Sustainable long-distance travel

– Mapping and reducing climate impact

Mid seminar text

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This text is intended to be an introduction to my work. Although it can be seen as a very first draft of ideas for a cover essay, it is written in more of an essay format. As it is in its early stages of development, it is not yet to be understood as an embodiment of my work. It rather highlights some of the themes I have so far identified and reflected upon in preparation for this seminar.

While this text is written for a so-called midterm seminar, it will become evident that I have published a bit more that typically achieved at this point. Perhaps calling it a three quarters seminar would be closer to the truth. I feel it necessary (and fair) to point out that I was a research engineer within the same field for a few years prior to my PhD studies. So in many ways I got a head start on my PhD. Nonetheless, I would like the opportunity to discuss my work before my dissertation, to understand my work better and which direction this last stage might go.

List of publications

1. Larsson, J., **Kamb, A.**, Nässén, J., Åkerman, J. (2018) 'Measuring greenhouse gas emissions from international air travel of a country's residents methodological development and application for Sweden', Environmental Impact Assessment Review. Elsevier, 72(June 2018), pp. 137–144. https://doi.org/10.1016/j.eiar.2018.05.013
2. **Kamb, A.**, Lundberg, E., Larsson, J., & Nilsson, J. (2021) 'Potentials for reducing climate impact from tourism transport behavior', Journal of Sustainable Tourism. Informa UK Limited, 29(8), pp. 1–18. https://doi.org/10.1080/09669582.2020.1855436
3. Åkerman, J., **Kamb, A.**, Larsson, J., & Nässén, J. (2021) 'Low-carbon scenarios for long-distance travel 2060', Transportation Research Part D: Transport and Environment. Pergamon, 99(103010). https://doi.org/10.1016/j.trd.2021.103010
4. Happonen, M., Rasmusson, L., Elofsson, A., & **Kamb, A**. (2022) 'Aviation's climate impact allocated to inbound tourism: decision-making insights for "climate-ambitious" destinations', Journal of Sustainable Tourism. Routledge, pp. 1–17. https://doi.org/10.1080/09669582.2022.2080835
5. **Kamb, A.**, Åkerman, J., Englund, O. (Manuscript)
   Working title: Alternatives to fossil air travel on mid distances
   Target journal: maybe Transportation Research Part D: Transport and Environment

My contributions to the papers:

1. The primary authorship of this paper is more or less evenly divided between Larsson and me. I was involved in all stages of this paper, from conceptualization, methodology, formal analysis, data curation, writing the original draft, as well as the review and editing. In particular, I worked on collecting data and the formal analysis of it.
2. The order of authors reflects my contribution to this paper. I was involved in every stage of developing the paper; conceptualization, methodology, formal analysis, survey development, writing of original draft, review and editing, and funding acquisition. For data analysis, I took the lead on travel habits and climate calculations, while data analysis of the primary survey data was conducted by co-authors.
3. For this paper, I was involved in conceptualization, methodology, formal analysis, writing of original draft, and review and editing. While Åkerman had the main responsibility of the scenario work, the novel analysis of model shift potentials was conducted by me.
4. For this paper, I had more of a supervisor role, as this work started as a master's thesis. I was involved in conceptualization, methodology, review & editing, supervision, and funding acquisition. My main contribution came in the review and editing stage, which was divided between Happonen and me, to find clearer focus and consistent conclusions.
5. For this paper, I have the main responsibility of all stages.

Additional papers not planned to be included in the dissertation, a short summary can be found at the end of this document.

I. Curtale, R., Morfeldt, J., **Kamb, A.**, Larsson, J., Nässén, J. Submitted manuscript.
Title: Could night train trips replace flights and reduce the carbon footprint of European tourism? Scenarios for Sweden up to 2050.
Target journal: Transportation Research Part D: Transport and Environment

II. Åkerman, J., **Kamb, A**., Johansson, D. Analysis started.
Working title: Mitigation of non-CO2 from aviation

Introduction

To introduce my field of study, I often describe it as *sustainable long-distance travel*. Long-distance travel has several different definitions depending on the context, but all have some core ingredients; travel should be outside your everyday sphere of movement and should typically be longer than 300 km. In my case, it also includes all transport modes; air, rail, ferries, bus, and car. That being said, I have particular focus on air travel, as this is the largest emissions source in the long-distance travel segment, at least for a country like Sweden. The concept of *sustainability* is broad and is often used loosely and in ambiguous ways. In my research, I typically only look at climate impact, ignoring other sustainability aspects.

Long-distance travel differs in many ways in relation to everyday travel and has many interesting entries of study; the frequency is low, which differs with regards to habits and practices; the distances are far longer, which typically means large climate impact per trip; trips often cross national borders, which raises questions on responsibility and allocation of emissions between countries; emissions from air travel are excluded from many climate policies, e.g. exempt from climate tax on the fuel and the Nationally Decided Contributions reported to the UN; and the governing UN body, ICAO, has difficulty reaching strong enough multilateral agreements on climate action.

My main aim in my research is to understand how to limit climate impact from long-distance travel. I am interested in understanding how large the emissions from this segment are and how emissions can be reduced, both today and in medium- and long-term futures. More specifically, my, at this stage very tentative, research questions could be formulated as follows;

- How large are the emissions from long-distance travel?
- How can emissions from long-distance travel be reduced through behavioural changes and technological development?
- What can emissions from future long-distance travel be reduced?

To answer these questions, I employ a number of methods; life-cycle assessments focusing on greenhouse gases, allocation principles, surveys (with secondary and primary data), and futures studies (back casting and what if scenarios).

Summary of research

Below follows a description of the papers, in chronological order.

1. Measuring greenhouse gas emissions from international air travel of a country's residents: Methodological development and application for Sweden

Global civil aviation accounts for 4–5% of total greenhouse gas emissions and these emissions are increasing. In the absence of sufficiently effective global climate instruments, national instruments might be considered as a complement, in which case some way of allocating emissions from international air travel between countries is needed. The purpose of this paper is to develop an accounting method that reflects one country's greenhouse gas emissions from international air travel, and to apply this methodology to Sweden. The new methodology

consists of three parts: the number of international air trips made by the country's residents; the average distance of these trips; and the greenhouse gas emissions per passenger km. For Sweden, data for 1990 to 2014 show an increase in the number of trips by Sweden's population of 3.6% per year, resulting in, on average, one international journey (round trip 5800 km) per capita in 2014. The average distance to the final destination has increased only marginally due to simultaneous growth in both long and short trips. However, global average greenhouse gas emissions per passenger km have decreased by 1.9% per year between 1990 and 2014. Because the increase in the number of their trips has outweighed the decrease in emissions per km, the total emissions from Swedish residents' international air travel have increased by 61% between 1990 and 2014. The total emissions from Swedish residents' air travel, including both CO_2 and non-CO_2-effects, were 11 Mt CO_2 equivalents in 2014, which is the same level as the emissions from Swedish car traffic. This type of reliable data is important when designing policies and for getting public support for new policies.

2. Potentials for reducing climate impact from tourism transport behaviour

Emissions of greenhouse gases from tourism transport are rising globally, with air transport accounting for the largest share. Although travel is not likely to decrease drastically, people could travel differently, and still have similar experiences. This study aims to map the emissions from air travel and analyse the theoretical potential for emissions reduction by changing transport mode and destinations, and the readiness potential for emissions reduction based on tourists' stated readiness to change their travel behaviour. The theoretical potential was assessed by analysing alternative trips to closer destinations and using transport modes with lower emissions or through virtual meetings. The readiness potential was assessed by a survey designed to capture people's stated readiness to change their behaviour. The results show a theoretical potential for an emissions reduction of 67%, while the readiness potential is 26%. About half of the readiness potential for reductions is from changing destination, while only a small share is from changing transport mode. This shows that, when accounting for people's readiness to change behaviour, destination choice has a greater potential to reduce emissions compared to transport mode choice. This finding has implications for policy makers in designing policy measures to reduce emissions.

3. Low-carbon scenarios for long-distance travel 2060

In many industrialised countries, the climate impact from long-distance travel is greater than that from short-distance travel. In this paper, we present five scenarios for long-distance travel in 2060, which are consistent with a 67% probability of limiting global warming to 1.8 degrees. The scenarios concern travel by the Swedish population, but per capita travel volume and fuel use could be generalised globally. A key result is that all scenarios require reductions in Swedish per capita air travel in the range of 38–59% compared to 2017. The direct effect on air travel of implementing a high-speed rail network in Sweden and Northern Europe was found to be modest. A higher emission reduction could be achieved if mixed mode trips comprising rail and air legs were more widely adopted. Finally, the pros and cons of future aviation fuels are discussed, the main candidates being biofuel, electrofuel, and liquid hydrogen.

4. Aviation's climate impact allocated to inbound tourism: decision-making insights for "climate-ambitious" destinations.

The climate impact from international aviation was 2.4% of the world's total climate impact in 2018, and is expected to grow. International regulation of this impact is not aligned with trajectories to stay below 1.5C of global warming. Conventional approaches to allocating climate impact to international aviation also lack one of the important drivers for air travel: tourism. Existing studies have focused on the carbon foot- print of residents' outbound air travel, but there is a lack of focus on the climate impact from inbound air travel. This article quantifies the cli- mate impact of inbound air travel, and presents it alongside the impact of outbound air travel, to get a full picture of the climate impact of tourism-driven air travel and provide insights for tourism's decision makers. This was done in a case study for Sweden. The results show that the emissions from inbound air travel have grown 3 times more than emissions from outbound air travel each year, at a faster rate than the yearly growth for all international air travel. Responsibility for the cli- mate impacts of inbound and outbound air travel is discussed, along with further actions such as demarketing and focusing on closer source markets.

5. Alternatives to fossil air travel on mid distances

Long-distance travel is not as well research as every day shorter travel, but for many rich countries the GHG emissions are of the same magnitude. There are currently many alternative modes of transport being discussed and developed, like all electric aircraft and train travel. Most of the alternatives that are or will become available in the coming decades are most relevant for mid distances, meaning that they compete for the same travel volumes. This paper aims to analyse 7 alternatives on a number of characteristics, such as travel time and specific energy, to understand their potential to reduce emissions from long-distance travel. Furthermore, what-if scenarios will be developed for different types of travel, i.e. business and leisure travel, based on travel habit data.

Discussion

Below will follow some of the main results and discussion points I have identified so far. Most of my reflections are also centred on published works, and less so on current work.

Allocation

One theme in my work is on the *allocation* of greenhouse gas emissions, which perhaps not surprising is one of the concepts I have reflected on extensively. Allocation is defined as "an amount of a resource assigned to a particular recipient" in the Oxford Dictionary of English. The problem of allocation arises in my work in several ways, but the most prominent is on the allocation of air travel emissions, which refers to how large air travel emissions should be assigned to each country. In particular, Paper 1 and Paper 4 relates to the concept of allocation.

While CO_2 emissions based on in which county the fuel is sold (sometimes called *bunkering*) is reported to the UN as a separate item on a voluntary basis, there is currently no consensus on how the emissions from international air travel should be allocated between countries and these emissions are typically not included in national totals or national climate goals. There are

a number of different possible allocation options, and in Paper 1 we evaluated 9 options (see Table 1) on the basis of 5 criteria; *sensitivity, additivity, non-leakage, validity,* and *reliability*. Based on our analysis, we argue that allocation based on *residency* is the most appropriate, meaning allocation to the country where the passenger resides (lives). In practice, this means that we include trips made to and from Sweden by Swedish residents and exclude those made by foreign residents, and that trips include transit trips to final destination, regardless of if those trips both depart and arrive in other countries. For a country like Sweden, allocation based on residency results in a doubling of the CO_2 emissions compared to bunkering emissions, and if non-CO_2 emissions are also included, three times the emissions. Hence, depending on the allocation method, very different images emerge on the climate impact from air travel of a nation.

Table 1 Nine options for the allocation of GHG emissions from international aviation. Options 1–8 were presented by the SBSTA (UNFCCC, 1996). We also add a ninth option of consumption-based allocation.

1) No allocation.
2) Allocation of global bunker sales and associated emissions to parties in proportion to their national emissions (from all sectors).
3) Allocation according to the country where the bunker fuel is sold.
4) Allocation according to the nationality of the transporting company, or to the country where an aircraft of ship is registered, or to the country of the operator.
5) Allocation according to the country of (a) departure or (b) destination of an aircraft or vessel; alternatively, emissions related to the journey of an aircraft or vessel (c) shared by the country of departure and the country of arrival.
6) Allocation according to the country of departure or destination of passengers or cargo: alternatively, emissions related to the journey of passengers or cargo shared by the country of departure and the country of arrival.
7) Allocation according to the country of origin of passengers or owner of cargo.
8) Allocation to a party of all emissions generated in its national space.
9) Allocation according to the country of residency of the final consumer (consumption-based accounting).

In Paper 4 we argued that there are reasons for countries to also calculate the emissions from incoming tourists, not only residents. For many countries, the relationship between emissions from *inbound* (tourists arriving in a country) and *outbound* tourism (residents leavening the country) can be quite off balance. For example, for a developing country with a booming tourism industry, the residents may travel by air very little compared to the global average, while the inbound tourism is far above the global average. Only accounting the outbound air travel emissions in this case would result in very low emissions per capita, while we argue that it would not give a fully valid picture of that country's air travel emissions, as the country still reaps the benefits of the inbound tourists. And for a country like Sweden, it turns out that the inbound emissions are growing, while the outbound emissions have stagnated, meaning that the inbound tourism is driving the aviation emissions related to Sweden. Again, depending on the allocation principle considered, very different images emerge.

While I do not aim to make any climate justice claims in my work, it to some extent has such implications. For example, in Paper 1 we make a comparison between the average air travel emissions per capita of Swedish residents and the global citizen, showing that Swedish

residents emit five times more.[1] This is in line with several other studies, showing that only a small proportion of the world's population travels by air in a given year. While we do not dig deeper into this result in the paper, again, depending on the allocation method used, the implications for climate justice differs.

Behavioural change

Another recurring theme is that of potential emissions reduction through behavioural changes. Behavioural change is a complex field of study that can be studied through many different lenses, theories, and methods. In my work, I have been particularly interested *modal shift*, i.e. shifting the mode of transport to one with lower emissions, and *destination shift*, i.e. shifting to a destination which lowers the emissions of the travel.

Paper 2 specifically aims to analyse how large the potential emissions reduction through these two behavioural changes is, based on the *readiness* of people to change behaviour, i.e. how able and willing people are to change their behaviour. In this paper, we asked people who had made certain types of trips (e.g. beach holiday trips) if they would be willing to change the destination or mode of travel, to reduce emissions. The major result from this study is that based on the Swedish residents' destination or modal shift readiness, about a quarter of air travel emissions could be avoided, what we call the *readiness potential*. Important to point out however is that this is a *stated* readiness study, and significant stated vs revealed preference gaps have been identified in the literature.

Paper 3 explores the potential of different types of changes based on modal shift from air to train, without addressing people's readiness. One of the main components of this analysis can be seen in Figure 1. This depicts the rail market share on the rail-air market, as a function of travel time by train, and is based on many city pairs from around the world. As the travel time by train becomes longer, less people travel by train and more opt for air travel. If preferences were to change in the future and people would accept say one more hour of travel time by train, e.g. through changing attitudes towards climate impact or changing price relations between the modes, the curve would shift and the train market share would increase.

[1] In the paper it says seven times, but the time series has since the publication of the paper been updated with data for more years, resulting in five times more.

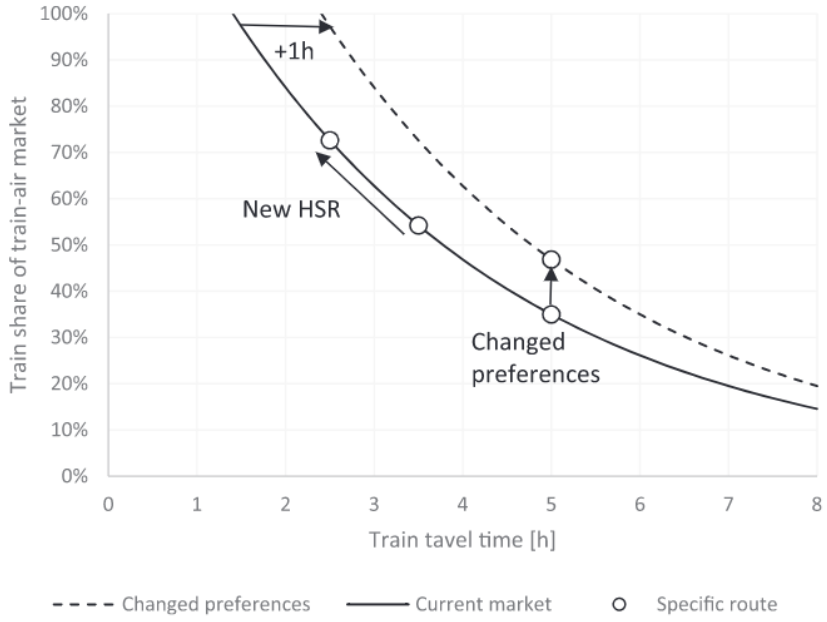

Figure 1 Rail travel's market share as a function of travel time by rail, in the rail and air market. The dashed line indicates how the market share would shift if people accepted one hour longer travel times. The solid line is adapted from Lundberg (2011) and Nelldal and Andersson (2012).

The overall result from this analysis is that the potential for emissions reduction is fairly limited, resulting in shifts of 1-2% of the total transport work (in pkm) for changing preferences, construction of new high-speed railways, banning of all flights under 500km, and night trains, respectively. The largest potential is for mixed modes, i.e. combining train and air in different ways, with a potential shift of 9-14% of total pkm.

These studies show that behavioural changes can contribute to reducing emissions form long-distance travel. However, many of these changes would likely need strong policy instruments to be achieved. The pandemic resulted in unprecedented behaviour changes for air travel, and was often forced through strong border restrictions. How air travel behaviours will develop post COVID is uncertain, as the prolonged behaviour changes might have resulted in some permanent changes, for example changed business travel practices. At the same time, Paper 2 shows that there is also potential to reduce emissions on a voluntary basis. Sweden might even have been showing signs of reducing air travel prior to the pandemic, as the number of passengers at Swedish airports in 2019 was decreasing. Why is however difficult to say, and with only one year reduction pre-pandemic, nothing can be said about a trend.

Technological development

Not surprising perhaps, technological development is the other ingredient to emissions reductions, and is a recurring theme throughout the papers. More specifically, Paper 3 and Paper 5 relates to future emissions reductions through technological development, for all transport modes and the aviation sector in particular. My main conclusions on this topic are still developing, as my work on Paper 5 progresses, and I think I will have more to say here come dissertation writing. That being said, what I think becomes evident in my work is that while there are new technologies in aviation coming that will reduce emissions, some of them have

limited potential (such as electric aircraft) or are far into the future due to the significant inertia of aircraft development and turn over (such as hydrogen aircraft). Reducing emissions in the near future will thus likely rely more on sustainable fuels and behavioural changes.

Present vs future

In my work, there is an evolution of first understanding the magnitude of the emissions from long-distance travel (Paper 1 and Paper 4), then looking at what can be done today to reduce the emissions (Paper 2), and finally what can be done in the future (Paper 3, Paper 5). Paper 3 has scenarios furthest into the future, 2060, while Paper 5 looks into 2035. In this evolution, I think there is something to be said about that relating to climate targets depends on the system boundaries, allocation principles, and different understandings of time frames and climate budgets. My ideas here are far from fully developed, and I think this is something I would like to develop in my dissertation.

And now?

As I mentioned in the beginning of this text, I wanted this opportunity to discuss my work to understand how my work fits in to a larger context. As my path in academia coming to this point has perhaps not been typical, where I have participated in different projects throughout the years, I sometimes feel that my work lacks a clear field. While all of the papers deal with long-distance travel in general and air travel in particular, they use different methods and theories, making it not so obvious to be what my main contribution is. So, at this stage, I am wondering how to situate my work in a wider theoretical and methodological context. What is my main contribution? Also, what my contribution will be depends some on which papers I decide to include. Does the selection make sense? Furthermore, does my tentative ideas for aim and research questions hold, given the work I have done and plan to do?

I am lucky at this point to have more time on my hands, than perhaps does the typical PhD student. So one question is how I can use this time in a smart way, to try to answer some of the questions above. So what should I focus on moving forward? Am I lacking some key perspective, concept, or theory, that I could add to my repertoire?

Additional research not included

I. Could night train trips replace flights and reduce the carbon footprint of European tourism? Scenarios for Sweden up to 2050.

To tackle the climate impact associated with long-distance flights, shifts to closer destinations and sustainable transport modes are needed. In this paper, we analyse scenarios for the carbon footprint associated with a switch from flights to night trains for holidays in Europe up to 2050 for the case of Sweden, including outbound, inbound and domestic tourism. The analytical framework includes a stated preference experiment and prospective lifecycle assessment for flights and train journeys. The results indicate that progressive night train policies resulting in both fewer transfers and similar price levels for train journeys and flights could lead to shifts in transport mode. The mode shifts from flights to night trains could result in 7–9% lower cumulative carbon footprints in relation to a baseline travel demand scenario for the period 2025–2050, depending on the decarbonization pathway. Decarbonization of long-distance travel in line with the Paris Agreement would likely require a combination of many different types of measures including new aviation technologies.

II. Mitigation of non-CO_2 from aviation

Work is in its initial stages and no abstract is available.

Themes: non-CO_2 aviation emissions, air traffic management, sustainable aviation fuels, consumption-based emission targets, travel habits, scenarios