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Cities, Long-Distance Travel, and Climate Impacts

Editors

Jukka Heinonen and Michał Czepkiewicz

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Editorial

Cities, Long-Distance Travel, and Climate Impacts

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Abstract

This thematic issue focuses on important but understudied connections between cities and climate impacts of long-distance travel. While urbanization and urban density have climate change mitigation potential in short-distance travel (e.g., by reducing car use and supporting public transportation, walking, and cycling), they have been associated with a higher level of emissions from flights. This highlights the role that city-regions could potentially play in reducing climate impacts of aviation. At the same time, the development of airports and flight connections has been an important driver of economic growth at regional scale and a factor contributing to global competitiveness of city-regions. This thematic issue includes seven interesting articles focusing on different aspects of the theme, all of which are briefly presented in this editorial. We also lay down some suggestions for future research directions based on the findings presented in this thematic issue.

Keywords

aviation; cities; climate impacts; long-distance travel; urban living

Issue

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1. Long-Distance Travel, Climate, and Urban Living

Reducing transport-related greenhouse gas (GHG) emissions to mitigate climate change has been strongly on the agenda since the climate change threat was identified. However, transport remains one of the main emissions sectors and one where the emissions have not declined but rather been on a continuous rise (Intergovernmental Panel on Climate Change, 2018). Moreover, while aviation has been considered of much less importance for climate change mitigation than ground transport, it had been growing steeply until the Covid-19 stoppage (Gössling & Humpe, 2020). It will also likely return to a previous pathway during the recovery. And while the science is still developing, it is already broadly accepted that non-CO₂, particularly the short-lived climate forcers, significantly enlarge the warming impact of aviation, by a multiplier of three according to a recent state-of-the-art overview (Lee et al., 2020).

Tourism and tourism-related emissions have grown rapidly in the 2000s and are projected to continue to grow proportionately quickly (Lenzen et al., 2018). The most affluent, many of whom reside in urban areas, drive this development (Wiedmann, Lenzen, Keyßer, & Steinberger, 2020). Flights are among the most income-elastic and unevenly distributed activities (Oswald, Owen, & Steinberger, 2020). Urban elites lead increasingly globalized lifestyles with distributed social networks and influence the lifestyles of those who aspire to the affluent classes (Czepkiewicz, Heinonen, & Ottelin, 2018). Urban lifestyles often go along with interest in the world’s diversity, which fuels many travel motivations (Czepkiewicz, Heinonen, Næss, & Stefansdóttir, 2020). Interestingly, while many of the international urban centers are the strongholds of the green movement, recent studies reveal that pro-environmental attitudes and climate change concerns do not necessarily converge to low trip frequencies among green urbanites

(Árnadóttir, Czepkiewicz, & Heinonen, 2021; Bruderer Enzler, 2017).

In affluent and well-connected urban locations, flights can dominate all transport-related GHG emissions, even in locations with a strong role of the car in local mobility (Czepkiewicz, Árnadóttir, & Heinonen, 2019). In these locations, flying is also quickly becoming normalized, losing its luxury status. It should, therefore, receive more attention in climate change mitigation considerations in global cities. Moreover, it is not just aviation but also other aspects of long-distance travel that connect to lifestyles and the urban structure. Second-home possession, including summer cottages, is more common in more urbanized areas (Heinonen, Jalas, Juntunen, Ala-Mantila, & Junnila, 2013), and visiting them is a significant source of emissions in the Nordics (Næss, Xue, Stefansdóttir, Steffansen, & Richardson, 2019).

2. Unraveling the Role of Urban Form, Lifestyles, and Governance

This thematic issue focuses on the important but understudied topic of the connections between cities, urban living, and climate impacts of long-distance travel. Whereas literature showing how urbanization and urban density have a climate change mitigation potential in short-distance travel (e.g., reducing car use and supporting public transportation, walking, and cycling) is extensive (Ewing & Cervero, 2010), the research is only in its infancy when it comes to long-distance travel and urbanity (Czepkiewicz, Heinonen, et al., 2018). Yet, already multiple studies to date have shown an intriguing spatial trend, in which participation in and frequency of long-distance travel (particularly international flights) and associated emissions are higher in large cities, urban cores, and densely built neighborhoods (Czepkiewicz et al., 2019; Czepkiewicz, Ottelin, et al., 2018; Holden & Linnerud, 2011; Næss, 2006; Reichert, Holz-Rau, & Scheiner, 2016).

Such a correlation can be interpreted as a challenge to urban densification policies (Holden & Linnerud, 2011; Holden & Norland, 2005). Implications of such a claim for urban planning are significant, and thus it requires a closer look. In particular, are there any causal influences of the built environment on long-distance travel? If yes, how robust are they, and in what circumstances do they occur? Are there any effects through which urban planning policies can “rebound” or “backfire,” as suggested in studies by Ottelin, Heinonen, and Junnila (2014, 2017), where households spending less on cars spend more on flights? Is densification worsening living conditions to the point of making people want to escape urban environments, as suggested by the *compensation* hypothesis (Czepkiewicz et al., 2020; Næss, 2006)? Or, conversely, is the correlation due to other geographical trends, such as grouping of people with certain attitudes, lifestyles, or socio-economic status in urban centers?

Regardless of the reasons, the high mobility of urban residents raises the question of the role of urban gov-

ernance in curbing travel-related emissions. Sustainable urban mobility has long been regarded as a key sphere of policy intervention by local governments who want to reduce GHG emissions while improving living conditions for the residents. Policy-making in long-distance travel and aviation has been mostly delegated to national and international levels. Local governments usually consider improving long-distance connectivity as an important driver of city-regions’ economic growth and global competitiveness, with urban planning often leaving ample space for airport expansions. Could city-regions take a stronger role in reducing the climate impacts of long-distance travel of their residents, as explored by Elofsson, Smedby, Larsson, and Nässén (2018)?

3. A Collection of Seven Articles Connecting Urban Living and Long-Distance Travel

This thematic issue comprises seven articles focusing on different aspects of urban living and long-distance travel nexus. Two articles accentuate the pattern in which residents of large capital cities fly more than do others: Greater London in the UK (Mattioli, Morton, & Scheiner, 2021) and Vienna in Austria (Falk & Hagsten, 2021). The study in Austria also points out other factors of high air mobility, including higher education and young age. Mattioli et al. (2021) provide further explanations, concluding that airport accessibility, migration background, and dispersion of social networks all contribute to this pattern. Results of these two studies also reiterate that flying and associated emissions are unevenly distributed (e.g., Gössling & Humpe, 2020): A large proportion of the populations does not fly at all, while a small minority of high-flyers generates much of the traffic and GHG emissions.

Raudsepp, Árnadóttir, Czepkiewicz, and Heinonen (2021) provide further nuance to relationships between urbanity and long-distance leisure travel using qualitative data. They find multiple factors that might indeed “push” urbanites towards seeking relief from urban life in long-distance trips. They go beyond the typically narrow framing of the compensation hypothesis. Besides poor access to green areas, the hectic character of urban life and stressful commutes may motivate leisure trips, particularly those associated with seeking calmness in nature and the countryside. Car-free lifestyles did not seem to lead to increased spending on flights, even though they limit access to domestic leisure travel to some extent. Similarly, Mattioli et al. (2021) did not find evidence for rebound effects between car ownership and flights.

Pukhova, Moreno, Llorca, Huang, and Moeckel (2021) apply agent-based modeling to long-distance travel emissions in Germany to estimate and illustrate the potential of reducing GHG emissions via air travel demand reduction. Among the ways to achieve it are increases in ticket prices and restricting short-haul flights. The results suggest a relatively high potential of these

policies in reducing emissions, even though they are limited to domestic flights, which comprise a high proportion of flights but a relatively small proportion of emissions. Two other articles reflect on the role that global cities, such as Brussels in Belgium and Geneva in Switzerland, can have in reducing emissions from long-distance travel (Boussauw & Decroly, 2021; Sahakian, Nagel, Donzelot, Moynat, & Senn, 2021). How to reconcile Net-zero pledges made by cities with their strong dependence on international mobility and connectivity? Boussauw and Decroly (2021) highlight the role of allocating emissions caused by international travel to territorial units, such as urban regions and municipalities.

Sahakian et al. (2021) study the process of co-designing a city-wide change initiative aiming at reducing flights in Geneva. They highlight the value of going beyond an individualistic approach and understanding flying as a social practice embedded in socio-material arrangements that involve infrastructures, technologies, social norms, and shared meanings. Similarly, using a distinct methodology grounded in rhetoric, Wormbs and Wolrath Söderberg (2021) study a change process in Swedish residents who decided to quit or reduce flying. They highlight the role of knowledge about the climate impact of flying in motivating change, particularly when internalized through experience or emotional distress. Feelings of fear and guilt had important roles, while shame was rarely mentioned, contrary to certain popular claims. Despite their focus on individual narratives, Wormbs and Wolrath Söderberg (2021) succeed in bridging the chasm between “the individual” and “the social” by illustrating how decisions to reduce or quit flying are deeply embedded in social networks and connected to the notions of morality and climate justice.

4. Future Research Directions

The articles in this thematic issue further confirm the connection between urbanity and long-distance travel, particularly between living in well-connected urban centers and traveling abroad frequently. While early evidence about the reasons behind this connection and potential factors of change towards reducing air travel demand has been compiled, it is a research field with a lot left to study. Rebound effects and behavioral lock-ins are interesting issues with contradictory results to date. Future research should continue to unravel how interventions in built environments and the spatio-temporal organization of everyday life (e.g., work time reductions, telework) influence the long-distance travel of urban dwellers. More research is needed on how travel-related social norms and status aspirations form and circulate in urban social networks, contributing to both highly mobile urban lifestyles and the emergence of social movements that contest them. Particularly understudied is the importance of long-distance travel for well-being and lifestyles organized with sufficiency in mind, i.e., ones with simultaneously low climate impacts and good living standards.

Finally, more research is needed on how local governments can mitigate emissions from long-distance travel. Can they accelerate processes of collective and individual change? Should they take responsibility for emissions from the travel of their residents and visitors? Can we imagine models of local and regional development that do not depend on long-distance connectivity?

Conflict of Interests

The authors declare no conflict of interests.

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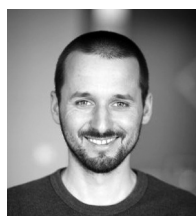
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Article

Air Travel and Urbanity: The Role of Migration, Social Networks, Airport Accessibility, and ‘Rebound’

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Abstract

Residents of urban areas, and particularly urban cores, have higher levels of long-distance travel activity and related emissions, mostly on account of greater frequency of air travel. This relationship typically remains after controlling for basic socio-economic correlates of long-distance travel. There is an ongoing debate in the literature about what causes this association, and whether it calls into question urban densification strategies. Understanding this is important from a climate policy perspective. In this article, we investigate the role of three factors: i) access to airports; ii) the concentration of people with migration background and/or geographically dispersed social networks in urban areas; and iii) greater air travel by urban residents without cars (‘rebound effect’). We use representative survey data for the UK including information on respondents’ air travel frequency for private purposes and derive estimates of greenhouse gas emissions. The dataset also includes detailed information on migration generation, residential location of close family and friends, car ownership and use, as well as low-level geographical identifiers. The findings of regression analysis show that Greater London residents stand out in terms of emissions from air travel. Airport accessibility, migration background, and dispersion of social networks each explain part of this association, whereas we find no evidence of a rebound effect. However, proximity to town centres remains associated with higher emissions after accounting for these issues, indicating that this association is due to other factors than those considered here. We conclude by discussing implications for urban and climate policy, as well as future research.

Keywords

airport accessibility; air travel; greenhouse gas emissions; long-distance travel; migrants; rebound effect; social networks; travel behaviour; visiting friends and relatives

Issue

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1. Introduction

Climate change mitigation in the transport sector is particularly challenging, due to ever-increasing levels of travel activity, which tend to offset improvements in the energy efficiency and carbon intensity of vehicles. This trend is particularly pronounced for aviation, where

emissions have increased rapidly, and technological solutions are in short supply.

There is a long tradition of urban and transport planning research arguing that large, compact cities are better placed to reduce carbon emissions and other negative environmental impacts from transport. Most of this literature, however, refers to everyday travel

and specifically to lower levels of car use in dense urban areas. Yet, an emerging body of research shows that levels of long-distance travel are higher in large cities and urban cores, which can offset lower emissions from everyday travel. Czepkiewicz, Heinonen, and Ottelin (2018) review this literature, and find that this is mostly due to urban residents travelling more internationally by air, and that the association cannot be entirely accounted for by basic differences in socio-economic composition (e.g., higher income and education).

As a result, there is an ongoing debate about what other factors are responsible for greater levels of long-distance travel, and notably air travel, among urban residents. Several hypotheses have been put forward to explain this association, although only scant evidence exists to support them (as discussed in Section 2). Some posit the existence of a direct link between built environment characteristics and greater levels of long-distance travel. This, if confirmed, would question the assumption that urbanisation and compact city policies contribute to climate change mitigation in the transport sector. Other hypotheses posit that the association between urbanity and long-distance travel is spurious, i.e., accounted for by other factors. Understanding which explanation is empirically supported is thus key from an urban planning perspective. Getting a better grasp of the determinants of air travel among urban residents also helps shed light on what is driving the rapid increase of air travel emissions globally.

This article presents a study on greenhouse gas (GHG) emissions from personal air travel, which investigates the role of three factors: i) access to airports; ii) the concentration of people with migration background and/or geographically dispersed social networks in urban areas; and iii) greater air travel by urban residents without cars (often referred to as ‘rebound effect’).

As such, the article makes four contributions to existing knowledge. First, it simultaneously explores three plausible mechanisms responsible for the association between urbanity and air travel, which have rarely been examined before.

Second, we use data from a large survey that is nationally representative, unlike many previous studies in this area that relied on smaller, ad-hoc surveys. This has advantages in terms of the robustness and generalizability of the results.

Third, our study focuses on England (the largest constituent country of the UK), which is interesting in several respects. Due to population size and high levels of air travel per capita, the UK is responsible for 4% of global CO₂ emissions from commercial aviation, second only to the US and China (Graver, Zhang, & Rutherford, 2019). England includes a diversity of urban areas, ranging from small towns to large conurbations to the global city of London. This helps us investigate how levels of air travel vary across the urban-rural continuum.

Finally, the availability of small-area geographic identifiers enables us to simultaneously investigate dif-

ferences across the urban-rural continuum as well as within urban areas (i.e., depending on proximity to town centres), two aspects that have often been explored separately.

In the next section, we provide a short review of the literature on the relationships between urbanity, air travel, and the factors under investigation.

2. Background

A growing body of literature has explored the association between urbanity and long-distance leisure travel. Czepkiewicz, Heinonen, et al. (2018) provide an excellent recent review of 27 studies on this topic, to which the reader is referred for more information. In the remainder of this section, we focus more specifically on the theoretical explanations researchers have put forward for this association. Czepkiewicz, Heinonen, et al. (2018) identify five different explanations:

1. A ‘rebound effect’ for reduced car ownership and driving, whereby less expenditure on motor-ing among urban residents results in more long-distance travel by other modes, notably by air;
2. The ‘compensation hypothesis’ whereby people compensate for deficiencies in urban environments by ‘escaping’ the city more often;
3. Better access to long-distance transport infrastructure, including airports;
4. Lifestyles and socio-psychological characteristics (e.g., cosmopolitan attitudes) that are more prevalent among urban residents, while also inducing more long-distance travel;
5. Greater dispersion of social networks among urban residents.

Two observations are in order. First, assessing the relative importance of the different explanations has implications for urban planning. If rebound and compensation effects played a major role, this would question the assumption that urbanisation and compact city policies are beneficial for climate change mitigation in the transport sector. If other factors were prevalent, this would not necessarily be the case. Second, Czepkiewicz, Heinonen, et al. (2018, p. 21) conclude that there is “currently not enough evidence to decisively support any of these explanations.” In this article, we add to this literature by investigating the impact of accessibility to airports, social network dispersion, and rebound effect of non-car ownership on air travel. In the remainder of this section, we briefly review existing evidence on each of these factors.

Regarding airport accessibility, to the best of our knowledge, only one previous study examined this factor in the context of debates on long-distance travel and urbanity (Bruderer Enzler, 2017). It finds that, among Swiss residents, GHG emissions from air travel for private purposes are positively associated with proximity to and

passenger volume of the closest airport, even after controlling for population density. The author of the study speculates that this might be due to a residential self-selection effect, whereby those who live near airports have personal social networks that are more spatially dispersed. The study, however, does not control for this possible confounding factor, so that no firm conclusion can be drawn on this point.

Empirical evidence is ambiguous on the existence of a rebound effect of non-car ownership on air travel. Based on a bivariate analysis of travel survey data, Ottelin, Heinonen, and Junnila (2014) find that emissions from flying can offset the gain from reduced driving for middle-income residents of the densest parts of Helsinki (Finland). They argue that this may be due to “a trade-off between private driving and air travel...based on a simple rebound-effect of consumption” (Ottelin et al., 2014, p. 7). In a subsequent econometric modelling study, Ottelin, Heinonen, and Junnila (2017) find further evidence for this hypothesis, based on Finnish budget survey data. Other multivariate studies based on travel behaviour data, however, have typically found a neutral (e.g., Bruderer Enzler, 2017; Czepkiewicz, Klaas, & Heinonen, 2020; Czepkiewicz, Ottelin, et al., 2018) or positive association (e.g., Czepkiewicz, Árnadóttir, & Heinonen, 2019; Czepkiewicz, Heinonen, Næss, & Stefansdóttir, 2020; Reichert & Holz-Rau, 2015) between car ownership and air travel, which challenges the rebound hypothesis.

While often mentioned in the literature, there is little empirical evidence to support or reject the hypothesis that urban residents fly more in order to maintain spatially dispersed social networks. Recent quantitative empirical studies in Helsinki and Reykjavík (Iceland) find that cosmopolitan attitudes (i.e., the importance attributed to experiencing different places and cultures) account for much of the association between urbanity and international leisure travel (Czepkiewicz et al., 2019; Czepkiewicz, Klaas, et al., 2020). For some at least, cosmopolitan attitudes might be caused by international interconnectedness and dispersion of social networks, although the reverse causal link is possible as well. Czepkiewicz, Heinonen, et al. (2020) find qualitative evidence that dispersion of social networks is a driver of international travel among urban dwellers.

A related factor is migration background. Migrants typically have personal relationships that span across borders and tend to travel more by air (e.g., Bruderer Enzler, 2017; Demoli & Subtil, 2019; Hunecke & Toprak, 2014). Greater levels of air travel in cities may thus reflect the overrepresentation of migrants in large urban areas. Migration background can thus be seen either as a socio-demographic confounder that is generally omitted from the analysis, or as a proxy for the dispersion of social networks. To the best of our knowledge, this study is the first to explicitly investigate the role of migration background as an intervening factor in the relationship between long-distance travel and urbanity.

3. Research Hypotheses

Our study is oriented by two sets of hypotheses, derived from the literature. First, we expect to find an association between higher levels of GHG emissions from air travel and residence in: a) large urban areas; and b) in closer proximity to town centres, even after controlling for basic socio-economic correlates of air travel. This hypothesis is grounded in previous research—recently reviewed by Czepkiewicz, Heinonen, et al. (2018)—which has found a net association between residence in large urban areas and long-distance travel. Some of these studies (e.g., Bruderer Enzler, 2017; Demoli & Subtil, 2019; Reichert & Holz-Rau, 2015) find a net association between residence in large urban areas and air travel more specifically. Further studies have investigated differences within urban areas, finding a net association between living in proximity to the city centre and international travel (Czepkiewicz et al., 2019; Czepkiewicz, Heinonen, et al., 2020; Czepkiewicz, Klaas, et al., 2020; Czepkiewicz, Ottelin, et al., 2018). In this context, the contribution of our study is to test these hypotheses for a country (England) for which limited evidence exists to date.

We advance the state-of-the-art by testing a second set of hypotheses, concerning the factors responsible for the association between urbanity and air travel emissions. More specifically, we expect the association to be accounted for by: a) an overrepresentation of people with migration background and/or geographically dispersed social networks; b) better accessibility to airports; and c) lower levels of car ownership and use (resulting in a ‘rebound effect’). As discussed in Section 2, while these hypotheses have been put forward in the literature, only scant evidence exists on the confounding role played by accessibility to airports, migration background, and social network dispersion, while evidence on the rebound effect is conflicting.

4. Data and Methods

4.1. Data

We analyse data from the UK Household Longitudinal Study (UKHLS; University of Essex & Institute for Social and Economic Research, 2018a), a nationally representative, general-purpose survey providing information on a range of topics, which are not usually found together in the same dataset. While our analysis is cross-sectional, we combine variables on personal social networks from Wave 3 (2011–2012) with other variables from Wave 4 (2012–2013). Our sample is therefore restricted to respondents included in both waves and weighted accordingly. UKHLS provides geographic identifiers of respondent residence at the level of Lower Layer Super Output Areas (LSOA), i.e., small, homogeneous census units, including on average 1,500 inhabitants (University of Essex & Institute for Social and Economic

Research, 2018b). We use LSOA identifiers to link respondents to geographical information, as described below, except for the urban-rural classification, which is based on Output Area (OA) level data and provided as part of the UKHLS dataset (University of Essex & Institute for Social and Economic Research, 2019). As several of the spatial variables used in our analysis are not available in comparable form for Scotland, Wales, and Northern Ireland, we exclude these regions from our analysis, and focus on England only (Figure 1). After listwise deletion of missing data, our sample consists of 16,696 English residents aged 16 or older.

The dependent variable in our analysis is GHG from private air travel. UKHLS respondents to Wave 4 (2012–2013) reported the number of flights they had taken in the previous 12 months ‘for leisure, holidays or

visiting friends or family,’ distinguishing between flights within the UK, to European countries and to countries outside of Europe (travel ‘for work or business purposes’ was explicitly excluded). We adopt the approach developed by a study that used the same data (Alcock et al., 2017) to assign representative flight distance values to the three types of destinations. We then estimate GHG for each respondent, based on UK Government GHG conversion factors for domestic, short haul international, and long-haul international flights (Department for Environment, Food and Rural Affairs & Department of Energy and Climate Change, 2015). We add up the estimated emissions for flights within the UK, to European countries and to countries outside of Europe into a single variable, to derive the respondent’s GHG emissions from air travel in the 12 months prior to the

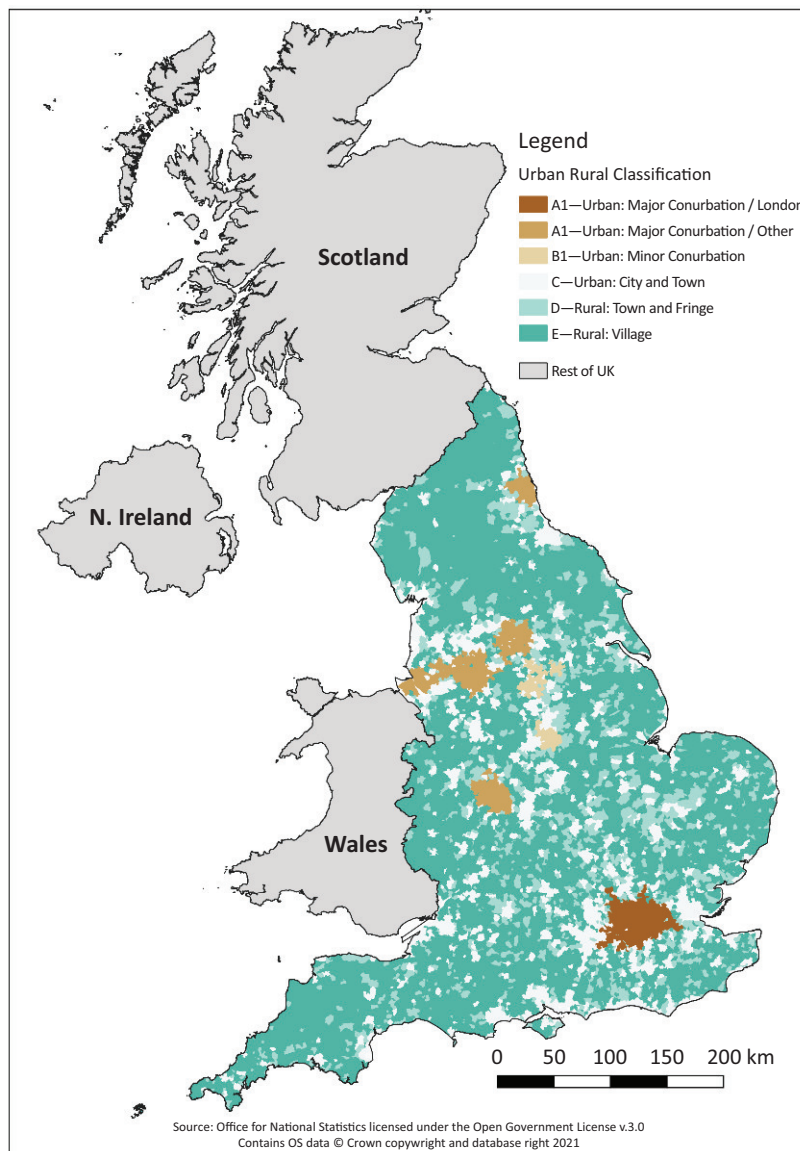


Figure 1. England and other constituent nations of the UK, with English urban-rural classification. Source: Own elaboration based on Office for National Statistics (2013). Note: ‘Category F—Rural: Hamlets and Isolated Dwellings’ is not shown in the map due to a discrepancy between the OA-level urban-rural classification included in the UKHLS household dataset and the publicly available LSOA-level urban-rural classification.

interview (in kgCO₂e). For details on travel distance and GHG estimation and imputation see Table SM1 in the Supplementary File. Due to the nature of the data, the resulting variable is only an approximation of GHG emissions from air travel. It is however useful in that it allows us to ‘weight’ information on air travel frequency in a way that reflects the associated climate impact. As sensitivity analysis, we have repeated the analysis using a count variable (number of flights, all destinations confounded), obtaining results that are broadly consistent with those presented here.

Our analysis includes five sets of predictors. First, spatial variables covering the degree of urbanity of the respondents’ residential area. For this we include two variables. First, the 2011 rural-urban classification which distinguishes between different types of rural, urban and conurbation areas (Figure 1). We further differentiate between Greater London and other conurbations, on account of London’s top position in the urban hierarchy. We complement the rural-urban classification with a continuous variable measuring proximity to the nearest town centre. This allows us to further distinguish, within each type of area, between respondents that are in more or less close accessibility to town centres. We draw this information from the UK Government ‘Journey Time Statistics’ on travel time from each LSOA to the nearest town centre by public transport or walking (whichever is the quickest) for 2014 (Department for Transport, 2019). The Journey Time Statistics adopt a definition of ‘town centre’ that is based on four criteria: economy (type of employment), property (building density), diversity of use, and visitor attractions (for details see ODPM & Centre for Advanced Spatial Analysis, 2002; Thurstain-Goodwin & Unwin, 2000). Large urban and metropolitan areas in England (including Greater London) have more than one ‘town centre’ within their territory, reflecting their polycentric nature. It must be noted that this variable does not measure as-the-crow-fly distance to town centres, but rather travel time by walking or public transport. As such, it reflects to some extent variations in levels of public transport service, which is arguably appropriate for a measure of urbanity. Further to the analysis presented in this article, we have tested the inclusion in the regression models of a measure of population density as a third indicator of urbanity, finding no support for its inclusion.

The second set of predictors refers to accessibility to airports. We use Journey Time Statistics estimates of travel time by car and public transport from each LSOA to the 12 English airports that had at least 1% of total UK terminal passengers in 2015 (roughly corresponding to at least one million passengers per year). We use this information to compute two variables: i) travel time to the nearest airport; and ii) number of airports that can be reached within 60 minutes. For both variables, we considered travel time by car if the respondent’s household had at least one car, and by public transport otherwise. As such, these predictors consider the accessibility differ-

ential between households with and without cars. A third predictor—number of annual passengers at the nearest airport—captures level of service differences between airports, based on Civil Aviation Authority data for 2012 (Civil Aviation Authority, n.d.).

A third set of predictors covers migration background and social network dispersion. As an indicator of migration background, we use the UKHLS ‘migration generation’ variable, which distinguishes between respondents in the ‘first generation’ (not born in the UK), the second (at least one parent born abroad) and third generation (grandparents born abroad), and others (referred to as ‘fourth generation or higher’ in the dataset). For a minority of respondents with missing information on parents and/or grandparents, we assume that these were UK-born. We further distinguish between first generation migrants who have moved to the UK in the five years prior to the Wave 4 interview (i.e., since 2007–2008) and others. The resulting variable includes five categories and combines information on migration generation and (for first generation migrants) year of arrival in the UK. For the sake of simplicity, in the remainder of the article we refer to this variable as ‘migration generation.’ We further include a predictor for self-reported ethnicity, distinguishing between the ‘White British’ majority and the main minority groups in the UK (‘Other White,’ Asian, Blacks, and others). We capture the geographical dispersion of social networks with three variables: i) share of friends living in the local area (note that the definition of what ‘local area’ meant was left up to the respondents); ii) whether at least one of three ‘best friends’ lives abroad; and iii) whether any ‘close family’ member (i.e., parents or children) lives abroad.

The fourth set of predictors includes household-level measures of car ownership (binary variable) and car use. UKHLS respondents reported the approximate number of miles driven in the previous 12 months. We compute the total mileage driven by all household members, as we expect trade-offs between expenditure on cars and flights to be made based on household income.

Finally, we include several socio-economic control variables that previous research found to be associated with air travel (e.g., Alcock et al., 2017; Bruderer Enzler, 2017; Demoli & Subtil, 2019; Dobruszkes, Ramos-Pérez, & Decroly, 2019; Reichert & Holz-Rau, 2015). These include age, sex, net household monthly income (adjusted for taxes and housing benefits, equivalised after housing costs), education, employment status, as well as whether the respondent was in a cohabiting couple, was responsible for children under 16 years old, and had a long-standing illness or disability. The ‘responsibility for children’ variable refers to whether the individual was the responsible adult for cohabiting children, and not to household composition (although the two are obviously related). In households with two parents, this indicator is typically non-zero for the mother. We include this variable as we assume it is more closely associated with air travel than household composition.

4.2. Methods

Our analysis consists of two steps. We start by presenting a bivariate analysis of the association between the main variables of interest and GHG emissions from air travel, then the results of multivariate analysis. We adopt a ‘two-stage’ approach to the multivariate analysis, whereby participation in air travel (i.e., having non-zero emissions) and the level of emissions (for respondents with a non-zero value) are modelled separately. The first stage (selection equation) consists of a logistic regression model, while for the second (outcome equation) we adopt Ordinary Least Square (OLS) regression with a log-transformed dependent variable. The two-stage approach and the log-transformation are justified in light of the high share of respondents who reported taking no flights, and the long-tailed distribution in the GHG emissions of respondents who took flights. We report coefficients for OLS models based on the full sample and non-transformed dependent variables separately in the supplementary material. These coefficients provide estimates of the overall magnitude (although not the statistical significance) of the effects.

As sensitivity testing, we conducted the same analysis using an alternative modelling approach, namely a two-step Heckman model (excluding the variable long-standing illness or disability from the second stage), obtaining results that are broadly consistent with those presented here. The Heckman model is able to calculate unbiased coefficients and significance levels. In this article, we present the results of the two-stage models as they are easier to interpret, while the corresponding Heckman models are included in the supplementary material.

Other models have been developed to overcome the limitations of Heckman models, including ‘multiple discrete-continuous extreme value models’ (MDCEV), which explicitly take account of discrete and continuous choice data (e.g., Lu, Hess, Daly, & Rohr, 2017). In the context of our analysis, MDCEV would allow the exploration of variable substitution patterns between UK-based flights, continental flights, and long-haul flights. In this article, however, we present the results for two-stage and Heckman models, for three reasons: i) for ease of interpretation; ii) for consistency and comparability with previous studies on emissions from long-distance travel (e.g., Czepkiewicz, Ottelin, et al., 2018; Reichert, Holz-Rau, & Scheiner, 2016); and iii) because questions about patterns of substitution between air travel segments are outside of the immediate interest of this article (although they are an interesting direction for future research).

We present four versions of both two-stage and Heckman regression models, reflecting the sequential adjustment of covariates:

1. Model 1, including the main spatial variables of interest and basic socio-economic control variables;

2. Model 2: further adjusted for migration generation, ethnicity, and social network variables;
3. Model 3: further adjusted for accessibility to airports;
4. Model 4: further adjusted for car ownership and use.

Model 1 tests the first set of hypotheses set out in Section 3, concerning the net association between urbanity and air travel. The sequential adjustment procedure provides evidence to test the second set of hypotheses, by showing whether and how the coefficients associated with living in urban areas and in closer proximity to town centres change when controlling for the three sets of intervening factors. We performed a collinearity test on the fully adjusted model (Model 4), obtaining no Variance Inflation Factor value higher than four.

5. Results

More than half of respondents in the analysis sample (57.3%) reported zero flights. Among those who did report flights, the distribution of GHG emissions is highly positively skewed (median: 1373 kgCO₂e; mean: 3135; standard deviation: 4491; skewness: 10.29). This means that there is a long tail of high values, corresponding to individuals who flew frequently and/or over long distances in the year prior to the interview.

A bivariate analysis of the associations between GHG emissions and the main predictors (Table 1) mostly confirms theoretical expectations. Participation in air travel and GHG emissions are highest for London residents. Outside of London, however, there is no clear urban-rural gradient, with slightly higher levels of air travel in rural area than in urban and conurbation areas (Figure 2). Emissions from air travel are somewhat higher for people living in closer proximity to town centres (Table 1).

There is a clear gradient in both participation and emissions across different migration generations, with particularly high levels of air travel among recent first-generation migrants. All minority ethnic groups have higher average emissions than ‘White British,’ although Blacks also have the highest non-participation rate. There is a strong association between geographical dispersion of social networks and emissions. We find higher emission and participation levels for respondents with better accessibility to large airports. Levels of air travel are higher for respondents with access to household cars and increase with mileage.

Patterns of association between GHG and basic socio-economic control variables (see Table SM2 in the Supplementary File) are broadly in line with the literature, with higher levels of air travel among respondents in employment, with higher income, and with tertiary education, as well as males, and among individuals in the 30 to 59 years old age band, and those in a cohabiting relationship. Respondents with long-standing illness or disability and those with responsibility for children

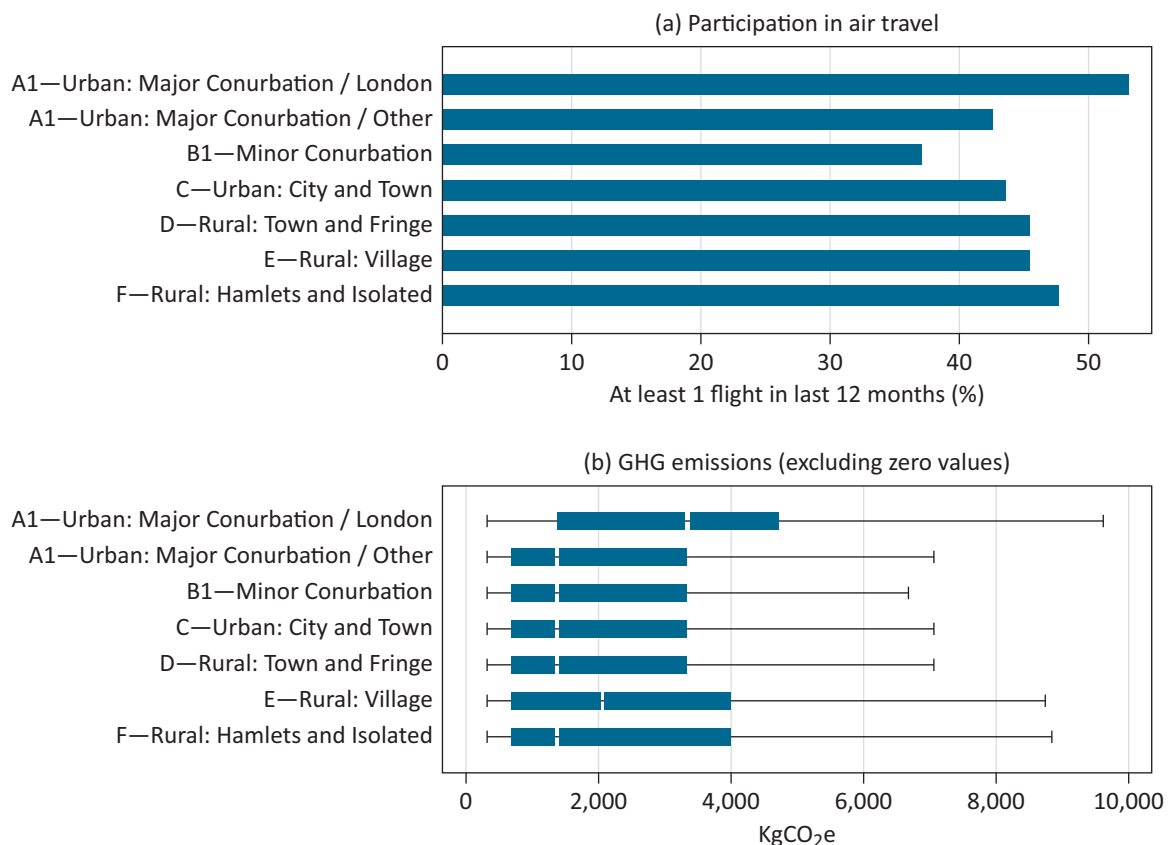


Figure 2. Participation in private air travel (panel a, N = 16,696) and distribution of associated GHG emissions for respondents with non-zero values (panel b, N = 7,518), by categories of the rural-urban classification. Note: The boxplots in panel b do not display outside values.

reported lower average levels of air travel. Note that the effect of income is particularly large, with average GHG emissions among respondents in the top income quintile nearly four times as large as for the bottom quintile.

The two-stage regression analysis (Table 2) shows that when controlling for basic socio-economic correlates (Model 1), there is no statistically significant difference between types of area, except for London and (to a lesser extent) rural villages, where emissions are higher. The coefficients for London change greatly in the adjusted models though. In Model 2, we control for migration generation and social networks: Here we find no significant association between London and the level of emissions (in the OLS model), while the coefficient for participation in air travel (in the logit model) is still significant but of lower magnitude as compared to Model 1. When further controlling for accessibility to airports (Model 3), neither coefficient for London is statistically significant. This suggests that a large part of the association between London and participation in air travel is accounted for by better accessibility to airports, while greater emissions are mostly accounted for by an over-representation of people with migration background and/or spatially dispersed social networks. The association between living in rural villages and air travel emissions, however, is not modified in the adjusted models.

We find a positive association between living in closer proximity to town centres and emissions (for air travel participants), which is only marginally reduced in magnitude in Model 2 and 3. This suggests that those who live in closer proximity to town centres, when they do fly, tend to do so more often and/or to further destinations. The reasons for this cannot be identified in our analysis. Note, however, that the magnitude of the association is very weak, with the OLS analysis (see Table SM3 in the Supplementary File) showing that living one minute further away from the nearest town centre is associated with a reduction in air travel GHG of just 1 kgCO₂e per year in the fully-adjusted model.

Model 2 confirms the positive association between air travel and first-generation migration background. With regard to social network dispersion, both having close friends abroad and having close family abroad are positively associated with air travel. The effect of the share of friends outside of the local area is not linear, as the ‘half or less’ category is positively associated with participation in air travel, while the ‘more than half’ category is not. This may be due to the correlation between this category and other migration background, ethnicity and social network variables that are being controlled for. Overall, the effect of migration background and social network dispersion predictors is large, with

Table 1. Main independent variables: Group size and descriptive statistics for GHG emissions from air travel (N = 16,696).

Variable	Value	Group size (%)	Zero flights (%)	GHG emissions (kgCO ₂ e, mean)
Rural-urban classification	A1—Urban: Major Conurbation/London	14.9	47.6	2045
	A1—Urban: Major Conurbation/Other	16.4	59.0	1187
	B1—Minor Conurbation	3.8	66.4	804
	C—Urban: City and Town	45.0	59.0	1217
	D—Rural: Town and Fringe	9.6	57.4	1204
	E—Rural: Village	5.8	57.3	1434
	F—Rural: Hamlets and Isolated Dwellings	3.5	56.3	1379
Travel time to nearest town centre by public transport or walking	Low (3–16 minutes)	37.4	[56.7]	1454
	Medium (17–22 minutes)	29.4	[57.7]	1271
	High (23 or more minutes)	32.2	[57.4]	1262
Migration generation	4th+	71.3	59.3	1187
	3rd	7.6	56.8	1316
	2nd	9.3	55.4	1579
	1st (5+ years)	10.1	46.0	2017
	1st (less than 5 years)	0.7	42.9	3775
Ethnicity	White British	85.9	58.4	1232
	Other White	4.1	35.1	2349
	Asian or Asian British	5.2	54.3	2173
	Black or Black British	2.1	63.1	1409
	Other + Mixed	1.8	54.0	1610
Friends outside of local area	None	14.3	68.4	830
	Half or less	45.6	55.1	1310
	More than half	39.0	55.6	1556
Best friends abroad	No	91.4	58.6	1245
	Yes	7.6	40.9	2453
Close family abroad	No	92.1	58.5	1244
	Yes	7.0	40.0	2571
Travel time to nearest large airport	Low (10–45 minutes)	34.7	48.8	1708
	Medium (46–77 minutes)	32.5	57.8	1275
	High (78 or more minutes)	31.8	65.9	996
Number of airports within 60 minutes travel time	None	47.6	63.8	1049
	1	35.3	54.0	1409
	2 or more	16.1	45.0	2035
Annual passengers at nearest large airport (millions)	Low (5 or less)	34.3	58.5	1209
	Medium (5–18)	33.5	59.2	1226
	High (18 or more)	31.2	53.8	1598
Cars in household	No	18.1	77.8	681
	Yes	80.9	52.6	1484
Distance driven by car in last 12 months (household total; thousand miles)	Low (4 or less)	34.4	70.4	847
	Medium (4–12)	33.6	53.9	1476
	High (12 or more)	31.0	46.3	1732

Notes: Values between square brackets indicate that there is no statistically significant difference between the categories of the independent value (Chi-square and t-tests at $p < 0.05$). Continuous predictors were categorised into three groups (low/medium/high) based on terciles of the distribution.

Table 2. Parameter estimates for two-stage regression models of GHG emissions (kgCO₂e) from air travel, including selection equation (Logit—participation in air travel) and outcome equation (OLS—emissions of air travellers, log-transformed).

	Model 1		Model 2		Model 3		Model 4	
	Logit	OLS	Logit	OLS	Logit	OLS	Logit	OLS
	Coef. (b)	Coef. (b) [in log(kg)]	Coef. (b)	Coef. (b) [in log(kg)]	Coef. (b)	Coef. (b) [in log(kg)]	Coef. (b)	Coef. (b) [in log(kg)]
Rural—urban classification (ref.cat.: C—Urban: City and Town)								
A1—Urban: Major Conurbation/London	0.39 ***	0.21 ***	0.3 ***	0.08	0.06	0.02	0.25 **	0.04
A1—Urban: Major Conurbation/Other	0.08	0.01	0.12	0.01	−0.03	0.01	0.06	0.01
B1—Minor Conurbation	−0.11	−0.09	−0.06	−0.08	−0.07	−0.04	−0.03	−0.03
D—Rural: Town and Fringe	−0.01	−0.04	−0.01	−0.03	0.02	−0.02	−0.01	−0.03
E—Rural: Village	−0.10	0.12 *	−0.10	0.13 *	−0.03	0.14 *	−0.09	0.13 *
F—Rural: Hamlets and Isolated Dwellings	−0.16	−0.03	−0.16	−0.02	−0.11	−0.01	−0.17	−0.02
Travel time to nearest town centre by public transport or walking (minutes)	0.002	−0.004 *	0.002	−0.003 *	0.003	−0.003 *	0.001	−0.004 *
Income quintile (ref. cat.: 1st)								
2 nd	0.18 *	−0.08	0.21 **	−0.05	0.17 *	−0.05	0.10	−0.05
3 rd	0.55 ***	−0.02	0.60 ***	0.06	0.56 ***	0.05	0.46 ***	0.05
4 th	0.97 ***	0.08	1.00 ***	0.16 **	0.95 ***	0.16 **	0.84 ***	0.15 **
5 th	1.60 ***	0.33 ***	1.60 ***	0.42 ***	1.60 ***	0.41 ***	1.40 ***	0.39 ***
Tertiary education qualification (dummy)	0.39 ***	0.09 ***	0.34 ***	0.04	0.32 ***	0.04	0.32 ***	0.04
Employment status (ref. cat.: In employment)								
Retired	−0.37 ***	−0.05	−0.36 ***	−0.05	−0.35 ***	−0.05	−0.30 ***	−0.04
Other (non-employed, non-retired)	−0.37 ***	0.08 *	−0.36 ***	0.06	−0.35 ***	0.06	−0.31 ***	0.07 *
Age (ref.cat. 16–29 years old)								
30–59 years old	−0.24 ***	0.12 **	−0.30 ***	0.11 **	−0.29 ***	0.11 **	−0.26 ***	0.12 **
60–74 years old	−0.04	0.15 **	−0.07	0.18 ***	−0.07	0.18 ***	−0.04	0.20 ***
75+ years old	−0.71 ***	0.08	−0.74 ***	0.12	−0.70 ***	0.12	−0.61 ***	0.14
Cohabiting couple (dummy)	0.33 ***	0.02	0.31 ***	0.01	0.28 ***	0.01	0.19 ***	0.00
Female (dummy)	0.18 ***	−0.02	0.19 ***	0.00	0.19 ***	0.00	0.21 ***	0.00
Responsible for children < 16 years old (dummy)	−0.33 ***	−0.19 ***	−0.36 ***	−0.20 ***	−0.37 ***	−0.20 ***	−0.38 ***	−0.20 ***
Long-standing illness or disability (dummy)	−0.36 ***	−0.09 ***	−0.34 ***	−0.08 **	−0.33 ***	−0.08 **	−0.31 ***	−0.07 **

Table 2. (Cont.) Parameter estimates for two-stage regression models of GHG emissions (kgCO₂e) from air travel, including selection equation (Logit—participation in air travel) and outcome equation (OLS—emissions of air travellers, log-transformed).

	Model 1		Model 2		Model 3		Model 4	
	Logit	OLS	Logit	OLS	Logit	OLS	Logit	OLS
	Coef. (b)	Coef. (b) [in log(kg)]	Coef. (b)	Coef. (b) [in log(kg)]	Coef. (b)	Coef. (b) [in log(kg)]	Coef. (b)	Coef. (b) [in log(kg)]
Migration generation (ref. cat.: 4th+) 3rd								
			0.03	0.05	0.01	0.05	0.03	0.05
2nd								
			0.11	0.02	0.11	0.01	0.11	0.01
1st (5+ years)								
			0.28 **	0.02	0.28 **	0.01	0.3 **	0.02
1st (less than 5 years)								
			0.03	0.47 **	0.05	0.48 ***	0.14	0.49 ***
Ethnic group (ref. cat.: White British)								
Other White								
			0.35 *	-0.05	0.34 *	-0.05	0.34 *	-0.05
Asian or Asian British								
			-0.14	0.51 ***	-0.18	0.51 ***	-0.20	0.51 ***
Black or Black British								
			-0.49 ***	0.23 **	-0.49 ***	0.25 **	-0.42 **	0.26 **
Other + Mixed								
			-0.082	0.15	-0.09	0.16	-0.05	0.16
Friends outside of local area (ref.cat.: none)								
half or less								
			0.22 ***	0.02	0.20 ***	0.02	0.19 **	0.02
more than half								
			0.08	0.08	0.06	0.08	0.05	0.08
Best friends abroad (dummy)								
			0.33 ***	0.14 ***	0.32 ***	0.14 ***	0.32 ***	0.14 ***
Close family abroad (dummy)								
			0.51 ***	0.28 ***	0.52 ***	0.28 ***	0.56 ***	0.28 ***
Travel time to nearest large airport (hours)								
					-0.19 ***	0.00	-0.12 *	0.00
Number of airports within 60 minutes travel time								
					0.12 **	0.04	0.06	0.04
Annual passengers at nearest large airport (millions)								
					0.001	0.002 **	0.001	0.002 **
Cars in household (dummy)								
							0.53 ***	-0.02
Distance driven by car in last 12 months (household total; thousand miles)								
							0.005 **	0.003 **
Constant	-1.0 ***	7.4 ***	-1.2 ***	7.2 ***	-1.0 ***	7.1 ***	-1.5 ***	7.1 ***
N	16696	7518	16696	7518	16696	7518	16696	7518
Pseudo-R ² /R ²	0.11	0.06	0.12	0.09	0.13	0.10	0.13	0.10
AIC	22235	20614	22016	20342	21921	20329	21805	20320

Note: * p < 0.05, ** p < 0.01, ***p < 0.001.

e.g., having close family members abroad being associated with an additional 776 kgCO₂e for air travel per year in the fully adjusted model (see Table SM3 in the Supplementary File).

The effect of ethnic minority background is complex. Non-British ('other') Whites are more likely to participate in air travel than any other ethnic group, but those of them who fly do not tend to generate higher levels of emissions, perhaps because of shorter flights to Europe. Conversely, Asians, Blacks, and those with 'other or mixed' background are less likely to participate in air travel, but those of them who do tend to fly longer distances as compared to the White British majority (Table 2). The overall impact on GHG emissions is strongly positive for Asians, but negative for Blacks and respondents with 'other and mixed' background (see Table SM3 in the Supplementary File).

Regarding accessibility to airports, Model 3 shows higher participation in air travel for those who live closer to a large airport, and for those who are able to reach several airports within 60 minutes travel time, even after controlling for confounders (Table 2). The number of passengers at the nearest airport is associated with an increase in GHG emissions for those who fly, although of small magnitude (see Table SM3 in the Supplementary File).

Contrary to expectations, we find a net *positive* association between car ownership and participation in air travel, as well as between car mileage and both dimensions of air travel (Table 2, Model 4), although the magnitude of the latter coefficient is not very large (see Table SM3 in the Supplementary File). The inclusion of these variables modifies the coefficients for London which, in the fully adjusted model, is again positively associated with participation in air travel. This can be interpreted as follows: Londoners fly more than residents of other areas, if one considers lower car ownership and use in London, and that car drivers tend to fly more. Conversely, in Model 4 the positive association between the number of airports that one can reach within 60 minutes and participation in air travel loses significance. This suggests that access to a car improves access to airports, and that this explains part—but only part—of why car owners fly more.

Regarding socio-economic control variables, the multivariate findings broadly confirm the bivariate analysis, with high income, tertiary education, employment, couple cohabitation, and middle adulthood all associated with greater GHG emissions. As expected, the impact of income is particularly large, with the top income quintile emitting roughly 1,600 kgCO₂e more than the bottom quintile when controlling for other factors (see Table SM3 in the Supplementary File). Conversely, being responsible for children and long-standing illness or disability are associated with substantial reductions in GHG. It is interesting to note however that when other factors (including notably retirement and disability) are controlled for, the young elderly (60 to 74 years old) have the highest GHG emissions from air travel (see Table SM3 in

the Supplementary File). Younger adults (16 to 29 years old) appear more likely than other age groups to fly at least once a year, although on the whole they emit less GHG. Females are more likely than men to participate in air travel when responsibility for children is controlled for (Table 2), although the magnitude of the effect in terms of GHG is trivial (see Table SM3 in the Supplementary File). This suggests that lower levels of air travel among women are largely due to childcare responsibility.

The results of the corresponding Heckman models (see Table SM4 in the Supplementary File) are largely consistent with those discussed above, showing only marginal differences in terms of statistical significance of single coefficients.

Further to the analysis presented here, we tested whether there is evidence of a rebound effect among respondents in the lower-middle income groups, as suggested in the literature (Czepkiewicz, Heinonen, et al., 2020; Ottelin et al., 2014, 2017). The rationale is that, since both air travel and car driving are relatively cheap for higher income households, one would expect to see a rebound effect only among households with more limited resources. To test this conjecture, in Model 5 (see Table SM5 in the Supplementary File) we include interaction terms between income and car ownership and use. We find no evidence of a rebound effect between car ownership and mileage and air travel.

6. Discussion and Conclusions

Our findings provide qualified support for the first set of hypotheses: Levels of private air travel are higher in the largest English conurbation (London), and among those living in closer proximity to city centres, even after controlling for basic socio-economic characteristics such as income, age, sex, and household composition. This is consistent with previous research (Czepkiewicz, Heinonen, et al., 2018). In contrast with previous studies showing a clear urban-rural gradient in air travel (e.g., Demoli & Subtil, 2019; Reichert & Holz-Rau, 2015), we find no clear difference between rural areas and urban areas other than London (including other large conurbations), and a persistent positive association between rural villages and air travel emissions. A possible explanation is that in England rural villages attract people who are particularly wealthy, educated, and/or internationally connected, in ways that are not entirely captured by our predictors.

We find evidence that the association between London residence and air travel is partly due to better airport accessibility, as well as to the overrepresentation of migrants, ethnic minorities, and people with otherwise dispersed social networks. This confirms hypotheses that had been put forward in the literature, but for which scant evidence existed to date. However, when controlling for all predictors (including car ownership and use), we find a residual positive association between London residence and participation in air travel. This suggests that other factors might also be at play.

Unlike for London residence, greater levels of air travel among people who live in closer proximity to city centres are largely not due to any of the factors considered here, although the magnitude of the association is very weak. Recent research suggests that this association may be due to the cosmopolitan attitudes of urban core residents (Czepkiewicz et al., 2019; Czepkiewicz, Klaas, et al., 2020). This factor could not be included in our study as it is not available within the survey, although one would expect it to correlate to some extent with migration background and social networks abroad. More research is needed on the interrelationships between these factors, notably from a life course perspective (Mattioli, 2020).

Against our hypothesis, the study finds a net positive association between car ownership and use and air travel. This contradicts the hypothesis of a trade-off between the two but is consistent with studies that found a neutral or positive association (see Section 2). Since car ownership and use are lower in London than elsewhere, this implies that a ‘rebound effect’ is not responsible for higher levels of air travel in the British capital. The reasons for the positive association are not clear from our analysis though. Apart from shorter journey times (which are controlled for in our models), research on airport surface access suggests that people find driving more convenient than public transport in terms of cost, comfort, reliability, and ease of transporting luggage (Budd, 2019). This may discourage households without a car from flying. Another possible explanation is that underlying attitudinal or lifestyle factors are associated with both car and air travel, and account for the observed positive association. Finally, it might be that in an island country like the UK, where a very high share of international travel is by plane, car and air travel are not perceived as substitutes for long-distance travel.

Our results have three main policy implications. First, from an urban planning perspective, they are not supportive of the thesis that encouraging urbanisation and/or urban densification would increase air travel and thus backfire in terms of transport emission. This thesis is predicated on the ‘compensation hypothesis’ (which we did not test here) and the ‘rebound effect’ (for which we find no evidence). We find evidence that better access to airports and social network dispersion are important factors in explaining why Londoners fly more, which tends to suggest that alternative explanations for higher levels of air travel in large urban areas are of secondary importance.

Second, the association between air travel and the size and proximity of airports could be interpreted as suggesting that air travel supply induces demand to some extent. This would provide support for a moratorium on airport expansion for the sake of the climate (Stay Grounded, 2019). Yet one could also see the association as demand-led, as airline hubs prefer to locate near large markets. Global cities like London, with concentrations of high-skilled workforce and migrants, tend to pro-

vide such conditions. Residents with international lives and/or careers might self-select into such cities, precisely because of the ease of air travel that they provide (Dobruszkes, Lennert, & Van Hamme, 2011). Conversely, airport hubs may result in overprovision and induced demand among those who happen to live nearby. While our analysis controls for many of the demand-side factors that might explain the association (e.g., migration background, social networks, and education), the recursive causality between supply and demand must be kept in mind and investigated further.

Finally, the positive association between car travel and air travel, if confirmed, would suggest that there are synergies between measures aimed at reducing car ownership and use and those aimed at curbing air travel. This would be good news for sustainable transport policy, since car and air travel account for most transport emissions.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Characteristics of Middle European Holiday Highfliers

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Abstract

This article estimates a count-data model on the flight behaviour of Austrian holiday-makers based on information from a large representative quarterly survey spanning the years 2014–2016. On average, the number of holiday flights ranges between 0.6 and 1.2 per year for residents in the least populated region and the capital, respectively. Results of the estimations reveal that the number of holiday flights is highest for persons with tertiary degrees, of a young age (16–24 years) and capital city residents, while it is lowest for individuals with children and large households. Residents of the capital city fly 78 percent more often in a given quarter than those living in Carinthia, the most rural region. The Oaxaca-Blinder decomposition analysis reveals that the difference is rather related to location than to variations in individual characteristics. Socio-demographic aspects such as age, household size and travelling with children are of no relevance for the holiday flying behaviour of capital residents.

Keywords

count data model; holiday travel; tourist air travel; travel frequency

Issue

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1. Introduction

Travelling by air is considered particularly harmful for the environment (Becken, Friedl, Stantic, Connolly, & Chen, 2021; Gössling & Peeters, 2007; Gössling & Upham, 2009). Despite this, long distance air travel is the fastest growing passenger mobility segment in the pre-Covid-19 world (Gössling & Humpe, 2020).

Present discussions encompass the sustainability of not only frequent flyers (Young, Higham, & Reis, 2014), but increasingly also “unnecessary” leisure and holiday travel (Alcock et al., 2017; Cohen, Higham, & Reis, 2013; Graham & Metz, 2017; Hares, Dickinson, & Wilkes, 2010; Holden & Norland, 2005; McDonald, Oates, Thyne, Timmis, & Carlile, 2015; Morten, Gatersleben, & Jessop, 2018). Since the deregulation of the aviation market and the emergence of low-cost airlines in Europe, the share of leisure travellers is increasing (O’Connell & Williams, 2005).

Air travel for purposes of business, migration, education as well as to visit friends and relatives might be difficult to avoid. Many firms, institutions and organisations are active in the international arena and long-distance relationships are not uncommon. There are also national as well as European members of parliament, who are expected to have a close relationship with their constituencies, for instance. Yet, holiday travel by air might to a certain extent be prevented because there are environmentally friendly transportation modes available for short- or medium-long distances. There is, however, no detailed information available on the role played by socio-demographic aspects in the flight behaviour of holiday-makers.

The aim of this study is to gain more insights into the determinants of air travel for holiday purposes. For this objective, the frequency of flights is estimated by use of a count data model. Socio-demographic characteristics

are employed to explain the flight behaviour of residents in both rural and urban areas. In addition, evidence of the flight destinations for holiday purposes is provided. The analysis is based on a representative survey of Austrian residents (17,400 observations) who travel at least once per quarter for holiday purposes during the period 2014–2016.

Previous studies indicate that air travel behaviour depends significantly on age, education, income, city of residence and accessibility to airports (Graham & Metz, 2017; Reichert, Holz-Rau, & Scheiner, 2016). Most studies focus on total air travel and do not distinguish travel for holiday purposes from travel for business or visiting friends and relatives. The few exceptions include research on the holiday air travel behaviour of residents in Helsinki and Reykjavik as well as students in Sweden (Czepkiewicz, Heinonen, Næss, & Stefansdóttir, 2020; Czepkiewicz, Klaas, & Heinonen, 2020; Gössling, Hanna, Higham, Cohen, & Hopkins, 2019). Research based on official representative surveys are rare (Schubert, Sohre, & Ströbel, 2020) and the use of count-data models, that allows to explain the number of holiday flights, are seldom employed so far. Exceptions to this are Czepkiewicz, Heinonen, et al. (2020) relating to the approach, Gössling, Lohmann, Grimm, and Scott (2017), Dargay and Clark (2012), Alcock et al. (2017) and Bruderer Enzler (2017) concerning the dataset as well as Schubert et al. (2020) regarding both aspects.

The structure of this study is as follows: Section 2 outlines the conceptual background; Section 3 describes the empirical approach; and Section 4 introduces the dataset and the descriptive statistics. The results are presented and discussed in Section 5, while the conclusion is presented in Section 6.

2. Conceptual Background

Investigations on flight behaviour can be found in travel and transportation as well as in tourism literature. Many studies explore the determinants of international travel, air travel or long-distance travel with a focus on socio-demographic characteristics. Common features analysed are age, gender, household type, education, occupation and income. However, air trips for holiday purposes are seldom treated separately (exceptions include Czepkiewicz, Heinonen, et al., 2020; Czepkiewicz, Klaas, & Heinonen, 2020). Graham and Metz (2017) discusses the distinction between “discretionary” leisure travel (including holiday travel) and “non-discretionary” business travel where air travels motivated by visiting friends and relatives are in principle voluntary but in practice often indispensable. Based on the latter argument, and on the fact that two out of three flights by Austrian residents are holiday-oriented, this study focuses specifically on the segment that is considered dispensable.

Several studies show that the probability and number of air travels depend on socio-demographic factors (Bruderer Enzler, 2017; Czepkiewicz, Klaas, &

Heinonen, 2020; LaMondia, Aultman-Hall, & Greene, 2014). Proximity to the airport and residency in large metropolitan areas or in the capital region is also regarded as important factors for the likelihood of air travel (Bruderer Enzler, 2017; Graham & Metz, 2017; Holden & Norland, 2005; LaMondia et al., 2014; Schubert et al., 2020; for a review of the literature see Czepkiewicz, Heinonen, & Ottelin, 2018). Holden and Norland (2005) demonstrate that individuals living in dense, centrally located neighbourhoods in Oslo take the plane for leisure purposes more often than the average holiday traveller. Næss (2006a, 2006b) suggests that air travel has become an integral part of the urban and cosmopolitan lifestyle of inner-city residents, particularly so among young students and academics (see also Große, Fertner, & Carstensen, 2019). The high urban density constrains the quality of life by frequent traffic jams and restricted access to nature and thus creates demand for regular weekend trips or other short breaks. This phenomenon is referred to as “escape travel” or “compensation hypothesis” (Holden & Norland, 2005; Holz-Rau, Scheiner, & Sicks, 2014; Muñiz, Calatayud, & Dobaño, 2013; Næss, 2006a, 2006b; Reichert et al., 2016). Czepkiewicz et al. (2018) show that the positive relationship between urban density and long-distance travel behaviour is still significant when demographic and socio-economic variables are controlled for. Correspondingly, Heinonen, Jalas, Juntunen, Ala-Mantila, and Junnila (2013) report that air travel by urban residents in Finland (especially in the Helsinki Metropolitan region) is more frequent. The rebound effect of consumption is also used as a possible explanation behind the higher level of flying by individuals living in urban areas. In such areas you may not need to own a car for local transportation. Giving up car-ownership saves a significant amount of money, which can then be used for other purposes, such as holiday travel. Literature indicates that car-free people fly more frequently than car-owners (Ornetzeder, Hertwich, Hubacek, Korytarova, & Haas, 2008; Ottelin, Heinonen, & Junnila, 2017).

A number of studies discover that education and income are important drivers of air travel (Bruderer Enzler, 2017; Czepkiewicz, Klaas, & Heinonen, 2020; Dargay & Clark, 2012; Graham & Metz, 2017; Holden & Norland, 2005; LaMondia et al., 2014; Ornetzeder et al., 2008). Randles and Mander (2009) suggest that flying remains an activity that is used disproportionately by higher income and higher social class groups, and Graham and Metz (2017) find that the proportion of highly skilled air travellers is twice as large as that of unskilled persons. Czepkiewicz, Klaas, and Heinonen (2020) show that persons in the highest income class and those with a university degree in the larger Reykjavik area have a significantly higher number of non-work-related flights.

The freedom to travel independently of transportation mode seems to attract young adults in particular. Shaw and Thomas (2006) conclude that environmental awareness among young adults is relatively high, such as sustainable local transportation and waste recycling.

However, this does not necessarily apply to air travel. The phase of life appears to be important for the decision to travel by air (Davison & Ryley, 2013). Dargay and Clark (2012) document that United Kingdom families with children and those living in large households fly less often. Based on the Swiss environmental survey, Bruderer Enzler (2017) finds that household characteristics and family size are important, while the role of gender is less obvious. To the contrary, Dargay and Clark (2012) exhibit that women in the United Kingdom undertake less air travel.

Because of marked differences in sample designs and sizes (time period, reference period for survey questions; individual or trip level and representativeness), definitions of air travel (probability of flying, number of flights), travel distances as well as methods used (multivariate or bivariate) results in recent literature are difficult to compare. There are also few studies that distinguish between air travel for leisure, visiting friends or relatives and work among groups of residents. The few common denominators available indicate that contextual (purpose, destination, length of stay, etc.) and socio-demographic factors are of importance. However, the contextual part is less prominent here since the analysis focuses on one specific context: holidays. Based on the determinants highlighted in the literature, the first hypothesis is formulated:

H1: The number of holiday flights depends on individual socio-demographic characteristics.

Although residents in urban and rural areas may exhibit different characteristics, literature is less clear on how this aspect affects their flying behaviour, leading to the second hypothesis:

H2: The importance of individual socio-demographic characteristic for the number of holiday flights varies between residents in the capital city and those living in other regions.

3. Empirical Approach

The specification of the number of holiday flights per person and quarter builds on count data models similar to those employed by Czepkiewicz, Klaas, and Heinonen (2020) on urbanite leisure travel and by Falk and Hagsten (2021) on emissions caused by air travel. The flight frequency is modelled as a function of several socio-demographic factors:

$$g(\mu_{it}) = \ln(\mu_{it}) = \beta_0 + \sum_{A=1}^5 \beta_{jA} AGECAT_{it}^A + \sum_{E=1}^2 \beta_{jE} EDU_{it}^E + \beta_{jW} WOMEN_{it} + \beta_{jK} CHILDREN_{it} + \sum_{S=1}^3 \beta_{jS} LABOURSTATUS_{it}^S + \sum_{H=1}^5 \beta_{jH} HHSIZE_{it}^H +$$

$$+ \sum_{R=1}^8 \beta_{jR} REGION_{it}^R + \sum_{Y=1}^2 \beta_{jY} YEAR_{it}^Y + \sum_{Q=1}^3 \beta_{jQ} QUARTER_{it}^Q + \varepsilon_{it},$$

$$\mu_{it} = g^{-1}(X'_{it}\beta)$$

with i as the individual, t as the quarter in a given year of travel, vector X representing a set of covariates and β is the corresponding group of coefficients. The link function $g(\cdot)$ transforms the probability of the categorical variable to a continuous scale that can be modelled by linear regression. The explanatory variables in vector X encompass *AGECAT* denoting age-class, *EDU* indicating the level of education and *WOMEN* if the traveller is female. *CHILDREN* is a dummy variable for travelling with children, *HHSIZE* is a set of dummy variables measuring household size and *LABOURSTATUS* is a group of dummy variables reflecting the labour market status (employed, unemployed, student or retired). Variable *REGION* relates to the region where the traveller resides. Macroeconomic factors such as price effects and fluctuations of the business cycle are captured by annual year dummy variables *YEAR*, indicating the year of travel and *QUARTER* controls for calendar effects within the year. To uncover the possible differences between urban and rural agglomerations, separate estimations are conducted for the capital (Vienna) and non-capital regions, the latter consisting of eight federal states.

Since the dependent variable is a highly skewed count with values ranging from zero to four and a few above, the Poisson or Negative Binomial models are suitable. The Poisson model is a special case of the Negative Binomial regression model where the dispersion parameter alpha is constrained to zero (Cameron & Trivedi, 2010). A Likelihood ratio test can be used to test the Negative Binomial regression model against the Poisson model. Besides the count data model, the Pearson-Chi-Square and G tests are used to identify if the different holiday flight destinations are independent of residence (Cochran, 1954; McDonald, 2009).

4. Data and Descriptive Statistics

Data for this analysis originate from the official Austrian Travel Survey (Statistics Austria, 2017). This is a quarterly representative survey on holiday and business travels with at least one overnight stay, undertaken by persons living in Austria aged 15 years or older. The survey is stratified by federal state, age of the individual and gender. Each quarter, around 3,500 randomly selected persons are interviewed by telephone. Participation in the survey is voluntary and the non-response rate is on average 29 percent.

The dataset encompasses information on actual domestic as well as international (outbound) flights by destination country or region (42 international destinations) and travel purpose, length of stay, accommodation

type, departure month, transportation mode and expenditures. In this analysis a distinction between the capital and non-capital regions are made by use of population density measures (Thrall, 1988). Vienna has a population density of 4,600 inhabitants per square metre, which is a factor 55 higher than in the non-capital regions (Statistics Austria, 2017). The non-capital regions show a spread between 59 and 153 inhabitants per square metre (Carinthia and Vorarlberg).

The travel data are accompanied by a wide range of socio-demographic factors such as educational attainment, labour market status and travel company size. Although data are available from 2012 onwards, methodological changes of the travel survey, restrict the estimation sample to the period 2014–2016. In this study, the sample is confined to holiday trips, which amounts to two-thirds of total travels, of which 18 percent are undertaken by air transportation (Table 1). Descriptive

Table 1. Proportion of persons flying to their holiday destinations 2014–2016 (percentage).

	Other transportation	Flying	1 Flight	2 Flights	≥ 3 Flights
All residents					
2014 Q1	85.9	14.1	12.9	1.2	0.1
2014 Q2	80.2	19.8	18.2	1.5	0.1
2014 Q3	75.6	24.3	22.1	2.1	0.1
2014 Q4	84.4	15.6	14.6	1.0	0.1
2015 Q1	81.8	18.1	17.0	1.1	0.0
2015 Q2	80.3	19.7	18.0	1.5	0.2
2015 Q3	78.7	21.3	19.4	1.7	0.2
2015 Q4	87.6	12.3	11.3	0.9	0.1
2016 Q1	86.8	13.2	12.4	0.6	0.2
2016 Q2	80.7	19.3	18.0	1.2	0.0
2016 Q3	79.6	20.3	18.0	2.2	0.2
2016 Q4	86.2	13.8	12.3	1.4	0.1
2014–2016 mean	82.3	17.7	16.2	1.4	0.1
Capital residents					
2014 Q1	77.8	22.2	19.3	2.8	0.0
2014 Q2	72.8	27.2	24.9	2.3	0.0
2014 Q3	62.6	37.4	33.9	3.5	0.0
2014 Q4	78.2	21.8	20.3	1.5	0.0
2015 Q1	72.5	27.1	24.9	2.2	0.0
2015 Q2	75.2	24.8	21.7	2.3	0.8
2015 Q3	71.4	28.6	24.0	4.4	0.3
2015 Q4	77.0	22.6	20.4	1.9	0.4
2016 Q1	79.9	20.1	17.9	1.8	0.4
2016 Q2	73.6	26.4	23.2	3.3	0.0
2016 Q3	66.9	32.8	28.0	4.2	0.5
2016 Q4	80.2	19.8	15.4	4.0	0.4
2014–2016 mean	74.0	25.9	22.8	2.9	0.2
Residents in other regions					
2014 Q1	87.2	12.8	11.8	0.9	0.1
2014 Q2	81.8	18.2	16.7	1.3	0.1
2014 Q3	77.2	22.7	20.7	1.9	0.1
2014 Q4	86.1	13.9	13.0	0.8	0.1
2015 Q1	84.4	15.6	14.7	0.8	0.0
2015 Q2	81.6	18.4	17.1	1.3	0.0
2015 Q3	80.4	19.6	18.4	1.1	0.2
2015 Q4	90.7	9.3	8.7	0.7	0.0
2016 Q1	88.6	11.4	10.9	0.3	0.2
2016 Q2	82.2	17.7	16.9	0.8	0.0
2016 Q3	82.6	17.4	15.6	1.7	0.1
2016 Q4	87.7	12.3	11.5	0.8	0.0
2014–2016 mean	84.2	15.8	14.7	1.0	0.1

Source: Austrian Travel Survey (Statistics Austria, 2017).

statistics also reveal that only 16 percent of Austrian residents outside the capital region travel by air for holiday purposes in a given quarter, compared with more than one fourth of those living in the capital region. This latter group also flies more than once per quarter.

The representative sample holds data on 3,471 holiday flights over the period 2014–2016, of which less than one percent is domestic. The average number of holiday flights per person and year is 0.8, with the capital residents flying somewhat more frequently, 1.2 times (Figure 1; see also Table A1 in the Supplementary File). For Germany, Aamaas, Borcken-Kleefeld, and Peters (2013) report that total trips by plane occurs with a spread of 0.6–6.6 per person and year on average, spanning from low to high-income groups.

Both the proportion of Austrians flying to their holiday destinations and the number of flights are larger for highly skilled individuals (tertiary degrees), residents of the capital city (Vienna) and young people, while travellers with children and those living in large households exhibit the opposite pattern (Table 2). Individuals with a tertiary degree undertake 0.24 holiday flights per quarter on average as compared to those without degrees (0.16 flights). Young persons (aged 15–24) fly the most while middle aged (35–44) persons the least. Individuals who mainly travel with children fly less. Residents of the capital Vienna show an average of 0.30 holiday flights per quarter, while inhabitants of Carinthia, the least populated region, exhibit the lowest number of flights (0.13). It should be noted that this region is the Austrian lake district, with both the Alps and the Mediterranean Sea within driving proximity. The highest number of holiday flights can be observed in the second and third quarters.

Additional descriptive statistics reveal that the vast majority of holiday flights (78 percent) goes to European destinations, followed by Asia, the American continent and Africa (Table 3). Given the dominance of intra-European flights and data limitations, the empirical

analysis does not distinguish between European and non-European destinations. The most common destinations are Spain, Greece, Italy and Turkey, but there are differences across residence of the travellers. Viennese residents show a stronger preference for overseas trips (to North and South America) and for holiday flights to expensive destinations in Europe (France, Sweden and Switzerland) than residents of the non-capital region.

5. Empirical Results and Discussion

The Poisson estimations show that the number of quarterly holiday trips by air relates to individual socio-demographic factors, implying that H1 cannot be rejected (Table 4). Socio-demographic factors are relevant not only for the total sample but also for the sub-sample of residents living in the less populated non-capital regions. As a contrast, holiday flying behaviour of residents in the capital city area is less dependent on these aspects except the level of education, coinciding with H2. Capital city residents are also not particularly dependent on the season since only the third quarter renders significant estimates.

Younger persons, those with a tertiary degree and residents of the capital city (Vienna) show significantly higher number of air travels. The number of holiday flights are also significant and more pronounced for women than for men. Persons travelling with children and those living in larger households take the plane less often. The labour market status is not or only weakly related to the number of holiday flights. Season is also important with the largest number of flights in the summer quarter followed by spring. The Incidence Rate Ratio (IRR) coefficient reveals that residents of Vienna travel 79 percent more often by air than individuals in the region with the lowest population density (Carinthia). This difference is large given the average number of holiday flights of 0.2 per quarter (equal to 0.8 per year).

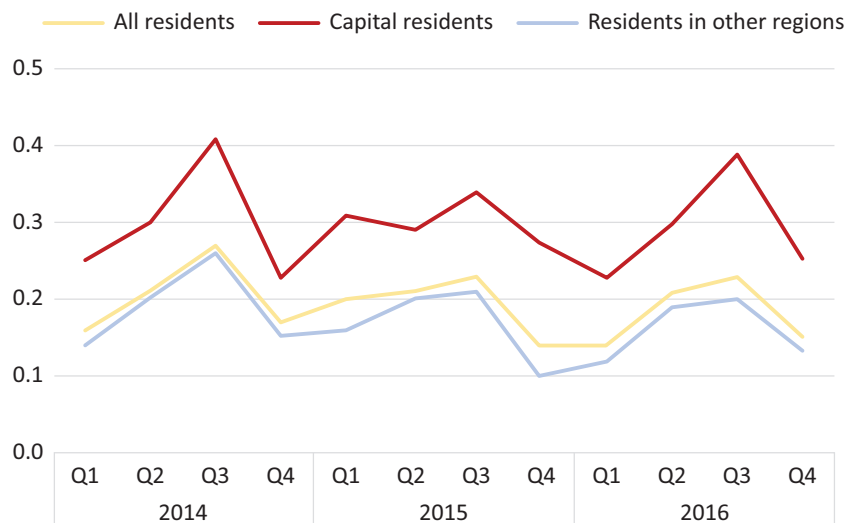


Figure 1. Evolution over time, average number of holiday flights per person and quarter. Source: Statistics Austria (2017) and own calculations.

Table 2. Individual holiday flying behaviour by characteristics (per quarter).

	Proportion	Number of flights
	Percent	Mean
Age 15–24	20.5	0.23
Age 25–34	18.2	0.20
Age 35–44	14.5	0.16
Age 45–54	19.0	0.20
Age 55–64	18.1	0.20
Age 65+	18.5	0.20
Education low level	14.9	0.16
Education medium level	17.6	0.19
Education tertiary level	21.6	0.24
Men	16.8	0.19
Women	19.3	0.21
Travellers (all) no children	19.0	0.21
Travellers (all) with children	14.0	0.15
Employed	18.0	0.20
Unemployed	18.3	0.23
Student	20.7	0.23
Pensioner/out of labour force	17.9	0.20
Household size = 1	20.7	0.23
Household size = 2	20.2	0.23
Household size = 3	18.8	0.21
Household size = 4	16.0	0.17
Household size = 5	14.7	0.16
Household size = 6	11.6	0.12
Burgenland	17.0	0.18
Lower Austria	18.0	0.20
Vienna	26.1	0.30
Carinthia	12.1	0.13
Styria	14.7	0.16
Upper Austria	15.5	0.17
Salzburg	17.3	0.18
Tyrol	16.5	0.18
Vorarlberg	20.2	0.22
Travel year 2014	18.9	0.21
Travel year 2015	18.4	0.20
Travel year 2016	17.2	0.19
Quarter 1	15.1	0.16
Quarter 2	19.6	0.21
Quarter 3	21.9	0.24
Quarter 4	14.0	0.15

Source: Statistics Austria (2017) and own calculations.

In order to identify the major factors responsible for the differences in holiday flying behaviour between residents in the capital and those in the non-capital regions, the Oaxaca-Blinder decomposition translated to the case of count data models is used (Stata command “nldecompose”; Bauer & Sinning, 2008; Sinning, Hahn, & Bauer, 2008). This technique decomposes the variation in the holiday air travel behaviour into a coefficient (or residual) effect and a characteristic effect. The decomposition is important if the characteristics of the residents diverge

Table 3. Choice of holiday flight destination by residence, pooled 2014–2016 (percent).

	Total	Vienna	Other regions
	Belgium	0.4	0.7
Denmark	0.6	0.5	0.6
Germany	7.6	7.7	7.6
Finland	0.1	0.0	0.2
France	4.1	5.1	3.8
Greece	11.0	11.0	11.0
United Kingdom	5.6	5.8	5.5
Ireland	1.3	1.3	1.4
Italy	8.0	9.3	7.5
Luxembourg	0.1	0.2	0.0
Netherlands	2.0	2.5	1.9
Portugal	3.1	3.0	3.2
Sweden	1.2	1.6	1.1
Spain	17.7	14.4	19.0
Iceland	0.6	0.0	0.8
Norway	0.8	0.7	0.9
Switzerland	0.6	0.9	0.5
Baltic states	0.3	0.3	0.3
Croatia	0.7	0.4	0.8
Malta	0.6	0.5	0.6
Poland	0.5	0.8	0.4
Romania	0.5	0.6	0.4
Slovakia	0.0	0.0	0.0
Slovenia	0.0	0.0	0.0
Turkey	7.8	6.9	8.2
Czech Republic	0.0	0.0	0.0
Hungary	0.0	0.0	0.0
Cyprus	1.1	1.8	0.9
Bosnia Herzegovina	0.0	0.0	0.0
Serbia	0.1	0.1	0.0
Bulgaria	0.9	0.6	1.0
Russia	0.8	0.9	0.8
Other Europe	0.5	0.8	0.3
Egypt	3.4	2.7	3.6
Tunisia	0.4	0.4	0.4
Rest of Africa	2.9	3.1	2.8
United States	3.5	4.3	3.2
Canada	0.5	0.3	0.6
Middle and South America	3.1	3.9	2.8
China	0.3	0.2	0.4
Other Asia	6.6	5.9	6.9
Australia, New Zealand etc.	0.5	0.5	0.5
Total	100	100	100

Regions:

Europe	78.8	78.6	78.8
America	7.1	8.4	6.6
Africa	6.6	6.3	6.7
Asia and Pacific	7.5	6.7	7.8
Number of holiday flights	3,465	960	2,505

Source: Statistics Austria (2017) and own calculations.

Table 4. Determinants of holiday flights 2014–2016, Poisson estimations.

	Total sample		Vienna		Other regions	
	IRR	z-stat	IRR	z-stat	IRR	z-stat
Age 15–24 (ref cat.: 45–54)	1.308 ***	3.48	1.028	0.18	1.388 ***	3.73
Age 25–34	0.925	-1.28	0.970	-0.27	0.910	-1.30
Age 35–44	0.804 ***	-3.49	0.894	-0.95	0.768 ***	-3.59
Age 55–64	0.920	-1.37	0.994	-0.06	0.907	-1.33
Age 65+	0.924	-1.00	0.876	-0.89	0.947	-0.59
Education medium (ref.: low)	1.234 ***	3.77	1.344 **	2.13	1.210 ***	3.12
Education tertiary level	1.512 ***	6.60	1.526 ***	2.97	1.525 ***	5.91
Women	1.147 ***	3.94	1.101	1.47	1.167 ***	3.76
Travellers with children	0.808 ***	-3.48	0.915	-0.79	0.779 ***	-3.39
Unemployed (ref.: employed)	1.213 *	1.73	1.030	0.16	1.297 *	1.88
Student	1.235 *	1.66	1.120	0.52	1.321 *	1.80
Pensioners/out of labour force	1.128	0.98	1.081	0.36	1.154	0.95
Household size = 2 (ref. = 1)	1.107 *	1.81	1.161 *	1.71	1.079	1.02
Household size = 3	0.963	-0.58	0.967	-0.31	0.954	-0.58
Household size = 4	0.849 **	-2.38	0.832	-1.44	0.844 **	-1.99
Household size = 5	0.797 ***	-2.64	0.762	-1.54	0.789 **	-2.30
Household size = 6	0.644 ***	-3.98	0.829	-0.72	0.609 ***	-3.94
Burgenland (ref.: Lower Austria)	0.940	-0.56			0.944	-0.52
Vienna	1.445 ***	7.27				
Carinthia	0.664 ***	-4.30			0.666 ***	-4.26
Styria	0.820 ***	-2.99			0.822 ***	-2.95
Upper Austria	0.869 **	-2.46			0.869 **	-2.45
Salzburg	0.930	-0.96			0.931	-0.93
Tyrol	0.931	-0.96			0.928	-1.01
Vorarlberg	1.132	1.51			1.133	1.51
Quarter 2 (ref.: quarter 1)	1.304 ***	5.09	1.101	1.00	1.396 ***	5.40
Quarter 3	1.545 ***	9.00	1.431 ***	3.99	1.596 ***	8.15
Quarter 4	0.912	-1.58	0.940	-0.59	0.900	-1.49
Year 2015 (ref.: year 2014)	0.924 *	-1.91	1.001	0.01	0.899 **	-2.20
Year 2016	0.890 ***	-2.76	0.994	-0.07	0.858 ***	-3.08
Constant	0.118 ***	-14.87	0.182 ***	-6.77	0.113 ***	-12.47
Number of observations	17,381		3,216		14,165	
Log pseudo likelihood	-9032		-2182		-6836	
Pseudo R ²	0.030		0.014		0.025	
LR-test alpha = 0, p-value	0.292		0.500		0.200	

Notes: ***, ** and * represent significance at the 1, 5 and 10 percent levels; dy/dx denotes the marginal effects and IRR is the incidence rate ratio. A likelihood ratio test indicates that the negative binomial regression model is rejected in favour of the Poisson model. Therefore, the interpretation of the results focuses on the Poisson estimations. Source: Statistics Austria (2017) and own calculations.

between the capital city and the other regions. Vienna has, for instance, the highest share of persons with tertiary degrees among all regions. The characteristic effect measures the difference in the predicted number of holiday flights by air for the total sample when the parameter vector is held constant. On the other hand, the coefficient effect is the variation in predicted number of holiday flights by air when the characteristics of capital city residents are held constant. Results of the decomposition show that the coefficient effect account for between 88 and 90 percent of the total capital resident effect (given the 59 percent higher flight intensity when only the Vienna dummy variable is included) indicating that deviations in the characteristics between the capital and

non-capital regions are negligible. In other words, if residents in the capital city region would have the same characteristics as those in the non-capital areas, the observed difference in the flying behaviour would only be reduced from 59 to 53 percent.

Besides location, education is a major variable of influence. Persons with tertiary education fly on average 51 percent more often to their holiday destinations $((1.51-1) \times 100 = 51$ percent) than people without degrees. This means that the average number of holiday flights by tertiary educated individuals is 0.10 larger compared with those without, given a sample mean of 0.2 holiday flights per quarter. Young people fly 31 percent more often than middle-aged persons (45–54) while

persons aged 35–44 show the lowest number of flights (minus 20 percent).

In general, the results coincide to some extent with recent, but fragmented literature in that educated individuals (Graham & Metz, 2017) living in urban areas fly more (Bruderer Enzler, 2017; Czepkiewicz et al., 2018). Schubert et al. (2020) use both a similar approach to the present study and a representative (Swiss) dataset, although their explanatory variables expand beyond socio-demographic aspects. In line with this study, Schubert et al. (2020) find that residents in urban areas have a higher probability to travel by air, but only short and middle distances. As a contrast, education and age are variables of no importance for the Swiss travellers, while gender is the only significant socio-demographic factor for long distance flights. The differences in results could originate from variations in travel behaviour across neighbouring countries as well as from the survey or the modelling itself, where certain lifestyle questions in the Swiss study also implicitly capture educational level, income and age, for instance.

As compared to other studies, the present approach also allows a ranking of the importance of the explanatory variables, where young persons, those with higher degrees or residents of the capital city both have a higher probability to take the plane for their holiday and use this transportation mode more often than others. The two latter variables may also be indications of a certain income level. Thus, the suggestion of escape or compensation travel by inhabitants in urban areas cannot be dismissed (Czepkiewicz et al., 2018), although it should not be forgotten that capital cities attract individuals with certain characteristics. This could mean preference for a lifestyle without car ownership, for instance, but use of other transportation modes, including air (Ornetzeder et al., 2008; Ottelin et al., 2017). An alternative explanation, that closeness to an international airport leads to more flying (Bruderer Enzler, 2017; Graham & Metz, 2017), is not convincing in this case since the neighbouring provinces of Vienna show significantly lower number of holiday air travel despite the fact that the travel time is less than two hours for the majority of these residents.

Given the geographical location of Austria, in the middle of Europe, several European holiday destinations are easily reached by car, bus or train. The same is valid for a large group of countries around Austria. Thus, the results are expected to be representative beyond the Austrian borders, but not necessarily for the countries in the outskirts of Europe or the islands, where the probability of flying to a holiday destination might be higher.

The first robustness check, where the flight intensity is estimated by a Probit model, confirms that low age, high education, being a woman, large household size, travelling with children and region of residence give the largest marginal effects (Table A2 in the Supplementary File). Among the predictors, location of residence has the largest effect. Persons living in the capital city region have a 12.7 percentage points higher probability to fly per

quarter than those living in Carinthia. The decomposition analysis for Probit models developed by Fairlie (2005) shows that the characteristics effect explains 90 percent of the difference in the number of holiday flights between the capital and the other regions. In other words, if capital residents share the same characteristics as those in rural areas, then the observed difference in the number of holiday flights would be reduced from 8.8 to 7.8 percentage points.

The third robustness check uses Chi-square and G-tests to establish whether the choice of destinations differs between the residents in capital and non-capital regions. Due to the features of the tests, which do not allow small number of observations in the cells, 35 out of 42 destinations need to be excluded. This reduces the number of holiday flights with eleven percent to 3,437. The results of the Pearson Chi square test show that the null hypothesis is rejected, implying that there is evidence of a statistical association between different flight destinations and place of residence at the five percent level (Table 5). The G-test (or Likelihood ratio test) comes to a similar conclusion.

Table 5. Test of interdependence for choice of holiday destination and residence in the capital city 2014–2016.

	<i>chi</i> ² (34)	p-value
Pearson Chi square test	51.536	0.027
Likelihood-ratio (G) test	50.222	0.036

Notes: The number of holiday flights used in the test is 2,477 and 960, for capital and non-capital residents, respectively. Slovakia, Hungary, Czech Republic Bosnia and Herzegovina, Finland, Iceland as well as Slovenia are excluded because there is no flight in at least one of the two groups. The test is recommended for large sample sizes with 1000 or more observations. The Pearson Chi-square test and the G-test require not only a large sample size, but also that no more than 20 percent of the cells in the expected frequency table contains fewer than five observations and that no cell has less than one (Cochran, 1954).

6. Conclusion

This study estimates a count-data model on the flight behaviour of Austrian holiday-makers, based on a large quarterly representative dataset for the years 2014–2016. In general, flying to a holiday destination is a rare event and the majority of holiday-makers do not even fly once per year (0.8 holiday flights), although capital city residents use this transportation mode somewhat more often (1.2 flights per year). Those who fly twice or more for holiday purposes amounts to almost two percent per quarter on average. This means that excessive holiday flying is not a general trend, even if two out of three flights have holiday purposes. A presumptive explanation behind this could be the central location of Austria, where several sun and beach as well as winter sport destinations can be reached within a few hours by car, bus or train.

Persons with higher education, those who live in the capital city and young people, fly more regularly. This coincides with the existing, somewhat fragmented literature and could be related to the idea of escape travel. Alternatively, people who habitually travel often, may search for dwelling in larger cities. While the average results indicate the importance of several socio-demographic aspects, the flying by residents in the capital region is mainly driven by individuals with higher education.

The findings imply that only a small group of Austrian residents engage in extensive holiday flying. In light of this, presumptive policy measures to reduce flying need to be customised. Some limitations of the study should be noted. The central location of Austria in the middle of Europe means that the conclusions may not be fully representative for countries at the outskirts where flying might be a necessity to reach a holiday destination. Income level is an important variable in determining the demand for air travel. This variable is not available in the dataset at hand. Instead, income effects are expected to be captured by the variables for region, employment status and education. There are several ideas for future work. One idea is to investigate the determinants of holiday destination choice by using a Multinomial Logit model. Another is to focus on the supply side of air travelling.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Long-Distance Travel and the Urban Environment: Results from a Qualitative Study in Reykjavik

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Abstract

A compact urban form has shown many benefits in efficiency. Yet multiple studies have found that residents of urban, dense, and centrally located areas travel more frequently than those living in suburbs, small towns, or the countryside. As air travel is already causing more emissions than ground transport in many affluent urban locations and is predicted to increase, this pattern could undermine efforts in climate change mitigation. Explanations of these patterns and motivations for long-distance travel connected to the built environment have been examined quantitatively before, but with inconclusive answers. We studied this topic qualitatively in Reykjavik, Iceland, offering an in-depth perspective through semi-structured interviews. Results showed various links between the urban environment and long-distance travel. Some indications of compensatory travel behavior emerged, particularly connected to a lack of quality green areas, hectic urban life, and commuting stress. Compensatory trips were typically domestic. Furthermore, residential preferences seemed connected to leisure travel preferences—living in green neighborhoods was connected to more domestic travel to nature. The results show there are more factors for ‘escape’ trips than urban density and lack of green spaces. Examples of car-free lifestyles hindering domestic leisure travel were also found. Our study shows how a qualitative approach offers nuanced insight into the travel motivations of urbanites. Considering our results and travel motivation literature, the compensation hypothesis appears to be an overly narrow theoretical framing. Our study supports the conclusion that planning policies should aim at reducing car-dependence. Further research is needed for specific policy recommendations.

Keywords

climate change; compensation hypothesis; Iceland; long-distance travel; Reykjavik; tourism; travel motivation; urban environment

Issue

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1. Introduction

Climate change has become an existential threat to our living environment, vastly due to anthropogenic impact on global systems (Intergovernmental Panel on Climate Change, 2018). Rapidly growing anthropogenic greenhouse gas emissions have caused Earth to behave increasingly unpredictably (Barnosky et al., 2012; Steffen et al., 2018). At the current trajectory, annual greenhouse gas emission will continue to rise, but to reduce

the impact of climate change, global greenhouse gas emission needed to peak in 2020 and rapidly decrease afterward (Intergovernmental Panel on Climate Change, 2018; United Nations Environment Programme, 2019).

Cities contribute to about 3/4 of global energy-related CO₂ emissions (Hoorneweg, Sugar, & Trejos Gómez, 2011; Intergovernmental Panel on Climate Change, 2014; Kennedy, Demoullin, & Mohareb, 2012) and thus have high climate change mitigation potential (Bai et al., 2018; Hertwich & Peters, 2009; Wiedmann,

Lenzen, Keyßer, & Steinberger, 2020). A large part of emissions generated in cities results from transportation, largely attributable to private vehicles (Intergovernmental Panel on Climate Change, 2018; Sims et al., 2014).

Increased density of the built environment and mixed-use neighborhoods have been considered as a path to climate change mitigation in urban areas. This has been suggested to lead to reduced daily travel distances, reduced dependency on cars, and consequently lower emissions from urban transport (Ewing & Cervero, 2010; Glaeser & Kahn, 2010; Hall, 2014). However, residents of large cities in central densely built areas tend to engage in more long-distance travel than residents of other areas (Árnadóttir, Czepkiewicz, & Heinonen, 2019; Czepkiewicz, Heinonen, & Ottelin, 2018b). Studies in affluent locations indicate that the increase in long-distance travel among downtown dwellers may offset the emission reductions in daily travel (Czepkiewicz et al., 2018a; Ottelin, Heinonen, & Junnila, 2014, 2017; Reichert, Holz-Rau, & Scheiner, 2016), and air travel might become the main source of transport-related emissions (Czepkiewicz, Árnadóttir, & Heinonen, 2019).

Several explanations for this phenomenon have been proposed, such as the compensation hypothesis (e.g., Holden & Norland, 2005; Næss, 2006), monetary rebound effects related to car ownership (e.g., Ottelin et al., 2014, 2017), access to transport infrastructure (Bruderer Enzler, 2017), geographical clustering of certain lifestyles, attitudes, and socio-demographic characteristics (Czepkiewicz et al., 2018b; Heinonen & Junnila, 2011), and dispersion of social networks (Mattioli & Scheiner, 2019). While the connections between the urban environment and local travel behavior have been broadly studied and are well understood (e.g., Ewing & Cervero, 2010; Næss, 2012; Næss, Strand, Wolday, & Stefánsdóttir, 2019), the connections between the urban environment and long-distance travel still offer several areas of investigation (Czepkiewicz et al., 2018b). The majority of studies to date have relied on quantitative data while leaving a gap for more in-depth research. Our study takes a qualitative approach, using interviews to explore the possible connections and explain correlations between the urban environment and long-distance travel.

The study is based on 21 interviews with people aged 26–42 living in the Reykjavik Capital Region (Reykjavik) in Iceland, selected from voluntary respondents of a preceding survey (e.g., Czepkiewicz et al., 2019; Czepkiewicz, Heinonen, Árnadóttir, & Njeru, 2020c; Czepkiewicz, Heinonen, Næss, & Stefánsdóttir, 2020a; Czepkiewicz, Klaas, & Heinonen, 2020b). Iceland is an interesting subject for such a study because it is an island with air travel being the main mode of transport to any other country. What is more, 2/3 of its population lives in the capital area, and its highly affluent society is also highly mobile (Czepkiewicz et al., 2019; Icelandic Tourist Board, 2018).

The study demonstrates various links between the urban environment and long-distance travel. The results

show some indications of compensatory travel behavior, but the reasons behind it are not completely covered within the compensation hypothesis frame. The study identifies potential areas of improvement for the theoretical framing. The results of the study expand on recent quantitative studies conducted in Reykjavik (e.g., Czepkiewicz et al., 2019, 2020a, 2020b, 2020c) by providing a more nuanced understanding of the travel motivations of Reykjavik urbanites, and uncovering more kinds of causal connections between residential location, the built environment, and long-distance travel.

2. Background

The connection between urban density and long-distance travel has been previously highlighted as an unintended side effect of densification (Holden & Linnerud, 2011; Holden & Norland, 2005). From this vantage point, it is vital to study the character of relationships between urban form and long-distance travel and determine to what extent the higher level of leisure mobility is due to increased urban density and compactness and to what extent it is a parallel phenomenon that is largely unaffected or only indirectly affected by urban form. In recent years, several studies have provided possible theoretical explanations and some empirical evidence in their support, primarily in Western and Northern European contexts.

2.1. Monetary Rebound Effect

The effect is hypothesized to occur when people living in dense urban areas reduce costs and emissions because of structural benefits of urban density, such as smaller living space and a reduced need for car ownership and use, but spend the saved money on consumption of other goods and services, canceling out the benefits (e.g., Heinonen, Jalas, Juntunen, Ala-Mantila, & Junnila, 2013; Muñiz, Calatayud, & Dobaño, 2013; Næss, 2012, 2016; Strandell & Hall, 2015). Ottelin et al. (2014, 2017) further connect reduced car ownership with higher levels of air mobility among middle-income groups of Finnish urbanites and suggest focusing on reducing driving rather than car ownership in urban policies. Conversely, Czepkiewicz et al. (2019, 2020b) found that high rates of air mobility occur particularly among those who drive the most, concluding that the proposed monetary rebound effect is not visible in aggregate travel patterns in this highly affluent locality. Existing qualitative studies conducted in the Icelandic context did not observe shifts in spending between car ownership and flights but pointed to the existence of similar trade-offs in daily consumption and housing costs (Czepkiewicz et al., 2020a).

2.2. Compensation Hypothesis

The compensation hypothesis proposes that people who live in densely built and populated urban areas might

want to ‘escape’ it or compensate for its deficiencies by traveling more for leisure, either domestically or internationally (e.g., Czepkiewicz et al., 2018a; Holden & Norland, 2005; Næss, 2006; Strandell & Hall, 2015). The compensation hypothesis primarily focuses on ‘push’ factors for traveling (cf. Dann, 1977) related to some deficiencies in the residential environment. As such, it could potentially provide a causal link between urban planning policies and long-distance travel. The deficiencies of the urban environment typically mentioned in this framing include a lack of nature in densely built cities and neighborhoods, and that the travel destinations facilitate contact with nature (Næss, 2006). Studies on the hypothesis have thus far been inconclusive (Czepkiewicz et al., 2020b; Maat & de Vries, 2006). There are clear examples of seeking nature and calmness as an important motivation of inner-city residents’ travel, primarily to domestic destinations in qualitative studies (Czepkiewicz et al., 2020a; Næss, 2006) but quantitative studies show mixed results. Higher urban density and living in a larger city have been related to higher rates of second home access (Große, Fertner, & Carstensen, 2019) or use (Strandell & Hall, 2015), but other similar studies did not find such association (Næss, 2006). Access to a private garden and local area density have been associated with less frequent long-distance travel for leisure purposes (Czepkiewicz et al., 2020b; Holden & Norland, 2005) but the studies have been ambiguous in attributing it to compensatory behavior. Recent studies also show a lack of connection between dissatisfaction with dwellings or residential neighborhoods and long-distance travel (Große et al., 2019). Furthermore, most evidence in favor of the compensation hypothesis applies to domestic trips and not international trips (Große et al., 2019). The compensation hypothesis thus does not appear to be the primary explanation behind the urban density–air travel correlation (Czepkiewicz et al., 2018a).

2.3. Residential Self-Selection

Travel-related attitudes and preferences can be a reason for why people choose to live in some areas in the city, which has been described as residential self-selection (Cao, 2014; Czepkiewicz et al., 2018b; Große et al., 2019; Maat & de Vries, 2006; Næss, 2006). Residential self-selection could also point to an effect opposite to the typical definition of compensation hypothesis, where, for example, residential location is chosen for its green and calm character by people who also enjoy engaging in nature- and calmness-seeking travel outside a city (Czepkiewicz et al., 2020b; Maat & de Vries, 2006). Therefore, it could prevent the compensation effect from showing in quantitative studies. It has also been hypothesized that nature-related compensatory behavior explains travel patterns only of those who are mismatched with their residential environment (Czepkiewicz et al., 2020b).

2.4. Cosmopolitan Attitudes

It has also been proposed that high mobility of urban dwellers results from the concentration of cosmopolitan lifestyles and attitudes in the densest, most lively, and internationally connected city centers of capital and other central cities (Czepkiewicz et al., 2018b, 2019, 2020a, 2020b; Holden & Norland, 2005; Næss, 2006). Cosmopolitan attitudes describe people’s affinity towards experiencing different cultures, exploring the world, and visiting other urban destinations (Czepkiewicz et al., 2018b; Muñiz et al., 2013; Næss, 2006, 2016). These attitudes have been connected to a higher frequency of international flights (Oswald & Ernst, 2021) and downtown living (Czepkiewicz et al., 2020a, 2020b). Czepkiewicz et al. (2020a, 2020b) suggest that this is the most plausible explanation behind the concentration of high air mobility in urban centers.

2.5. Social Networks

Many long-distance trips are taken to maintain and strengthen social connections (Pearce & Lee, 2005). It has been proposed that high mobility and globalization of social networks is specific for urban lifestyles, especially among the young, affluent, and well-educated urbanites (e.g., Reichert et al., 2016). Some studies point to the importance of previous international mobility and temporary migration (Frändberg, 2014) for predicting air travel intensity (Oswald & Ernst, 2021). Mattioli and Scheiner (2019) found that first-generation migrants tend to travel more by air than other groups, mostly due to their dispersed social connections.

2.6. Socio-Demographic and Economic Characteristics

Socio-demographics could both vary in space and be predictive of travel behavior, e.g., childless and single households tend to live closer to the city center and travel more frequently (Czepkiewicz et al., 2018b; Heinonen & Junnila, 2011). Tourism and air travel are also highly income-elastic, meaning that the more affluent engage in it to a higher degree than the less affluent (Ivanova & Wood, 2020; Lenzen et al., 2018). Studies conducted in Iceland (e.g., Czepkiewicz et al., 2019) indicate that high mobility appears in all income groups and that money is not a limiter to travel, so this explanation might not apply to Reykjavik.

This study focuses on the compensation hypothesis as it potentially connects long-distance travel behavior to urban environments more directly compared to other theories. Noticeably, there exist only a small number of qualitative studies (Czepkiewicz et al., 2020a; Næss, 2006), and there is a need for a more nuanced and contextual understanding of the topic (Czepkiewicz et al., 2018b, 2020a, 2020b). Empirical studies have been using a variety of variables to test the compensation hypothesis, but have mostly been inconclusive, while studies

that include qualitative analysis show examples of travel behavior that underpins the theory (Czepkiewicz et al., 2020a; Næss, 2006). As noted, the compensation hypothesis may only partly explain the connections between the urban environment and travel behavior. Therefore, when studying this topic, one needs to be ready for other explanatory concepts to appear during data analysis (Große et al., 2019; Strandell & Hall, 2015).

3. Research Design

This qualitative study builds on previous quantitative studies focusing on Reykjavik and is situated in a broader sequential mixed-methods research design. These previous studies have identified a geographical trend of higher levels of international air travel among residents of central Reykjavik neighborhoods, partly explained by geographical trends in cosmopolitan attitudes, with room for other explanations (Czepkiewicz et al., 2019, 2020a, 2020b). No statistical support for the compensation hypothesis has been found in the case of domestic travel (Czepkiewicz et al., 2020a, 2020b). Car ownership levels in Reykjavik are very high, with only the immediate downtown area having a higher rate of car-free households (Heinonen, Czepkiewicz, Árnadóttir, & Ottelin, 2021).

3.1. Study Area

The Capital Region of Iceland consists of the city of Reykjavik, which is the country's center of economic, cultural, and administrative activity, and the neighboring municipalities of Kópavogur, Hafnarfjörður, Mosfellsbær, Garðabær, Seltjarnarnes and Kjósarhreppur (Samtök sveitarfélaga á höfuðborgarsvæðinu, n.d.). Reykjavik is the largest urban area in Iceland with a total population of around 230,000, making up nearly 64% of the country's total inhabitants (Statistics Iceland, 2020). Several large foreign populations live in Reykjavik, with the Polish population being the largest sub-group (Statistics Iceland, 2019). Reykjavik is currently working with densification as a strategy to limit urban sprawl and reduce the environmental impact (City of Reykjavik, 2014). Today, the city still has a low building density and is sparsely populated when compared to other European cities (World's Capital Cities, 2020). Reykjavik has several large green spaces and a waterfront in and around the city which people enjoy for leisure. The public transport system is based on buses only, and large parts of the urban area are not served with diverse or frequent bus connections. Czepkiewicz, Heinonen, and Árnadóttir (2018c) have defined five transport-related urban zones for the region from pedestrian to bus and car-oriented zones, the car zone having a dominant role (see Figure 1). Population density of the central pedestrian zone is higher than most other areas but similar to some of the less central areas (Czepkiewicz et al., 2018c). However, due to workplace proximity and good walking access to services, the zone allows for a higher share of car-less

households than do other zones (Heinonen et al., 2021). In this article, we refer to the central pedestrian zone and its fringe as 'downtown,' 'the city center,' or 'central and dense areas,' and to the remaining zones as 'suburban areas.'

3.2. Methods

Data was collected through semi-structured interviews, which were conducted one-on-one at the respondent's chosen location in 2019 and 2020, finishing before Covid-19 restrictions were placed. This method can deepen the understanding of the connections between the urban environment and people's motivations for long-distance travel (Berg, 2009; Berg & Lune, 2017; Leech, 2002; Ngumbi & Edward, 2015). Furthermore, several previous studies have called for more qualitative studies on the matter (Czepkiewicz et al., 2019, 2020b; Næss, 2006, 2016). The method aims to complement the recent studies done in Reykjavik which have mainly been using quantitative data (Czepkiewicz et al., 2019, 2020a, 2020b).

Semi-structured interviews allow the researcher to ask further questions if interesting points are raised (Berg, 2009; Ngumbi & Edward, 2015; Waller, Farquharson, & Dempsey, 2016). The questions have a guiding function and allow the interviewee to express their thoughts freely within the predetermined topics. These are often in the form of open-ended questions (Berg & Lune, 2017; Leech, 2002; Ngumbi & Edward, 2015). Interviewing allows one to see how a person reacts to different topics, which could hint at underlying attitudes (Leech, 2002). On the other hand, there is a risk of misinterpretation of results by the researcher (Leech, 2002). To minimize this risk, extra notes were made during the interviews, and two researchers participated in the interpretation process.

3.3. Data Collection and Analysis

Respondents from a previous survey who had volunteered for further research (Czepkiewicz et al., 2019, 2020a, 2020b, 2020c) were contacted to participate in the study. Of those volunteers, people still living in Reykjavik were selected to be interviewed, with an aim for a balanced selection regarding residential location, income level, and car ownership. The interviewees were men and women of various backgrounds between the ages of 26–42. Each interviewee was assigned an ID (for example I1, M40, where I1 stands for the order of the interview, M for gender 'male' and F for 'female,' and the last two digits are the age of the person; see Table 1).

A total of 21 interviews were collected, transcribed, and analyzed. The interviews consisted of questions covering the topics of neighborhood and dwelling, daily travel, and travel modes, traveling away from the city domestically and abroad, and lastly, environmental attitudes connected to travel. The interviewees were made

Residential locations of interview participants in Reykjavik Capital Region and its travel-oriented urban zones

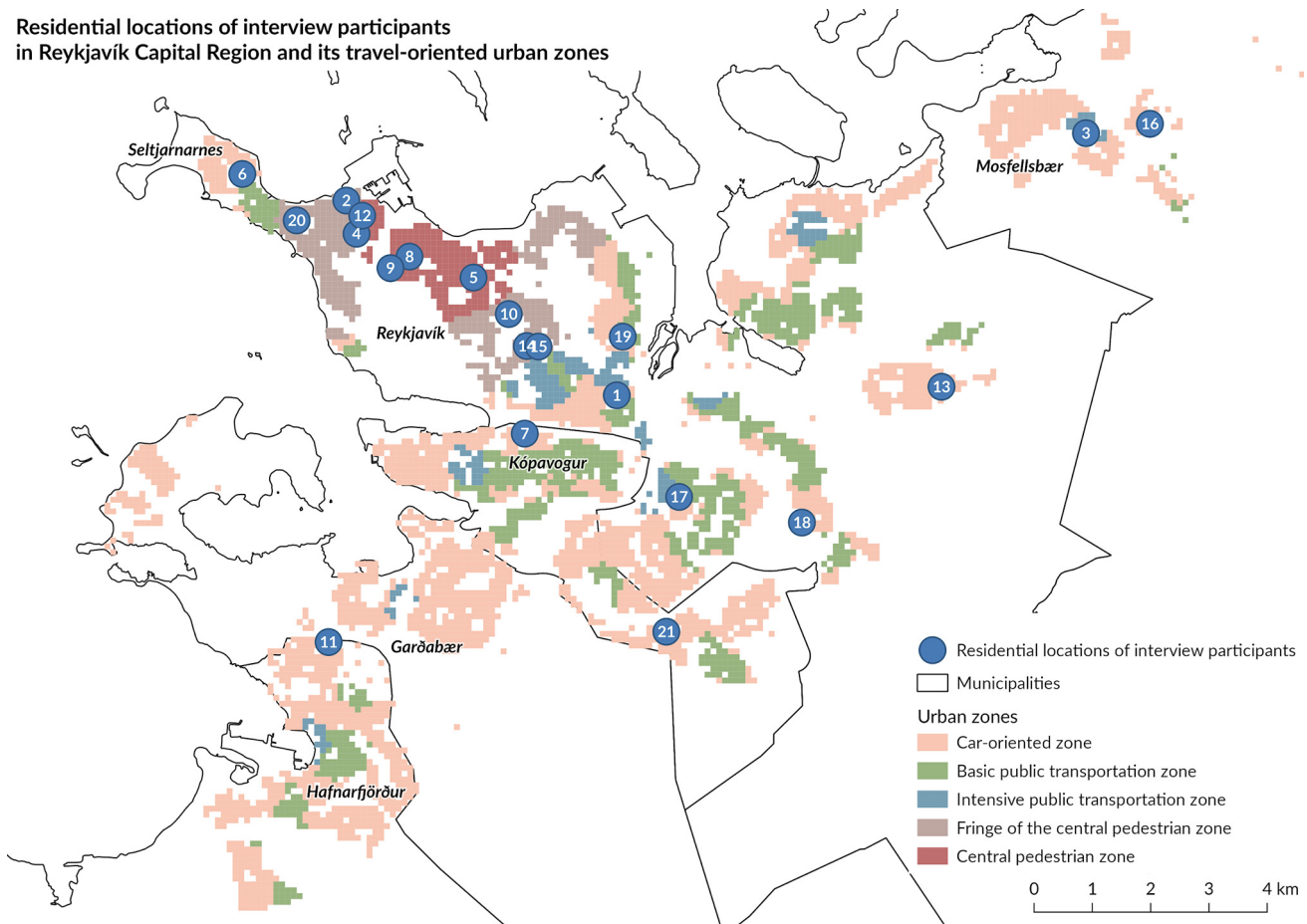


Figure 1. Residential locations of interview participants in Reykjavik Capital Region and its travel-oriented urban zones.

aware beforehand of the broad topics that the questions would cover, but not the specific questions themselves to receive authentic responses. The interviews took between 45 to 90 minutes and were conducted in English, Icelandic or Polish, with the latter two later translated into English by the interviewer whose native language was the language of the interview. The analysis was performed on the English versions only.

For analysis, a two-step interpretation process was followed, as described by Næss (2018) and Czepkiewicz et al. (2020b). The first step was interpreting individual answers to the set of 35 predetermined themes and guiding questions. The second step involved summarizing the individual interpretations into an overall interpretation of each theme. We allowed for new themes to emerge as well. Each interview was interpreted by two researchers: The lead author performed both steps of interpretation, and a second researcher validated them.

4. Results

Our results showed various links between the urban environment and long-distance travel. Compensatory behavior was detected, but other causal links emerged as well. Moreover, signs of compensatory behavior through complex causal chains were found, the complexity poten-

tially explaining partially why previous quantitative studies have often found no or only weak evidence of compensatory behavior. The presentation of the results is divided into three subsections of urban density, greenness, and broader urban environment.

4.1. Urban Density, Compactness, and Car Ownership

Density near people’s dwellings was not noted by respondents as bothersome. A few said that they would not like their immediate urban environment to get any denser, but none raised urban density as the reason to travel more. Besides, we found an indirect influence of city compactness on long-distance travel mediated through car ownership (Figure 2A). Residents of the city center can opt for a car-free lifestyle due to proximity to services and workplaces:

I can’t stand cars, I preferably want never to be close to them, umm, which is another thing which is a complete luxury [in downtown]. I can walk on the street to work, I just go down one street... it’s really calm car traffic, which I really like. (18, F38)

Yeah, we were looking for [a place in] the central area, where we could be car-free, or pretty much car-free...

Table 1. Overview of respondents in the study.

ID	Dwelling type	Household type	Car	Employment status	Urban zone
I1, M40	Apartment	Family w. children	Yes	Employed full-time	Basic public transportation
I2, F40	Apartment	Single or other	Yes	Employed full-time	Fringe of the central pedestrian
I3, M29	Detached house	Single or other	Yes	Employed full-time	Intensive public transportation
I4, M29	Apartment	Family w. children	Yes	Employed full-time	Fringe of the central pedestrian
I5, F29	Apartment	Couple	No	Employed full-time	Central pedestrian
I6, M41	Semi-detached house	Family w. children	Yes	Employed full-time	Car-oriented
I7, F40	Detached house	Family w. children	Yes	Self-employed/ Entrepreneur	Car-oriented
I8, F38	Apartment	Family w. children	No	Employed full-time	Central pedestrian
I9, F26	Detached house	Single or other	Yes	Other	Central pedestrian
I10, F37	Apartment	Single or other	Yes	Employed full-time	Fringe of the central pedestrian
I11, F30	Detached house	Family w. children	Yes	Employed full-time	Car-oriented
I12, M36	Apartment	Family w. children	Yes	Employed full-time	Central pedestrian
I13, F39	Apartment	Family w. children	No	Unable to work	Car-oriented
I14, F36	Apartment	Family w. children	Yes	Employed full-time	Fringe of the central pedestrian
I15, F36	Other	Family w. children	Yes	Employed full-time	Fringe of the central pedestrian
I16, F34	Apartment	Couple	Yes	Employed full-time	Car-oriented
I17, F30	Apartment	Couple	Yes	Employed full-time	Basic public transportation
I18, F36	Apartment	Couple	Yes	Student	Car-oriented
I19, F42	Semi-detached house	Family w. children	Yes	Student	Car-oriented
I20, F27	Apartment	Single or other	Yes	Student	Fringe of the central pedestrian
I21, F42	Other	Single or other	Yes	Employed full-time	Car-oriented

so it was just that, sort of mainly that with the carlessness and local services. (I4, M29)

Several suburban dwellers brought up that they could not live in the city center, since they need a car for something important to them, which is made difficult due to the lack of parking spaces or higher dwelling expenses in the city center. This is illustrated by the following: “I have to say the price is a very strong influence and the size... we have to have parking space as we have so many cars, so we could never go and live downtown Reykjavik” (I18, F36).

A car-free lifestyle can, in turn, limit one’s options for domestic travel and thus could encourage more international travel as an alternative. I5, F29, stood out in the study—she has chosen to live in a central area of Reykjavik to enable a car-free lifestyle, although not owning a car means she cannot travel domestically as frequently as she used to when owning a car. On the other hand, living in this environment and not having the possibility for domestic travel makes her feel claustrophobic. Instead, she now takes more trips abroad. She describes her situation as follows:

It’s just about cities, there’s something like claustrophobia and an overwhelming feeling that I can’t stand....[We travel domestically] a lot less since we

sold the car. We used to do it a lot....It’s expensive to take the bus there....And that’s what I miss—just getting outside a little bit, getting some nature, without having to borrow anything or anything like that. (I5, F29)

In international travel, city trips for sightseeing and cultural experiences are common among several respondents, but nature trips, particularly to cabins, are preferred domestically. Furthermore, those who own both a car and a cabin in the countryside tend to take frequent domestic trips additionally to international ones. The same people might also choose not to live in the city center, which indicates an indirect causality of the built environment on long-distance travel through car ownership. It can also be deducted that the cost of owning both a cabin and a car might limit one’s international travel. An example is I1, M40, who owns a summer house and a car, likes taking four to five trips to the summer house per year, and says going abroad would require saving up: “The salary isn’t too high so you know I haven’t, or you know I would have to save up, scrape together for a trip, and so that maybe reduces the interest somewhat” (I1, M40).

Other than the two cases observed of central dwellers (I8, F38; I4, M29), who had a strong preference for international trips to cities rather than to nature,

there was no clear connection between residential location and international travel preferences. Both respondents preferred commuting on foot, did not own a cabin, and had no longing for domestic nature trips. Their low car dependence and low expenditure on domestic trips, and their preference for city trips, which are often direct and available for low airfare, might be what resulted in more frequent international leisure travel. All in all, it seems that these factors are strongly interconnected and thus it is difficult to separate one from the other.

4.2. Greenness

To capture the potential impact greenness might have on long-distance trips taken by the respondents, the respondents were asked about their perceptions of the greenness of the urban environment in Reykjavik in general and that of the neighborhood they live in. Questions about neighborhood greenness were included both as a potential factor in choosing the current residential location as well as to find out how it was perceived at the time of the interview. Furthermore, they were asked if they possess a yard or have access to one, if they utilize it, and if they feel that this affects their travel choices.

Respondents described Reykjavik to be generally 'green enough' (i.e., I11, F30; I16, F34; I17, F30). The interviews highlighted that the quality of green areas is more important than the access to green areas near their dwellings. If a green area is not inviting, people do not use it and therefore it cannot have a direct impact on their travel behavior.

Access to a private yard or garden was found to have some implications for domestic travel behavior, but less for international. It could be observed that some people who have gardens and use them actively might take fewer domestic trips because of that (i.e., I10, F37; I20, F27; I11, F30):

Yeah, so like, in the summer when I can actually be in my garden, like now it's just a thick layer of snow, I spend more time there, rather than taking these trips, I feel at least. (I20, F27)

There is a lot less stimuli exactly here because I'm just looking at a tree if I look outside... if I was in downtown then there would always be stimuli but here, somehow. Yes, it's just... it maybe has minimized the desire [to travel]. (I10, F37)

Yes, I think it matters less to go someplace else when you've got a nice setup to just be here on the sun deck, or out in the sun. (I11, F30)

Some actively use their garden and travel more domestically, but less internationally (I19, F42; I7, F40; I16, F34; I21, F42). A parallel pattern emerged for these respondents: They are people who have a preference for outdoor activities and being in nature regularly. They

have chosen to live in locations with access to a garden or green area (a sign of residential self-selection) and actively enjoy nature (Figure 2C). They also take more domestic trips into nature for activities like hiking and skiing. This situation is exemplified by respondent I21, F42, who said: "What I want is [to be] close to nature and a good walking area" when talking about her preferable residential neighborhood qualities, and who likes outdoor activities in both everyday life and away from town.

What is more, interviewees who live in greener areas have mentioned that greenness is good for their wellbeing and reduces their need to travel in general (I17, F30; I10, F37; I20, F27; I9, F26; I7, F40). One interviewee illustrates her neighborhood as follows:

I often feel like during the summer; I feel like I live somewhere in the Nordic countries. There is so much forest in there; this is kind of weird... you just feel the smell of the trees, I don't know what it is completely... you feel like this is a Swedish forest. It's a good feeling. (I7, F40)

While the connections between urban green spaces and domestic travel were easier to observe, the connection to international travel could also be noticed. Two cases were observed among residents of the city center (I4, M29; I8, F38) where the person does not have any access to a garden and prefers to travel internationally, but they did not make this connection consciously themselves. Interestingly, both these respondents felt that they did not need a garden and both preferred international trips to other cities rather than to natural areas.

4.3. Stress and Stimuli in the Urban Environment

Alongside the immediate residential environmental characteristics like density, proximity, and greenness, it was evident from the interviews that broader urban environments and lifestyles can have an impact on leisure travel behavior. Respondents mention stimuli in an environment beyond their dwellings and neighborhood, connected to the pace of life, as something that makes them feel the need to get out of the city (I5, F29; I9, F26; I15, F36; I19, F42; I10, F37) and into nature (I1, M40; I5, F29; I17, F30). Respondents mention a fast-paced lifestyle in the city, bothersome daily commute to work, and a lack of cultural diversity in activities (e.g., restaurants) as push factors for leaving the city:

I suppose it's just to escape for a bit from the tumult of the city....I feel like most Icelanders like getting out into nature a bit. (I1, M40)

Reykjavik—it's not a very big city, but people are really stressed. They drive badly and you know, it's like you... you feel it in the air somehow. So as soon as you get out, it's a completely different pace even though you're not exactly having a cottage in the mountain,

but just staying in a little village... it's a lot quieter and more calm. (I19, F42)

It's just about cities, there's something like claustrophobia and an overwhelming feeling that I can't stand. (I5, F29)

Umm, most often it's that I want to get away from the... like a tornado, it can be a bit. It's the culture that you always have to be doing something and go somewhere and la-la-la. (I10, F37)

The explanations people give could further indicate that the stressors or deficiencies in the urban environment (dwellings, neighborhood, general atmosphere) are not something that people actively recognize, often accepting them as a part of regular urban living. Respondent I19, F42 describes a hectic urban atmosphere, adding that "you feel it in the air somehow." Besides, daily commutes to work have been mentioned as bothersome due to long distance from dwellings (I2, F40; I11, F30; I21, F42) and a stressful driving culture (I19, F42). Yet when talking about why they travel, respondents reveal a need for something that the urban environment does not provide for them, whether it be calmness, relaxation, or a general wish for being in nature. As a response to these urban stimuli and stressors, domestic trips, particularly short weekend trips to summer houses, are taken often.

There are also some (e.g., I4, M29; I17, F30) who seek different cultures and therefore travel internationally to other cities for relaxation. One respondent (I17, F30) provided a comparison of her experience with downtown living and suburban living, saying that there was "nothing to do" and a lack of variety in leisure activity options in her new more suburban area. There seems to be a need for activities and activity spaces near dwellings. The complexity of urban deficiencies might thus explain why compensatory trips are taken to other urban destinations as well as to natural environment locations.

5. Discussion and Conclusion

5.1. Discussion of the Results and Theoretical Contribution

The findings showed that general push factors of the urban environment play a role in Reykjavik, primarily, a lack of good quality green spaces and urban stress for domestic travel, and a lack of activities and diversity for international travel. The study found some issues with the premise of the compensation hypothesis, which allegedly challenges urban densification policies (Holden & Linnerud, 2011; Holden & Norland, 2005). Even though the theory is directly connected to the physical urban environment, it does not provide the most compelling explanation for the relationship between residential location, built environment, long-distance travel patterns in Reykjavik. The results indicate more complex relation-

ships between the urban environment and leisure travel behavior. As Næss (2006, 2016) has suggested, even if there are indications of a denser urban form being connected to increased leisure travel in some cases, such findings do not necessarily challenge densification as a climate change mitigation strategy. Instead, qualitative studies such as this one might provide the much-needed information to fill the gaps, creating a broader overview of travel motivations among urbanites.

In this study, density was not mentioned by respondents as a push factor for taking more long-distance trips, which challenges the premise of the compensation hypothesis, wherein increased urban density is connected to increased leisure travel (e.g., Holden & Norland, 2005; Holz-Rau, Scheiner, & Sicks, 2014; Næss, 2006; Strandell & Hall, 2015). This could be explained by the relatively low built environment and population density in Reykjavik, compared to other capital cities (World's Capital Cities, 2020). It is still possible that in higher-density cities the negative impacts would be more prominent. A different kind of causal connection between living in a central and dense location and long-distance travel was detected, in which central living encourages car-free lifestyles (see Heinonen et al., 2021, for an in-depth analysis) which in turn hinders domestic travel and encourages international travel instead (Figure 2A). The pattern is also visible in quantitative analyses, in which car ownership was connected to a higher frequency of domestic leisure trips (Czepkiewicz et al., 2020b). This kind of rebound effect is different from the monetary rebound proposed by Ottelin et al. (2014, 2017), but works in a similar direction. Our findings show some degree of substitutability between domestic and international travel, which points to the idea of constant monetary or temporal travel budgets that underpin theories of rebound (Czepkiewicz et al., 2018a).

The study also explains why people who live in greener suburbs might be taking more domestic trips than those who live elsewhere. Some of those who enjoy nature and outdoor activities choose to live in a greener area with good access to open spaces, typically suburban, to realize their preferences in both everyday leisure activities and in domestic trips. Suburban locations also enable owning a car, which further facilitates domestic travel (Figure 2B). It exemplifies the tendencies behind the residential self-selection theory (Czepkiewicz et al., 2018b; Große et al., 2019; Maat & de Vries, 2006; Næss, 2006), which operate in an opposite direction to the typical compensation hypothesis (Czepkiewicz et al., 2020b). In the quantitative study by Czepkiewicz et al. (2020b), high preference for a green residential environment correlated with living away from the city center and close to large green areas and was a significant predictor of a higher frequency of domestic leisure trips. It confirmed that tendencies in residential choices documented in interviews are common and influence the aggregate patterns of leisure travel. Similarly, as in Czepkiewicz et al.

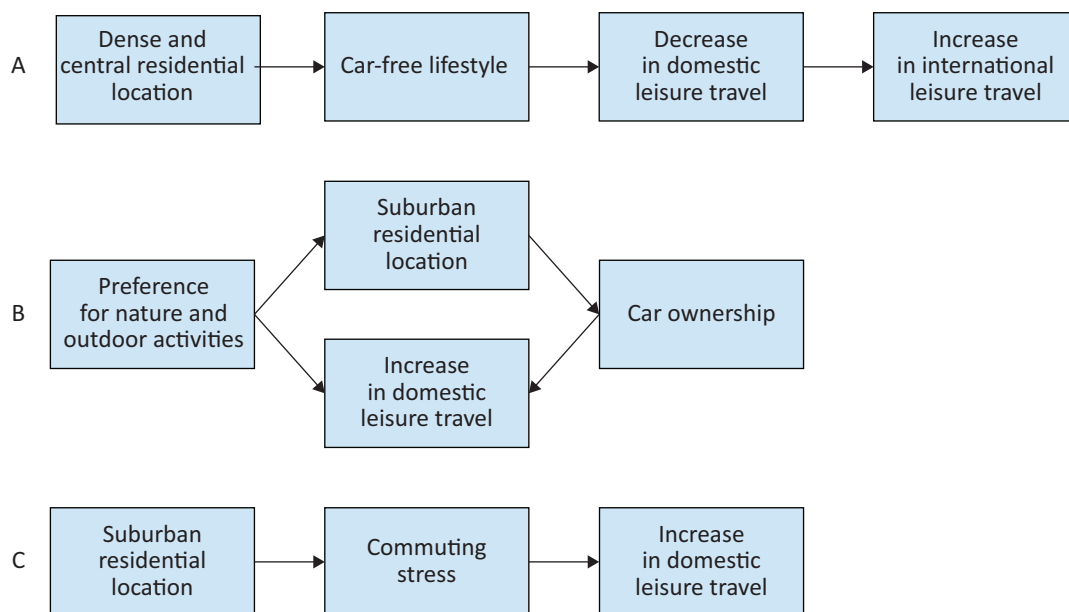


Figure 2. Connections between residential location characteristics and long-distance leisure travel detected in the study.

(2020a), the interviewees in this study were satisfied with their dwellings and/or neighborhood, which suggests a high strength of residential self-selection tendencies in Reykjavik. The age range and good material situation of the respondents might have influenced this as they have a stable living situation, most of them being the owners of their dwellings and therefore probably invested time into choosing a location suitable to their lifestyle, preferences, and needs. This kind of residential self-selection related to nature/outdoors preferences might thus prevent existing examples of compensatory travel behavior from showing in aggregate analyses.

Several respondents noted experiencing stress created by the hectic and fast pace of the city (e.g., I5, F29; I19, F42; I10, F37)—it is “just in the air somehow” (I19, F42). People need to escape the city because of it (I5, F29; I9, F26; I15, F36; I19, F42; I10, F37). Urban stress caused by noise, traffic, pollution, crowding and a hectic environment has been mentioned in studies about compensation hypothesis before (Czepkiewicz et al., 2018b; Næss, 2006; Strandell & Hall, 2015). Our study strongly suggests that urban stress is an important push-factor for compensation or escaping behavior. A common response was taking short domestic trips, particularly on weekends, into natural destinations with the aim of relaxation and feeling less “stuck” (I6, M41). It was difficult, however, to connect this general stress and pace of urban living with particular residential locations or density levels. There were examples of both inner-city and suburban residents experiencing this kind of effect in our sample. It appears to be a more general urban condition, related to the demands of everyday life that are not directly related to residential location and built environment characteristics on a neighborhood level.

A more direct connection between residential location and the need to escape the city points to the stress

associated with long commutes and driving (Figure 2C). This effect is similar to the typical compensation hypothesis but has an inverted meaning for urban planning policies: it is not only densification or compact city policies that would induce escape travel, but also car dependence, which in Reykjavik is particularly high and deeply rooted in its mobility culture (Heinonen et al., 2021). Similarly, as in other cities (Cao, Næss, & Wolday, 2019; Ewing & Cervero, 2010), car ownership rates in Reykjavik are lower in centrally located and densely built areas than elsewhere (Heinonen et al., 2021). Our findings thus suggest that the compensation hypothesis should be re-thought and expanded if indeed it is true that long commutes by car induce escape trips rather than, or similarly as, negative side-effects of density. It might be, as suggested in Czepkiewicz et al. (2020b), that different types of urban environments and exposure to them are all connected to motivations to travel away, but the types of trips and modes of travel vary. Our findings also expand on studies that connect commuting with well-being deterioration (Morris & Guerra, 2014; Stutzer & Frey, 2008) by adding an environmentally detrimental effect in the form of induced ‘escape’ trips. Relationships between urban form and leisure travel are further complicated by car-ownership effects. For instance, I5, F29 chose to move to a central neighborhood to stop using a car, but also says that the city feels “claustrophobic” to her and she needs to get away. However, she cannot revert to her domestic travel habits because she has no car.

It was noticed that lack of greenness and good quality green spaces in Reykjavik could be a push factor motivating domestic leisure trips, which is in line with the compensation hypothesis and previous research (Czepkiewicz et al., 2020b). Holden and Linnerud (2011), and Næss (2006) emphasize the importance of urban green areas’ quality for their usage. Participants of this

study recognized that there are green areas available in their neighborhoods, but they do not use them much. Previous studies on the compensation hypothesis have shown some connection between having a private garden and traveling less domestically, or not having one and traveling more internationally (Czepkiewicz et al., 2020b; Holden & Norland, 2005; Strandell & Hall, 2015). The connection also occurs in our study. Similar to the usage of green spaces, active usage of the garden was key in potentially reducing domestic travel.

Our results also showed that the lack of cultural diversity in Reykjavik makes some seek it abroad—an aspect more in line with the cosmopolitan attitudes theory (Czepkiewicz et al., 2018b; Muñiz et al., 2013; Næss, 2006, 2016) and novelty-seeking travel motivations (Pearce & Lee, 2005). What is more, our study shows that a trip abroad to another urban destination can offer relaxation as well. The compensation hypothesis traditionally considers natural destinations for this purpose, indicating its narrow theoretical scope. Czepkiewicz et al. (2020b) provide quantitative support for this theory by revealing that geographical clustering of high international mobility in Reykjavik's city center is mainly due to the clustering in cosmopolitan attitudes.

Theoretical limitations also pertain to focusing on specific push factors, while overlooking others. Our study indicates that features which one might compensate for, or escape from, extend beyond the residential environment. People interact with diverse urban areas in daily life, and therefore a broader definition of living environment would need consideration. Also, other aspects of urban lifestyles, such as fast pace of life, overstimulation, or general stress of daily life might motivate escape trips, which is noted in travel motivation literature. Crompton (1979) mentions a 'mundane environment' as a push factor, while Pearce and Lee (2005) identify getting away from various stresses, pressures, routines, worries, and everyday demands as important motivations to travel.

Furthermore, the assumption of nature-seeking travel motivation predominates the compensation hypothesis, while tourism literature notes that it is far from dominant, and highlights the importance of novelty-seeking, strengthening personal relationships, and self-development (Pearce & Lee, 2005). People also differ in their travel preferences, which makes the compensation hypothesis narrowly applicable. The definition of compensation also typically does not account for other deficiencies created by the built environment such as noise, crowding, pollution, or broader environmental factors, such as lack of sun or harsh weather (Czepkiewicz et al., 2018b). Finally, the primary focus of the compensation hypothesis on the potentially adverse effects of densification obfuscates environmental adversities resulting from car dependence and urban sprawl. Overall, the takeaways from this study and travel motivation literature suggest that the compensation hypothesis is an overly narrow framework that is unlikely to explain a large proportion of leisure trip motivations.

5.2. Study Limitations

The authors recognize the limitations of the study. Firstly, predetermined topics and questions in interviews enabled us to explore topics in-depth and link them to previous work (Leech, 2002; Ngumbi & Edward, 2015), but also limited the emergence of new themes. A similar issue could emerge from the analysis method described by Næss (2018). Secondly, there is a common risk of misinterpreting qualitative data, potentially stemming from cultural or language barriers, or personal bias (Berg & Lune, 2017; Ngumbi & Edward, 2015). Thirdly, although a qualitative approach can help explain patterns, the error margin in interpretation means that the strength of evidence is still dependent on the researchers' bias and the context (Leech, 2002). Involving other members of the research team at different stages, however, potentially helped minimize these effects. Fourthly, the interview results cannot be generalized for the whole population (Galvin, 2015). However, simply because there is no strong evidence, it does not mean that a connection is not there (Strandell & Hall, 2015).

Notably, we did not find much evidence on other hypothesized explanations for the urban form–travel connection, such as cosmopolitan attitudes or globalized social networks. While these issues appear in our interviews, they are not explicitly connected to residential locations. We do not see it, however, as evidence against these explanations, but rather an inability to uncover connections that are not within the conscious reflection of study participants. For instance, people with a cosmopolitan outlook might tend to choose inner-city residential locations (e.g., Czepkiewicz et al., 2020b), without explicitly realizing it. We also observed that respondents struggled with consciously making connections between the urban environment and reasons to travel. Connections, if any, were more often implied, owing to the subconscious nature of motivation.

5.3. Future Study Recommendations

The study suggests that a critical evaluation of the definition of the compensation hypothesis is needed. We encourage further conceptual work that would go beyond the narrow framing and elaborate on more diverse links between urban environment and leisure travel. It should be supported with more qualitative or mixed methods studies, including using other qualitative research methods (e.g., focus group interviews). We encourage including the connections identified in our study (Figure 2) in future quantitative studies to assess their prevalence in general samples. Expanding studies on the connection between preferred travel destinations and residential location to include household situations or life stages to better distinguish between preferences on one hand and choices on the other could provide valuable information on the connection. The conscious connections between the urban environment and

travel behavior could be researched in the field of travel psychology.

Furthermore, we encourage using unified and/or comparable methodologies and expanding the set of environmental characteristics with the perception of noise, air pollution, crowding, commuting stress, and other sources of annoyance and dissatisfaction, not limited to the built environment (e.g., hectic schedules). There is a general need to study push factors connected to everyday life and their influence on both medium- and long-distance leisure travel in the context of reducing travel demand. One might hypothesize that improvements in everyday liveability, such as work time reductions, could minimize the need to 'get away,' but there is currently not enough evidence on the influence of such interventions on travel demand. Further research should also strive to better understand the importance of green space quality and accessibility on meeting the recreational needs of urban dwellers within cities without the need to get away. Particularly relevant for urban planning is studying how cities can strive for reducing car-dependence, e.g., through densification, while protecting green spaces and improving equitable access to them for all residents (Haaland & van den Bosch, 2015).

Other factors, such as cosmopolitan attitudes and social networks, should be explored using qualitative and quantitative methods as well (Mattioli & Scheiner, 2019; Oswald & Ernst, 2021). However, one should remember that evidence of these other explanations does not eliminate the possibility of compensating for the deficiencies of the urban environment (Strandell & Hall, 2015), or vice versa. Czepkiewicz et al. (2018b) note that distinguishing between seeking and escaping behavior within the compensation hypothesis might help better understand links between urban environments and leisure travel. What follows, is the need to consider travel motivations more explicitly in future studies.

5.4. Policy Relevance

We identify a link between long commutes by car and escape trips, which suggests that an improved public transport system and reducing travel distances through densification could reduce stress and the need to get away. The issue of car dependence also pertains to domestic travel, as a lack of a private vehicle hinders the possibility to travel within Iceland. On the other hand, reduced car ownership might lead to increased travel by airplane through monetary (Ottelin et al., 2014) or other kinds of substitution. Similarly, policies to reduce everyday life demands, e.g., work time reductions, could potentially limit the need for escape travel, but could also expand travel time budgets and thus encourage more leisure mobility (Kallis, Kalush, Flynn, Rossiter, & Ashford, 2013). Our results on car-dependence, green spaces, and domestic travel support a common conclusion (e.g., Haaland & van den Bosch, 2015) that planning policies should aim at reducing car-dependence through com-

pact and transit-oriented development while protecting and improving access to quality green areas. Further research is needed before more specific policy recommendations can be formulated.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Agent-Based Simulation of Long-Distance Travel: Strategies to Reduce CO₂ Emissions from Passenger Aviation

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Abstract

Every sector needs to minimize GHG emissions to limit climate change. Emissions from transport, however, have remained mostly unchanged over the past thirty years. In particular, air travel for short-haul flights is a significant contributor to transport emissions. This article identifies factors that influence the demand for domestic air travel. An agent-based model was implemented for domestic travel in Germany to test policies that could be implemented to reduce air travel and CO₂ emissions. The agent-based long-distance travel demand model is composed of trip generation, destination choice, mode choice and CO₂ emission modules. The travel demand model was estimated and calibrated with the German Household Travel Survey, including socio-demographic characteristics and area type. Long-distance trips were differentiated by trip type (daytrip, overnight trip), trip purpose (business, leisure, private) and mode (auto, air, long-distance rail and long-distance bus). Emission factors by mode were used to calculate CO₂ emissions. Potential strategies and policies to reduce air travel demand and its CO₂ emissions are tested using this model. An increase in airfares reduced the number of air trips and reduced transport emissions. Even stronger effects were found with a policy that restricts air travel to trips that are longer than a certain threshold distance. While such policies might be difficult to implement politically, restricting air travel has the potential to reduce total CO₂ emissions from transport by 7.5%.

Keywords

aviation emissions; long distance travel; mode choice modelling; transport emissions; transport modelling

Issue

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1. Introduction

According to the UN emissions gap report from 2019 (UN Environment Programme, 2019), emissions need to be reduced by 7.6% every year from 2020 to 2030 to limit global warming to 1.5°C. Otherwise, temperatures are expected to rise 3.2°C above pre-industrial levels, with severe impacts on the environment, agriculture, and human well-being. While many sectors in Germany were able to reduce greenhouse gas emissions over the past 20 years (including agriculture, manufacturing,

and energy), emissions from the transport sector stagnated over the past 28 years (Umwelt Bundesamt, 2020). Aviation generated 2.4% of all CO₂ emissions in 2018 (Graver, Zhang, & Rutherford, 2019), with a growth rate of 32% over the past five years. In Germany alone, the amount of CO₂ equivalent emissions (CO₂eq) from international aviation increased 2.5-times over the last 30 years, while emissions from domestic aviation showed a 10% reduction in CO₂eq (Umwelt Bundesamt, 2020). Air travel needs to be an important contributor to reduce greenhouse gas emissions to achieve climate protection goals.

At the time of writing this article, the airline industry has been decimated by an ongoing pandemic that severely restricted long-distance travel. Most airlines were only able to survive with massive governmental subsidies. Passenger air travel in Europe dropped by 89% (Nižetić, 2020), and emissions were reduced accordingly. IATA predicts, however, that air travel will recover by 2024 with an annual global growth rate of 3.7% over the next 20 years (IATA, 2020). Despite the severe impacts of the pandemic on the airline industry, the concern about growing emissions from air travel remains unchanged in the long run.

Transport studies, on the other hand, tend to focus on urban travel (Aultman-Hall, Harvey, & Jeffrey, 2015). Transport modeling in particular has a long tradition of focusing on shorter distances only (Moeckel, Fussell, & Donnelly, 2015). There is a need to study policies and regulations that help reduce emissions from long-distance travel. Long-distance transport models may help to quantify the impact on greenhouse gas emissions. Hence, this article focuses on the investigation of different policies that could be applied in the aviation sector to shift travel from air to ground modes.

2. Literature Review

2.1. Long-Distance Mode Choice Modelling

Typically, long-distance travel demand refers to non-recurrent trips over a certain distance threshold. There is no common definition of the boundary between long-distance and short-distance travel demand. For instance, the Travel Survey of Residents of Canada (Statistics Canada, 2011) defines a long-distance trip as a trip that is an overnight trip, or a trip that is longer than 40 km, but Nordenholz, Winkler, and Knörr (2017) define long-distance travel starting at 100 km. Motivated by several references (Creemers et al., 2012; Llorca, Ji, & Molloy, 2018; Sandow & Westin, 2010), a threshold of 40 km was selected to differentiate between long and short-distance trips in this study

Although most trips are short-distance trips, long-distance trips are very relevant for the transport system. According to Shiffer (2012), 75% of all trips are shorter than 15 km, but they account for only around 30% of the vehicle-distance travelled. Moreover, the number of long-distance auto trips in Germany is expected to grow further by 13–16% by 2030, depending on the purpose of the trips. Similarly, distances are expected to grow by 12% (Federal Ministry of Transport and Digital Infrastructure, 2014).

Traditionally, most transportation studies focused on short-distance trips because of their higher frequency, better data sources, and the higher number of urban and regional planning studies. Therefore, many transport models omitted long-distance travel demand. Long-distance travel behavior is different from short-distance travel, thus the second one cannot be extrapolated from

the first one (for instance, they include different transportation modes, such as bike and walk versus air and high-speed rail, respectively).

The development of statewide models was a milestone for long-distance modelling (Miller, 2004). The statewide model of Ohio (US) includes a long-distance travel demand module (Erdhardt, Freedman, & Stryker, 2007). A long-distance travel demand model for Europe was presented by Rich and Mabit (2012). This very large-scale model was (according to the authors) not accurate enough because the resolution was too coarse. Runtime issues were also reported. Lu, Zhu, Luo, and Lei (2015) developed a nested logit formulation for trip generation, destination, and mode choice that was applied for inter-city trips among a set of seven Chinese cities. In the US, Outwater, Bradley, Ferdous, Trevino, and Lin (2015) developed a national long-distance model by jointly estimating destination and mode choice. Recently, Zhang et al. (2020) applied another US-wide model to test the impact of high-speed rail at the national level. Similarly, Outwater et al. (2010) described a long-distance model for the state of California that was used to estimate the impact of new high-speed railway lines. Llorca et al. (2018) estimated trip generation, destination choice, and mode choice in multinomial logit models for the province of Ontario (Canada) based on domestic and international travel survey data. The authors added data of visitors' check-ins (Foursquare, 2017) to better characterize the variety of attractions of the destinations (e.g., to differentiate touristic ski resorts from industrial or business areas, as described in Molloy & Moeckel, 2017).

The following issues are commonly reported by the above-mentioned studies. Firstly, the quality of the long-distance travel demand data is lower compared to the detailed travel dairies used for short-distance travel. In Germany, the German Household Travel Survey (*Mobilität in Deutschland* in German; see Federal Ministry of Transport and Digital Infrastructure, 2017) only reports up to three overnight trips for the last three months and does not even identify their destination. For short-distance travel, on the other hand, all respondents report a full-detail travel diary for one day. Zhang et al. (2020) used data from the largest US long-distance travel survey from 1995, which was already 25 years old. Secondly, transport supply data limited the model development as well, especially with regard to public transport schedules. The use of General Transit Feed Specification (GTFS) has partially solved these data issues, although these data are not available everywhere. The supply data of air travel is not provided in most cases. Moreover, the data of destination attractions, relevant for discrete choice models for destination choice, is limited as well (Van Nostrand, Sivaraman, & Pinjari, 2013) and needs to be more specific than population or number of jobs of alternative zones. Nordenholz et al. (2017) evaluated modal shifts for long-distance passengers in Germany. With an aggregated model of about 400 zones, the authors modelled changes in modal share due to

changes in cost or travel times. Changes were described to be very moderate. Third, due to the large scale of the models, the resolution is often too coarse to evaluate local changes (Llorca et al., 2018; Rich & Mabit, 2012), where the importance of access and egress trips would be more relevant (i.e., the model zones are too large to differentiate travel patterns of travelers who live close to public transport facilities from others). Lastly, travel demand models are rarely used to evaluate the impact of transport policies and investments on emissions.

2.2. Greenhouse Gas Emission Estimation

Previous studies show many alternative methods to estimate transport-related emissions, from complete life-cycle analyses to only tailpipe emissions. In this section, we summarize methods for emission estimation for ground and air transport.

The emissions produced by ground transportation are usually calculated as the product of a vehicle emission factor and the distance travelled. The energy consumption of a vehicle depends on the age of the vehicle, its engine, type of fuel, but also on external factors such as road type and homogeneity of the road segments, the road surface, slope, idling, congestion, or weather conditions (Brand & Preston, 2010; Llopis-Castello, Camacho-Torregrosa, & Garcia, 2019; Reichert, Holz-Rau, & Scheiner, 2016).

Thanks to a microscopic simulation it is possible to assign different emission factors to different vehicles and different driving situations. The Multi-Agent Transport Simulation (MATSim) emission extension implements this approach (Hülsmann, Gerike, Kickhöfer, Nagel, & Luz, 2011). Simpler large-scale emission estimations are based only on the product of emission factors and the total amount of fuel used or the total number of kilometers travelled by mode. The emission calculation for public modes follows a similar approach but additionally considers the number of seats and the average occupancy on the public transport vehicle (Reichert et al., 2016). Such emission factors allowed nationwide emission calculations, based on distances travelled as reported by household survey data (Brand & Preston, 2010; Heinen & Mattoili, 2019; Hoyer & Holden, 2003; Pagoni & Psaraki-Kalouptsidi, 2016; Reichert et al., 2016).

In aviation, the emissions are typically separated into two parts: (1) landing/take-off emissions (LTO), including all activities around the airport and (2) climb-cruise-descent emissions (CCD or non-LTO) for activities above 1,000 m. This is done to account for the high difference in energy consumption and related fuel burn during the LTO part of the flight compared to the CCD part. After the cruise altitude has been reached, the aircraft's engines burn less fuel per kilometer due to the thinner atmosphere and flying at a stable altitude (Miyoshi & Mason, 2009; Pagoni & Psaraki-Kalouptsidi, 2018; Pejovic, Noland, & Williams, 2008). This division follows the Tier 2 methodology provided by the

Intergovernmental Panel on Climate Change (IPCC, 2019). As an example, Mayor and Tol (2008) used the emission factor of 6.5 kg of CO₂ per passenger during LTO and 0.02 kg of CO₂ per passenger-kilometer during CCD.

Due to the difference in emissions in the LTO and CCD parts of the flight, the amount of emissions per km on long and short distance flights varies as well. Therefore, some studies define separate emission factors for short or domestic flights and for international (long-distance) flights (Brand & Preston, 2010; Miyoshi & Mason, 2009; Pejovic et al., 2008; Reichert et al., 2016). The distance threshold for this separation varies. It is difficult to argue which flight length is more harmful in terms of emissions released because short flights spend a smaller part of the flight in high altitudes where contrails can occur, but they consume more fuel per passenger and km (Aamaas, Borken-Kleefeld, & Peters, 2013; Hofer, Dresner, & Windle, 2010; Reichert et al., 2016). The short-haul flights CO₂ emissions are so high compared to ground modes that, in general, the shift from short-haul aviation to ground transportation results in reductions of CO₂ emissions (Hofer et al., 2010).

The most common fuel used in civil aviation is kerosene (Lee, Pirati, & Penner, 2009). Nevertheless, the emission factor depends not only on the amount of fuel burned but also on aircraft and engine type and the distance of the flight. The carbon dioxide emission has been usually calculated based on the amount of fuel burned multiplied by a factor of 3.157 kg CO₂ per kg of fuel (International Civil Aviation Organization [ICAO], 2016). This emission factor is used in various studies (ICAO, 2016; Larsson, Kamb, & Akerman, 2018; Pagoni & Psaraki-Kalouptsidi, 2016, 2018; Pejovic et al., 2008). Some studies introduce additionally a factor of 1.9 while calculating CO₂ emissions to include the magnitude of radiative forcing effect (Boussauw & Vanoutrive, 2019; Caset, Boussaw, & Storme, 2018; DEFRA, 2016, 2020; Larsson & Kamb, 2019). Due to high uncertainty, this factor may vary (Foster, Berntsen, & Betts, 2007; Lee, Fahey, & Skowron, 2020; Rädcl & Shine, 2008).

3. Methodology

This research applied an agent-based model to simulate long-distance travel behavior during an average weekday day in Germany. The approach follows the trip-based travel demand model framework and includes the first three steps: trip generation, destination choice, mode choice. Travel demand is simulated at the agent-based (microscopic) scale, thus the individual behavior of travelers is explicitly represented. The model structure is shown in Figure 1.

Our study area covers all of Germany. It is divided into 11,717 number of zones to allocate structural data, such as population, employment, schools and shops. Zones correspond to municipalities (*Gemeinde* in German) and the boroughs of the 14 most populated cities (Hamburg, Hanover, Bremen, Dortmund, Düsseldorf,

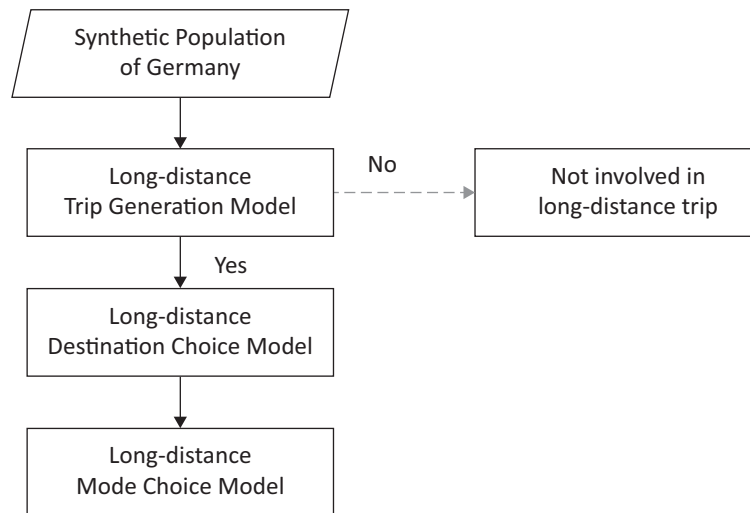


Figure 1. Model framework.

Duisburg, Essen, Cologne, Frankfurt, Stuttgart, Munich, Berlin, Dresden, and Leipzig), shown in Figure 2. The number of zones is substantially larger than in previous Germany-wide models. Winkler and Mocanu (2017), for example, included 412 zones corresponding to the counties (*Landkreis* in German) for their Germany model.

A synthetic population of persons and households was generated. This synthetic population matches socio-demographic attributes at the aggregate as reported by census data. During the generation of the synthetic population, census microdata records are selected to match the control totals of the study area. We used Iterative Proportional Updating (Konduri, You, & Garikapati, 2016) with three geographical levels (borough, municipality and

county) and two personal levels (person, household), as described by Moreno and Moeckel (2018). The synthetic population has around 80 million persons in 53 million households. The information of socio-demographic data (control totals) is obtained from the German Household Census and the GENESIS online database (for municipalities and counties; see Statistische Ämter des Bundes und der Länder, 2011; Statistisches Bundesamt, 2019). Additionally, census data at the borough level were collected from the websites of the 14 most populated cities. These include, for example, persons by gender and age, employment by sector or households by size. As an example, Table 1 shows the average of the absolute error of all controlled attributes by municipalities. The average error

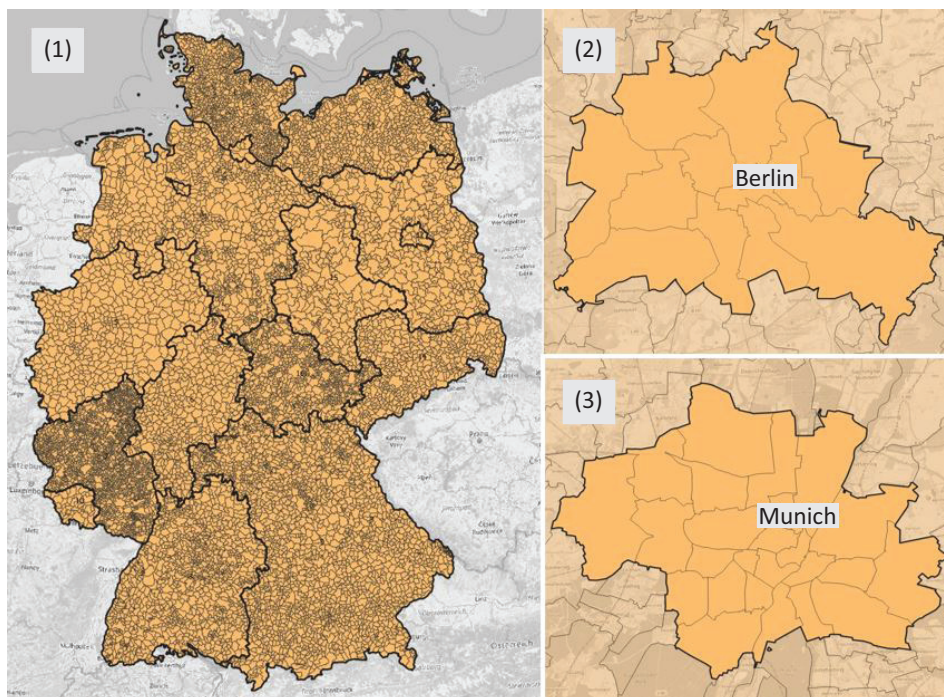


Figure 2. Zone system: (1) Germany, (2) Berlin, (3) Munich.

Table 1. Average absolute error of controlled attributes by municipalities.

Average error	Number and share of municipalities	Average population by municipalities
0%—5%	9,689 (85.47%)	7,617.03
5%—10%	1,135 (10.01%)	4,778.17
10%—15%	282 (2.49%)	2,580.20
15%—20%	126 (1.11%)	737.55
20%—30%	104 (0.92%)	521.96
Total	11,336 (100%)	7,065.94

by municipalities ranges between 0% and 30%. Smaller municipalities tend to be more difficult to match.

The synthetic population was used as input for the long-distance travel demand model. First, the long-distance trip generation module simulates whether a person makes a long-distance trip or not on a given day using multinomial logit model. Among those individuals who make a long-distance trip, we distinguish individuals making daytrips (outbound and inbound trips on the same day), overnight trips (either the outbound or the inbound trip is made during the observed day), and individuals who are away on the simulated day (since they started an overnight trip before and return after the simulated day). A threshold value of 40 km was chosen to distinguish short- and long-distance trip for all non-work trip purposes (Llorca et al., 2018). Commute trips of any length are treated as habitual travel and not included as long-distance trips. Long-distance trips distinguish three purposes: business, leisure and private. Business trips are trips to see customers or business partners and conference visits (travel costs are commonly paid by the employer). Leisure trips contain trips for recreational purposes. Private trips cover long-distance trips to visits family and friends, shopping, seeing a doctor, and others.

The second module is the long-distance destination choice model, which selects the destination for the long-distance trips with a multi-nominal logit model. The 11,717 zones described above form the choice set. The last component is the long-distance mode choice model. Four modes are considered by a multinomial logit model: auto, air, rail, and long-distance bus. For long-distance bus and rail, local transit is considered for access and egress trips, while auto was chosen for airport access and egress.

These models are estimated and calibrated based on the household travel survey described in Section 4.1. The multinomial logit model calculates the utility for a traveler to select a given alternative. In the case of trip generation, the alternatives are, for example, no long-distance travel, long-distance daytrip, long-distance overnight trip, or being away on a long-distance trip. The main assumption of the multinomial logit model is that the alternatives are irrelevant and independent from each other and that people can make rational choices by differentiating the utility of each alternative (Ortuzar, Hensher, & Jara-Diaz, 1999). The probability of choosing an alternative is shown in Equation 1 and Equation 2:

$$P_{pj} = \frac{e^{V_{pj}}}{\sum_{k=1}^{K} V e^{V_{pk}}} \quad (1)$$

Here, the following applies:

- P_{pj} is the probability for individual p to select alternative j .
- V_{pj} is the utility for individual p to select the alternative j , as described in Equation 2.
- $k = 1, 2, \dots, K$ is the set of alternatives.

$$V_{pj} = \sum_{s=1}^{S} \beta_s x_s \quad (2)$$

Here, the following applies:

- $s = 1, 2, \dots, S$ is a set of explanatory variables for the number of trips.
- β_s is the coefficient of the explanatory variables s .
- x_s is the value of the explanatory variables s .

Explanatory variables that were highly correlated were excluded from the models. If two variables correlated by more than $R^2 = 0.5$, only one of the two was retained.

4. Data

In the following paragraphs, household travel survey, transportation networks, and attraction data are presented.

4.1. Household Travel Survey

We used the latest household travel survey available in Germany—the German Household Travel Survey—which is a nationwide survey conducted by the German Federal Ministry of Transport and Digital Infrastructure (2017). The survey includes household and person characteristics, as well as daily travel diaries during one day. The surveyed days are distributed equally across seasons, months, and days of week, allowing to analyze the behavior in relation to weekdays/weekends, vacation/non-vacation days and seasons. In total, 156,420 households (around 0.38% of all households in Germany) participated. Every household member was invited to answer this survey regardless of their age, gender, or

occupation status. This survey included 316,361 people (0.38% of the population) and 960,619 trip records. The survey includes a second dataset of overnight trips in the last three months. This dataset, however, does not specify trip origins or destinations and includes a maximum of three overnight trips per person.

We use the daily travel diary dataset of the survey for our model estimation. This dataset provides trip origin, destination, mode, time of day, and purpose of every trip made on the surveyed day.

4.2. Network

The network provides travel time and distances by mode for both selected and non-selected destinations and modes. Travel times and distances by mode between all zones are stored in skim matrices. The following data sources were used to generate the skim matrices:

- **Road network:** The road network was downloaded from OpenStreetMap (wiki.openstreetmap.org). For Germany, it includes freeways, trunk roads, as well as primary, secondary and tertiary roads. For each link, length, speed limit, number of lanes and capacity are provided by OpenStreetMap (2021). In exceptional cases where these attributes were missing, default values were used. To obtain the travel time by auto for each trip of the German Household Travel Survey, we used the simulation model MATSim (Axhausen, Nagel, & Horni, 2016). MATSim was also used to calculate skim matrices.
- **Ground public transport network:** Networks for all public transport modes were obtained from GTFS (Brosi, 2019). Stop locations, lines (in the sequence of stops) and journeys (individual services of each line on a selected day) were available for download. Timetable information represents a complete all-day timetable. We distinguished between long-distance rail (intercity rail, interregional rail) and long-distance bus services, covered by the Deutsche Bahn and by FlixBus or BlaBlaBus, respectively. Local public transportation such as commuter rail, subway, tram, interregional bus, and local bus were used as access/egress modes to long-distance travel modes. Using GTFS data, travel times from point to point were calculated using the SBB router within MATSim (Swiss Federal Railways, 2018).
- **Air network:** flight data from before the COVID-19 pandemic were used to construct the air network. The data were downloaded from OpenFlights (github.com/jpatokal/openflights) and contain flight connections between airports, including departure and destination, airline and aircraft type. Connections that are not covered by a direct flight were calculated in a second step by calculating the route from the starting point to the destination via all possible hubs. Access and egress

time by car were added to the total trip duration. To obtain the total travel time by air, we also added an average pre-boarding waiting time (90 minutes), post-landing processing time (15 minutes), and transfer time (between 30 and 100 minutes depending on the hub).

4.3. Trip Attraction

To estimate the long-distance destination choice model, information about destinations was required. Apart from population and employment, and to better reflect the attractiveness of places for leisure trips, we also included the number of hotels in each potential destination (Statistische Ämter des Bundes und der Länder, 2020).

5. Model Estimation

This section summarizes the model estimation results for trip generation, destination choice and mode choice.

5.1. Trip Generation Model

German Household Travel Survey provides 316,361 person records. After removing records with missing or non-plausible values (7.32% removed), there were 293,216 records available for model estimation. The results for long-distance trip generation are summarized in the Supplementary File (Table A1). In this model, there are four alternatives: not to conduct long-distance travel, long-distance daytrip, long-distance overnight trip and being away.

Car ownership has a positive impact on the generation of long-distance daytrips of all trip purposes, but it has a negative impact on private overnight trips and no impacts on other overnight trips. People living in households with a higher economic status are more likely to make any forms of long-distance trips, especially for private and leisure purposes. Employed people tend to be less likely to conduct long-distance private and leisure trips than non-employed, but more likely to make long-distance business trips. Presumably, this is related to the availability of time for long-distance travel.

After the model was estimated, it was implemented with the synthetic population for Germany and calibrated to match the share of alternatives observed in the German Household Travel Survey. The calibration factors were added to the utility function. In Table 2, the modeled and observed (in the survey) shares of the different trip types are compared, showing a close match after calibration. The majority of the population (around 94%) does not make long-distance trips on a given day.

5.2. Destination Choice Models

While the German Household Travel Survey has 960,619 trip records (including short- and long-distance), only 12,451 records describe long-distance trips with

Table 2. Long-distance trip generation results.

Trip purpose	No long-distance trip		Daytrip		Overnight trip		Being away	
	Model	Survey 2017	Model	Survey 2017	Model	Survey 2017	Model	Survey 2017
Private	98.14%	98.16%	1.11%	1.11%	0.68%	0.70%	0.07%	0.04%
Business	97.93%	97.96%	1.65%	1.65%	0.35%	0.35%	0.07%	0.04%
Leisure	98.11%	98.12%	0.88%	0.89%	0.89%	0.88%	0.12%	0.11%
Total	94.18%	94.23%	3.64%	3.65%	1.92%	1.93%	0.26%	0.19%

complete origin and destination information (applying the 40 km threshold for non-commute trips, as described above). The distance by car is assigned for each trip record using the MATSim model for estimating and calibrating the destination choice model. The model estimation result of long-distance destination choice is shown in the Supplementary File (Table A2). Three attributes were included in this model: the logarithm with base 10 of car distance, total population and employment at destination, and the number of hotels at the destination. Ideally, the model should be estimated with the full choice set of 11,717 alternatives. Due to the computational limitations, we selected 500 random alternatives and the actually chosen alternative for each trip to conduct model estimation.

The results show, as expected, that the probability of a destination decreases as the distance increases. Total population and employment and the number of hotels have a positive impact on the utility, which means destinations with more population, employment and hotels are more likely to be chosen. The model was implemented and calibrated to match the average one-way distance between survey and model. The calibration factors of the destination choice model, as shown in the Supplementary File (Table A2), are multiplied with the distance parameter. The calibrated results are summarized in Table 3. Overall, the model matches the average one-way travelled distance, as it should be expected from a calibrated model. The modeled standard deviation is slightly smaller than observed, which indicates that the model has a tendency to slightly underestimate rather short and very long long-distance trips.

5.3. Mode Choice Model Estimation

The mode choice model considers four modes: auto, air, long-distance bus, and long-distance rail. The complete

data set for mode choice model estimation consists of 7,098 records, with 5,125 records for day trips and 1,973 records for overnight trips. Two separate mode choice models were estimated for domestic day and overnight trips, assuming that a decision of choosing a mode is influenced by the duration of the trip. The results of the multinomial logit model estimation are presented in the Supplementary File (Tables A3 and A4). To include the sensitivity to travel time and cost, and to avoid the strong correlation between the two, we convert both terms into generalized travel time, as described in Equation 3:

$$gTime = time + \frac{cost}{VOT} \times 60 \quad (3)$$

Here, the following applies:

- *time* is the travel time in hours;
- *cost* is the cost of the trip in euro;
- *VOT* is the value of time (65 EUR/h for business trip, 32 EUR/h for private and leisure trips; see Llorca et al., 2018)

According to Equation 3, business trips are less sensitive to price increases than leisure or private trips, where the value of time is smaller. This reflects that business trips are commonly paid by the employer, making those trips less price sensitive. Generalized travel cost and socio-economic attributes are included in the utility calculation for each mode and purpose.

The model was calibrated to match the observed modal shares in the survey (Federal Ministry of Transport and Digital Infrastructure, 2017). As shown in Table 4, auto is the predominant mode for long-distance travel. The model estimation results for day and overnight trips are summarized in the Supplementary File (Tables A3 and A4) and consist of 18 attributes. Auto was selected as the base alternative (with an alternative specific constant set

Table 3. Long-distance destination choice model results.

One-way average travelled distance and standard deviation (in parenthesis) by car (km)	Daytrip			Overnight trip		
	Private	Business	Leisure	Private	Business	Leisure
Model	204.97 (162.35)	180.50 (147.48)	174.56 (146.07)	226.78 (171.37)	257.13 (179.09)	229.79 (173.07)
Survey 2017	206.94 (187.13)	179.78 (154.60)	176.09 (172.71)	226.69 (187.50)	258.21 (193.18)	229.18 (189.32)

Table 4. Summary of the choice results.

Travel Mode	Daytrip		Overnight trip		Total	
	Model	Survey 2017	Model	Survey 2017	Model	Survey 2017
Auto	86.05%	87.53%	81.19%	74.69%	83.54%	81.11%
Air	0.39%	0.80%	3.96%	5.71%	2.23%	3.26%
Bus	3.13%	2.34%	3.13%	4.63%	3.13%	3.49%
Train	10.44%	9.32%	11.71%	14.96%	11.10%	12.14%

to zero). Although the coefficients vary slightly among purposes and trip types, we generally observed that females and persons of single-person households are more likely to choose rail. This is also observed for both young and elderly travelers. Bus and train tend to be preferred by low-income households. As expected, generalized time negatively affect the utility, making closer destinations more attractive.

6. Calculation of Greenhouse Gas Emissions

This study focuses on calculating CO₂ emissions of all considered long-distance modes. Unfortunately, it was not feasible to work with CO₂ equivalent emissions (CO₂eq), as CO₂eq takes into account the commonly-known GWP (global warming potential) of CO₂, CH₄, and N₂O gases (Brander, 2012). In this study, we estimate emission factors for the air mode based on the distance flown, and information about the amounts of CH₄ and N₂O emitted per km depending on the flight distance was not found.

The emission factor for auto was taken from HBEFA for the year 2020 for diesel and gasoline light-duty vehicles (HBEFA, 2020). The share of gasoline and diesel-powered vehicles was 65.9% and 31.7%, respectively (Kraftfahrt-Bundesamt, 2020). The emission factor for auto trips used for this study is 170.89 gCO₂/km travelled. This emission factor does not account for start emissions. To account for the presence of multiple passengers in the car, the amount of CO₂ emissions released by auto was divided by 2.25 (Federal Ministry of Transport and Digital Infrastructure, 2017). The coefficient 2.25 represents the average occupancy rate for domestic auto long-distance trips in Germany. The emission factor for a long-distance bus was taken from HBEFA as well for the year 2020 and it is equal to 1,291.847 gCO₂/km travelled (HBEFA, 2020). Considering the average occupancy of long-distance buses of 60% and the average number of available seats of 49, a long-distance bus carries 29 passengers on the average. Therefore, the emission factor per passenger on a long-distance bus is 44.55 gCO₂/km. In Germany, there are several types of trains operating long-distance travel and the energy consumption varies for each train

type. Most trains are electrically powered and the average energy consumption per passenger is 28.33 Wh/km (DeutscheBahn, 2010). Considering Germany's federal electricity mix, the emission factor per passenger traveling by train is 14 gCO₂/km (DeutscheBahn, 2010).

As mentioned earlier the emission factor for air travel depends on the distance travelled. The shorter the travelled distance, the higher the emission factor per km. The ICAO carbon emission calculator was used to calculate flight CO₂ emissions for almost 800 city pairs (ICAO, 2016). Based on the data collected, we estimated the amount of CO₂ emissions released per passenger per kilometer travelled subject to the total travelled trip distance. For flights that require a transfer, emission factors were derived for each leg. Table 5 shows the emission factor for each air trip based on trip distance. The estimated CO₂ emission factor was multiplied by 1.9 to account for the radiative forcing effect (DEFRA, 2016, 2020; Larsson & Kamb, 2019). We recognize that this factor of 1.9 is an overestimate for short-distance air trips and an underestimate for the long-distance trips. However, to the authors' knowledge, there is no method to take into account the trip length and adjust the 1.9 factor accordingly (Larsson & Kamb, 2019). As explained earlier (Section 4.2), auto was set as the access and egress mode to and from airports and the emission factor by auto was used to account for access and egress emissions. Flight emissions and auto emissions were added to calculate total emissions. All the presented emission factors are summarized in Table 5 and were used for emission calculations in this study.

7. Scenario Analysis

We tested different scenarios with policies that aim at reducing air travel. We studied restrictions of air trips below a distance threshold and increases of the airfare. We considered four different thresholds for air trips: 300, 500, 700, and 900 km, below which the air mode was made unavailable. Regarding the airfare increase, we considered three scenarios with 100%, 300%, and 500% increase.

Table 5. Emission factors for long-distance modes.

Mode	Auto	Air	Bus	Rail
Emission factor, kg/passenger-km	0.171	$1.8453 \times \text{air traveled distance}^{-0.401} \times 1.9$	0.045	0.014

As the model is agent-based, a random number is needed to select a discrete travel choice for each agent. Therefore, every model run is slightly different. We run the model 8 times with different random seeds and calculated the average to obtain more reliable results. The results of the base scenario are presented in Table 6. A total of 4,512,610 domestic long-distance trips were simulated for an average day for Germany. Air trips accounted for 0.39% of daytrips in Germany and for 3.96% of overnight trips. However, the total amount of CO₂ emissions released by aviation was significantly larger: 8.54% of daytrip CO₂ emissions and 43.30% of overnight trip emissions. Long-distance bus and rail, on the other hand, produced lower shares of CO₂ compared to their shares in the number of trips.

After analyzing the base scenario, we run the above-mentioned policy scenarios and calculated CO₂ emissions by air and ground modes. The results of scenarios that restrict air travel below a certain distance are summarized in Figure 3. The amount of air emission steadily decreases as the threshold is increased. When the dis-

tance threshold is 900 km, air travel is strongly reduced and emissions drop by 93.1% with the number of air trips dropping to 4,917 trips. At the same time, the emissions of the remaining long-distance ground modes increase due to the shift from the air mode, with the highest increase of 3.6% in the 900 km scenario. Overall, emissions are reduced by 24.2% in this scenario. In reality, some travel might be suppressed by this scenario, which could reduce emissions even further but is not accounted for by the model.

With respect to the scenarios with higher airfares, an increase of 100% already reduced CO₂ emissions from aviation by 28.42% compared to the base scenario (11,086.95 tons of CO₂ per day), as seen in Figure 4. As airfare was increased by 500%, the reduction in CO₂ emissions was 53.2% (equivalent to 20,745.64 tons of CO₂). The emissions from ground transportation increased due to the shift from air mode (up to a 2.1%, when air fares increase by 500%). The total emissions are reduced by up to 13.8% with the highest airfare increase.

Table 6. Base scenario modal share of domestic long-distance trips and CO₂ emissions by mode.

	Travel Mode				Total
	Auto	Air	Bus	Train	
	Number of trips				
Day Trip	1,879,515 (86.05%)	8,449 (0.39%)	68,315 (3.13%)	227,990 (10.44%)	2,184,269 (100%)
Overnight Trip	1,890,301 (81.19%)	92,304 (3.96%)	72,950 (3.13%)	272,748 (11.71%)	2,328,303 (100%)
Total	3,769,815 (83.54%)	100,793 (2.23%)	141,264 (3.13%)	500,737 (11.10%)	4,512,610 (100%)
	CO ₂ emissions, tons				
Day Trip	49,134.10 (87.34%)	4,762.05 (8.46%)	1,226.62 (2.18%)	1,133.54 (2.01%)	56,256.31 (100%)
Overnight Trip	42,969.60 (54.01%)	34,253.56 (43.06%)	1,080.48 (1.36%)	1,249.39 (1.57%)	79,553.02 (100%)
Total	92,103.70 (67.01%)	39,015.61 (28.39%)	3,937.06 (2.86%)	2,382.93 (1.73%)	137,439.30(100%)

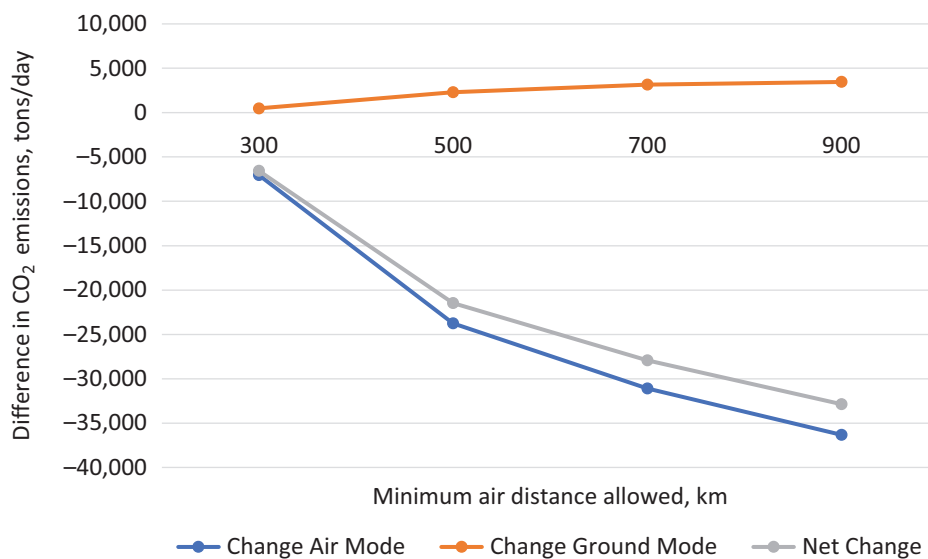


Figure 3. Change in CO₂ emissions due to minimum distance restriction for air travel.

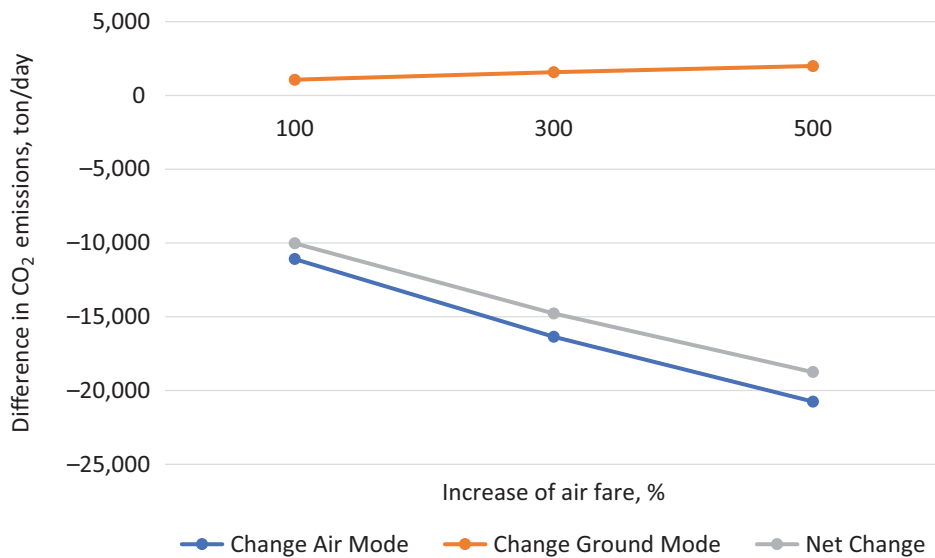


Figure 4. Change in CO₂ emissions based on air fare increase.

8. Conclusion

This research evaluated the potential of policies to reduce CO₂ emissions produced by long-distance travel. Specifically, we used an agent-based travel demand model to estimate the demand for long-distance travel and coupled the model with a CO₂ emissions calculator. It was shown that policies that restrict air travel below a defined threshold distance were more effective in CO₂ emissions reduction than increasing airfares. Compared to urban travel, air travelers are less sensitive to price increases due to higher values of time in long-distance travel. Also, many domestic air trips in Germany are business trips for which the employer covers the travel costs, which tends to reduce price sensitivity.

Another important aspect of this study is to quantify the shift from air mode to ground modes, and the corresponding levels of emissions. Traveling by auto is often more economical than other public ground modes, particularly when traveling with more than one person. Overall, the best CO₂ emission reduction with almost 33,000 tons per day was achieved with the scenario that restricted air travel to trips above 900 km. While politically difficult to implement, the strict air travel restrictions are most powerful in reducing the number of air trips and associated CO₂ emissions.

One aspect that sets this model apart from most other existing long-distance models is that it is built as an agent-based model. Agent-based models introduce a lot of flexibility to design scenarios (Donnelly, Erhardt, Moeckel, & Davidson, 2010). If someone wanted to test the impact of increasing eligibility for telework on long-distance travel, it is simple to add the attribute “eligible for telework” to each agent and adjust the choice models accordingly. However, agent-based modeling comes at a price. Such models require a random number generator

to simulate choices of individual agents. Depending on the random numbers chosen, every model run produces slightly different results. The differences between model runs are marginal if a large number of agents is simulated or if a lot of choices of these agents are simulated, as a large number of events averages out. Whenever a small number of agents or rare events are studied, agent-based models need to be run many times and the average across many model runs needs to be calculated (Wegener, 2011).

Long-distance travel is not as rare that it would be difficult to study it with an agent-based model, at least not for common destinations and modes. In this application, however, agent-based models proved to be challenging. Some scenarios tested to limit air travel to trips above a certain threshold distance only. While the number of air trips eliminated by these policies was stable across different model runs, the alternative modes chosen were not. If 100 air travelers with trips under 300 km switch to ground modes due to this policy, it makes a large difference in terms of CO₂ emissions if 30 of them chose bus in one model run and 35 in another model run. While both results might be perfectly plausible outcomes, it would be invalid to assess this policy based on a single model run. Therefore, the model had to be run multiple times to calculate the average of every scenario presented in this article.

A limitation is that the effects of congestion of the road network were not considered. If congestion on the road network was considered, travelers shifting from air to car could impact the congestion of the road network and affect travel times and emissions. The selected trip-based sequential travel model does not take into account the interaction between the steps. The application of copula models could better account for this issue, but a study area with 11,717 zones makes a joint destination

and mode choice unfeasible. An improvement could be to include mode choice logsums as terms of the utility of destinations in the destination choice model. This would affect destination of trips after modal restrictions are introduced (e.g., if flights under 500 km are prohibited, former air travelers may decide to travel to closer destinations). Last but not least, induced demand due to new modes or dampened travel demand due to restrictive scenarios are not considered in this model, as they are difficult to quantify.

It is planned to test more policies to reduce total CO₂ emissions including tolls on freeways and ride-sharing solutions. International travel will be added. This would allow to implement additional policies that promote more local travel and penalize short-duration overseas trips. More detailed emission factors for cars and buses that account for traffic conditions are planned to be used to account for the negative impacts of road congestion.

The policies analyzed in this article explored the potential to reduce CO₂ emissions of long-distance travel. It was shown that certain policies would significantly reduce long-distance emissions. The most impactful scenario tested was to limit air travel to destinations with a distance of 900 km or more, which led to a reduction of 32,900 tons of CO₂ per day. In a country like Germany where decent rail connections are available between all major cities, this might not be too much of a burden for travelers (even though travel times would increase for many trips). This policy would reduce the total emissions from the transport sector in Germany (160 million tons CO₂ per year in 2018; see Statista, 2018) by 7.5%. Given that the emissions of the transport sector were rather constant over the past 30 years, such a policy could be an important start to reduce transport emissions.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Territorializing International Travel Emissions: Geography and Magnitude of the Hidden Climate Footprint of Brussels

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Abstract

In the present article we investigate the geography and magnitude of the climate footprint of long-distance travel with Brussels, Belgium, as a destination. The internationally networked position of this city goes hand in hand with a strong dependence on international mobility, which largely materializes in impressive volumes of long-distance travel and associated consumption of important amounts of fossil fuel. Despite a surge in concerns about global warming, the climate footprint of most international travel, notably air travel, is not included in the official national and regional climate inventories, or in other words, it is not territorialized. The official climate footprint of the Brussels-Capital Region attained 3.7 Mton CO₂eq per year (in 2017). Based on our exploratory calculations, however, the total estimated climate footprint of all Brussels-bound international travel equalled an additional 2.7 Mton CO₂eq. In terms of geographical distribution, over 70% of international travellers to Brussels come from Europe, while these represent only 15% of the climate footprint of all international travel to Brussels. We conclude that the practice of not allocating emissions caused by international travel to territorial units has kept the magnitude and complexity of this problem largely under the radar and contributes to the lack of societal support for curbing growth of international aviation.

Keywords

air travel; Brussels; cities; climate footprint; tourism

Issue

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1. Introduction: A Territorial Approach to the Climate Footprint of International Travel

Although the climate footprint of long-distance travel is not a new object of study in the academic literature (see, e.g., Patterson & McDonald, 2004; Sun, Cadarso, & Driml, 2020; Wood, Bows, & Anderson, 2010), the theme has only recently seeped into the public climate debate (Wolrath Söderberg & Wormbs, 2019) and is not included in often-cited indicators such as national greenhouse gas inventories that need to be maintained by all industrialized countries (‘Annex I countries’) under the

Kyoto protocol (Gössling, 2013), according to prevailing agreements. While in recent years serious efforts were done to also make aviation accountable for its contribution to global warming, through instruments such as the EU Emissions Trading System (within the European Economic Area, since 2012) and the aviation sector’s own carbon offset scheme CORSIA (as from 2021; Larsson, Eloffson, Sterner, & Åkerman, 2019), governments of nations, regions, or cities are not eager to recognize ownership of the emissions that are associated with long-distance travel towards or from their territories. This attitude is implicitly supported by national greenhouse

gas inventory regulations that do not allocate such emissions to individual countries (Warnecke, Schneider, Day, La Hoz Theuer, & Fearnough, 2019). The complexity of the climate issue, to which both embedded emissions in imported products and the contribution of long-distance travel are of great importance, is hardly recognized in governmental climate policy plans. Although an inventory of such plans is beyond the scope of this article, we quote here the official climate policy plan of our case study, the Brussels-Capital Region, in which none of both themes is mentioned (Brussels-Capital Region, 2019). The current territorial approach to the allocation of climate footprints causes an important bias in the way the climate issue is viewed by the public and by policy makers. However, both emissions from international transport and imported products are caused by consumers, citizens, and organizations that are established in certain and identifiable countries and regions. The emissions from international transport are not only absent from the climate inventories but seem also underexposed in the climate debate itself.

In fact, the territorial focus of climate inventories ignores the internationalization of production chains and the structural shift towards service industries (tertiarization) of the economy of the most developed countries. Emissions are viewed as soil-bound affairs, while economic activities have increasingly become foot-loose. The shift from a manufacturing to a service economy means that emissions got detached from geolocalized production processes and shifted towards the geographically diffuse sector of long-distance transport. Reductions within national industrial production are clearly visible in the national climate inventories. However, increases in international travel associated with the rise of the service industry remain invisible in these inventories (Afionis, Sakai, Scott, Barrett, & Gouldson, 2017; Davis & Caldeira, 2010; Ottelin et al., 2019).

But international travel does not only support the manufacturing industry. The knowledge industry is also an important consumer of air kilometres (Achten, Almeida, & Muys, 2013; Ciers, Mandic, Toth, & Op't Veld, 2019; Klöwer, Hopkins, Myles, & Higham, 2020), including participation in scientific meeting (Burtscher et al., 2020; Nevins, 2014) just like higher education (Davies & Dunk, 2015), notably international student mobility (Shields, 2019), international politics, business travel (Kitamura, Karkour, Ichisugi, & Itsubo, 2020; Poom, Orru, & Ahas, 2017), sports (Collins, Munday, & Roberts, 2012; Pereira, Filimonau, & Ribeiro, 2019), culture (Bottrill, Liverman, & Boykoff, 2010; Collins & Cooper, 2017; Connolly, Dupras, & Séguin, 2016), tourism (e.g., Dube & Nhamo, 2019; Luo, Becken, & Zhong, 2018; Sharp, Grundius, & Heinonen, 2016; Smith & Rodger, 2009), and all kinds of visits by foreigners to their families and friends (Sun & Pratt, 2014). Within the academic sector, Erasmus programmes financially support European students to study away from home, while compensation increases with travel distance. Researchers are encour-

aged to develop international networks and are therefore supposed to travel on a regular basis, often by air (Arsenault, Talbot, Boustani, Gonzàles, & Manaugh, 2019; Wynes, Donner, Tannason, & Nabors, 2019). Also, international politics, such as European institutions, have an important ecological footprint. Moreover, relocation of families of which one member is active in an international sector usually entails additional journeys, for example by relatives and friends who come over for a visit. The last kind of journeys fall under the category of 'tourism,' which in the Global North comprises the bulk of all international journeys (Dobruszkes, Ramos-Pérez, & Decroly, 2019). The emissions associated with such trips are not visible in the national climate inventories.

2. The Case of Brussels, Belgium: A Focal Point of the Travel–Climate Issue

The aim of this article is to provide insight into the geography and magnitude of the climate footprint of the international attractiveness of a city with an important international position as a business and political centre, in relation to the official, territorialized climate footprint of this city. We will explore this issue for the case study of Brussels by taking a traditional bottom-up approach that estimates climate footprint based on the distribution of transport modes used by travellers (Sun & Drakeman, 2020). The choice for Brussels was inspired by the role played by this city as a forum for international political decision-making, which includes European climate policy, while the city and the activities it hosts are an important generator of international travel and the related climate footprint (Van Parijs & Van Parys, 2010). In what follows, we consider the Brussels-Capital Region, which is one of the three administrative regions in Belgium (next to Flanders and Wallonia), home to 1.2 million residents, out of 11.5 million Belgians.

We start with a look at the official climate footprint of Brussels, in relation to its geographical context. In 2017, according to the Belgian greenhouse gas inventory, the total climate footprint amounted to 114.5 Mton CO₂eq (FPS Public Health, Food Chain Safety and Environment, 2019), of which only 3.7 Mton CO₂eq (3.2%) was on account of the Brussels-Capital Region (Bruxelles Environnement, 2019). This remarkably modest contribution is even more noteworthy when we learn that in 2017 the Brussels-Capital Region not only housed 10.5% of the Belgian population, but even generated 17.8% of the Belgian gross domestic product. These figures are grist to the mill of those who claim that city dwellers, by definition, live more sustainably than suburban or rural dwellers, or as Banister (2008, p. 73) put it: "The city is the most sustainable urban form." Indeed, the official carbon intensity of the Brussels economy is around 5.5 times smaller than that of Belgium as a whole. However, just as Belgium is externalizing an important part of the emissions for which the Belgian economy is responsible to low-wage countries and to all sorts of

foreign travel destinations, Brussels is externalizing an even larger part of its emissions to its hinterland, being an important consumer of food and industrial products, almost none of which are produced on its own territory. Also, no airports (Boussauw & Vanoutrive, 2019) or sea-ports are located within the modest area of the territory of Brussels, which means that even the climate intensity of travel by Brussels' residents, which may be well higher than the Belgian average (Czepkiewicz, Heinonen, & Ottelin, 2018), is invisible in any relevant databases.

Mapping the actual climate footprint of the Brussels-Capital Region is beyond the scope of this article. Instead, we aim to understand the geography of the climate footprint of inbound international travel, and identify any knowledge gaps that may prevent us from doing so in a comprehensive and reproducible manner. This concerns all international journeys with Brussels as a destination, regardless of the purpose of the trip (business, politics, science, education, tourism). In this way, we subscribe to an existing tradition of research into sustainable tourism (Gössling et al., 2005; Le & Nguyen, 2021; Sun, 2014), although we expand leisure with business travel. In that context, Peeters and Schouten (2006), for example, already investigated the ecological footprint of tourism to and in Amsterdam. A similar assessment was recently carried out for Barcelona (Rico et al., 2019). In both cases, the results show that the overwhelming majority of the climate footprint of tourist visits are attributable to travel to the destination, in particular to long-distance air travel. These studies take into account the climate footprint related to touristic activities in the destination (accommodation, leisure and professional activities, intra-urban transport). However, they measure the climate footprint of transport to the destination just roughly, distinguishing between large categories (e.g., short, medium, long haul travel; or classifying trip origins merely by continent). In our case, we have sought to measure the climate footprint of travel from each country of origin. Such an approach, which considers at the same time the territory where the tourist activities take place (here Brussels) and the territories where the tourists come from is still quite rare in the research field of climate footprint of tourism (see Becken, 2002, for international passenger air travel to New Zealand; Dawson, Stewart Lemelin, & Scott, 2010, for polar bear viewing tourism in Churchill, Canada; El Hanandeh, 2013, for the pilgrimage to Mecca; Lenzen et al., 2018, for tourism-related global carbon flows between 160 countries; and Sharp et al., 2016, on Iceland). Finally, it is important to note that our bottom-up approach is only one possible option, prompted by our research question and the availability of data. By nature, this approach suffers from many limitations (Lenzen et al., 2018). In order to arrive at a more global picture of the climate footprint of international travel patterns, it might however make more sense to consider the resident as a statistical unit, rather than the visitor, as was argued by Larsson, Kamb, Nässén, and Åkerman (2018).

3. Method

Various bottom-up methods have been developed to assess the importance of the climate footprint of tourist trips to specific destinations, which usually and deliberately do not include outward trips made by residents of the city or region in question (e.g., Dwyer, Forsyth, Spurr, & Hoque, 2010; Peeters & Schouten, 2006; Rico et al., 2019). Other studies focus specifically on estimating the climate footprint of the residents of a certain area, such as Eijgelaar, Peeters, de Bruijn, and Dirven (2017) or Larsson et al. (2018). In what follows we will stick to the first of both approaches. The studies referred to above combine data on the number and origin of international overnight visitors (or 'tourists' according to definition of the World Tourism Organization (2010)) with modal split figures that vary according to their origin, trip lengths, and standardized emission rates per passenger kilometre. In this article, we will use the terms 'overnight visitor' and 'tourist' as synonyms. When making a distinction between overnight visitors or tourists who are on holiday or on business trip, we will use the concepts of 'leisure' versus 'business.' The time frame of our study is the year 2018 and the unit of analysis is one round trip of inbound travel of one international passenger.

3.1. Number and Origin of Overnight Visitors

With respect to the number and the origins of overnight visitors, the quality of available data sets considerably varies between countries and even between cities. Two key determinants are, first, the way in which the geographical basis of data collection is demarcated, and second, the tourist counting method that was applied. In the case of the Brussels-Capital Region, the statistical basis includes all officially registered tourist accommodation. This comprises around 180 hotel and hotel-like branches with a total capacity of 35,000 beds, 9 hostels offering around 1,400 beds, and around 100 other accommodations such as bed and breakfast and tourist residences additionally offering about 500 beds. However, this statistical basis covers only part of the actual offer of commercial accommodation. According to Wayens et al. (2020), covering the year 2017, nearly 34,000 beds available on the Airbnb and Home Away platforms would be off the radar. Not taking into account this vast set of unregistered accommodation, which is more or less equivalent to the capacity in registered branches, will lead to underestimating tourist arrivals by around 30%. Furthermore, it should be borne in mind that these figures are still exclusive of informal accommodation offered by friends and family members, a phenomenon which is probably important in Brussels, taking into account the high proportion of foreign residents, particularly those originating from wealthy states such as the European Union, North America, and Japan. According to a survey carried out in 2018–19 in the Brussels museums, one fifth of all international overnight visitors in Brussels

were staying with friends or family members (Decroly & Tihon, 2019).

Even though statistics of tourist accommodation in the Brussels-Capital Region are incomplete, they provide detailed data on international arrivals in officially registered accommodation. In these, for each guest or group of guests, staff members are required to collect information about the state of residence, the purpose of the stay, the day of departure, and the number of nights spent. The data is then transferred to Statistics Belgium, which procures detailed tables of the number of arrivals and overnight stays by purpose, for each country of residence. Residence is an important variable here, since it corresponds more frequently to the actual place of departure of the trip, compared to nationality (a variable that is more commonly collected than residence).

3.2. Travel Modal Split According to Country of Origin

Official statistics on tourist arrivals in Brussels do not contain information on the mode of transport used. Therefore, we complement these statistics with data from visitor surveys collected by the Art Cities Research project (Toerisme Vlaanderen, 2018). This survey was conducted between April 2017 and April 2018 among 1,400 people staying in Brussels for leisure purposes and includes travel mode choices by tourists from the nine most important sending countries that visited Brussels.

At first glance, a surprising share, larger than or equal to 60%, of incoming trips by leisure tourists from Russia, China, Japan, and the United States seems to be over land travel (car and coach statistics cover ferry trips from the UK; Figure 1). This result is indicative of the way in which many international tourist trips materialize. A majority of intercontinental overnight visitors take advantage of the opportunity to visit multiple destinations, e.g., using the format of the low-cost coach tours that are offered by many non-European tour operators

and have become popular, in particular among Chinese tourists (Arlt, 2013; Bui & Trupp, 2014; Xiang, 2013). Independent multi-destination tours are also common practice among Japanese, Korean, or Chinese tourists (Pendzialek, 2016). Although less well documented, this phenomenon is probably common as well among individual overnight visitors from other distant markets, such as the United States, Canada, or Australia.

But even if tourists from distant markets frequently visit Europe in the form of a tour, which mainly involves surface transport, the initial trip to Europe was mostly a flight. The Art Cities Research (Toerisme Vlaanderen, 2018) summary tables confirm that about 100% of these incoming trips consist of air travel. This illustrates how difficult it is to determine the footprint of travel, which becomes even more problematic in attempts to allocate corresponding climate footprints to territorial units (such as the Brussels-Capital Region). It is not obvious whether we need to take into account the mode of transport used to get to Brussels, the one used to reach Europe, or both at the same time. Ideally, both would be combined, by distributing the emissions linked to transport to Europe across the various destinations visited, and by calculating the specific emissions that are associated with intra-European travel to Brussels. However, given the lack of data on intra-European tours by leisure tourists from distant markets, we cannot implement such a strategy. Instead, in line with the Art Cities Research summary tables, we assumed that all incoming travel of leisure overnight visitors in the Brussels-Capital Region that originate from a remote location at 2,000 km or more were done by air.

In the current article, we use the Art Cities Research data to estimate the distribution of international arrivals in Brussels by travel mode, according to the overnight visitors' origins. Although the data relate only to a limited number of origins, only cover leisure trips, and do not resolve the complicated question of multi-destination

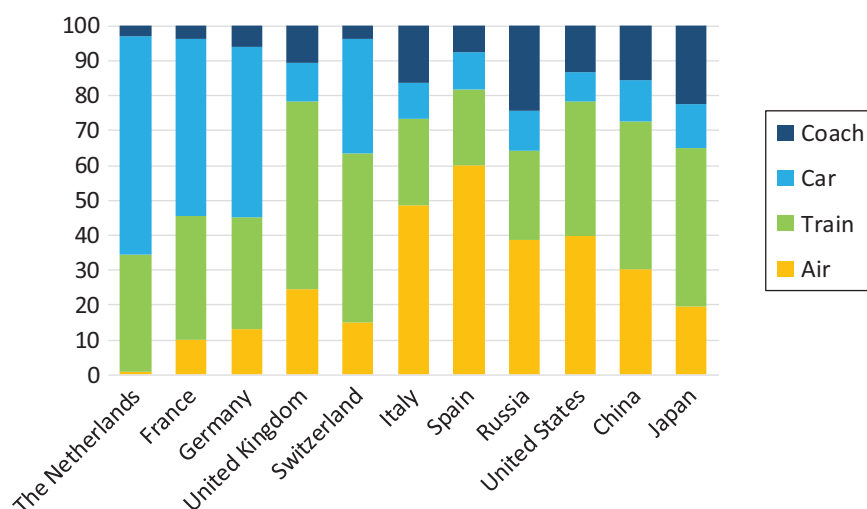


Figure 1. Modal split of tourist arrivals (leisure purpose only) in Brussels by origin country, according to the Art Cities Research survey (2017–2018). Source: Toerisme Vlaanderen (2018).

tours in which tourists from distant markets take part, they offer the advantage that they represent real trips instead of modelled ones, as was done by Gunter and Wöber (2019), among other studies.

However, Fiorello, Martino, Zani, Christidis, and Navajas-Cawood (2016) show that for equal trip lengths modal split differs, depending on travel purpose. Statistics on international arrivals in Brussels distinguish between leisure and business trips, which urges us to correct the modal split of business trips, a category of travel that is not included in the Art Cities Research survey. Therefore, we apply data from the annual outbound trip survey conducted in Norway (Statistics Norway, 2019), which provides a breakdown of international trips made by residents into travel purpose and travel mode. Mode choice of business travellers from Norway is not necessarily representative, partly because air travel is more common in Norway than in the rest of Europe and most of the world. That is why we only consider this data as indicative with respect to the use of cars and coaches. Results show that business overnight visitors do not use coaches, and that they have a much lower propensity to use cars and a higher propensity to use airplanes and trains compared to leisure tourists. On this basis, we assume that in the case of international business arrivals, the modal share of coaches would be systematically zero, that the share of car travel would be five times lower compared to leisure arrivals, and that the remaining trips would be shared between airplanes and trains in line with the distribution that was observed for leisure travel. In the case of Brussels-bound trips from France, for example, this leads to an increase in the share of plane travel from 10% to 20%, while train travel goes up from 35% to 70%, car travel is reduced from 50% to 10% and coach travel from 4% to 0%.

The modal split of arrivals from countries that were not included in the Art Cities Research survey was reconstructed as follows. In cases where the trip length was less than 1,500 km, we applied the modal split as observed in a country or (sub-national) region located at a comparable distance or in a similar spatial context. As an example, survey figures for Italy were equally applied to tourists from Croatia, figures for Piemonte to Austria, and for Ireland to Northern Ireland. For origins located at a distance between 1,500 and 2,000 km, we applied correction factors derived from a 2014 survey of tourists in the Netherlands which was carried out by NBTC Holland Marketing (2015). The NBTC survey is rare in its kind, since it collects modal split data with respect to countries or country sets of origin. Correction factors were applied for business trips up to 2,000 km. For longer trips, we opted for a maximalist solution, assuming that all trips were made by airplane.

Although one of the most accurate, feasible approximations, it is still important to realize that the outlined method attributes the entirety of emissions associated with travel to Europe to the Brussels-Capital Region as a single destination. It is important to keep in mind that

this choice causes an upward bias in the results, which could not be corrected for because of lack of data on multi-destination tours. This is one of the reasons why we want to underline the exploratory nature of our study, and urge the reader to put the results obtained from our calculations in perspective. Also, it is important to bear in mind that the outlined method was only applied to estimate the modal split of tourist arrivals in Brussels in 2018.

3.3. Estimating Distance between Origins and Destinations

Distance calculation between countries and the centre of Brussels was based on centroid locations that were weighted by the geographical distribution of population, as computed by the Center for International Earth Science Information Network of Columbia University. Nevertheless, the distances obtained are still imperfect approximations of actual distances travelled when arriving in Brussels. It not only treats all flights originating from a single country in the same manner, regardless of the (unknown) origin city or region (for example, no distinction is made between New York and Los Angeles in the United States), it is also based on the assumption that air travel is always choosing the shortest path (great-circle distance). Dobruszkes and Peeters (2019) show that the majority of commercial flights actually take longer routes, which on average adds 7.5% of distance. Therefore, we have corrected all 'shortest distances' between origins and destinations by means of the distance class-based coefficients as provided by Dobruszkes and Peeters (2019).

3.4. Climate Footprint per Passenger by Travel Mode

We distinguished between modes of transport with respect to emission rates per passenger kilometre travelled. We started from the figures provided by Peeters, Szimba, and Duijnisveld (2007), a well-cited source that nonetheless needed a slight update with respect to air and car travel data that date back to 2004. Indeed, both modes mentioned have faced fleet renewal which has led to lower emissions per passenger kilometre during operations. In the case of air transport, we have updated the rates ourselves, based on real air services at Brussels Airport (see Table 1 for more detailed explanation). Depending on the distance, the obtained rates are 15 to 30% lower than those calculated back in 2004. With respect to car transport, we used the results of a recent study in Denmark (Christensen, 2016), which shows that emissions per passenger kilometre were 25% lower in 2015 compared to 2004. Updating was not necessary, however, for emissions from trains and buses, as the current figures are very close to those measured in 2004 (see, e.g., Prussi & Lonza, 2018, for trains; and DEFRA, 2020, for coaches). For overland motor vehicles, only CO₂ emissions were calculated, given the limited

Table 1. Scope, indicators, and data sources.

Dimension	Indicators	Data sources
Number of international tourists	International tourist arrivals (for at least one night) in registered collective accommodation establishments Arrivals by purpose of the trip (leisure versus business) and country of residence of the guest	Statistics Belgium (2019)
Travel mode	Travel modal split according to country of origin	For leisure purposes: Art Cities Research (Tourisme Vlaanderen, 2018), a survey conducted between April 2017 and April 2018 among 1,400 people staying in Brussels for the purpose of leisure. For business purposes: adaptation of Art Cities Research results taking into account the annual Travel Survey conducted by Statistics Norway (2019; trips by mode of transport, type of trip and contents).
Distance between origin and destination	Distance between the centre of Brussels and centroid of each country of origin weighted by the spatial distribution of the population	Own calculations based on gridded population datasets (Popgrid Data Collaborative, 2019) provided by the Center for International Earth Science Information Network (2019). For air travel, distance between origin and destination was multiplied by a coefficient to take into account the existence of detours (i.e., longer itineraries than the great-circle distance). We used the coefficients computed by Dobruszkes and Peeters (2019): 1.143 for distance less than 1000 km, 1.073 for 1000–4000 km, and 1.048 for more than 4000 km.
Climate footprint	Climate footprint per passenger kilometre, class of distance, and travel mode	For airplanes: own calculations based on CO ₂ emissions for all the flights to/from Brussels airport in 2018. The data on the provision of regular air services in Brussels Airport have been extracted from the 2018 OAG Schedules Analyser (OAG, 2018). For each flight, CO ₂ emissions were calculated by using Eurocontrol Small Emitters Tools (Eurocontrol, 2019). Based on the World airline rankings 2018 (Flightglobal, 2019), a seat occupancy rate of 80% has been used to estimate the number of passengers for each flight. The calculated emission factors by classes of distance (expressed in kg CO ₂ pkm) are: 0.144 for distances less than 500 km, 0.108 for 500–1000 km, 0.090 for 1000–1500 km, 0.084 for 1500–2000 km, and 0.093 for more than 2000 km. In a second stage, according to the literature (DEFRA, 2020), the emission factors were multiplied by 1.9 to convert CO ₂ emissions into CO ₂ eq ('climate footprint').

contribution of other emissions to the climate footprint. Given the importance of the radiative forcing (RF) effect, however, it would be unacceptable to maintain this simplification with regard to aviation. So, in order to estimate the total climate footprint of air travel, effects caused by non-CO₂ forcing agents (nitrogen oxides [NO_x], water vapour, soot and sulfate aerosols, contrail cirrus) were accounted for by applying a multiplier of 1.9 to the amount of CO₂ emissions, a conversion factor that was derived from Lee et al. (2010) and is recommended by DEFRA (2020). This conversion factor is defined as the ratio between total CO₂-warming-equivalent emissions from all forcing agents and those from CO₂ alone,

with a 100-year time horizon (Global Warming Potential or GWP100). In a recent paper, Lee et al. (2020) have updated their estimates, based on new models of the RF effect of contrail cirrus. When using the same metric (GWP100), the conversion factor obtained is slightly lower (1.7 as opposed to 1.9). However, when using another metric that is assumed to better reflect warming potential under the current growth conditions of air travel, the conversion factor rose to 3.0. On this basis, it is concluded "that aviation emissions are currently warming the climate around three times faster than that associated with aviation CO₂ emissions alone" (Lee et al., 2020, p. 8). Therefore, the climate footprint of aviation

as an outcome of our analysis likely underestimates the impact of non-CO₂ agents. However, given the persistent uncertainties about these impacts, it seems more cautious to use a conversion factor that has been recommended for several years, than one that was only recently published. Besides, taking RF into account is the reason behind the deliberate use of the term ‘climate footprint’ in this article instead of the more common ‘carbon footprint.’ Table 1 provides more detail about the sources used and the calculation methods employed.

In order to estimate the entirety of CO₂ emissions linked to international tourist arrivals, we have performed the calculation for each of the 247 countries from which overnight visitors arrive in Brussels. First, the number of arrivals was disaggregated by purpose and by travel mode, and for air travel additionally by distance class. Then, results obtained per travel purpose and mode were added up and multiplied by two in order to account for both the inward and the outward trip, as we want to allocate emissions of the entire journey to Brussels.

4. Results

4.1. Amount and Geography of International Arrivals

In 2018, the Brussels-Capital Region registered around 2.9 million international arrivals in registered tourist accommodation. As such, Brussels represents an important, although not a major, urban destination in Europe. Its attractiveness remains modest not only compared to Paris (13.2 million international arrivals) and London (13.0 million), the two main poles of urban leisure and business travel in Europe, but also compared to cities

that are well-established as destinations for tourists from distant markets, both as city-trip destination and as part of intra-European tours, be it individually visited or as part of a group (Rome, 9.6 million arrivals; Barcelona, 7.4 million; Amsterdam, 6.9 million; Prague, 6.7 million; Vienna, 6.3 million; Madrid, 5.2 million; Berlin, 4.9 million; Lisbon, 4.3 million; Venice, 4.3 million; Budapest, 3.8 million). Even Munich and Copenhagen, which are less well-known as international tourist attractions, welcome more international overnight visitors than Brussels. The situation does not change if we account for the size of the city. Indeed, also the number of international arrivals per inhabitant is lower in Brussels than in all cities listed above, except for Budapest.

As shown in Figure 2 and Table 2, the vast majority of international tourists staying in Brussels arrive from a limited number of states: 70% of arrivals originate from just 12 origins. European states (70.5% of arrivals), especially neighbouring countries (41%), are the main source of overnight visitors, whether for leisure or business purposes. Among the most distant origins, the United States (217,000 arrivals, 7.7% of the total), China (88,000, 3.1%) and to a lesser extent Japan (48,000, 1.7%), Brazil (41,000, 1.4%), and Russia (38,000, 1.3%) stand out clearly. The map also highlights the significant volume of arrivals from Canada (32,000), India (27,000), and Australia (25,000).

Given the important presence of international political bodies and the rather limited attractiveness of Brussels as a leisure destination, for decades the number of arrivals with a leisure purpose has been significantly lower than the number of business trips. Since the early 2000s, the ratio between both kinds of travel

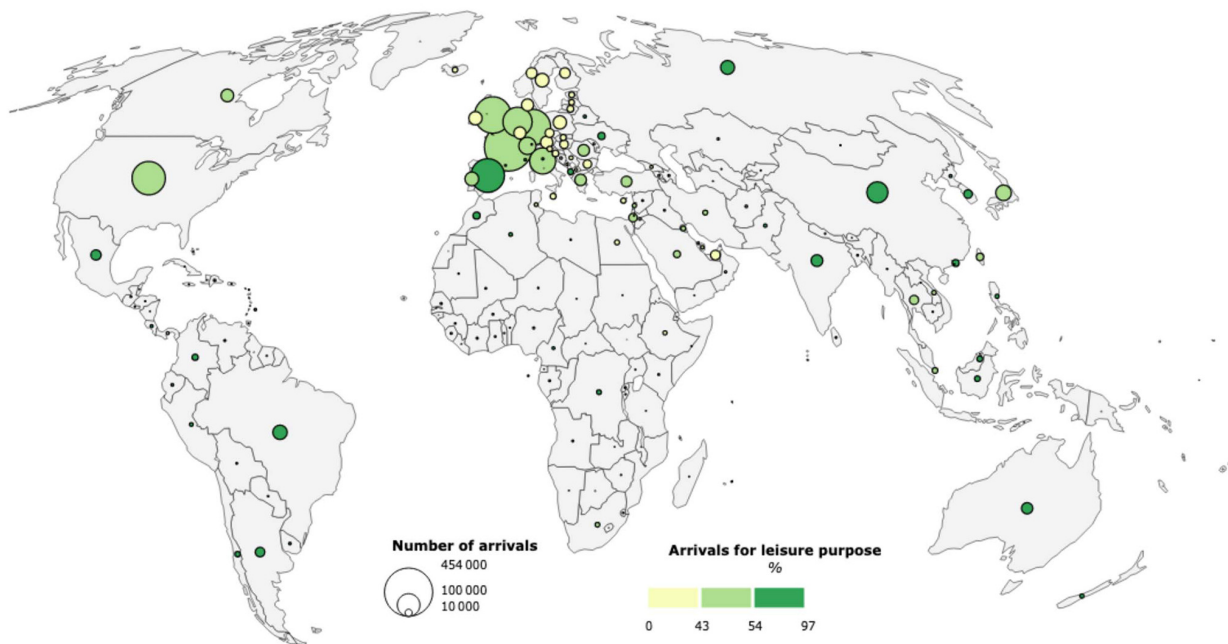


Figure 2. Number of international arrivals in the Brussels-Capital Region by country of residence and by purpose (2018). Source: Statistics Belgium (2019).

Table 2. International tourist arrivals and associated climate footprint in the Brussels-Capital Region (in 2018) by distance class.

Distance class (km)	International tourist arrivals			Climate footprints						
	number (× 1,000)	%	per 100,000 inh.	For all travel modes		By travel mode (% of total GHG emission)				
				Total (kton CO ₂ eq)	By tourist arrival (kg CO ₂ eq)	Airplane	Train	Car	Coach	Total
< 1,000	1,330	47.3	486	108	81	2.4	0.6	0.9	0.0	4.0
1,000—1,999	639	22.7	179	242	378	8.1	0.3	0.5	0.1	8.9
2,000—2,999	71	2.5	52	61	868	2.3				2.3
3,000—3,999	67	2.4	20	85	1,265	3.1				3.1
4,000—4,999	32	1.1	5	54	1,677	2.0				2.0
5,000—5,999	30	1.1	6	59	1,975	2.2				.2
6,000—6,999	40	1.4	12	95	2,372	3.5				3.5
7,000—7,999	251	8.9	13	680	2,707	25.2				25.2
8,000—8,999	155	5.5	8	503	3,246	18.6				18.6
9,000—9,999	119	4.2	21	419	3,523	15.5				15.5
> 10,000	81	2.9	14	396	4,911	14.7				14.7
Total	2,814	100.0	37	2,701	960	97.6	0.9	1.4	0.1	100.0

Sources: Christensen (2016); Peeters et al. (2007); Statistics Belgium (2019); Toerisme Vlaanderen (2018); World Development Indicators database (World Bank, 2019); and own calculations based on Eurocontrol Small Emitters Tool (Eurocontrol, 2019) and OAG (2018) data.

has gradually become more balanced. Currently, overall shares are more or less equal, although the relative importance between both purposes still depends on the origin (Figure 2). Looking at origin countries, business overnight visitors are generally overrepresented in Europe (except for Spain), the United States, the Arab-Persian Gulf countries, and Southeast Asia including Japan, while the reverse is true for arrivals from Latin America, Russia, India, China, Australia, and New Zealand.

In line with related research (e.g., Le & Nguyen, 2021; Wu, Liao, & Liu, 2019), we hypothesize that the geography of the origin of the flows of international tourists staying in Brussels results from the combined effects of distance, the economic and population-based potential for sending travellers in the origin countries, and local preferences in terms of destination choice behaviour. In an attempt to disentangle the influence of these different factors, we have broken down international arrivals by distance class (Table 2). The results show that the volume of flows decreases rapidly with distance: Nearly half of the arrivals come from within a radius below 1,000 km from Brussels, a fifth from a radius between 1,000 and 2,000 km, while barely 2.5% originates from countries located at a distance between 2,000 and 3,000 km. Beyond 2,000 km, the relationship between distance and number of trips is altered by variations in population size and per capita income between distance classes. The two distance classes between 7,000 and 9,000 km each produce more international overnight visitors to Brussels than those between 2,000 and 7,000 km, because they respectively include India and the United States (7,000 to 8,000 km) and China and Brazil (8,000 to 9,000 km). The expected negative relationship between distance and number of arrivals is only partly compensated for by

the larger population in more remote distance classes, as shown by the number of arrivals in Brussels per 100,000 inhabitants in the origin classes (Table 2). Indeed, if the relative volume of flows to Brussels decreases steadily up to 5,000 km, it increases between 5,000 and 8,000 km, then again between 9,000 and 10,000 km. These variations result in part from differences in per capita income on number of tourists sent. It is clear that those intermediate distance classes, which represent lower numbers of arrivals per 100,000 inhabitants, are generally characterized by a fairly modest per capita GDP (see for example the classes of 4,000 to 6,000 km).

4.2. Volume and Geography of Climate Footprints

According to our calculations, international tourist arrivals in the Brussels-Capital Region generated a total of 1,452 kilotonnes of CO₂ (or 1.45 Mton CO₂) in 2018, taking into account both inward and outward trips. After applying the 1.9 multiplier to air trips, the climate footprint of all international travel to Brussels that is included in our analysis, in 2018, amounts to around 2,701 kilotonnes of CO₂ equivalent (i.e., 2.70 Mton CO₂eq), which equals about 73% of the entire climate footprint (all activities combined, including the residential sector and internal transport, but obviously excluding international travel) that were officially reported by the Brussels-Capital Region in 2018.

Examination of the distribution of the tourism-induced climate footprint reveals a geography that is radically different from the geography of tourist arrivals. In fact, while the number of flows sharply decreases with distance, the amount of emissions increases with distance (Table 3). Thus, while visitor flows from Europe

Table 3. Geographic origin of international tourist arrivals in the Brussels-Capital Region and climate footprint of these arrivals (2018).

Origin (country of residence)	Distribution by purpose and region of origin of international tourist arrivals in Brussels- Capital Region (in 2018) (%)			Distribution by origin of the climate footprint of international travel towards Brussels-Capital Region (in 2018) (% of total climate footprint)				
	Leisure	Business	Total	All journeys				
				Airplane	Train	Car	Coach	Total
Neighbouring countries (Europe)	20.1	20.9	41.0	2.1	0.4	0.9	0.0	3.4
Southern Europe	7.5	6.3	13.9	5.1	0.2	0.3	0.0	5.6
Central Europe	2.0	2.7	4.7	0.6	0.1	0.1	0.0	0.8
Northern Europe	1.9	3.4	5.3	1.9	0.0	0.2	0.0	2.2
Eastern Europe	2.3	3.3	5.6	3.2	0.0	0.2	0.0	3.3
Russian realm and Central Asia	1.1	0.9	2.1	2.5				2.5
Indian realm	0.6	0.5	1.1	3.0				3.0
China	2.1	1.4	3.5	11.5				11.5
East Asia and Oceania	2.1	1.5	3.6	15.7				15.7
Southeast Asia	0.8	0.8	1.6	6.0				6.0
Arab-Muslim realm	1.8	2.0	3.8	5.1				5.1
Sub-Saharan Africa	0.5	0.6	1.1	2.6				2.6
North America	4.0	4.8	8.8	24.1				24.1
Latin America and the Caribbean	2.7	1.2	3.9	14.2				14.2
Europe	33.9	36.6	70.5	12.8	0.8	1.6	0.1	15.3
Rest of the world	15.8	13.7	29.5	84.7	0.0	0.0	0.0	84.7
Grand total	49.7	50.3	100.0	97.5	0.8	1.6	0.1	100.0

Sources: Peeters et al. (2007); Statistics Belgium (2019); Toerisme Vlaanderen (2018); and own calculations.

account for 70.5% of arrivals, they generate barely 15% of emissions, while flows from outside Europe, which represent less than 30% of tourists, generate nearly 85% of the climate footprint.

This striking result can be explained by the specific relation between air transport and climate footprint, which is brought forward by Figure 3, a map that links emissions by origin country to journeys to Brussels. The very significant climate footprint of flows from the United States (21% of footprint for 7.6% of flows) and China (10% versus 3%) stand out, but so do Japan (6% versus 1.7%) and Australia (5.5% versus 0.9%). Also, one European state is present among the top ten countries in terms of emissions—Spain—which is the only origin country that combines a very large number of tourists to Brussels with an important share of air travel.

5. Conclusions

Territorializing the international share of Brussels's climate footprint is not an easy task. In the above analysis, numerous methodological choices had to be made, and furthermore, the scarce availability of data imposes important limitations. In our calculation, we chose to only include the climate footprint of tourists with Brussels as a destination, assuming that the climate footprint of journeys undertaken by Brussels's residents

needs to be allocated to the destination territory. Then, we were unable to cover international overnight visitors who stayed in unregistered accommodation, which means that our analysis significantly underestimates the total number of tourists to Brussels. Furthermore, we were not able to redistribute the climate footprint of tourists arriving in Brussels among the often multiple destinations they visit within Europe, which implies that we overestimated the climate footprint of long-distance overnight visitors. We are also aware that the climate footprint resulting from our calculations covers only one, albeit an important, aspect of Brussels's international position. Embedded emissions in imported products were not included, nor was the share of the Brussels economy in the climate footprint of international sea shipping. A last caution that needs to be mentioned is the significant degree of uncertainty associated with the multiplier (defined as 1.9) that was applied to convert air transport related CO₂ emissions into overall climate footprint. Therefore, an important initial conclusion of our study is that resources should be made available to collect better data. An extensive sample of detailed questionnaires about travel itineraries could be obtained from arriving tourists, especially at airports, but also in a variety of other venues, which would lead to more accurate insights. Such information could be supplemented with big data, in particular from mobile telephony that

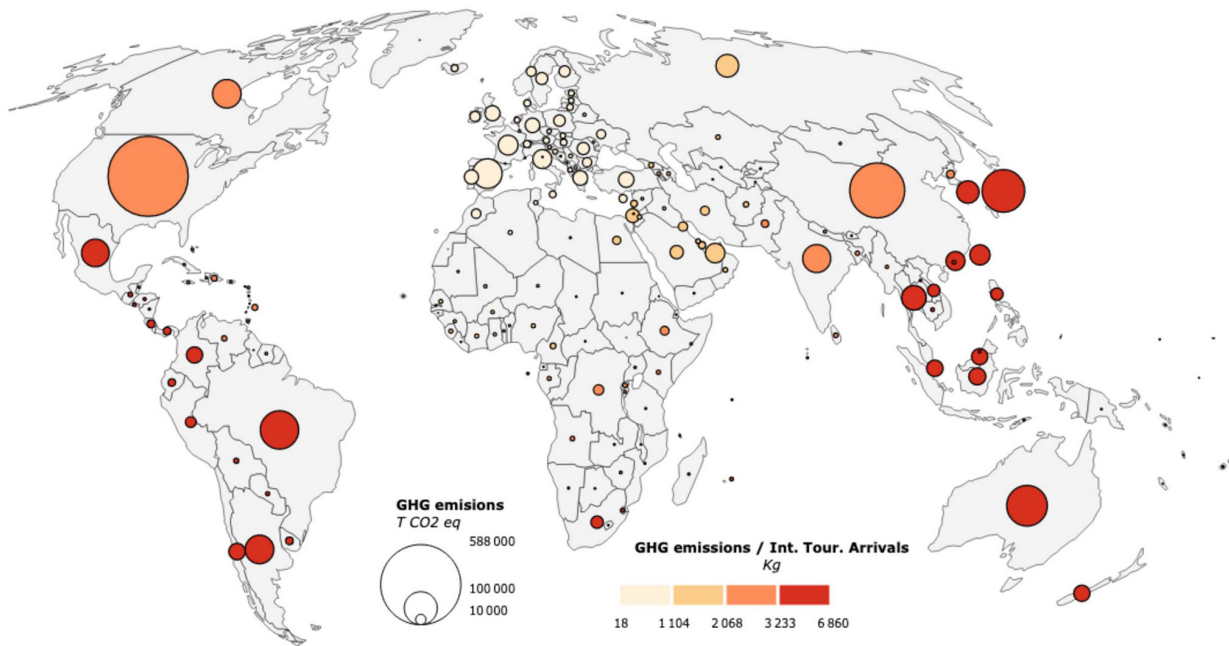


Figure 3. Climate footprint of international travel towards Brussels-Capital Region (in 2018) by country of origin: Absolute amount and amount per international tourist arrival. Sources: Christensen (2016); Peeters et al. (2007); Statistics Belgium (2019); Toerisme Vlaanderen (2018); and own calculations based on Eurocontrol Small Emitters Tool (Eurocontrol, 2019) and OAG (2018) data.

allows to reconstruct travel (see, e.g., Ahas, Aasa, Mark, Pae, & Kull, 2007; Saluveer et al., 2020).

Despite all reservations that need to be taken into account, and the exploratory nature of our calculations, we can still report a number of interesting findings on the geography and magnitude of the climate footprint of international travel to Brussels. In terms of geographical distribution, over 70% of international travellers to Brussels come from Europe, while these represent only 15% of the climate footprint of all international travel to Brussels. It is clear that distance matters. The climate footprint of a journey from a non-European country is not only greater in absolute terms, due to the larger distance, but also in relative terms (expressed in CO₂eq/km) due to the more favourable modal split for intra-European journeys. Besides, we note that Brussels is very conveniently located within Europe, centrally between the two main European travel destinations—London and Paris—and with a convenient high-speed train connection to all surrounding major cities. In terms of magnitude, the calculated climate footprint of international journeys with Brussels as a destination equalled 2.7 Mton CO₂eq in the year 2018, which is equivalent to about three quarters of the official total amount of emissions of the Brussels-Capital Region as recorded by the Belgian national climate inventory (3.7 Mton CO₂eq in 2017). Moreover, emissions from international journeys are increasing at a rapid pace, with an average growth of more than 4% per year over the past 18 years (up to 2019, before the Covid-19 crisis). If the current growth rate would persist, by 2036 the climate footprint of international travel to

Brussels will be more than twice as high as the official climate footprint of Brussels, a ratio that will be even higher in case the emission reduction targets in the other sectors will be achieved. The problematic nature of this finding is to be nuanced only to a limited extent by the observation that the climate footprint of international journeys to Brussels is smaller, both counted per trip and in total, than that of comparable cities such as Munich, Budapest, or Zurich (Gunter & Wöber, 2019).

The typical position of Brussels as a centre of political decision-making urges to reflect on the finding that some locations may be better positioned than others to host such functions. Our analysis shows that Brussels is in fact doing remarkably well, since the climate footprint of intra-European travel to Brussels is rather low, while the overall climate footprint of inbound long-distance travel is considerably lower in comparison to other cities with a strong international position. Although Brussels's central location helps keeping modest the climate footprint of its incoming business travel, we should not forget that the favourable score of Brussels compared to cities such as Barcelona, Prague, or Amsterdam is largely due to the relatively limited touristic appeal of Brussels compared to the cities mentioned.

From a wider perspective, we can conclude that in a rapidly globalizing and at the same time warming world, it is no longer tenable to omit territorializing the climate footprint of international transport, while this is well-established practice for emissions caused by industrial activities, agriculture, buildings, and domestic transport. Not including these emissions in climate inventories

leads to major biases in the climate debate itself. While climate movements argue for the adaptation of Global Northern consumption patterns and production processes, a less visible threat seems to be situated in the increasingly globalized and networked nature of society. Dependence on long-distance travel not only makes the economy more carbon intensive, but also education, research, culture, and leisure activities, and even family visits rely ever more on the consumption of tremendous amounts of kerosene. Long-distance travel patterns seem to be increasingly anchored in society, and ever less reversible. And even as for medium-distance journeys in Europe, less carbon-intensive alternatives such as trains and coaches are available, an absolute reduction in the number of aircraft kilometres travelled is a particularly unattractive idea for many citizens, businesses, and organizations, for which broad societal support is virtually non-existent. Nevertheless, it is clear that a carbon neutral future is one where jet aircraft will no longer play a substantial role.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Flying Less for Work and Leisure? Co-Designing a City-Wide Change Initiative in Geneva

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Abstract

Geneva prides itself on being an international city, home to the United Nations and international organizations. The airport plays an important role in this image, tied to a quest for hypermobility in an increasingly globalized society. Yet, mobility accounts for close to one quarter of the territory's carbon emissions, with flights responsible for 70% of these emissions. With recent legislation that includes ambitious targets for net zero carbon emissions by 2050, the role of air travel can no longer be ignored. In 2020, a partnership was formed between the City, the University of Geneva, and a community energy association to explore the possibility of co-designing a city-wide change initiative, focused on reducing flights through voluntary measures. The team consulted with a variety of actors, from citizens who fly for leisure, to those who fly for professional reasons, with a spotlight on academic travel. A review of the scientific and grey literature revealed what initiatives already exist, leading to a typology of change initiatives. Inspired by this process, we then co-designed a series of workshops on opportunities for flying less in Geneva. We demonstrate the value of going beyond an 'individual behaviour change' approach towards understanding change as embedded in socio-material arrangements, as well as identifying interventions that seek to address both negative and positive anticipated outcomes. We conclude with insights on how a social practice approach to understanding mobility reveals both material and immaterial challenges and opportunities, involving infrastructures and technologies, but also social norms and shared meanings.

Keywords

co-design; flying less; Geneva; participative methods; social practices; Switzerland

Issue

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1. Introduction

Air travel is increasingly recognized as having a significant environmental impact, in terms of carbon emissions and equivalents (Ritchie, 2020) while being a form of transport that is unevenly distributed—only 2 to 3% of the world's population flies each year (Nevins, 2014; Peeters, Gössling, & Becken, 2006). Among those that travel, urbanities show a higher disposition to be frequent flyers (Czepkiewicz, Árnadóttir, & Heinonen, 2019).

In Geneva, mobility is responsible for 23% of all carbon emissions and equivalents in 2015, with air travel counting for 70% of emissions in the mobility sector (State of Geneva, 2015). Prior to the outbreak of the Covid-19 pandemic, the Federal Office of Civil Aviation (OFAC) and Geneva Airport predicted a significant increase in numbers of passengers and flights by 2030 (OFAC, 2018). Indeed, there were almost 2,5 times more passengers departing from Geneva in 2019 than in 2000 (Federal Statistical Office [OFS], 2020). Switzerland also exhibits

more air travel per capita than neighbouring countries, such as France or Germany (OFAC, 2018).

As home to the United Nations, Geneva prides itself on being an 'international city' and the airport contributes to this image, as a symbol of hypermobility in an increasingly globalized society (Harvey, 1990). At the same time, in light of the climate crisis and the mobilization of citizens around climate strikes, there is growing political will to reduce carbon emissions. In Switzerland as is the case elsewhere, a variety of campaigns have been launched—by policy-makers, institutions and associations, and individual citizens—to identify opportunities to reduce air travel, both for leisure and professional reasons. In this context and in the Summer of 2019, prior to the outbreak of the Covid-19 pandemic, the City of Geneva—Agenda 21—Sustainable city unit contacted the University of Geneva's Institute of sociological research to reflect on how the city could support a voluntary initiative to 'fly less' in 2021. The project was co-designed between a core team of people at the City, the University, and Terragir, a community association with expertise in energy transitions. The project reflects the role that municipalities and other actors can play at the urban level, to reduce the aviation emissions of city residents.

While the overall project aims to develop a better understanding of what might support or hinder a social change initiative towards flying less, we focus here on the collaborative, co-design process, as well as the theoretical framework which informs our understanding of complex problems. The article is structured as follows: first, we introduce the problem of air travel and the conceptual framework, or designing social change initiatives through social practice theory. Second, we present a review of 37 initiatives world-wide that aim towards reducing flights, for leisure or professional purposes, towards a typology of change initiatives. Third, we discuss the results of three multi-actor workshops on reducing flights, whereby impacts were identified in relation to different 'elements' of practice. We stop short of detailing the approach chosen by the City, as this process is still ongoing, but provide some indication of the preferred way forward. We conclude with a discussion on both the process and outcomes of this co-design effort.

2. Literature Review, Conceptual Framework, and Methods

2.1. *Why Flying Less Is a Complex Aim*

More affluent consumers are responsible for higher environmental impacts, not least due to forms of mobility based on fossil fuels, including air travel. The top 10% of the global population, also known as the 'consumption elite,' consume 55% of the energy resources allocated to mobility (Oswald, Owen, & Steinberger, 2020). In Switzerland, people fly an average of 0,83 times a year, with a large difference between people with low

incomes (0,3 times a year), high incomes (once per year) and very high incomes (1,7 times a year; OFS, 2017). The airplane represents an unequalled form of travel for some, in its ability to cover great distances in minimal time, and as a symbol of technical prowess, which adds to its symbolic qualities—as discussed by Harvey (1990) in relation to hypermobility and increased connectivity of people across spaces. While flying remains a luxury for many around the world today, a discourse analysis in Swedish magazines and media demonstrates how air travel evolved from a consumer good of desire or a dream to a generalized and normalized practice in the 1980s (Ullström, Nicholas, & Stripple, 2020)—a more affluent country, similar to Switzerland. Analyses of aviation carbon emissions confirm the trend: "The cumulative emissions of global aviation (1940–2018) are 32.6 billion (10^9) tonnes of CO₂, of which approximately 50% were emitted in the last 20 years" (Lee et al., 2020, p. 4). In Sweden, 2017 is seen as a turning point, when the discourses on air travel and travel seem to converge towards a certain moralization around flights and appreciation of a slower lifestyle and reduced carbon footprints (Ullström et al., 2020)—a similar trend has not yet been documented in the Swiss case.

Mobility is not only a question of movement, but also something useful, such as a capacity for action in a geographical and social space, what sociologist Vincent Kaufmann has termed 'motility' (Kaufmann, 2003). This capacity for action is particularly significant in the city of Geneva, which positions itself as an 'international' city and sees the airport as aligned with other symbols of this status, such as the United Nations headquarters. Global cities have developed in conjunction with the development of the aviation sector, which allows hyperconnectivity, creating a network on which these cities depend to remain competitive on a global scale. Certain urban planning models articulate the city around the airport, referred to as aerotropolises (Chohan, 2019). This capacity to move by airplane relates to a growing leisure industry; thus, travel facilitates consumption, understood as the appropriation and appreciation of spaces and experiences (Warde, 2017). In a consumer society, messages conveyed by the media but also through social networks seem to glorify flight travel—leading to a 'tourist's gaze' captured through shared photos, postcards, or other souvenirs (Urry & Larsen, 2011), the cumulation of which is facilitated through air travel. People living in urban areas are embedded in global social networks; they also fly more because they generally have higher incomes, are mostly single and non-parents, have language skills related to their increased mobility, and seek to escape the city either to compensate for the lack of nature or for acquiring new cultural experiences (Czepkiewicz et al., 2019). Flying as a form of 'motility' is thus powered by high aspirations around air travel and an imagined network of 'global citizens' who pursue professional and leisure ambitions through the (over)consumption of spaces, making the reductions of flights a challenge.

To add to this complexity, the travel market can be divided into two segments: travel for work, or travel for leisure. In the world of work, travel is often synonymous with success, towards maintaining networks and supply chain relations, for example. In 2018, 63% of all flights from Switzerland were for leisure purposes, up 10% from 2017. This was followed by flights for visiting close friends or relatives (25%). Professional trips represented only 6% of all flights, half of which were for flights within Switzerland (OFS, 2019). As these figures only represent trips with overnight stays, the portion of day trips for professional reasons is under-estimated. In academia and in a globalized knowledge economy, flying is one way of maintaining international networks. Studies on the Swiss case are lacking, but for Sweden, Burian (2018) notes that one in two Swedish academics believe that carrying out research would be impossible without flying, thus hindering their careers. From an organizational perspective, possibilities for change within universities is significant, when such entities have a clear independence from the market—moving beyond voluntary travel policies, towards changing academic standards, and supporting adequate alternatives (Burian, 2018). *Travel for professional reasons* (in the public or private sector, including academic travel, or for non-governmental organizations) is thus built around a model of success that can be questioned, in relation to climate change as well as health and wellbeing (Cohen, Hanna, & Gössling, 2017; Espino, Sundstrom, Frick, Jacobs, & Peters, 2002; Ivancevich, Konopaske, & DeFrank, 2003). Regarding *leisure travel*, the environmental impact of flying and the un-sustainable nature of some forms of tourism are garnering attention in research and general press. Links between travel and wellbeing or self-development are equally emphasized (Hall, Gössling, & Scott, 2015). While ‘sustainable tourism’ is a growing field of research and practice, the negative impacts of tourism on the climate do not seem to be decreasing (Peeters, 2016; Scott, Gössling, & Hall, 2012), no doubt bolstered by low-cost air travel.

Büchs (2017) offers us a typology of people more or less inclined to reduce holiday flights, suggesting that values and norms are important when considering opportunities for change. For Randles and Mander (2009), understanding the moral dimension of flying or not flying is critical. And yet, Alcock et al. (2017) suggest that individuals who are more environmentally conscious tend to fly more kilometres per year than those who are not (no doubt due to the links between higher revenue, higher education, and travel, discussed above). This suggests an attitude-behaviour gap, revealing how people attempt to reconcile the actions they value, such as flying, with pro-environmental attitudes (Kroesen, 2013). Facing this complexity, it could be more effective to focus on changes in the aviation industry (such as financial or regulatory burdens), rather than inciting individuals to fly less, thus de-emphasizing the importance of consumer lifestyle choices (Kantenbacher,

Hanna, Cohen, & Miller, 2018; Peeters, 2016). For Cohen, Higham, Gössling, Peeters, and Eijgelaar (2016), existing socio technical arrangements and infrastructure is what hinders attempts to reduce flying. In the same line, Larsson, Elofsson, Sterner, and Akerman (2019) outline existing (inter)national government-based policies and their effectiveness in relation to national measures, demonstrating the need to understand flying concomitantly at a global and local scale.

Flight travel for both professional reasons and leisure decreased dramatically during (semi-)confinement measures experienced around the world due to the outbreak of the Covid-19 pandemic. In terms of total energy, changes in demand were largest in the aviation sector, with a decrease in daily activity of –75% (–60 to –90%) during confinement, although the sector contributed to only 10% of the decrease in global CO₂ emissions (Le Quéré et al., 2020). Understanding how air travel can be reduced, once restrictions on mobility will be lifted, remains a pressing issue.

2.2. *Embedding Air Travel in Social Practices*

In sustainable consumption studies, there is a long-standing critique of the limits of individual approaches to change—whereby small actions, such as riding a bicycle and recycling, might render invisible the need for more structural and political change (Maniates, 2001) or where change is solely understood through green consumer scapegoatism (Akenji, 2014) rather than collective and transformative action (Balsiger, Lorenzini, & Sahakian, 2019). Another approach that is critiqued in the literature is the idea that technologies will provide a silver bullet solution to un-sustainable practices (Cohen & Murphy, 2001; Sahakian, 2019). Building on these insights, a review of over 1,000 initiatives focused on changing household energy usage in Europe revealed that a great majority (74%) relied on either changing individual people’s behaviour, or changing technologies (Jensen, Goggins, Røpke, & Fahy, 2019). The authors stress the question of problem framing, which directly informs the types of solutions that are then proposed, contrasting changes in individual behaviour to more complex changes in everyday life.

A rapidly-growing body of literature in the social sciences has emerged in recent years, suggesting that social practices—rather than individual people or units of technology—should be the locus for change, as more representative of complexity. Building on earlier theoretical reflections by Bourdieu and Giddens, social practices focus on the doings and sayings of everyday life as a way to overcome the structure-agency dichotomy in social sciences (Schatzki, 1996). In such an approach, the focus is moved away from “cognitive and rationalist theories of action to embrace a theory of agency in which past experiences and the things with which the individual interacts are regarded as important to current and future actions” (Wilhite, 2016, p. 24). While there

are different interpretations of what makes up a practice, approaches share an interest in practices—such as preparing a meal or planning a trip—as made up of different elements. Building on Shove and Pantzar (2005), these ‘elements’ involve interactions between skills and competencies, material arrangements and things (including technologies), and social norms and other meanings. Planning a trip involves all of these elements, which play out differently depending where and when the practice is performed.

While social practice theory has been used to understand how practices change over time (Sahakian & Wilhite, 2014; Shove & Pantzar, 2005), a growing body of work seeks to understand how social practices might inform policy and social change in the future (Devaney & Davies, 2017; Jack, 2013; Sahakian & Bertho, 2018; Spurling, McMeekin, Shove, Southerton, & Welch, 2013; Strengers, Pink, & Nicholls, 2019). A parallel body of work is concerned with the process, or how the design of change initiatives might be informed by social practice theory (Hoolohan & Browne, 2020; Kuijjer & Bakker, 2015; Sahakian et al., 2021; Scott, Bakker, & Quist, 2012; Vihalemm, Keller, & Kiisel, 2015), in stark contrast to approaches which center on behavioral and individual change. Common to some approaches is a stage where people come together to reflect on social practices, by mapping the network of social and material elements that make up a practice (Vihalemm et al., 2015) and identifying ‘change points,’ towards more sustainable practices (Hoolohan & Browne, 2020). These developments informed our research design in two ways. As an understanding of social change, we used social practice theory to guide our analysis of different initiatives that aim to reduce flying. In addition, practice theory informed the design of three focus groups with different sets of actors.

2.3. Our Approach and Methods

The research project is divided into two phases: In a first phase, we engaged in an exploratory review of mostly European initiatives that seek to reduce flying. First, we provided an overview of 37 initiatives (see Annex 1 in the Supplementary File), with information gathered from secondary sources and, when necessary, through email and video-call correspondence. This review led to a typology of initiatives, discussed below. Through discussions with the team (city representative, community energy association, and sociology research group at the university), we selected five initiatives to be further developed as case studies; this selection was made based on the diversity of audiences the initiative was addressed to (from individuals, to companies, to universities), the variety of travel purposes (leisure, professional, and academic), and the illustration of the different typologies of change initiatives. The case studies were developed through interviews with initiators.

In a second phase, and inspired by this exploratory work, we designed a series of World Café focus groups,

where a selection of three initiatives were discussed and debated in groups, using a Futures Wheel methodology. The objective of the workshops was to ascertain the strengths and weaknesses of a proposed initiative, focused on two of the typologies identified in the first phase: 1) changes in systems, institutions, or infrastructures or 2) the promotion of alternatives, both understood as embedded in complex socio-material arrangements and thus related to everyday practices. We explicitly avoided any examples that focus on change solely through individual choice. Originating in the 1970s, Futures Wheel was recently used in the Swiss context and in a project interested in the implications of policy change initiatives towards energy transitions (Defila, Di Giulio, & Schweizer, 2018). Actors come together to reflect on the first, second, and third level impacts of a proposed change initiative. In this process, the moderators at each table were able to bring in different ‘elements of practices’ in asking participants, for example, to reflect on how such a change initiative might relate to existing rules and regulations, social norms and expectations, investments in infrastructure, or people’s skills and competencies.

Workshop participants were recruited through various means. In order to attract people of diverse backgrounds, we issued a call for participation through social networks, but also in cafés and schools in different neighbourhoods, and at train stations. We attracted students, researchers, and university administrative staff for the academic workshop, as well as airport ground staff, retirees, members of associations, employees in private companies, and public administrators, among others, for the other workshops. People were invited to complete a short questionnaire when signing up, generating some data on participant profiles. We achieved a gender balance and a good representation of different age groups, with people mostly between the ages of 31 and 50 years old (Figure 1).

Two workshops were hosted in a café in downtown Geneva, which offered break out rooms; due to confinement measures, the last workshop was hosted online. The three groups reflect the differences between travel for leisure ($n = 14$; 15.10.2020) and professional travel ($n = 8$; 3.11.2020), with a specific group on academic travel ($n = 14$; 30.09.2020). When asked about flying frequency, most respondents take a flight two to four times per year, and only one person never flies (Figure 2). In Europe, most flights are short-haul (Figure 3). When asked how they planned to travel in the future, in relation to flying, half of the respondents would like to fly less often, reflecting a bias in workshop recruitment, while about a third would like to fly again or more frequently (Figure 4).

3. Typology of Initiatives to Reduce Flying

A total of 37 initiatives were identified, which aim at a partial or total reduction of air travel. Acting on different

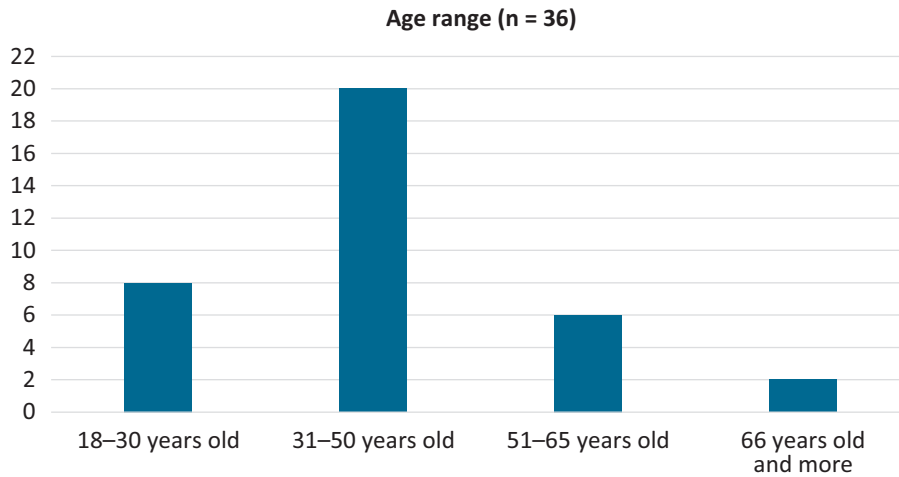


Figure 1. Age range of the workshop participants.

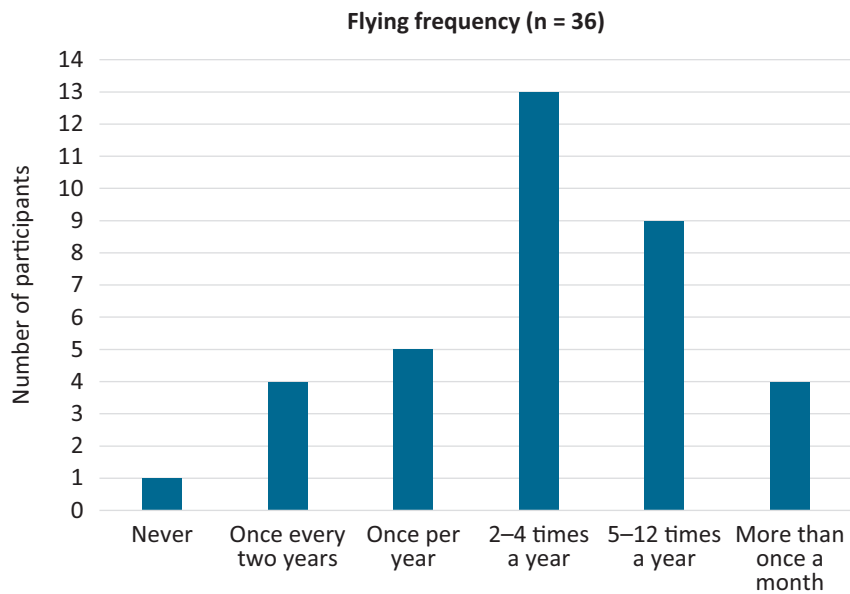


Figure 2. Flying frequency of the workshop participants.

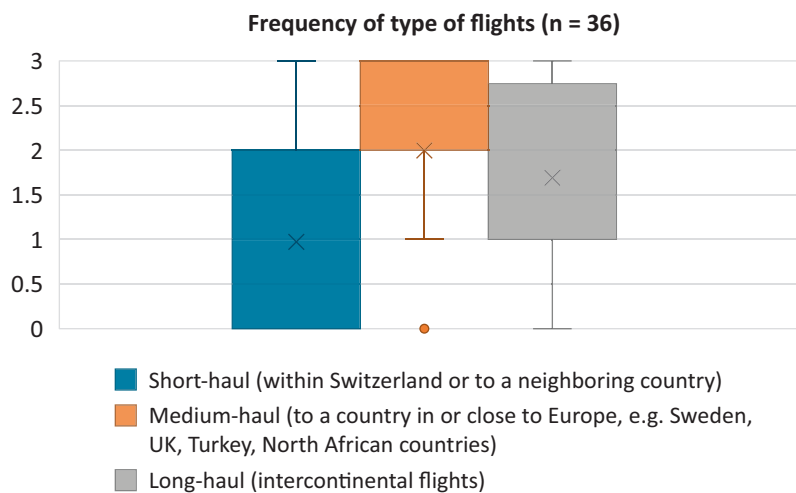


Figure 3. Flying frequency by type of flight for the workshop participants.

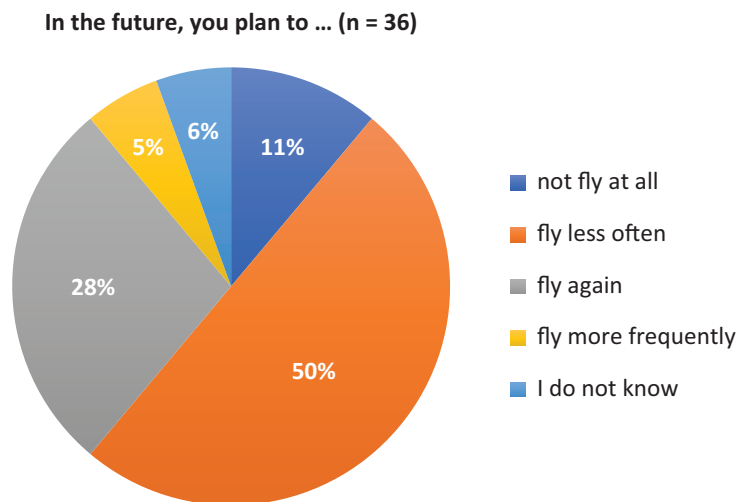


Figure 4. Expectations around future travel for the workshop participants.

scales (international, national, regional, for a city), they are distinguished by their target audience, their vision of change implied in the design of the initiative, and the tools put in place for their implementation. We present the distribution trends according to these categories in order to describe our sample, but in no way to generalise, as important biases arise from the selection we made, based on what data was readily available online. We also chose to group together various similar initiatives which counted as a single initiative, such as multiple carbon emission calculators, or similar university policies. Very few initiatives were launched before 2017, a turning point in media discourse in some countries (Ullström et al., 2020) or at least in actions to reduce flying: only nine initiatives (out of a total of 37) date from before 2017. On the basis of our review, we have drawn up a typology of initiatives based on the vision of change that their actions imply (Table 1). Although the initiators' vision of change is not reduced to a single type, they show a dominant inclination towards one of the following: change understood as being an individual choice, which is the dominant typology; change as happening

at the level of systems, including constraints or encouragements across the system; and changes through the promotion of alternatives, oftentimes through collective efforts.

For each typology, various tools are used by the initiators (see Annex 2 in the Supplementary File). Among the 37 initiatives identified, one-way communication tools are often privileged, which see people as passive recipients of information, without any interactions (24.4% of sample); two-way communications that ask something concrete of people are much less common (5.4% of sample); the impact of such measures is difficult to observe and measure. Participation tools for engaging people at a collective level are also prominent, particularly through charters or petitions.

Behind each initiative, we have identified the following initiators: committed citizens, associations/NGOs, public figures, politicians, private or public companies, and institutions and academics. Initiators tend to change as projects evolved, but generally we found that certain actors tend to collaborate together—such as public institutions with academics, or citizens working with

Table 1. A typology of how change is understood for flying less initiatives (n = 37).

Type 1: Change through individual choice (41%)

Initiatives that promote this form of change see individuals as the main actors towards reducing air travel, through an individual choice framing. Such initiatives focus on informing people (communication or education campaigns), as well as encouraging (bonus) or discouraging (carbon tax) air travel.

Type 2: Systemic change, including constraints or encouragements (32%)

Initiatives that promote systemic change recognise that the decision to fly or not to fly is part of a broader context, including social practices, socio-technical systems, and involving institutional and regulatory frameworks. Individuals have the opportunity to change the system as consumers, actors, or engaged citizens.

Type 3: Change through promoting alternatives, oftentimes through collective efforts (27%)

Change is expressed in the form of emerging alternatives, existing or new. These alternatives are put forward through demonstrations, or various forms of communication. Oftentimes, such change initiatives are supported through collective efforts.

associations/NGOs, or associations/NGOs with public figures. Also, projects can be initiated by citizens who end up joining together in the form of an association to facilitate their legal, administrative, or organizational approach. We can nevertheless note that associations and NGOs, committed citizens, and institutions (to a lesser extent) are most often involved in initiatives that seek to promote flying less. When it comes to the target audience of such initiatives, most are aimed towards individuals, seen as change agents. Some consider governmental and institutional structures as responsible for instigating change, while others private entities to promote flying less. A small subset considers change as coming from a collective effort.

The initiatives are increasingly aimed at a particular type of travel, reflecting a growing understanding around the distinction between professional travel and leisure travel, and the different meanings around these practices. Even leisure travel needs to be further differentiated, to include the subset of people who travel specifically for visiting family and friends in distant countries, as opposed to travel for tourism and exploring new destinations, a topic we will come back to later (see Annexes 3 and 4 in the Supplementary File for target audiences and forms of travel targeted by the initiatives).

4. Workshop Findings

Inspired by the typologies and initiatives discussed above, the research team (City of Geneva representative, community energy association, academic partners) came together to select three main initiatives that would be discussed at each workshop in Fall 2020. All of the initiatives represent a form of systemic change, which could also include a promotion of alternatives (Types 2 and 3). By situating all initiatives in a social practice framing, participants were able to discuss how different elements of practices inter-relate—involving material arrangements in relation to mobility, the development of new competencies and skills, and the shifting of social norms related to why and in what way people travel. Through the Futures Wheel process, the change initiatives were studied in relation to how negative impacts could be attenuated, towards encouraging positive impacts, and doing so with a consideration for complex socio-material arrangements. A behavioural approach might have placed an undue emphasis on information campaigns, or bonus/malus approaches, which we felt would have been insufficient when accounting for the systems of provision that make some forms of consumption more normalized as desirable than others. In some instances, political economy considerations were clearly identified by the participants, such as the force of advertising for low-cost travel. Through a systemic approach to change, a negative impact identified in one area—such as reduced employment opportunities at the Geneva airport—could be tempered by other, positive impacts, such as increased employment in the rail

sector or local tourism. Here, we discuss the findings and group together the two workshops on professional travel, followed by the one on leisure travel.

4.1. Workshops on Professional Travel (Work-Related, with a Spotlight on Academic Travel)

Three initiatives were chosen and presented in two workshops: a systemic change approach, whereby professionals come together in an institutional context to 1) sign a charter not to fly for any distance of under 1,000 km, inspired by the 'Unter1000' initiative, launched by academics at German, Swiss, and Austrian universities (Scientist for Future, 2020) and two initiatives focused on supporting alternatives, involving 2) promoting virtual conferences and exchanges and 3) promoting slow travel, even for longer distances.

For not flying under 1,000 km, participants saw time as the main constraint: For those who had families, this meant less time spent with family members at home, including children, and more time traveling for work and in transit. Another negative impact was the notion that some forms of travel may not be conducive to working in transit. To overcome these barriers, participants came up with ideas, including employers supporting child-care services for traveling parents. The train system was also seen as needing some form of change, either by ensuring comfortable spaces for working, or safe and comfortable overnight trains, with consistent internet connectivity. In accordance with the typologies developed above (Table 1), this relates to the need for systemic change—as it is not sufficient to change individual choices; the systems of provision around alternatives to train travel need to be tackled head on. In relation to social practices, changes in material arrangements would be necessary, but also social norms or collective understandings of how things ought to be—which would need to evolve within companies and universities towards valuing remote working, or being allowed to combine personal and family travel with professional travel. Participants highlighted the need for a consideration of work-life balance, if more time is dedicated to work through an increase in working time while travelling. Another main challenge identified was the price difference between the plane and alternative means of transport. Here, also, expectations might need to change, as employers must be agreeable to paying higher costs for travel in some cases. One imagined scenario devised by participants was to create an internal compensation scheme, whereby a carbon tax on flights would subsidize train travel. To limit the effect of people nonetheless preferring flights, such a strategy could be combined with an upper limit to flight travel for employees.

The second initiative on promoting alternatives focused on the development of online conferences and virtual exchanges. This initiative was seen as positive in several ways, as it would allow professionals to save time, reduce stress around travel (for some), and

eliminate travel-related costs (transport and accommodation). However, there was concern around whether virtual meetings could replace informal contacts and the development of professional networks that are made possible in physical meetings (e.g., for younger versus more-established professionals). Participants came up with the idea of a new type of space, or a hub for virtual meetings, located in Geneva, and equipped with appropriate technologies and infrastructure for facilitating such meetings. Such a hub could host European satellite events around international conferences, for example. Ways of interacting informally would need to be encouraged in such settings, however, with attention paid to inequalities of access—or who can and cannot participate in such event formats. This idea takes the form of change through alternatives. In relation to practice theory, new skills and competencies might have to be developed in relation to this new socio-technical setting. An individual choice to attend a conference without engaging in air travel would not suffice: The alternative form of participation needs to be made available through this hub. For all virtual meetings, it is also essential to consider what material support people need—from computers to internet connectivity—and the energy intensity of such an alternative. In addition, employers could also support the development of new traveller skills, whereby people could determine if and when it is appropriate to travel physically, and for what type of meeting—supported by institutional guidelines.

The last ‘promoting alternatives’ initiative discussed was about supporting slow travel by privileging the use of trains, buses, bikes, ships, or shared means of transport, rather than flying. Here again, travel time and costs were mentioned, but time and energy spent on organizing travel was also emphasized by the participants. Non-flight travel is seen as complicated to implement, sometimes impossible depending on the destination, and particularly for long distance travel. The creation of a European-scale application to book all tickets at once, in relation to multi-modal transport (bus, trains, bikes, ride sharing, etc.) was mentioned, as well as service centres that are specialized in planning such forms of travel for professionals. Participants also felt that security, sanitary, and hygiene risks need to be accounted for. Some ideas that emerged underlined the need for employers to acknowledge the collective value of slow travel, by considering travel time as working time, but also giving visibility to people who travel this way, as a form of social recognition, or allocating extra holiday time for people to choose slow travel options over flights as a reward. From a social practice perspective, this means changing systems of provision for slow travel, but also collective conventions around the desirability of such forms of travel.

Participants were able to understand change in relation to social practices through evolving material arrangement, the acquisition of new skills, and competencies and changing social norms. Employers are seen as the primary change agents towards making ‘flying

less’ a more compelling proposal, with the active engagement of a collective, as well as changing systems of provision. As public universities, such as the University of Geneva, grapple with the need to align their operations with ambitious carbon reduction targets, at the State and National levels, institutional conditions may be supportive towards efforts to reduce flying. Carbon monitoring is one first step in this direction and can demonstrate institutional support for alternative forms of travel, particularly when the results of a monitoring exercise are regularly made available and are accompanied by targets for planned reductions.

In Table 2, we present, in summary form, some of the impacts at multiple levels developed in the Future Wheel exercise, along with anticipated outcomes and ideas that emerged from that analysis.

4.2. Workshop on Leisure Travel

In the workshop on leisure travel, more emphasis was placed on what everyday people could do to reduce flying, through a practice-informed approach. The first initiative proposed was a voluntary challenge not to fly for one year, inspired by a similar initiative in Sweden. Flight Free World (2021) is a worldwide network, resulting from growing interest in the Swedish pledge launched in 2019 by We Stay on the Ground. Many recent initiatives aimed at reduction of flights (We Stay on the Ground, and the flygskam anti-flying movement) originated in Sweden and inspired other initiatives in Europe and elsewhere. As a systemic change initiative, the individual decision not to fly is part of a collective effort, supported by the media and organized at the level of a city or country. While flying less for leisure was generally seen as having more negative impacts than reducing flights for professional reasons, some positive effects were identified, such as developing local tourism, or enjoying ‘staycations’ and holiday-at-home practices. Participants recognized that agreeing to ‘a year on the ground’ could compel people to fly directly before or after this period. Thus, one negative impact would be the planning of elaborate future trips, once the challenge time is up. A second negative impact also raised was in relation to people who have family and/or close friends living in distant places. This underlines the need to distinguish between forms of leisure travel, as travel to support social relations is different from travel around acquiring new experiences (such as tourism to new destinations). One solution devised by participants was to create a challenge that would encourage people to visit nearby regions, countries, or capitals, encouraging visits to ‘exotic’ but nearby places—that would not merit flight travel. Another solution would be to provide options for reaching certain destinations without flying, which might involve a new platform for sharing such information if existing options are insufficient. Changes to the system of provision would be necessary to promote such solutions, for example through efforts by the City,

Table 2. Reducing flights for professional travel: Different levels of negative or positive impacts and anticipated outcomes and ideas.

Impact level 1	Impact level 2–3–4	Anticipated outcomes and ideas
(-) More travel time	(-) Difficult for people with family/care responsibilities	Assistance or support for family/care expenses (childcare costs)
	(+) More time to work during travel	Promote the train as a comfortable and isolated place to work; promote night trains
(-) More expensive	(+) Compensation for non-flight travel	Creation of a carbon tax scheme program in companies or institutions to tax flights, then redistribute the funds to support alternative transportation
	(+) Reduction in total amount of flights taken in a year	Promote both professional and private travel in a combined way, so as to reduce overall costs
(+) More selectivity about when to travel by plane	(-) Loss of professional contacts, from less travel	Support the development of new traveller skills to recognize if and when it is appropriate and important to travel, for what type of meeting, and what form of transport; provide institutional guidelines
	(-) Slow travel is less prestigious than flying	Positive recognition for those who travel less; recognize and encourage employees who travel less, or who use other modes of transportation; give slow travel more visibility
	(+) More investments in virtual meeting technologies	Develop alternatives, such as virtual tools for meetings; create a dedicated conference hub in Geneva, or a network of hubs, where professionals can follow international conferences virtually
(-) More complicated to plan	(-) Need time and skills/knowledge for planning	Creation of a travel information office and a platform combining all types of transport (bus, train, bikes, etc.)

Note: Based on a Futures Wheel exercise, designed to identify 1st level impacts of a change initiative, followed by 2nd, 3rd, and 4th level impacts, as relevant.

travel agencies, associations, or social entrepreneurs, thus emphasizing the need for a systemic approach.

The second initiative discussed in the leisure travel workshop was a combination of not flying for distances under 1,000 km, but also only taking one long-haul flight every two years. The participants mentioned several direct negative effects regarding this initiative, such as missing out on the discovery of new places, or in the possibility of seeing family and close friends, along with time and cost constraints. However, the participants then arrived at several positive impacts related to this initiative, such as the intra-European exchanges that could emerge from more local or regional travel. They imagined that a 1,000 km radius would lead to the development of travel guides, encouraging local travel (an idea that applies well to Geneva, a city in central Europe). This would lead to the development of local tourism, or the creation of 'low-cost train routes' that would promote connections between key cities and regions in Europe. Towards this aim, it would be necessary to have an entity that would be responsible for cooperation and joint organization between the various railway companies, towards centralizing and simplifying information.

Here, the idea of promoting alternatives is put forward. Amidst these reflections, participants nonetheless commented on the fact that such initiatives are not sufficiently focused on reducing travel, in absolute terms, and that the directive to take a long-haul flight every two years might create a bias towards those who can afford such flights and, ultimately, serve to normalize the desirability of long-haul flights.

The third initiative discussed during the leisure travel workshop was also around the theme of slow travel. Some people noted that Geneva airport is an important economic actor in the area; for some, reducing flights meant reducing work opportunities around the airport. Train travel was seen as more expensive, more time intensive, and more complex to organise, as discussed earlier. This would lead to more time in transit, and less time with family members or friends. However, a positive effect was that people might take more time to travel, thus spending more time at their destination. One idea that came up was to transfer airport employees to the rail system, by acquiring new skills and towards jobs in train transport. Participants questioned whether train travel could lead to the same form of social distinction

as flying, as traveling by air is seen as prestigious for some. Here again, participants noted that it would be important to not overcompensate the reduction of flying by traveling extensively through other means. Towards a shift in social norms, the participants suggested that solutions could be implemented to promote different meanings around family reunions or meetings with friends,

such as virtual interactions, but also ‘meeting half-way’ (Table 3).

5. Discussion and Conclusions

Designing a change initiative to reduce flying is no small feat. While different initiatives are emerging around the

Table 3. Reducing flights for leisure travel: Different levels of negative or positive impacts and anticipated outcomes and ideas.

Impact level 1	Impact level 2–3–4	Anticipated outcomes and ideas
(–) Less employment related to air-travel	(+) Job creation elsewhere	Promote trips in the back-country (not only big cities); promote train travel—both leading to economic/job opportunities
(–) Less distance travelled	(+) Local tourism promotion	Promote exoticism close to home (tourist guide); from Geneva, draw up with a compass a radius of 1,000 km to concentrate efforts for promoting slow travel
	(+) More holidays-at-home or stay-cations, more relaxing and economical	Promote the discovery of the area in your own backyard or close to home
(–) Less frequent trips	(–) Less frequent visits of distant family and friends	Promote virtual meetings (with training for people without technological knowledge/skills)
	(–) Less ability to cover distances	Meet halfway through the trip
(–) Less prestige from travel (fast and far)	(–) Less ability to ‘acquire’ new destinations	Propose challenges, for example: visit 3 capitals, 2 countries in one year, without flying
	(–) Less ability to ‘acquire’ new experiences	Promotion of fun trips by train, or thematic trips
	(–) Socially desirable to travel, for status	Get influencers on board to normalize not flying for leisure
(–) More expensive travel	(–) More inequalities between those who can afford alternatives and those who can not	Propose and illustrate ten ‘low-cost routes’ by train; or promote ten recurrent lines on major axes
		Provide subsidies or reward for non-flying travel
(–) More time spent traveling	(–) Less time on location (visiting friends, family, sites)	Encourage employers to allow remote-working while traveling for leisure, or provide an extra half day off for people who chose ‘slow travel’
		Provide faster, more comfortable, and secure infrastructures (night trains, fast trains, better lines and connections)
(–) More complicated to plan	(–) Less spontaneity	Encourage the creation of a travel agency for travel without airplanes
	(–) More time to organize	Support the creation of a structure to organize cooperation between transport companies and travellers
(+) Reduction of CO ₂ emissions	(–) Should not be up to a few heroic individuals	Make sure any initiative proposed is by the collective and for the collective
(+) More memorable and unique long-distance trips	(+) Socially desirable to have unique and memorable trips	Encourage people to be more selective in their travel choices

Note: Based on a Futures Wheel exercise, designed to identify 1st level impacts of a change initiative, followed by 2nd, 3rd, and 4th level impacts, as relevant.

world, many seem to be focused on better informing individuals to incite changes in behaviour—a limited understanding of how change takes place, and one that stops short of accounting for the political economy in which air travel is promoted as a desirable form of transport—in the interest of powerful groups. Through a collaborative research-action project, we set out to understand how everyday people could be engaged in reflecting on flying less. By embedding change in social-material arrangements, we sought to complexify how different change initiatives might play out. A social practice approach to understanding mobility reveals both material and immaterial (but nonetheless rigid) challenges and opportunities, involving infrastructures and technologies, but also social norms and shared meanings around travel for both leisure and professional reasons. Participants were able to reflect on questions of equality and solidarity, in discussing in what way air travel might be necessary for certain people in some instances, or how train travel might be cost prohibitive for others, thus enlarging the scope of reflections beyond individual decision-making to collective efforts.

By involving citizens in such deliberations, new ideas emerged in terms of re-thinking how social practices can play out, towards the development of richer responses to public challenges. In this respect, the Futures Wheel exercise was particularly effective, as it entails going beyond immediate reactions (e.g., too costly, too time consuming, too complicated) towards more indirect impacts that can be positive and also lead to new ideas. In terms of limitations to the study, the workshop format and chosen initiatives are specific to the city of Geneva; the idea of not flying for under 1000 km would be very different on an island, for example. While rich qualitative data was gathered through workshops, a representative survey might be useful towards gauging support for select initiatives among the broader population. We also recognize that more work could be done to factor in wellbeing, or to understand how flying relates to human needs. Finally, the City asked us to explicitly focus on voluntary initiatives; we stopped short of studying the regulatory frameworks that might further reduce the appeal of flights. That being said, the Futures Wheel exercise did lead to more constraining ideas, that could be operationalised by the city administration through different modes of governing that are often used in combination—following Elofsson, Smedby, Larsson, and Nässén (2018) and building on Bulkeley and Kern's (2006) work on climate governance. For example, participants suggested an upper limit to long-haul flights per capita, or the creation of carbon tax and redistribution schemes as a way to support alternative forms of transport in Universities—and as part of a *governing by authority* strategy.

The City of Geneva has not yet chosen a way forward at the time of this writing, not least because of the uncertainty around travel in the current pandemic. Rather than chose one initiative, one way forward might be to include insights from across different initiatives towards a toolkit

of possibilities, focusing on three main points. First, it is essential to differentiate and further complexify different forms of travel. Leisure travel for visiting family and friends who live in distant places represents a specific subset of leisure travel, for example, and one that needs to be handled differently from travel for tourism to visit new destinations. This relates to the need to account for diversity in travellers, as people with family members on different Continents are facing specific challenges when it comes to flying less. Efforts to reduce flights for professional travel must also further distinguish between trips that are seen as more necessary—for the promotion of early career employees, or for securing new supply chains, for example—versus those that can be effectively managed virtually. While the City of Geneva may not be in a position to influence employer policies, guidelines to support decisions on when flights are necessary or not may be useful, leading towards a strategy of *governing by enabling* (Elofsson et al., 2018).

Second, by engaging with a social practice perspective in the workshops design, we were able to move beyond the standard fare of providing more information as a way to incite individual behaviour change. The Futures Wheel exercises demonstrate the importance of changing material arrangements, for example in the alternatives to travel and the systems of provision that make some alternatives more appealing than others. This relates to *governing by provisions* (Elofsson et al., 2018), whereby the city supports air-travel alternatives. More investments could be made in promoting alternatives to individual travel for professional reasons at the City or State level, such as virtual conference hubs. But other dimensions of social practices were equally important, such as the meanings around flights, or the skills and competencies needed to travel through alternative means. Towards this aim, initiatives that bring more appeal to non-flight travel could be useful, as well as social learning opportunities—where citizens come together to learn and share new skills. Third, in terms of gaining insights from the different processes and tools described in Annex 1 in the Supplementary File, the workshop results suggest that the negative effects of any change initiative would need to be anticipated through two-way forms of communication such as the workshops—which could be expanded to a broader population through online platforms. Tools for influencer participation or for encouraging participation in communities of practice, such as the workplace or schools, could also be relevant.

This participatory dimension at the core of the project could also lead towards what Elofsson et al. (2018) have suggested as a new mode of local governance of greenhouse gas emissions for air-travel, the *governing by agenda setting*—building on work by scholars in urban governance. This governance strategy highlights “local government’s capacity to act through various types of partnerships and other fora in order to build visions and influence policy and industry agendas *beyond* the

local setting in a direction that supports the overarching goals set by local actors” (Elofsson et al., 2018, p. 580). Geneva, as home to international organizations, could set an example through its policies that might have a wider impact beyond the city.

The current Covid-19 pandemic also has implications for this study, as flying less is a given for many people experiencing reduced mobility, as is the case in Geneva at the time of this writing. If and when different forms of mobility are once again available to some, we might expect a rush to experience the speed of flight travel once again, or the desire to visit new places or old acquaintances. While virtual means of exchanges may have been uniformly promoted during the pandemic, they represent a poor substitute to physical interactions for many people. At the same time, being constrained to use virtual tools has contrived people into experimenting with such tools, making virtual exchanges more accessible and tangible as alternatives to physical travel but also showing the limits of solely online interactions.

Our participants may or may not have been interested in ‘flying less’ prior to attending the workshops, yet many expressed the need to re-think their approach to travel in terms of quantity (time spent, money spent, capitals visited, etc.) by the end of the workshops, towards reflecting on the need to reduce flight travel. This relates to a growing literature on sufficiency, which merits a public debate around how much travel is enough, for what purpose, and in relation to both environmental sustainability and human wellbeing (Toulouse et al., 2019). For this, more societal discussions could take place in our communities around ‘how much is enough’ and what a more qualitative approach to travel might look like. The social practice approach privileged in this project revealed the complexity of the challenge but also opportunities that were contextualized in relation to the everyday lives of citizens, towards a bottom-up public engagement process. Flying less is thus not solely an individual choice, but an opportunity for social learning that involves contesting established norms and supporting viable alternatives.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the authors (unedited).

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Article

Knowledge, Fear, and Conscience: Reasons to Stop Flying Because of Climate Change

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Abstract

Much research on the societal consequences of climate change has focused on inaction, seeking to explain why societies and individuals do not change according to experts' recommendations. In this qualitative study, we instead consider people who have changed their behaviour for the sake of the climate: They have stopped travelling by air. We first asked them to elaborate their rationales for the behaviour change. Then, using topos theory to find thought structures, we analysed their 673 open-text answers. Several themes emerged, which together can be regarded as a process of change. Increased knowledge, primarily narrated as a process by which latent knowledge was transformed into insight, through experience or emotional distress, was important. Contrary to certain claims in the literature, fear stimulated change of behaviour for many in this group. Climate change was framed as a moral issue, requiring acts of conscience. Children were invoked as educators and moral guides. Role models and a supportive social context played an important part. Alternatives to flying were brought forward as a motive to refrain from flying. Only a few mentioned shame as momentous. Instead, stopping travelling by air invoked a feeling of agency and responsibility, and could also result in a positive sensation.

Keywords

arguments; children; climate change; flight shame; inner deliberation; knowledge-action gap; stop flying; topos

Issue

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1. Introduction

Although the UN has declared this the Decade of Action, during which the UN Sustainable Development Goals (SDGs) should be met, progress toward SDG No. 13—"Take urgent action to combat climate change"—has been slow. Much research has been dedicated to understanding this inertia (Hulme, 2009; Oreskes & Conway, 2010). One prominent explanation for why people fail to act on the knowledge they possess has been characterised as the knowledge-action gap. This gap has spurred research in many fields, including media and communication studies (Kollmuss & Agyeman, 2002;

Moser & Dilling, 2011), anthropology (Norgaard, 2011), and psychology (Gifford, 2011). An alternate explanation characterises climate change as a "wicked problem" (Levin, Cashore, Bernstein, & Auld, 2012), laden with goal conflicts. Goal conflicts are at play on several levels, from the micro to macro. For instance, some of the SDGs actually stand in conflict with each other when more precisely articulated (Nilsson, Griggs, & Visbeck, 2016). On the level of individuals, the ambition to lead a climate-friendly life may stand in conflict with eating the food one loves or maintaining international friendships.

We are interested in how individuals and societies manage goal conflicts and overcome the inertia of

inaction concerning climate change. Travelling by air was chosen as a distinctive case, as flying typically presents an individual with several, potentially painful goal conflicts. Considering Swedes who stopped or drastically reduced their amount of travel by air because of stated concerns about climate change, we analyse the thought structures that they report motivated their decisions. The analysis is qualitative and the results are not generalizable. Our interest is the particular and non-representative group that overcame inertia and changed behaviour. In the Swedish population as a whole, very few have made this decision. In a general survey of Swedes and their attitudes toward climate and environmental issues, 14% said they had stopped flying for climate reasons in 2019 (Persson, 2020). However, studying this particular group illuminates the arguments that these people brought forward as they curtailed flights, and this, in turn, can give important insights into the work of further limiting emissions from commercial air travel.

To date, very few studies look specifically at people who have eliminated air travel because of concern about climate change. Jacobson, Åkerman, Giusti, and Bhowmik (2020) conducted interviews with a total of 25 “quitters,” “reducers,” and “non-reducers” and found phases and components of a process of transformation. Jacobson et al. (2020) show that internalised knowledge about climate change and the impact of air travel is crucial for instigating behavioural change. To investigate the role of values, Büchs (2017) likewise made interviews with people who voluntarily reduced flying. In a recent study, Mkono and Hughes (2020) have analysed how people relate to flying on social media, gathering examples of online discourse. They found that eco-guilt and eco-shame are common; their study objects, however, in general, did not cease travelling by air. The literature on people who continue flying despite their otherwise sustainable values is larger (e.g., Cohen & Higham, 2011; Juvan & Dolnicar, 2014; Kroesen, 2013; McDonald, Oates, Thyne, Timmis, & Carlile, 2015).

As a situated understanding of flying is important for individual motives, the next section relates to the Swedish context. The theoretical underpinning of our research design is discussed in Section 3, followed by a description of the methodology in Section 4. Section 5 details our empirical findings and Section 6 discusses the array of findings in relation to each other.

2. Flying and Climate Change in Sweden: Some Context

Air travel as an issue related to climate change is not new. The first Intergovernmental Panel on Climate Change (IPCC) report on the topic was published in 1999 (Penner, Lister, Griggs, Dokken, & McFarland, 1999). As a public topic for people in general, however, it was probably not an issue until climate change gained wider attention in the media. This occurred markedly in 2007, with news around the publication of the IPCC Fourth Assessment

Report and Al Gore’s film *An Inconvenient Truth* winning an Oscar, and even more so in 2009, with the hacked email from East Anglia and the COP15 meeting in Copenhagen (Boykoff, 2010).

In the Swedish context, early well-known examples of people who stopped flying include the climate researcher Kevin Anderson, and opera singer Malena Ernman, better known to international audiences as the mother of Greta Thunberg (Anderson, Andersson, Ferry, Ernman, & Hedberg, 2017; Ernman & Thunberg, 2018). By 2018, the Swedish public sphere saw an extensive discussion on flying habits and climate change. Occurring close in time but acting separately, three public figures published columns in the daily press detailing their personal struggles with flying. They testified to the goal-conflicts and troubled consciences they experienced when considering the large carbon dioxide emissions from trips they took to Kenya, Cuba, or Italy (Hadley Kamptz, 2018; Liljestrand, 2018; Mosskin, 2018). An intense and prolonged debate on flying in general and leisurely flying in particular followed, and to some extent continues in Sweden. The term ‘flight shame’ emerged, not as a precise scientific description of a psychological reaction, but as a loose and click-friendly response to an emotional discourse in which social media was key. In early 2019, an anonymous Instagram account began shaming so-called influencers who flew extensively and at the same time declared an interest in climate issues; to post pictures of long-distance trips on Facebook was no longer *comme il faut*. Most organised efforts to stimulate decreased flying were, however, supportive, such as the We Stay on the Ground movement. Their campaign on Facebook is also organised around positive examples and avoids shaming, even though it engages with moral issues. Still, ‘flight shame,’ translated from Swedish, began circulating internationally in debates (Eriksson, Pargman, Robèrt, & Laaksoalahti, 2020; Gössling, Humpe, & Bausch, 2020). The phrase established a common understanding that this particular mobility discussion was tightly coupled with one of the most difficult human emotions: shame.

Furthermore, the record-breaking Summer of 2018 saw extreme temperatures and extensive forest fires in Sweden. In the Fall, as the new school term began, the then 15-year-old Greta Thunberg started her School Strike for Climate under the hashtag #FridaysForFuture. It soon resulted in a social movement of global proportions (Wahlström, Kocyba, De Vydt, & de Moor, 2019). Mainstream and social media coverage increased dramatically (Boulianne, Lalancette, & Ilkiw, 2020; Mahl, Brüggeman, Guenther, & De Silva-Schmidt, 2020). It was in this national context that our survey was carried out.

3. Theoretical Basis and Methodological Starting Points

Our main interest is to understand the circumstances that allow people to change their behaviour with regards to climate change. A starting point is the hypothesis

that people orient and motivate action in dialogue with others, always against the background of a social context, but also through an internal dialogue where people negotiate with themselves. From a rhetorical perspective, this sort of human meaning-making is linguistic and argumentative. When we want to understand what enables action, or promotes inaction, we can look at how someone reasons or argues (this does not exclude the existence of other, non-linguistic dimensions). This rhetorical perspective is particularly relevant in issues where there is tension between knowledge and action, between different important values, or between short-term and long-term goals. In *A Rhetoric of Motives*, Burke (1969) argues that meaning-making in such matters takes place through identification and division. Burke (1969) proposes that people act based on how they identify and separate themselves from other people, ideas, thought systems, events, and things, and that these identifications also affect what people consider to be true and relevant. Burke (1984) uses the term *motives* to describe how people understand, explain, justify, excuse, or rationalize their actions to others and themselves, but also as “shorthand descriptions for certain typical patterns of discrepant and conflicting stimuli” (Burke, 1984, p. 30). Motives, according to Burke (1969), are not static. New knowledge, other social contexts, meetings, and dialogues can change how people perceive their moral situation and force or invite them into new patterns of meaning.

A prime assumption of rhetorical theory, already identified in Aristotle’s *Rhetoric*, is that people want to be consistent and avoid contradictions. If people act against their intention or knowledge, or in a manner that contradicts their morals, they experience unease, which Festinger (1957) later called “cognitive dissonance.” The occurrence of cognitive dissonance has been observed also in tourism studies, where for example Kroesen (2013) has used Q-methodology to study arguments used to overcome the discomfort of acting against knowledge. Likewise, Juvan and Dolnicar (2014) explore justifications concerning the discomfort of unsustainable tourism.

The drive to be consistent or coherent means that people strive to rationalize their behaviour. This rationalization, argumentation, or justification takes place in an inner dialogue, which Perelman and Olbrechts-Tyteca (1969) called “*deliberation intime*” in French. In our study, the action originally causing the cognitive dissonance—travelling by air despite knowing its negative effect on climate—was abandoned and thus few motives relate to justification. Instead, cognitive dissonance is revealed as a backdrop to behavioural change. This differs from most studies that engage with cognitive dissonance.

We focus on the thought structures that can be deduced from the arguments people use when explaining their motives, the structures by which they create and display coherence *between knowledge and action*. We are particularly interested in *the prototypical thinking structure behind recurrent arguments used to explain*

a certain action. In rhetorical theory, this is called *topoi* (*topos* in singular). Topos theory, with its roots in ancient sophistry, was articulated by Aristotle in his *Topica* and *Rhetorica*. It was then explored and developed by several rhetoricians, including Cicero and Giambattista Vico. We start from the understanding of *topos* developed in the 20th century by Perelman and Olbrechts-Tyteca (1969), which gives an ideal conceptual frame for studying and describing rhetorical negotiation between multiple perspectives. The theory thus offers a methodology akin to, but still significantly different from, discourse analysis as exemplified by Foucault or frame analysis as practised by Goffman, since we look for specific traits within the material: namely, arguments that motivate the action and create meaning for the individual.

The theory of *topos* does not see reasoning as isolated from context. Even the internal dialogue takes place between *topoi* that have been developed and are perceived as valid in a social context. People use the arguments that have the potential to be accepted and make sense in the context they belong to or want to belong to. These social traits of reasoning have recently been observed also in psychology as motivated reasoning or cultural cognition, and challenge the enlightenment idea of rationality based on knowledge (Kahan, 2015; Mercier & Sperber, 2017). In short, arguments are socially situated and also temporally and spatially dependent. Recurring types of argument can still be sorted into categories and described, albeit knowing that these categories and descriptions are contingent. We cannot expect to find universally valid or fully delimited *topoi*, or even a limited number of them.

To discern and describe this meaning-making we use phenomenography, a theory developed within pedagogy, with an empirical and interpretivist perspective (Marton, 1986; Marton & Booth, 1997; Svensson, 1997). A basic assumption in phenomenography is that learning and meaning-making manifest themselves in many ways and that there is a value in discerning, describing, and understanding this variety. Phenomenography is also a methodology for qualitatively studying different ways of experiencing or thinking about something and describing a range or repertoire of possible approaches. This harmonizes well with topical analysis.

4. Method

This study applied a mixed qualitative method including several steps. We used a survey to collect free-text answers. The respondents were self-recruited from a special group, namely people who stopped flying because of concern about climate change. In the free-text answers, we distinguished recurring types of arguments motivating behavioural change. These types constitute different *topoi*. Each discernible *topos* received a tag in the digital survey tool used to analyse and sort the material. Tags that were similar to each other were sorted together in groups. These were in turn arranged in

overarching categories that shared features. We expand on this method below.

The survey was open between May 29 and August 12, 2019, and was carried out via the tool Survey Monkey adhering to General Data Protection Regulation. It was published online on Twitter and in groups on Facebook that bring together climate-committed individuals as well as more specific groups such as Flight Free 2019/20 and We Stay on the Ground. Since we are interested in people who stopped flying due to concerns about climate change, we targeted groups with that profile. This approach can be compared to the sampling of Büchs (2017), who also looked for individuals within particular interest groups. It should be stressed that we did not seek to understand how people in general reason around climate change and air travel, nor in understanding the motives of those who stopped flying for economic, medical, or other reasons. This study focuses on those who actively changed flight behaviour due to concerns about climate change, and how they explain this change of behaviour. The answers were anonymous and in Swedish. We completed the translations into English.

The survey contained 15 questions, which included both open text and limited choice responses, and covered areas such as when did you fly or what kind of flying did you do. There were also questions related to age, gender, and education. A question central to this article was No. 6: “What made you change your behaviour?” This was a multi-choice question with the following options: a specific occasion, more knowledge or a new insight, specific arguments, role models or inspiring people, one or several people close to me, travelling alternatives, the debate, my social context or peer pressure, flight shame, bad conscience, I don’t know, and other. Another central question was No. 7: “Tell us how it happened (open text).” The survey method allowed us to gather a large corpus of information in a relatively short time. A total of 673 individuals completed the survey and our analysis builds primarily on the answers to question No 7. These 673 answers were of different length. Some were very short, a few words, and others longer, several hundred words. Regardless, *they all contained at least one motive for changing behaviour*. Most answers contained several motives. This means that our corpus comprised a great number of motives to stop flying because of concern about climate change. In traditional rhetorical critique, one generally analyses texts that have already been produced and have appeared in a particular context. Here we do something less common in rhetoric, but more common in phenomenography: namely, organizing the production of a material that we then study. The material is then analysed in the same way that rhetoricians examine artefacts.

We applied a phenomenological approach that seeks to capture a variation, a diversity of existing ways of thinking within a group. These ways of thinking are then described and organised from likeness in *categories of description*. The categories and their examples can then be related or compared with each other. Such a set of cat-

egories capturing the variation of reasoning concerning a phenomenon is called an *outcome space* (Marton, 1986). We combined the phenomenographical method with topical analysis. In the material, we specifically searched for topoi, prototypical thinking structures behind arguments, or recurring traits in meaning-making. When sorting the topoi in categories of description we could discern motives such as certain types of knowledge, experience, emotions, and values, which are the focus of our discussion.

It is not possible for us as scholars to distinguish between actual experiences, knowledge, or emotions, and the way these are accounted for in the responses. What we have are the written articulations of phenomena. From a rhetorical perspective, thinking is to a high degree constituted linguistically, especially regarding problematic issues where one needs to deliberate between different choices. By studying the linguistic choices, we can discern key features in thinking. Some of the articulated motives in the survey may be post-constructions, but even those are illuminating as they reveal what is considered meaningful to the respondent.

It is also not possible to know if the motives given in the survey are the real motives of the respondents. This is true for most types of argumentative analysis and has to be taken into consideration. However, we believe that there are few reasons for the anonymous respondents to make up motives, in particular since this survey dealt with a change that the respondents wanted to make. A distinct advantage of our design is that we refrain from asking people about their intentions, which might very well be separate from the outcome, but instead ask them to account for something that has already happened. The multi-choice question preceding the open text question may have had an impact on the responses, which is a possible weakness in the survey.

Topos analysis can be done deductively, using for example a set of pre-defined topoi and identifying their occurrence. We instead worked inductively, considering each answer for the topoi. For example, an answer stating “For long, I have known that flying was bad for the climate, but when I visited Bangladesh and saw the flooding of the homes of poor people, I realised the severity of climate change and I cannot contribute to this unfairness anymore” displays several topoi. One is that latent knowledge can become a realization through eye-witnessing a climate change incident, another topos is the recognition of one’s own contribution to the climate crisis, a third is to acknowledge a schism between personal behaviour and the severity of climate change, and a fourth is a justice perspective. None of these topoi are unique for reasoning concerning climate issues; in fact, they occur in reasoning around many issues, but they are prominent in this material.

Topos analysis has been used to analyse the rhetoric of climate change before (Cox, 1982; Farrell & Goodnight, 1981; Myerson & Rydin, 1996; Ross, 2013, 2017; Walsh, 2017; Walsh & Boyle, 2017). Concrete examples are

Kerr (2017), who studied how uncertainty was used by both environmental activists and companies in the fracking debate; Ceccarelli (2011), who studied how the same topos is used to give the appearance of scientific controversy and to postpone regulation; Walker and Walsh (2012), who looked at how environmental activists emphasize risks; and Walsh and Prelli (2017), who focused on how scientific models are understood and used in climate communication and by climate change deniers.

In our previous report on this study, we presented the topoi found in detail and gave an abundance of examples (Wolrath Söderberg & Wormbs, 2019). Here, we instead focus on the motives discerned behind the topoi and give a more overarching analysis of the process of change.

5. Results

Our inductive method resulted in a great number of possible motives for change, including within single individuals; it was common to describe several rather than singular motives, and these furthermore often made up a process of change comprising several stages and motives. Below, we place these different types of motives, or topoi, in nine different thematic categories, even if there are great overlaps and connections between them, and end with the process of change. In the material, there are also several more infrequent motives that we leave aside in this analysis.

5.1. Knowledge

The by far most common motive to stop or drastically reduce flying was, in the wording of the respondents, new knowledge. Among the pre-selected reasons to stop, four out of five ticked the box 'knowledge' and in the open text answers more than half of the responses dealt with knowledge. Some testified that they had had knowledge of the effects of flying on climate change for a long time, but now had internalised it, which resulted in change: "I have known, but just on the outside. When I internalised it and it became part of me, there was no going back." This process is both described as successive and sudden. Knowledge accumulates over time, somewhat uncomfortably, and then something happens resulting in an insight. Some respondents realised the severity of climate change, which made knowledge take a new form or resulted in an "epiphany." Several understood the relative weight of flying in relation to other emission sources, for example as the proportion of their own total footprint or a national or global average: "I read that emissions from Swedes flying equal that of car traffic. It made me realize how serious the problem of flying is" represented a prototypical example, based on the comparison. Sometimes this understanding had come by way of using a climate calculator, which would calculate impact based on one's own data.

Common to many of these arguments and thought structures was the economic idea of an account or a bud-

get. When learning about a global average, whether at present or representing an amount needed to meet the Paris Agreement over time, private flying stood out for many and was an obvious candidate in a quest to lower personal emissions.

5.2. Experience

Tightly connected to knowledge and with great overlap was the experience of climate change. The record-breaking Summer of 2018 constituted a bodily experience of what many interpreted as climate change. The smoke from burning forests, the dried-out wells, and the continuous heat were all experiences that respondents brought up as momentous in a process of awareness, providing a compelling insight, allowing knowledge to become real: "The warm and dry Summer of 2018 [with] forest fires and sinking levels of groundwater made me fear the consequences of future climate change." There were, however, also examples that related to experiences, not in Sweden but elsewhere:

My last flight was in November 2017 to Bangladesh for work. [T]he ocean makes Bangladesh so exposed to rising sea levels. A few weeks earlier, colleagues had been in Dhaka, which was flooded, and they described how they drifted in taxis with water up to the windshield. Their luggage was in the trunk, all soaked. I met people there who will most likely be hit by climate change, much harder than I. Yet I am the one causing these emissions. I felt there and then that I did not have any right to fly.

5.3. Emotions

The experience referred to above could also be expressed in emotional language, like worry in the face of lack of drinking water, or fear of fire and drought. Often these emotions were part of the process of experience that made knowledge real. But emotions were also brought forward in other settings, not connected to an experience. People wrote about anxiety, fear, disgust, and sorrow, emerging after reading an article, watching a film, or having a conversation: "In 2018, I realised the seriousness of the damage from flying in earnest and it gave me climate angst and panic." Another kind of emotion had to do with mourning the loss of the journeys, or lifestyle, one must refrain from: "Surfing in exotic places and snowboarding in the Alps was part of my lifestyle." After having decided to quit flying, other emotions could emerge, like relief: "I still have a positive feeling from having made this decision."

5.4. Moral

Prevalent in the material were the responses that treated flying as an ethical issue, belonging to the sphere of personal morality. A great number of answers pointed to a

“bad conscience” due to one specific trip or many historical trips. But it could also be due to the perceived injustice that climate change results in, and the realization of personal contributions to emissions. Some included people on other continents or future generations when assessing the ethics of flying. Feelings of guilt were often expressed also in physical terms, as bodily manifested stomach pain, the parable of an aching soul, or an inner conflict that needed to be solved: “I felt disgusted by the entire concept of flying and the unsustainable, egoistic impact it has on climate.”

Others mentioned how they “stopped fooling” themselves, pointing to a moment of realization and consequence. This argument suggests the importance of consistency for rhetorical actors: You should “practice what you preach.” Respondents could not justify their actions to themselves anymore and needed to stop. In fact, this version of the ethical argument was most common in the survey: “What you cannot defend, you should not do, and thus I stopped flying.”

To be consistent, avoiding an internal crack or cognitive dissonance, is also part of striving to be a role model for others. Many related arguments talk about the possibility to change the norm and inspire others, which cannot be done if you are not walking the talk. The most important audiences in this regard were future generations, primarily children and grandchildren. The need to be able to “look them in the eye” captures the moral position.

There are also absolute and internal positions in no need of an external audience. Some talk about responsibility, the need to do one’s “share” and contribute. Some simply say that flying is unjust, building on the understanding mentioned above that climate justice is key and that they have no “right” to fly. Others do not want to contribute more emissions, whether a specific temperature target is reached or not. The important thing is to act according to a moral conviction: “I simply could not find any more good excuses to ignore my values.”

5.5. Children and the Future

As previously mentioned, children show up as an important audience that one must face and answer to: “I decided [to stop flying] since I borrow the Earth from my children and I want to be able to look my grandchildren in the eye.” They also carry knowledge and challenge habits and norms: “Our daughter has taken the lead. Now the entire family eats vegetarian, we drive an electric car, and have stopped flying.” Children might object to flying or contribute an argument concerning a family vacation choice. At the same time, they figure prominently as embodying the future: “I love travelling to Asia, but I love my children more and therefore I will stop flying until the fuel is fossil-free.” Many responses mention their own children or children close to them as a turning point, putting things into perspective and enabling change: “When my daughter was born, I had

no more excuses to fly.” To become a parent or see a new life enter the world is brought forward as a motive to change behaviour.

5.6. The Public Debate and Role Models

Many respondents claim to have been influenced by the wider public debate. This debate took place in traditional media, but just as often social media, and particular groups are mentioned where news pieces might have circulated. Contexts such as a Facebook group or similar could offer social support. The debate itself could also serve not just as an information provider but also as an inspiration.

The most influential person and role model in the material is Greta Thunberg. “I listened to Greta. I read up. And I decided.” Greta Thunberg seems to have been able to transform latent knowledge for some at the same time as she reached new audiences. Thunberg’s mother, Malena Ernman, is also frequently mentioned in the material with the book she co-authored and her decision not to fly. Al Gore and *An Inconvenient Truth*, Naomi Klein and *This Changes Everything*, and David Attenborough’s recent TV-series are furthermore brought forward as important sources of knowledge and inspiration.

5.7. The Social Context

Greta Thunberg, then a child, was only matched by other anonymous children or children in the family. As mentioned above, it was very common that children influenced the behaviour of our respondents: “My teenage daughter said no to weekend trips” captures part of a process of change. Also, other issues are mentioned, such as a change in diet or a more sustainable lifestyle in general. Other people close to respondents can also be important, like a spouse, a sibling, or a friend. In those interactions, how a question was posed is often mentioned; empathy and courage are successful ingredients in such a process.

Family can be of great help in behavioural change: “When the debate became more intense and my husband gained more knowledge on the climate issue, we decided together to stop flying.” Friends or colleagues can have influence and lead the way. But a large number of respondents referred to groups on social media as decisive for their decisions: “It is not possible to fly when you know how much CO₂ it emits, to then see the flight free campaign also makes the decision more lasting as you know we are just becoming more and more.” It is important to remember that the survey was conducted in precisely such groups.

5.8. Shame

Finally, shame is mentioned in the material, but only a few times. Conscience, and other notions having to do with morality, is much more common, as discussed

above. Shame is thus not very visible, neither in the open-text answers nor among the pre-selected alternatives. Like with every word in the responses, we have taken them at face value but at the same time looked at their context and the argumentative structure. Shame is often understood as a socially formed conscience. Respondents mention many examples of social or media discourses that apparently impacted their decision to stop flying, either as role models or through normative or moral discussions. There is a social dimension of conscience, not mentioned as a negative feeling by the respondents, but rather as a kind of support to be the person one wants to be.

5.9. Alternatives

A large and distinct theme in the responses regards motives related to the existence of alternatives to long-distance flying. This theme could reveal a push from flying (e.g., “to fly is transport, not experience”), or a pull towards train travel, as in “I had forgotten how fun it is to travel by train.” The possibility to travel by train is also filled with new meaning and slow travel is regarded as more attractive: “Trains are nicer. I prefer the tempo and think it is both more adventurous and pleasant.” The time dimension can also be on a different scale: “You do not gain time through flying, but lose a future for coming generations,” illustrating that the trope of saving time might not apply. Furthermore, one does not have to travel far to experience something different, as there are many parts of Sweden to visit: “Vacation in Sweden instead. Simpler, cheaper, nicer!”

5.10. Process of Change

The motives analysed here can be brought together in a process-catalogue of how change might happen. Not everyone in our study experiences everything, but the experiences seem to occur in about the same order and similar relations in the material. There are also several responses where the stories are detailed. Below is one example which illustrates the process, invoking several of the motives that were previously mentioned:

I have long regarded myself as climate-friendly and done loads of things to lower my emissions. Then I saw the figures on how much a flight emits and realised that a flight to New York corresponds to all my emission during an entire year if I live like I want to this year. It feels like everything else I do for the climate is of no use if I continue flying. Greta made me raise my ambitions because she made me dead scared for my future. And I am grateful for that. Even if I might not have a reasonable future since most people don't understand the gravity of the situation, I can still say to the next generation that I did all I could, before it was too late.

6. Discussion

By reducing or stopping flying, our respondents have overcome the cognitive dissonance common for those who strive to live a sustainable life but continue flying. What we see in their given motives for change, however, are often residues of that dissonance and a story of transformation where several motives support each other and interact. For example, strong emotions seem to allow for new knowledge and a social context can help behavioural change. Below we unpack the nine different thematic categories and the process of change brought forward above.

In this study, *knowledge* surfaces as the single most important factor of any referred to by our respondents. This is consistent with findings in Jacobson et al. (2020). Important knowledge is particularly that which mediates the acuteness of the climate crisis and the size and proportions of emissions that allow for comparison. Also, and just as interesting, are the processes by which knowledge is *experienced* and hits close to home. When that happens, the earlier accumulated knowledge becomes real and meaningful and internalised. This is an interesting finding. There is a questioning of the power of knowledge in the very description of the inertia in climate change as a gap between knowledge and action. But there are also studies that more explicitly criticize the possibility to bring about behavioural changes by informing people about climate change, the so-called *information-deficit model* (Bulkeley, 2000; Moser & Dilling, 2011; Norgaard, 2011). These studies, which strive to explain why people do not change, have not completely rejected knowledge but rather emphasised that knowledge alone is not enough. In this context, the concept of knowledge is that of scientific discrete factual knowledge. The knowledge concept that our respondents bring forward is more complex and integrated with experiential, emotional, moral, and social dimensions.

By and large, the aggregated process is often connected to strong *emotions*, like fear, worry, and pain. Increased responsibility to others far away, both geographically and temporally, are also emotionally challenging. Before, during, and after the decision to stop or reduce flying, feelings of loss and grief are mentioned. The loss could be related to not being able to meet friends and family or to abstain from activities that were dear, if not existential. The decisions that people have made are not easy, which is also apparent in the responses to a specific question in the survey on hindrances to change. In general, it should come as no surprise that change is hard and painful. As Moser (2019, p. 152) recently put it, “deep change is—first and foremost—experienced and processed emotionally” (see also Randall, 2009, for a similar discussion on the importance of emotional engagement).

The respondents in our survey seem to experience strong agency through the action of stopping flying. They refute the idea that their flight is a drop in the ocean

and thus can be overlooked; they do not want to contribute even a single drop. For them, individual emissions are real and the quickest way to lower them is to stop flying. It seems to be empowering. This is truly interesting, particularly regarding the hypothesis that non-action can be partly explained by the fact that people are scared into passivity and powerlessness (Stoknes, 2015). Several studies have analysed the effect of appeals to fear (or rather alarmist discourse) and concluded that it does not work (Jost et al., 2007; Moser, 2007; O'Neill & Nicholson-Cole, 2009). This insight has been connected to studies that have shown that hopeful messages can promote action (Bennett et al., 2016; Stern, 2012), which in turn often led to the simplified conclusion in the climate communication discourse that one should communicate hope rather than fear (Shanahan, 2007; Stoknes, 2015). Our findings show that fear can be a driving force for behaviour change, which is supported also by Kleres and Wettergren (2017). This applies to fear as an emotion grounded in realizing the severity of climate change, which is not the same as saying that alarmist messages work.

Personal *morality*, often expressed in terms of conscience, is a category of particular interest and with different forms. This is consistent with the findings of Büchs (2017). One form of morality is justice, which can surface when individual emissions are made visible and material, and when associated with the Paris Agreement or a global average. This dimension seems to make knowledge ethical. Knowledge of what is sometimes called inequality invokes moral action. The term 'responsibility' is recurrent, which puts the individual in relation to others, either other people far away or future generations. Frequently this is connected to the maintenance of the self as a consistent whole. However, it also expands to the category of *children and future generations*.

The *public debate* and the *social context* are invoked among the motives for change in our material. The change process seems to be facilitated by a social context in which experience can be shared (e.g., groups on the internet, at work, or at home), or by inspiring *role models* and good examples. This is well known in the health sector. However, identifying alternative ways to live or be is also important. In fact, the process by which knowledge becomes real may be facilitated by a supporting social context. This would be in line with the theory of cultural cognition where human rationality is believed to be deeply social (Mercier & Sperber, 2017), and supported by research on deliberative social change processes and learning (Wals & Rodela, 2014). Our respondents display a deliberative individual rationality, a rationality that is emotionally grounded, morally responsible, and socially dependent.

Shame, which has taken centre stage in the Swedish context and, so to speak, acquired wings of its own, is not frequent nor articulated in the material. This is contrary to the common understanding of what feelings might be associated with stopping to fly (Mkono & Hughes, 2020).

Instead of invoking shame, our respondents talk about conscience or sometimes guilt. As this is of interest in the larger discussion on behavioural change, these findings need unpacking.

Shame is arguably a feeling that comes from a mismatch between how the outside world views you and how you view yourself. Shame can also be understood as a tension between who you identify as and how you act. Guilt, on the other hand, can be felt without an audience and be entirely an internal experience. Guilt appears when people do things they consider morally problematic, but without experiencing it as a threat to their perceived identity (Bedford & Hwang, 2003).

Shame, understood as a social emotion, is rather absent in the material. However, it is clear that the moral understanding of and reasoning about flying has been impacted by a changed public and social discourse. The social discourse of our respondents is described as supportive rather than shaming. It is also probable that our respondents, who have stopped flying, are less likely to relate to shame. Shame as an issue of identity resonates with looking at the internal deliberation as a conversation between the person you want to be and the choices that you make. From this viewpoint, the dissonance is not only cognitive but might also threaten one's perceived identity. This is for instance visible in the wish to look "future children in the eye." The two ways of understanding shame come together as two dimensions of the same emotion; the topoi include internalization of the gaze and expectation of an 'other.'

Guilt, felt when failing to meet one's moral standard, is abundant in the answers that bring up moral dimensions. Although a social context is discernible, it is not necessarily integrated or highlighted as a motive stated by the respondent. Respondents instead often view themselves as autonomous and bring forward motives stressing responsibility or justice.

Even though guilt and shame can be intellectually and emotionally separated, it might be more useful to view them as two perspectives on the same phenomenon. This would correspond to a rhetorical understanding of meaning-making as simultaneously social and identity-building. Furthermore, in the Swedish context, the words shame and guilt often come together ('skam' and 'skuld') and there are reasons to believe that the distinction is not withheld in the public discourse. There are also reasons to conflate them according to a media logic that privileges strong negative feelings over empathetic reasoning. To feel shame is indeed most disturbing and deeply negative, and thus talking about flying and shame is a functional way of colouring the entire discourse. To many of our respondents, the moral dimension is crucial, but the social discourse is supportive rather than shaming.

To our knowledge, there are thus far no attribution studies that can assert that those who stopped flying are the ones primarily using the term flygskam, nor engage in flight shaming, as some scholars have suggested (Mkono,

2020). On the contrary, the We Stay on the Ground movement explicitly works to avoid shame (Rosén, 2019). We believe it is more likely to be used by flyers to characterize and thereby dismiss a potentially disruptive movement, but more research is needed.

The last thematic category in our list, *alternatives*, can also be seen as part of a process of change, just like the social context. In theory, these alternatives exist to all, and the literature on sustainable tourism illustrates the complexity of the larger issue (Becken, 2019; Pyke, Hartwell, Blake, & Hemingway, 2016), but the alternatives become real only when it is possible to assess them as alternatives. Then they support the original issue of stopping flying. We suggest that it is not only the will to change behaviour that affects the willingness to find alternatives, but that the awareness of attractive alternatives also affects the ability to take on new knowledge.

Finally, as for the process of change, this is analogous to Vladimir Propp's structural elements of a story. He mapped 31 basic functions of a fairy tale. Not everyone is included in every story, but those who are often appear in a specific order and relationship to each other: The hero leaves the home. The hero is warned against some action. The hero does not listen to the command. The villain enters the story. The villain seeks information and later deceives the victim, etc. (Propp, 1968). We can discern a story of change in our material of separate arguments. This relates well to the study by Jacobson et al. (2020), where they describe a "tipping point" when awareness evokes negative emotions leading to a decision to reduce or quit flying and discern the workings of conscience and social discourse.

7. Conclusion

Contrary to existing understanding, knowledge and fear are brought forward as important factors for change among those who stopped or drastically reduced flying for climate reasons in this study. This underscores the importance of further studying which knowledge enables action, and if and how it can be promoted. The inner emotional conflicts that climate change brings about are also important. Moreover, the role of social context is underscored. Children, in particular, serve as those who bring knowledge, awaken conscience, demand consistency, and embody the future. It is particularly interesting to see how these dimensions—knowledge, emotions, and social context—speak to conscience, and interact with a sense of individual responsibility.

Finally, the sense of moral agency among our respondents is noteworthy. Not only is it contrary to a widespread assumption on maximizing personal gain, but it is also rewarding to watch a transition process take form.

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Conflict of Interests

The authors declare no conflict of interests.

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