freight transport would greatly contribute towards emissions reductions in the EU's transport sector. High-speed rail (HSR) in particular has significant decarbonisation potential, with up to 90% fewer emissions compared to driving or flying (Chen et al., 2021). The International Energy Agency's (IEA) Future of Rail report highlights the potential benefits of investing heavily in all forms of rail travel, including metros and trams. For instance, greenhouse gas (GHG) emissions in a scenario with high rail-use would be reduced by 2.1 GtCO2e 2050 compared to the current baseline, and there are lower particulate matter emissions, less energy demand, and decreased congestion (IEA, 2019). And while the required infrastructure investments are substantial, they can unlock the value of land surrounding railroads and stations, and reduce expenditure for fuel and road/parking infrastructure, making rail a more attractive investment.

Unfortunately, the EU is not fully utilising the potential of railways. This is broadly reflected in the financing and infrastructure investments for transport: between the years 2000 and 2018, the EU, UK, Norway, and Switzerland collectively invested more in road infrastructure (EUR 1341 billion) than in rail (EUR 843 billion) (Schmidt & Curic, 2021).

Within the EU, the development of transport links between member states is financed through the Cohesion Fund (CF) and the European Regional Development Fund (ERDF). For the financing period between 2014 and 2020, EUR 33.7 billion was allocated for roads, while EUR 19 billion was for rail.

There is no blueprint or historical precedent for the energy transition. But the EU can learn from other countries that have already taken steps towards transformative change across multiple sectors. While many experiences cannot be directly transferred to the EU's circumstances, it is

possible to understand the mechanisms that have worked in other countries and regions, and the enabling conditions that have allowed them to function.

This report looks at how Japan and Switzerland improved their railway systems, and what learning lessons can be applied to the EU context. This is a condensed version of a longer-form report entitled What can the EU learn from non-EU countries on its path to climate *neutrality*?.

2. EU railway policy: challenges and alternatives

While the EU is making some headway towards increasing the share of rail transport, particularly through committing greater funds to infrastructure development, it is not nearly enough to elicit the transformative modal shift that is necessary to effectively decarbonise the sector. In addition to there being more funding for the construction of roads than railway lines, the EU is facing a decline in active rail lines: between 2012 and 2019, the total length of serviceable rail lines decreased by more than 2000km.

The following deficiencies and challenges can be highlighted in the current state of EU railway policy-making:

1. There is no possibility of a top-down approach to mandate or implement the construction of railway infrastructure. Likewise there isn't a system to design a network of transboundary long-distance trains and bring them into operation (Treber, 2022). The European Railway Agency's (ERA) mandate relates solely to the certification of train safety and the implementation of the European Rail Traffic Management System (ERTMS), but the member states are responsible for the construction of infrastructure, and decisions on how and when to spend European infrastructure funding. This leads to a prioritisation of national interests over international ones (Witlox et al., 2022).
2. The fragmentation of EU railways policy to the national level leads to severe coordination and compatibility issues. The lack of a common language and differing technical train protection and control systems are but one side of the problem of interoperability. EU passengers are unable to book travel that requires multiple connections across various providers, whereas booking a plane ticket across multiple stops and providers usually requires just one stop. There are also few cross-border connections with a through-train service, requiring passengers to switch trains when crossing borders and reducing the convenience of such a journey, particularly when navigating different rail systems of neighbouring EU member states (Witlox et al., 2022).
3. The amount of public funding available is insufficient to effect the transformative change necessary for decarbonisation. The Connecting Europe Facility (CEF) only has EUR 26 billion available for railways for the period 2021 to 2027, and the EUR 85 billion for railway infrastructure in the framework of the Recovery and Resilience Fund (RRF) has to be spent by 2026, resulting in a focus on short-to-medium-term improvements.

4. EU member states are progressing at varying speeds: Poland makes greater use of the CEF for railway projects than any other member state, at EUR 6.3 billion for the 2014 to 2020 period (Schmidt & Curic, 2021). However, there are no minimum targets set for individual member states.

A need exists for a unified, top-down approach in railway governance at the EU level which can set rules and targets, both for infrastructure development and harmonisation of the sector from an operability and customer-facing perspective. There is also a need to provide requisite public financing for rail infrastructure, increase the share of rail in the modal mix, and decarbonise the transport sector faster.

3. Railway privatisation in Japan

Japan's railway system is managed by a privatised approach, very much different to that of the EU. Companies function along the lines of market-based competition, working towards the integration of infrastructure, management and train operation. Since the 1980s, privatisation of state-owned enterprises has been a global practice, with the goal of improving their performance and profitability coming with mixed success. It was against this background that the pressure to privatise the state-owned Japan National Railways (JNR) took place.

In April 1987, JNR was privatised, and the passenger section was divested into six regional joint-stock companies, with the government retaining a significant ownership stake. The distribution of roles was made based on the geography and functions, and conducted in a way that would ensure provision of high-quality transport services (Tomikawa & Goto, 2022). As opposed to the railway privatisation experiences in Europe, there was no separation of infrastructure and operation, which allowed these different enterprises to use their assets for the diversification of its business lines (Kim & Huang, 2019).

The Japanese approach to railway privatisation had six distinguishing features:

1. horizontal separation (or regional subdivision),
2. functional distinction (or passenger-freight distinction),
3. vertical integration (or operation and infrastructure integration),
4. lump-sum subsidies for low-density JRs,
5. the establishment of the Japanese National Railway Settlement Corporation (JNRSC) as an intermediary institution, and
6. allowance of non-rail service (e.g. bus operation or real estate development close to train stations) (Mizutani & Nakamura, 1997).

Combined, these features allowed for a significant increase in flexibility of the railways, while simultaneously ensuring that all regions continued to benefit from the railways' availability. To get there, the first step involved reducing the government's control of the railways system. This framework was expected to eliminate unnecessary outside interference, establish management autonomy, and clarify management responsibility (Mizutani & Nakamura, 1997; Tomikawa & Goto, 2022).

Figure 1: Geographical division of Japanese rail companies

Kurosaki & Alexandersson, (2018)

After consideration of several options for separation, regional subdivision by geographical demand was decided upon with the smaller, subdivided companies expected to meet their users' local needs, and to compete with each other to improve their performance (Mizutani & Nakamura, 1997). Accordingly, the JNR was divided into six vertically integrated regional passenger companies, and a single vertically separated nation-wide freight company, JR Freight — their business areas are reflected in Figure 1 above (Kurosaki & Alexandersson, 2018).

As a result of the privatisation, Japanese railway companies own the infrastructure, rolling stock, and other equipment, taking primary responsibility for their finance and management, especially regarding the procurement of new rolling stock. However, the government also plays an important role in providing a master plan for their long-term development and creating the necessary policy framework for railway construction by offering subsidies for the construction of new railways, particularly within urban centres and for high-speed rail. It also ensures that the railway companies meet high safety and security standards, and create a user-friendly railway system (Ministry of Land, Infrastructure, Transport and Tourism, 2008).

Discussion

The JNR privatisation and subsequent reforms resulted in Japanese railways being among the best in the world. This is demonstrated by Japanese railways exhibiting remarkable performance levels by international standards in terms of profitability (Mizutani & Shoji, 1997), punctuality and track capacity usage, and customer-orientation (van de Velde, 2013). This is reflected in the high utilisation rate, density of the railway network, reliability, and state-of-the-art character.

Japanese trains are globally renowned for their punctuality, despite tightly packed schedules and greater track utilisation rates than their European counterparts. Over the period of 1997 to 2010, over 95% of journeys on JR trains arrived within five minutes of their scheduled arrival time, on average, compared to a 90% figure for the EU (van de Velde, 2013).

The punctuality of Japanese trains can be attributed, in part, to the specific character of horizontal separation that has taken place since the privatisation of JNR. Unlike the European model of vertical separation, whereby the operator of rolling stock has access to the railways of another company in exchange for a fee, the Japanese model necessitates that each vertically integrated railway is responsible for train operation only within its own network (Kurosaki, 2016). As a result, journeys which go through multiple company jurisdictions are completed by switching conductors at a border station. Each company is only responsible for managing trains on its own infrastructure, meaning that conductors are familiar with the tracks on which they are running. Further contributing to the timeliness of Japanese trains is the complete separation of HSR and regional/local rail lines.

This system makes through-train services convenient, a frequent pain point for European travellers who must often switch trains when crossing borders (Witlox et al., 2022). For example, travel through the Tokyo Metro is streamlined by through-train services managed jointly with other vertically integrated companies. HSR trains between major Japanese cities cross these boundaries multiple times a day in either direction. Although it is difficult to make a direct comparison between company jurisdictions in Japan and the borders between EU member states, the Japanese system enables convenient and frequent cross-jurisdiction travel, whereas in the EU only an estimated 7% of all rail travel is cross-border (De Feo & Ferrari, 2021).

The ease of travel across different JR regions in Japan, as exemplified by through-train services from one region into another, lends itself to a high level of convenience for passengers and customer satisfaction. While a streamlined regulatory environment is important to achieving high satisfaction rates, improved regulations must be accompanied by higher investments. Financial support from both the public and private sectors towards infrastructure improvements have allowed Japan to expand its railways expansion as efficiently as it has. This is worth keeping in mind for EU decisionmakers, at cross-border connections which are often not prioritised by national governments in the EU.

Lastly, the dominance of vertically integrated rail companies has been critical to the success of the Japanese approach. By allowing companies to own tracks and stations along with the trains,

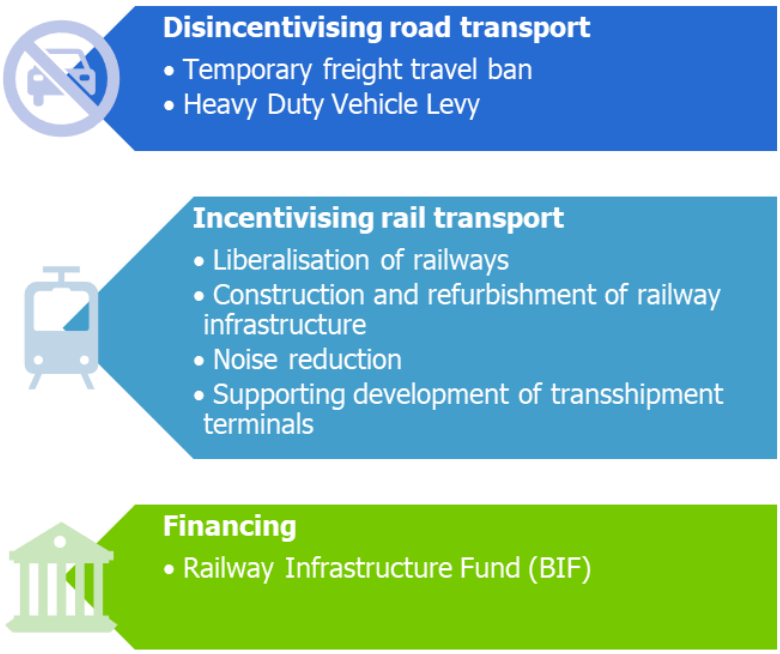
there is a greater incentive to make long-term investments in the infrastructure. As the companies are more proactive in maintaining the infrastructure, regular inspections and upgrades contribute to passengers' overall safety.

4. Swiss railways development

The development of the Swiss railways system has been determined by five main drivers:

1. The Rail 2000 programme created a framework that determined the goals and general framework for railway development in the coming decades.
2. Complementary ambitious infrastructure projects, some of which were not explicitly listed in the initial Rail 2000 programme.
3. The necessary funding for both the implementation of the Rail 2000 programme and the additional infrastructure projects.
4. Regulation to dissuade road freight came from additional charges on road freight transport, and numerous limits and bans for this mode of transport.
5. Finally, decentralisation of railways governance meant that the needs of local communities are met by rail, instead of the road network.

Figure 1: Five drivers of Swiss railways development



In 1985, the Federal Department of Environment, Transport, Energy, and Communications presented a draft of the Rail 2000 programme, which aimed to significantly develop the railways infrastructure in Switzerland to make it faster, increase the frequency of the connections, and to

make it more comfortable for passengers. To achieve these goals, the programme included, among others, the construction of new railway tunnels at the Saint-Gotthard and Lötschberg massifs, connection to the European high-speed network, the complete noise remediation of the trunk line network, and new financing to extend the system.

It also suggested a new timetable system for smoother connections, according to which trains would serve stations at the same minute every hour or half hour to allow better accessibility throughout Switzerland. This "clock-face scheduling" would minimise passenger waiting times, provide schedule alignment, and reduce overall travel times, while allowing trains to serve more stations (Swiss Parliament, 1986). The Rail 2000 project amounted to investments of CHF 30 billion over 20 years, making it the largest single extension and modernisation project in Swiss rail history at the time (Desmaris, 2014; Keller et al., 2008).

To fund the infrastructure initiatives, a heavy-duty vehicle levy (LSVA) was put in place that charges freight vehicles by their weight and distance travelled (Jörling, 2018). The rate was fixed by the federal council and the fee could be a maximum of CHF 0.03 per tonne per kilometre (Epiney & Heuck, 2012). A percentage of revenue from the LSVA (which generates around EUR 1.5 billion annually) is rerouted to further fund rail operations and infrastructure development. This makes it different from the heavy-duty levies in neighbouring European countries, which primarily route toll revenues back into road infrastructure (Jörling, 2018).

Federal railway subsidies rose during the 1990s, but stabilised between 1999 and 2008 (Keller et al., 2008). In 2022, Swiss Federal Railways (SBB) reported net profits of almost EUR 2.5 billion (Burroughs, 2023). In 2012, through a legislative initiative discussed in parliament, a new simplified way to finance railway infrastructure through a single fund, the Bahn-Infrastruktur-Fonds (BIF), was introduced as part of a proposed Financing Building of Rail Infrastructure programme (FABI) (Federal Office of Transport, 2020).

Discussion

Swiss rail policy has succeeded in shifting more of its overall transportation from roads to railways since the 1990s. This modal shift has achieved emissions reductions and reduced congestion on Swiss roads. Such a shift would have been highly unlikely without the hundreds of infrastructure expansion projects, larger wagons, and other accomplishments made under the first phase of Rail 2000. Within Phase one of Rail 2000, the average train-kilometres per day was increased by 14%, to 337,000 kilometres, and the introduction of the hub system (which improves coordination between different forms of transportation at strategic points) reduced travel times between Swiss cities to 70% of their original travel time requirements in some cases (SBB, 2004).

Between 1996-2008, long-distance public transport journey times reduced by 7%, compared to only 4% by individual vehicle transportation. This is significant as customers' tend to have a greater sensitivity towards train frequency and journey times in comparison with other transportation variables (Keller et al., 2008). 8% of railway transportation growth can be

attributed to timetable changeover from 2004-2005. The Lötschberg tunnel saw a 74% increase in passenger numbers between 1999 and 2016 and a 408% increase in goods transportation volumes in the same time period (BLS, 2017). Furthermore, not only is the share of Switzerland's rail-based traffic considerably higher than the EU average, rail is already almost fully electrified (Treber, 2017).

The strong financial support towards rail operations has contributed to successes. For instance, Switzerland spends five times more per capita on railway than its neighbour, Germany (Wüpper, 2021). Funding has been aimed towards both small and large infrastructure investments, as well as research and assessments. The shift of revenue from road traffic to rail investment is a unique and valuable element of transport policy that can serve as a lesson for other countries.

Though not directly related to the modal shift, it is likely that the liberalisation of rail infrastructure helped to make rail use more attractive. The vertical integration of the Swiss system allows for exceptional performance and is often cited as such. Other countries often praised for their rail systems, like Japan, also have vertically integrated rail systems.

However, challenges still exist which are of direct relevance to the EU. As a landlocked country, Switzerland is strongly affected by neighbouring countries. In 2007, 64% of freight measured in tonnes came through the Swiss Alps via railway, in contrast to neighbouring France and Austria, where the majority of freight was transported by road (Federal Department of Home Affairs, 2022e).

Further modal shifts are limited when neighbouring countries are not able to enforce stricter regulations on freight road transportation or achieve as efficient services. Freight that must cross between neighbouring countries may then require "combined transport" for most efficient transportation costs, in which the mode of transport for cargo is offloaded from road to rail or vice versa in its journey (Federal Department of Home Affairs, 2022e). Such a mismatch leads some companies to avoid transportation through Switzerland or to continue with road use in consideration of the greater journey. Greater coordination and a complementary transportation shift within the EU would therefore accelerate not only the EU's modal shift, but Switzerland's as well.

5. Lessons learned for the European Union

The identified case studies offer several lessons that could facilitate an increase in the use of railways in the EU (Treber, 2021). These can be grouped into three main categories: (1) further Europeanisation of railways governance; (2) increasing public funding for infrastructure development and provision of transport services; (3) setting minimum targets for railways development for the EU member states.

While both case studies highlight the various accomplishments of vertically integrated systems in Japan and Switzerland, EU policy relies on the separation of infrastructure and operation with

right-of-access laws. However, multiple aspects of Japan and Switzerland's railways policy are unrelated to their vertically integrated structure, and more easily replicable within the EU. Both case studies show the impact of top-down governance on railways development. This feature is missing in the EU.

While the European Railway Agency (ERA) has already facilitated train operations across different countries by standardising safety and operational requirements, its role is mostly technical. The Connecting Europe Facility does fund the development of railway infrastructure, with around EUR 26 billion for 2021 to 2027. Unfortunately, the budget is far less than what is needed to develop the infrastructure and operate connections that are not (yet) economically viable but are necessary for modal shift from aviation and road transport (Treber, 2021).

In the framework of the Recovery and Resilience Funds submitted by the member states, an additional EUR 85 billion is to be invested in railways, but most of the investments are to be executed by 2026, resulting in much needed but short-term infrastructure improvements, to the detriment of more long-term planning.

To make European railways compatible with the bloc's climate ambitions, the ERA's competences and resources should be significantly expanded. Alternatively, it could be incorporated into a new European Railways Research, Investments, and Information Agency. Its responsibilities could include:

- Developing more comprehensive planning of railways infrastructure, which would take into consideration not only existing but also future mobility needs.
- Co-funding development of transboundary connections — both in terms of regional trains as well as long-distance connections.
- Facilitating research that would allow faster decarbonisation of railways stock and development of rapid trains.
- Ensuring better coordination between timetables for intercity connections to make journeys across different countries more efficient, and therefore more competitive with aviation.
- Developing a pan-European booking system that would allow seamless train booking across the EU and, whenever possible, beyond.

The issue of funding railway infrastructure and operating unprofitable but essential connections constitutes another lesson learnt from the non-EU case studies. In order to meet the EU's "climate neutrality" goal, a massive modal shift from intra-EU aviation and road transport is needed. This can only be realised through significant infrastructure investments — ones which not only take current needs into account, but also satisfy (and promote) future demand. Such investments need to be covered to a large extent by public resources — as was the case for road transport.

While, the EU and its member states provide some funding for selected projects, to ensure a lasting scale-up of construction capacities a steady flow of funding needs to be ensured. In Switzerland, some of the funding of the railway infrastructure comes from taxing road freight transport. At the EU level, such an approach could also include fees on aviation, thus resulting in a bonus-malus system accelerating the necessary modal shift.

Such a modal shift would also increase the popularity of connections that, due to low occupancy, would not be initially profitable, but necessary to replace other modes of transport. Before this happens, such connections need to be subsidised from public resources (Treber, 2021), which increases the need for a more permanent funding scheme.

Finally, as is the case in other policy areas, especially the electricity sector, the EU should be empowered to introduce initially "indicative", later mandatory, targets for the role of railways in the transport sector. To increase the acceptance of these targets among member states, they should be supported by funding. Such targets could consider some of the following indicators, focusing on infrastructure and travel quality (Treber, 2017):

- Density of the railways network (e.g., km / 1000 citizens);
- minimum average speed of intercity trains;
- increasing the share of rail passenger-kilometres in the modal split for intra-EU trips;
- share of settlements above 1000 inhabitants with at least x train connections; and,
- share of electrification of the railways.

To reflect member states' different starting points, the targets, as well as the corresponding funding, should be adapted to the respective circumstances.

Introducing these changes, particularly those focused on increasing the ease of cross-border rail travel – among many others more specific to the national and local circumstances — is essential for rail to compete with carbon-intensive modes of transport, especially car and intra-EU aviation. In addition, faster and more reliable train connections could decrease activity levels for extra-EU aviation by providing an attractive alternative for extra-EU travel.

6. Conclusions

The rise of the personal vehicle and air travel have posed many challenges to rail transport networks in the EU, resulting in fewer train services, lower investment in rail, and rising greenhouse gas emissions from transport. Counteracting this trend is key to achieving carbon neutrality and provides additional benefits in the form of cleaner air, lower congestion, and easier commutes.

The EU's existing policy framework provides funding for member states to invest in their rail networks, as well as technical guidance allowing trains to safely operate across borders. On its own, this is insufficient to provide the transformative change necessary to effectively decarbonise the transport sector. As the case studies from Japan and Switzerland demonstrate, regulatory changes and large investments are needed to cut journey times, provide a seamless travel experience, and allow trains to compete with cars and planes. In turn, EU citizens will be able to easily commute to work, visit family over long distances, and travel to new destinations while the EU moves closer to carbon neutrality.

The current energy crisis gives further impetus to improving rail networks; with oil prices higher than they've been in years, many citizens find themselves unable to afford driving to work, while also lacking viable public transport alternatives.

While the privatisations in Japan were designed to wean the JR companies off government support for operational costs, it is a combination of regional and national government with private funding that allows rail companies to build new infrastructure and open new lines, as well as maintaining locally important, yet unprofitable, connections. Switzerland has likewise seen the importance of heavily investing in infrastructure, creating a financing scheme akin to a "polluter pays" principle that further makes rail transport more appealing.

Railways in the EU experienced manifold challenges in 2022. To alleviate the cost-of-living crisis, many governments provided financial support to incentivise public transport and rail travel. Germany's provision of a nationwide, subsidised ticket has provided insight into both the decarbonisation potential of railways, and the investments needed for them to be viable alternatives to personal vehicles: millions of tonnes of CO_2 emissions were avoided and the ease of a single ticket for the whole country without having to navigate multiple regional ticketing options proved popular. However, users reported crowded trains and having to switch multiple times, indicating the importance of infrastructure investments.

Learning lessons for improving the bloc's railways system can therefore come both from outside the EU as well as from within. A proper governance structure at the EU level, and requisite funding both to expand infrastructure and provide streamlined cross-border connections with simple ticketing options will go a long way towards increasing rail use. In turn, the EU and its member states can greatly benefit from an increase in rail ridership, lower congestion and GHG emissions, and a more connected citizenry.

References

BLS. (2017). *Lötschberg-Basistunnel*. BLS AG. https://www.alptransit-portal.ch/Storages/User//Meilensteine/Pin_072/Dokumente_072/Loetschberg-Basistunnel-BLS-Gesamtschau.pdf

Burroughs, D. (2023, March 1). SNCF reports €2.42bn profit in 2022 as revenue surpasses €41bn. *International Railway Journal*. https://www.railjournal.com/financial/sncf-reports-e2-42bn-profit-in-2022-as-revenue-surpasses-e41bn/

Chen, P., Lu, Y., Wan, Y., & Zhang, A. (2021). Assessing Carbon Dioxide Emissions of High-Speed Rail: The Case of Beijing-Shanghai corridor. *Transportation Research Part D: Transport and Environment*, *97*, 102949. https://doi.org/10.1016/j.trd.2021.102949

De Feo, G., & Ferrari, L. (2021). *More and more trains crossing European borders*. European Data Journalism Network. https://www.europeandatajournalism.eu/cp_data_news/more-and-more-trains-crossing-european-borders/

Desmaris, C. (2014). The Reform of Passenger Rail in Switzerland: More Performance Without Competition. *Research in Transportation Economics*, *48*, 290–297. https://doi.org/10.1016/j.retrec.2014.09.055

Epiney, A., & Heuck, J. (2012, November). *Environment and Land Transportation Law*. Avosetta Meeting, Fribourg. avosetta.oer2.rw.fau.de/switzerlandnationalreport.pdf

Eurostat. (2022a). *Air Passenger Transport by Reporting Country*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/AVIA_PAOC__custom_3345192/default/table

Eurostat. (2022b). *Goods Transported*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/RAIL_GO_TOTAL$DEFAULTVIEW/default/table

Eurostat. (2022c). *Passengers Transported*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/RAIL_PA_TOTAL$DEFAULTVIEW/default/table

Eurostat. (2022d). *Summary of Annual Road Freight Transport by Type of Operation and Type of Transport*. Eurostat. https://ec.europa.eu/eurostat/databrowser/view/ROAD_GO_TA_TOTT$DEFAULTVIEW/default/table

Federal Office of Transport. (2020). *Swiss Transport Policy from A to Z*. Federal Office of Transport. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwisnMeUz_j4AhVBX_EDHT-bAXIQFnoECAcQAQ&url=https%3A%2F%2Fwww.bav.admin.ch%2Fdam%2Fbav%2Fen%2Fdokumente%2Fthemen%2Fneat%2Fschweizer_verkehrspolitikvonabisz.pdf.download.pdf%2FSwiss%2520transport%2520policy.pdf&usg=AOvVaw14pRdEL8EuQYMzSWEBREh7

IEA. (2019). *The Future of Rail*. 175.

Jörling, K. (2018). *Modal Shift Policy in Switzerland* [Fact Sheet]. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. https://www.euki.de/wp-content/uploads/2018/09/fact-sheet-modal-shift-policy-ch.pdf

Keller, M., Frick, R., & Sager, F. (2008). Rail 2000: Infrastructure Modernization in the Light of the National Transport Policy. *Flux*, *7273*(2), 65–77.

Kim, C.-J., & Huang, M. C. (2019). *The Privatization of Japan Railways and Japan Post: Why, How, and Now* (Japan; Issue 1039). Asian Development Bank. https://www.adb.org/publications/privatization-japan-railways-japan-post-why-how-and-now

Kurosaki, F. (2016). Reform of the Railway Industry and Achievement. *Network Industries Quarterly*, *18*. https://www.network-industries.org/wp-content/uploads/2019/07/NIQ-Vol-18-No-4-2016.pdf

Kurosaki, F., & Alexandersson, G. (2018). Managing Unprofitable Passenger Rail Operations in Japan—Lessons from the Experience in Sweden. *Research in Transportation Economics*, *69*, 460–469. https://doi.org/10.1016/j.retrec.2018.07.019

Ministry of Land, Infrastructure, Transport and Tourism. (2008). *Railway Regulation in Japan*. http://mddb.apec.org/documents/2008/EC/SEM1/08_ec_sem1_006.pdf

Mizutani, F., & Nakamura, K. (1997). Privatization of the Japan National Railway: Overview of Performance Changes. *International Journal of Transport Economics*, *24*(1), 75–99.

Mizutani, F., & Shoji, K. (1997). A Comparative Analysis of Financial Performance: U.S. and Japanese Urban Railways. *International Journal of Transport Economics*, *24*(2), 207–239.

SBB. (2004). *Rail 2000—A Public Transport Network for the Third Millennium*. SBB Swiss Federal Railways. https://web.archive.org/web/20040624110841/http:/www.bahn2000.ch/pdf/sbb_summar%09y_e.pdf

Schmidt, A., & Curic, N. (2021, November 19). Datenanalyse: Unzureichende Investitionen in Bahninfrastruktur [Data Analysis: Insufficent Investment in Rail Infrastructure]. *Investigate Europe*. https://www.investigate-europe.eu/de/2021/entgleist-datenanalyse/

Swiss Parliament. (1986). *Bericht über das Konzept BAHN 2000 und Botschaft über den Bau neuer Linien der Schweizerischen Bindesbajnen vom 16. Dezember 1985 [Report on the BAHN 2000 concept and message on the construction of new lines of the Swiss railways from 16 December 1985]* (10 027 245; Bundesblatt). The Swiss Parliament. https://www.parlament.ch/centers/documents/de/do-bahn-2000-85-074-bericht.pdf

Tomikawa, T., & Goto, M. (2022). Efficiency Assessment of Japanese National Railways Before and After Privatization and Divestiture Using Data Envelopment Analysis. *Transport Policy*, *118*, 44–55. https://doi.org/10.1016/j.tranpol.2022.01.012

Treber, M. (2017). *Nicht erst seit der Dieselkrise: Der Schienenpersonenverkehr ist ein Schlüssel zum Erreichen des 2030-Emissionsziels im Verkehr [Not Only Since the Diesel Crisis: Passenger rail is a key to meet 2030 transportation emissions goals]*. Germanwatch. https://www.germanwatch.org/de/14180

Treber, M. (2021). *Klimaschutz und Konnektivität: Die große Transformation im europäischen Schienenpersonenfernverkehr [Climate protection and connectivity: The great transformation in European long-distance passenger rail transport]*. Lecture H_01 at the Autumn Meeting of the AKE (Arbeitskreises Energie) of the German Physical Society, Bad Honnef. http://www.fze.uni-saarland.de/AKE_Archiv/AKE2021H/Links_AKE2021H.htm

Treber, M. (2022). *TEE 2.0 und EUROPATAKT: Den Schienenverkehr gegenüber dem Flugverkehr attraktiver machen [TEE 2.0 and EUROPATAKT: Making rail transport more attractive than air transport]*. Facebook. https://www.facebook.com/media/set/?set=a.3360374850697697&type=3

van de Velde, D. M. (2013). Learning from the Japanese railways: Experience in the Netherlands. *Policy and Society*, *32*(2), 143–161. https://doi.org/10.1016/j.polsoc.2013.05.003

Witlox, F., Zwanikken, T., Jehee, L., Donners, B., & Veeneman, W. (2022). Changing tracks: Identifying and tackling bottlenecks in European rail passenger transport. *European Transport Research Review*, *14*(1), 7. https://doi.org/10.1186/s12544-022-00530-9

Wüpper, T. (2021, August 4). Deutschland gibt weiterhin wenig für die Schiene aus [Germany continues to spend little on rail]. *Der Tagesspiegel Online*. https://www.tagesspiegel.de/wirtschaft/schweiz-investiert-fuenf-mal-mehr-deutschland-gibt-weiterhin-wenig-fuer-die-schiene-aus/27482790.html

About the project

4i-TRACTION – innovation, investment, infrastructure and sector integration:
TRAnsformative policies for a ClimaTe-neutral European UnION

To achieve climate neutrality by 2050, EU policy will have to be reoriented – from incremental towards structural change. As expressed in the European Green Deal, the challenge is to initiate the necessary transformation to climate neutrality in the coming years, while enhancing competitiveness, productivity, employment.

To mobilise the creative, financial and political resources, the EU also needs a governance framework that facilitates cross-sectoral policy integration and that allows citizens, public and private stakeholders to participate in the process and to own the results. The 4i-TRACTION project analyses how this can be done.

Project partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement **No. 101003884**.