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The environmental impact of a shift to rail from short-haul flights

Kees van Goeverden[1]

Abstract: *In the context of mitigating climate change, a shift from air to rail is proposed for short-haul journeys. The impact of this policy on the GHG emissions of aviation is small and will be even marginal if only journeys < 500 km are involved. These journeys account for 2.2% of the mileage of air travel, and the impact on emissions will be even smaller than this figure, mainly because not all air travellers (likely) will shift, and part of the emission reduction will be undone by increasing emissions of rail transport. When the upper limit of involved distances increases, the impact increases significantly as well; but even at a limit of 1200 km, which is about the upper limit of the market range of the train, the impact will likely be smaller than the opposite impact of the annual growth of air travel. Policy intentions seem to be prompted by just to do something that doesn't hurt people so much rather than by a systematic analysis of possible measures and their effectiveness.*

Keywords*:* modal shift, short-haul travel, airplane, train, climate change

1. Introduction

Increasing concern on climate change tempts policymakers into proposing initiatives to reduce greenhouse gas (GHG) emissions, among others in the transport sector. Transport contributes significantly to climate change. In Europe, transport accounted for 25% of the GHG emissions in 2018, shortly before the COVID-19 pandemic (European Environment Agency, 2020). The European Green Deal includes the objective of reducing GHG emissions from transport by 90% by 2050 compared with 1990. The main contributors are road transport, marine transport and aviation with respective shares of 72%, 14%, and 13%. Zooming in on passenger transport, the private car and airplane are the main contributors. Policy initiatives to reduce GHG emissions are electrification of the car and inducing a shift from short-haul air travel to rail.

The paper discusses the potential of a shift from air to rail for reducing GHG-emissions. The first question to be answered is: to which extent can GHG emissions by aviation for short-haul passenger travel be reduced by a shift to rail? It is evident, that the answer depends on what is 'short-haul', that is: what is the upper limit of the distance range where the train is competitive? Therefore, we address a second research question: what is a valid upper distance limit for a shift from air to rail?

We are aware of just one other study that addresses this topic. Dobruszkes et al. (2022) calculate in an elaborated study that in Europe short-haul flights account for 6% (5.9%) of fuel burnt, assuming an upper limit of 500 km. The conclusion is, that the impact of a shift to rail is small. If all short-haul flights would be banned, the impact on the emissions would be even smaller than 6%, because the reduction of emissions by aviation will partly be undone by an increase of the emissions from alternative travelling. The latter results partly from a shift to other modes, and partly from a shift from short-haul air travel to long-haul air travel. One of the functions of short-haul flights is connecting to long-haul flights. Some long-distance travellers that currently use short-haul flights as an access mode to longer flights, will shift to a more nearby airport

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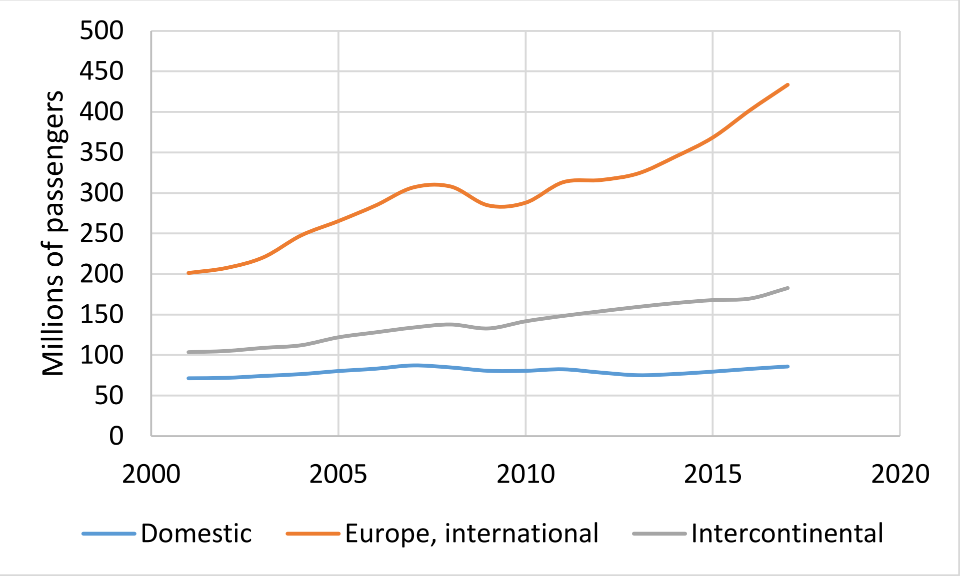
for entering long-haul flights, so increasing the mileage travelled by the latter. This implies that even the reduction of the emissions by air are less than 6%.
The analysis of Dobruszkes et al. (2022) concerns the supply side of the transport market. We propose an approach that starts from the demand side. The starting point is not the contribution of short-haul flights to GHG emissions, but the mileage of air travellers to destinations within the distance limit. Knowledge on the proportion of the latter in the total mileage by air is valuable input for a more accurate estimation of the impact of a policy that aims at a shift from air to rail. One may hypothesise that the proportion of mileage by air for journeys < 500 km is smaller than 6%.
The data that we use for the demand-based analysis are explained in Section 2. Section 3 discusses the upper distance limit of the train market, which regards research question 2. Knowledge about the upper limit is useful for answering research question 1 that is subsequently discussed in Section 4. Section 5 includes a discussion of the results.

2. Data

The main source for the demand analyses is the corrected and updated version of databases of the Dateline project. Dateline was a large survey on long distance travelling by European residents and was carried out in 2001/2002 in 16 countries: the 15 EU-countries at the time (mainly in Western Europe) and Switzerland. It was one of the projects in the 5th framework programme of the EU. The survey has since never been repeated EU-wide. The Dateline survey was a complex project performed by many organizations, and was bound to produce a number of errors. We corrected two types of errors: data errors and reporting errors. Data errors result from incorrect coding/entering and handling data, like a wrong selection of a location from a list of different locations that have the same name. We explained the corrections in Van Goeverden et al. (2014). Reporting errors are a well-known problem in long-distance travel surveys (Kuhnimhof et al., 2009) and have been observed for Dateline as well (Hautzinger et al., 2005). Long-distance journeys are rare events and in retrospective surveys, like Dateline, respondents are asked to report the journeys they made in a rather long period. They may not recall all journeys, implying underreporting. We analysed the recall effects in Dateline and developed new expansion factors that should correct for this problem (Van Goeverden et al., 2016). We also refined the grossing up of respondents. Originally, grossing up responding persons was performed by NUTS1-region. We observed in such large heterogeneous regions (frequently both with urbanized and rural areas) large differences in response. We refined the grossing-up procedure and choose the smaller and more homogeneous NUTS3-regions as the spatial basis.
The Dateline survey was conducted more than 20 years ago and the data are rather outdated. We made an update of the data to 2017, picturing the pre-COVID situation. The update is based on statistics on the growth of tourist travel and patronage of long-distance modes. The procedure is reported by (Van Goeverden et al., 2016) who made an update to 2013.
The most spectacular trend was a huge increase of international air travel (Fig. 1). Because domestic air travel was stable, the proportion of short-haul trips is decreasing and the shift-to-rail policy is likely becoming less effective.

Figure 1 : Trends in air travel by residents of the Dateline-countries



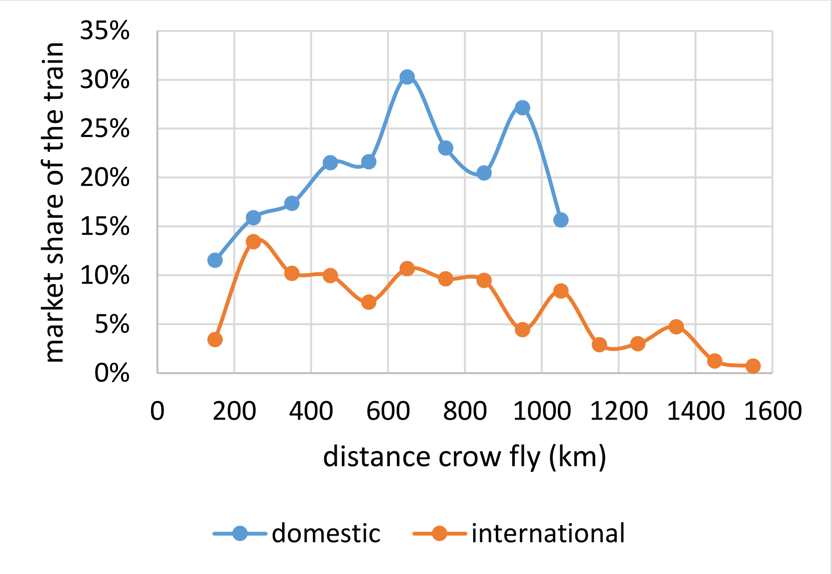
3. <u>The upper limit of the train market</u>

Investigation of the first research question about the GHG emissions by aviation for short-haul passenger travel demands for knowledge on the upper limit of the train market. This is the topic of the second research question. Therefore, it is better to start with addressing the second question.

In discussions about shift to rail in various media, usually distances of 500 km or 600 km are mentioned by stakeholders as the upper limit for shifts. The explanation why a limit is chosen is generally missing. Dobruszkes et al. (2022) set the limit at the distance where travel times by air and rail are similar; the resulting distance is 500 km. This approach does not account for other variables that affect the modal choice, like general preferences for air or rail. Such preferences may influence the accepted maximum distance of the train. And the approach neglects the highly efficient time use in night trains (travelling when sleeping).

We analyse the distance range for which the train is competitive. The upper limit of this range would be the upper limit for shifts from air to rail as well. Fig. 2 shows the market shares of the train by journey distance for both domestic and international journeys. Only journeys within Europe that have not to overcome an important sea barrier are selected (e.g. no journeys to the Canaries or Crete). The source is Dateline. We use the 2002 data unlike the update to 2017, because in 2002 a large network of night train services was operated. In 2017 nearly all services had been discontinued which will have lowered the competitiveness of the train significantly on larger distances. Then the figure shows the proven competitiveness in the case of an extensive night train network.

Figure 2 : Market share of the train by distance class in 2002



Focusing on the graph for international journeys –the only graph that has observations > 1100 km– we see a strong increase of the market share up to 200 km, then a stable share up to 900 km (except for a peak between 200 and 300 km and a dip between 500 and 600 km), and then a gradual, somewhat fluctuating, decline to about 1500 km when the share has become marginal. The peak between 200 and 300 km can be explained by the exceptional high market share (70%) on the Brussels-Paris route. Journeys by train on this route account for 30% of all international train journeys between 200 and 300 km. If journeys on this route are left out, the train share in international journeys between 200 and 300 km will be slightly lower than those between 300 and 400 km. The dip between 500 and 600 km could mark the transition from the day train market to the night train market.

The figure gives no evidence for a clear upper limit of the train market. The limit should be set at least at 900 km, but a somewhat higher value, somewhere between 900 km and 1500 km, seems more appropriate. If one has the opinion, that the train certainly is competitive on distances between 100 and 200 km (market share 3.4%), a value between 1100 and 1400 km could be chosen; the market shares in this distance range are in the same order. Anyway, the limit should be substantially higher than the most frequently mentioned limits of 500 or 600 km. In this paper, we choose 1200 km as the upper limit.

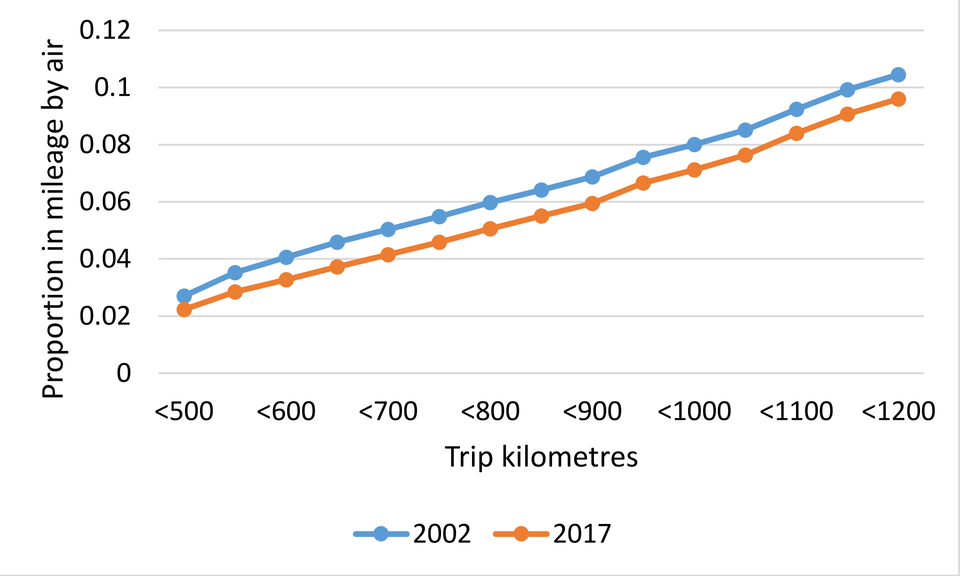
We add two comments on the analysis. First, the market share of the airplane for international journeys (not shown in Fig. 2) is continuously increasing from the start at about 300 km, except for a flattening of the curve between 700 and 900 km, possibly indicating the competitive strength of night trains for air travellers. Therefore, competitiveness of the train for air travellers is mainly decreasing at increasing distance. Policy measures that aim at a shift from air to rail may be less effective for the larger travel distances where the train is still competitive, but nevertheless, they are likely to induce some air travellers to shift to the train.

Second, the upper limit can be extended significantly by the introduction of a high-speed night train network. Then the limit will be between 2000 and 3000 km.

4. The mileage of short-haul travel by air and the impact on GHG emissions

The analysis of the impact of a shift from air to rail for short-haul journeys starts with the assessment of the proportion of the mileage of these journeys in the mileage of all journeys by airplane. This proportion is correlated with the upper limit of 'short-haul'. Fig. 3 shows the proportions for journeys by residents of the Dateline-countries in 2002 and 2017, for upper limits of 500 km up to 1200 km.

Figure 3 : Proportion of mileage short-haul journeys by air against trip length in 2002 and 2017



The figure reflects the finding in Section 2 that the proportion of short-haul journeys is decreasing in time. Moreover, the proportions are small. Taking the frequently proposed upper limit of 500 km, the mileage travelled for short-haul journeys by airplane was in 2017 only 2.2% of the mileage of all journeys by air (in 2002, it was 2.7%; today, it may be 2.0% or even less). However, increasing the upper limit goes together with a relatively large increase of the proportion of mileage for short-haul journeys. In 2017, the figures were 3.3% for an upper limit of 600 km, 4.1% for 700 km, 7.1% for 1000 km, and 9.6% for 1200 km. If the upper limit will be increased by introducing high-speed night train services, the proportion will increase to 24-38% (corresponding to upper limits of 2000 and 3000 km in 2017).

The proportions indicate the relative decrease of mileage by air if all air journeys below the upper limit would shift to other modes. Calculation of the impact on GHG emissions demands for knowledge on four other factors.

The first is the proportion of short-haul air travellers that will shift. This proportion depends on the nature of the policy. If all flights shorter than a certain distance are banned, or airlines are not allowed to issue tickets for shorter journeys, 100% of the air travellers will stop flying, though not all will shift to rail; some could shift to other modes or decide not to make the journey (and possibly shift to another journey). If the policy nature is making air travel less attractive and/or more expensive, or train travel more attractive and/or cheaper, a (possibly significantly) smaller number of travellers will shift. One should estimate the proportion of shifted travellers resulting from the proposed policy measures. There are many studies on shifts from air to rail that can help in assessing the proportion of shifting travellers. However, nearly all studies are dedicated to the impacts of high-speed train services (e.g. Givoni and Dobruszkes,

2013, Clewlow e.a., 2014). To the best of our knowledge, studies on the impact of night train services or of improving the accessibility of long-distance trains[2] are missing.
The second factor is the increase of GHG emissions by rail and other alternative modes to which air travellers shift. This increase has to be subtracted from the decrease of emissions by airplanes. Emission figures are provided by European Environment Agency (2020), among others.
The third factor is a possible difference between the emissions by seat km for short-haul flights and long-haul flights. If the emissions are relative large/small for short-haul flights, the impact will be larger/smaller. Some authors have the view that the emissions decrease when the distance increases: "the environmental costs of travelling by air increase less than proportionally because the environmental costs of landing and take-off do not change with distance on a direct flight" (European Environment Agency, 2020, p. 6). However, reality is not so simple. Airplanes have to transport all the fuel they need during the flight, and when the flight length increases, more fuel has to be lifted during the take-off and the environmental costs of the take-off increase. Therefore, it is not true that "the environmental costs of landing and take-off do not change with distance". Additionally, the demands for comfort and space are higher for longer flights implying a somewhat higher energy consumption per seat km. Dobruszkes et al. (2022) did a review on this topic, and this does not reveal a clear association between flight length and fuel consumption per seat km. According to some models, the fuel burnt increases slightly more than proportionally with distance, according to other models the increase is slightly less than proportionally. But in all models, the increase is close to a proportional increase. Neglecting this factor, that is: assuming no association between flight length and emissions per seat km, will likely give accurate results.
The fourth factor is a possible impact on the passenger load factor of airlines. We assume that, if there is any impact, the impact will be small and can be neglected as well.
The conclusion is, that the impact of a shift on GHG emissions can rather accurately be calculated from the figures of the proportion of short-haul air travellers if one can make a good estimate of the proportion of shifting travellers and has information about the extent the decrease of GHG emissions of aviation is undone by the increase of the emissions of the alternative mode(s). If 50% of the air travellers will shift and the emission per person km for the alternative mode is 20% of the emission by air, the decrease of GHG emissions is 0.5*(1-0.2)*the proportion of trip km for short-haul journeys. Assuming an upper limit of 500 km, the decrease is 0.5*(1-0.2)*2.2% ≈ 0.9%. If the upper limit is 1000 km, the decrease is 0.5*(1-0.2)*7.1% ≈ 2.8%.

5. <u>Discussion</u>

Our demand-based analysis supports the conclusion of Dobruszkes et al. (2022) that "targeting shorter flights will contribute little to reducing the impact of aviation on climate, and that policy initiatives that target longer flights are urgently needed" (p.1, abstract). The hypothesis in Section 1 that the analysis will produce lower figures than the supply-based analysis of Dobruszkes et al. is true; our finding is a reduction of about 2% of mileage travelled by air if all journeys < 500 km would shift to other modes, which is significantly lower than the 6% reduction of fuel burnt by airlines if all flights <

[2] Seat reservation is obligatory for most long-distance trains; this lowers the accessibility because trains can be fully booked. The limited accessibility will induce people to shift to other modes, particularly business travellers who frequently have to book shortly in advance.

500 km would be banned. The actual reduction of emissions by airlines can be somewhat higher than 2%, that is, if there is a shift to rail for access trips that take part of long-haul air journeys. The 2% from the demand-based analysis can be considered as the lower limit of the expected effect, the 6% from the supply-based analysis as the upper limit. We guess, that the actual values will be closer to 2% than to 6%. One should note, that these figures are valid for only the emissions of aviation in the case all passengers travelling on distances < 500 km will shift. The actual reduction in emissions will always be lower, because the emissions by alternative modes will increase, and, generally, not all air travellers will shift.

The reduction in emissions is strongly associated with the upper limit of distances involved. If the policy is more ambitious than only targeting journeys shorter than 500 or 600 km, larger reductions can be achieved. The market range of the train that goes up to about 1200 km gives rise to a more ambitious policy. Policymakers have a strong focus on the merits of high-speed trains which compete with airlines on relatively short distances. It is surprising, that they allowed the dismantling of the European night train network. Night trains are competitive on larger distances, and discontinuation of these services is immediately opposite to the objective of shift to rail. The current recovery of some night train services is not policy driven, but results from private initiatives and the strategy of one national railway operator that sees potential in extending its services.

Even if policy measures succeed in a significant shift to rail for journeys up to 1000-1200 km, the impact on GHG emissions is likely lower than the opposite impact of the annual growth of air travel (7-8% in the pre-COVID period). Direct measures that affect the attractiveness or costs of airlines will be more effective than indirect measures that aim at a modal shift. Policy intentions seem to be prompted by just to do something that doesn't hurt people so much rather than by a systematic analysis of possible measures and their effectiveness.

Bibliography

Clewlow, RR, Sussman, JM, Balakrishnan, H, 2014, *The impact of high-speed rail and low-cost carriers on European air passenger traffic*, Transport Policy, vol. 33, pp. 136-143, http://dx.doi.org/10.1016/j.tranpol.2014.01.015

Dobruszkes, F, Mattioli, G, Mathieu, L, 2022, *Banning super short-haul flights: Environmental evidence or political turbulence?*, Journal of Transport Geography, vol. 104, pp. 1-15, https://doi.org/10.1016/j.jtrangeo.2022.103457

European Environment Agency, 2020, *Transport and environment report 2020, Train or plane?*, EEA report No 19/2020

Givoni, M, and Dobruszkes, F, 2013, *A Review of Ex-Post Evidence for Mode Substitution and Induced Demand Following the Introduction of High-Speed Rail*, Transport Reviews vol. 33, no. 6, pp. 720–742, http://dx.doi.org/10.1080/01441647.2013.853707

Hautzinger, H, Stock, W, and Schmidt, J, 2005, *Erstellung von Microdatenfiles zu Ein- und Mehrtagesreisen auf Basis der Erhebungen MiD und DATELINE, Schlussbericht*, Institut für angewandte Verkehrs- und Tourismusforschung e.V., Heilbronn/Mannheim

Kuhnimhof, T, Collet, R, Armoogum, J, and Madre, JL, 2009, *Generating Internationally Comparable Figures on Long-Distance Travel for Europe*, Transportation Research Record, 2105, pp. 18-27, https://doi.org/10.3141/2105-03

Van Goeverden, CD, Van Arem, B, Van Nes, R, 2014, *Data errors and their impacts*, paper submitted to ETC

Van Goeverden, CD, Van Arem, B, Van Nes, R, 2016, *Volume and GHG emissions of long-distance travelling by Western Europeans*, Transportation Research Part D, vol. 45, pp. 28-47, http://dx.doi.org/10.1016/j.trd.2015.08.009