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How socially just are taxes on air travel and 'frequent flyer levies'?

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ABSTRACT

Policies to reduce air travel demand, including in the tourism sector, are urgently required as air travel's climate impact keeps growing while low-carbon aviation remains a distant perspective. Policy options include flat rate taxes per flight, taxes on flight miles or emissions, or frequent flyer levies, yet little is known about how their distributional impacts compare. This paper examines the distributional effects of various air travel tax options for the UK, informed by an analysis of the distribution of (frequent) flights and associated emissions over income and other social characteristics. We find that 'frequent flights' are even more unequally distributed than all flights and that all taxes on air travel are distributionally neutral or progressive. The most progressive option is a 'frequent air miles tax' based on both the number of flights and emissions. At the same time, some social groups like recent migrants are relatively likely to be 'frequent flyers' even on lower incomes. Overall however, our results show that taxing air travel is far less regressive than taxing home energy or motor fuels. Taxes on air travel, while often portrayed as unfair in public discourses, therefore raise fewer fairness concerns than other types of carbon taxes.

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Air travel taxes; Carbon taxes; Frequent flyer levy; inequality; fairness; social justice; demand reduction; climate change; regressive and progressive taxes

Introduction

Air travel is the most carbon intensive mode of travel per passenger kilometre, and its contribution to the climate emergency is increasing. Greenhouse gas emissions (GHG) from air travel have grown nearly seven-fold between 1960 and 2018, and they currently account for at least 3.5% of global heating if all climate forcing impacts are considered (Lee, Fahey et al. 2021). In high-income countries, air travel makes up a high proportion of transport emissions and of the carbon footprints of those who fly (Ivanova & Wood 2020). Frequent flyers contribute a particularly high proportion to all aviation emissions (Gössling & Humpe 2020).

While globally the fuel efficiency of air travel has improved by around 1.3% per year since 1960 (Grewe, Gangoli Rao et al. 2021), the decarbonisation of air travel remains challenging (Åkerman, Kamb et al. 2021, Gössling & Lyle 2021, Lai, Christley et al. 2022). This makes it difficult

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for the tourism industry to meet its climate goals. Air travel is responsible for a large and growing share of emissions from tourism (Lenzen, Sun et al. 2018, WTO & ITF 2019, Scott & Gössling 2022), with personal air travel accounting for the bulk of it, particularly in the international segment. Conversely, passenger aviation is the only travel mode that deals almost entirely with the tourism market (Graham & Dobruszkes 2019). As such, measures to reduce the climate impact of air travel are a key part of any sustainable tourism vision (Higham, Font et al. 2022, Scott & Gössling 2022). As Higham et al. (2022) put it, "most urgent priorities for advancing the net zero tourism agenda centre almost exclusively on high carbon transportation", and this "will require that decisive policy and regulatory actions are taken", notably with regard to aviation (p.3).

The UK is an interesting case study in this context, as it is the fifth country worldwide for outbound tourism departures (UNWTO 2019), the third departure country worldwide for CO_2 emissions from passenger aviation (Graver, Rutherford et al. 2020) and has some of the highest shares of people flying once a year or more (Hopkinson & Cairns 2021). At the same time, it was the first major nation to include international aviation in its emissions targets (CCC 2020) and one of the first countries where new tax concepts such as the 'frequent flyer levy' have been discussed. The UK Climate Change Committee recommended that air travel growth should not exceed 25% above current levels if the government wants to achieve net-zero emissions by 2050 (Allwood, Azevedo et al. 2019, Carmichael 2019). Even so, air travel would contribute 36% to the total UK carbon budget by 2050, the largest share of all sources (Chapman, Murray et al. 2021: 5). At the same time, UK air travel emissions are predicted to rise much faster than the recommended threshold of 25% (ibid.).

Currently, international aviation fuel is exempt from taxation due to a 1944 international agreement. In the UK, Air Passenger Duty is applied to around 70% of all flights departing from the UK due to certain exemptions (Chapman, Murray et al. 2021). In 2021, Air Passenger Duty on domestic UK flights was halved, and only increased for long-haul flights of 5,500 miles and over. Unlike motor fuels, electricity or gas, no value-added tax or fuel duty is charged on domestic flights in the UK. According to the UK Emission Trading Scheme (ETS), airline operators in the UK also need to purchase emission permits if they have exhausted their free allowance. Under the pilot phase of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), airline operators must purchase carbon offsets for routes between the UK and other participating countries to cover emission increases compared to the 2019 baseline. Airline operators can pass costs of the ETS or CORSIA on to consumers through ticket prices, but the extent to which this happens is unclear.

For these reasons, there are increasing calls for measures to curb air travel demand, including new air travel taxes (e.g. Bows-Larkin, Mander et al. 2016, Higham, Cohen et al. 2016, Lenzen, Sun et al. 2018, Larsson, Elofsson et al. 2019, Gössling & Lyle 2021). Several studies find that taxes on air travel could make an important contribution to curbing demand (Falk & Hagsten 2019, van Ewijk & Hoekman 2021, Oesingmann 2022).

What remains unclear is how socially just air travel taxes would be, especially if compared to carbon taxes in other consumption domains, and how their distributional implications would differ depending on the design of the tax. This article examines these questions by comparing the distributional impacts of four options for air travel taxes in the UK: The UK Air Passenger Duty; a single rate tax per tonne of CO_2 (flight emissions tax); a frequent flyer levy, and a 'frequent air miles tax' that takes both emissions and number of flights into account. We also compare the distributional impacts of the flight emissions tax with those of carbon taxes on home energy, motor fuel, and total emissions.

Distributional impacts of taxes mainly depend on the underlying distribution of consumption across income and other social groups. In this paper, we are interested in the distributional impacts of different types of flight taxes, especially in differences between distance-based flight taxes and frequent flyer levies, as the latter are often presented as a more socially just alternative to other flight tax models. To inform this analysis, we compare inequality of all air travel with inequality of 'frequent flights', which in this paper we define as flights that would be subject to a frequent flyer levy (see Methods section). Furthermore, we examine how the social characteristics of non-flyers, flyers, and frequent flyers differ, considering factors that have been overlooked to date such as migration background, ethnicity and dispersion of social networks. This analysis sheds additional light on which groups would be most impacted by flight taxes, and especially by frequent flyer levies. The analysis is based on two representative datasets for the UK which capture respondents' personal flights, excluding business flights.

In the next section, we review the literature on social justice and emission taxes, including those from air travel, and air travel inequality. Throughout the section, we highlight how our study advances the state-of-the-art in these areas.

Literature review and research contribution

Environmental taxes and social justice

Given that taxes on air travel are one of the most widely discussed instruments for reducing air travel demand, it is crucial to consider possible justice implications of such taxes. Perceptions of justice implications of air travel taxes are also likely to influence public support for and political feasibility of their introduction. The literature on justice issues, climate change and climate policy often distinguishes three dimensions of justice: distributive, procedural and recognition justice (Schlosberg & Collins 2014, Newell, Srivastava et al. 2021). In this paper, we focus on distributive justice related to different types of air travel taxes as well as carbon taxes in other consumption domains. In climate justice debates, distributive justice is often discussed in terms of responsibility and capability (Newell, Srivastava et al. 2021). Responsibility refers to an actor's or entity's role in contributing to climate change which then constitutes responsibility for mitigation. Since high emitters contribute more to climate change, they are deemed more responsible to pay for mitigation. Capability refers to the capacity to mitigate or adapt to climate change. Those who have the greatest resources are most capable to mitigate or adapt and are hence regarded as those who should bear more of the cost. Climate change policies can be regarded as distributionally unjust if those who have contributed least to the problem (low emitters) or who have least capacity to mitigate or adapt bear higher cost of climate policies (Martin, Sendra et al. 2021: section 3.5). The distributional impacts of climate policies, including carbon taxes, are called regressive if they burden people on low incomes more than people on high incomes relative to income, progressive if the opposite is the case, and neutral if relative tax burdens are evenly distributed across income groups.

Previous research shows that carbon or energy taxes tend to have regressive distributional impacts if they are levied on consumption or emissions that are fairly evenly distributed across income groups. This is often the case with necessities; domestic energy is a prime example. Several studies show strongly regressive distributional impacts of energy or carbon taxes on domestic energy (Büchs, Ivanova et al. 2021, Campagnolo & De Cian 2022, Preuss, Reuter et al. 2021) which raises considerable justice concerns. As we will review below in more detail, previous studies have shown that air travel emissions are highly unequally distributed across income groups as higher-income groups contribute considerably higher shares to total emissions from air travel than low-income groups (Ivanova & Wood 2020, Büchs & Mattioli 2021). We would therefore expect taxes on air travel to be less regressive than taxes on home energy.

In the field of transport studies, there is rapidly growing literature on inequalities (e.g. Lucas 2012, Lucas, Mattioli et al. 2016), equity (e.g. Di Ciommo & Shiftan 2017, Lucas, Martens et al. 2019) and justice (e.g. Gössling 2016, Martens 2017, Pereira, Schwanen et al. 2017). However, this literature mostly focuses on daily travel and access to everyday services and opportunities, while inequalities in long-distance travel, and the policy issues they raise have been comparatively less investigated (though see Banister 2018, Büchs & Mattioli 2021, Dobruszkes, Chen et al. 2022).

Distributional impacts of motor fuel price increases and motor fuel taxes have received some research attention within this field, showing regressive impacts for most high-income countries even though taxes on motor fuels tend to be less regressive compared to those on home energy (Mattioli, Wadud et al. 2018, Büchs, Ivanova et al. 2021). While there is emerging research on tourism and justice (Guia 2021, Jamal & Higham 2021), to the best of our knowledge it has not focused on the distributional impact of carbon taxes on air travel, despite aviation accounting for a large share of tourism-related transport and related climate impact.

Overall, research gaps remain on how socially just different types of taxes on air travel would be, and how their distributional impacts would compare to carbon taxes in other domains. When different types of taxes on air travel are considered, it is possible that their distributional impacts vary depending on whether all flights are included, or whether an allowance is made for the first return flight. Taxes that apply to all flights are sometimes regarded as unfair as they would also affect people who only take one return flight per year. For instance, perceptions of the unfairness of taxes on air travel are implicit in statements like the one by a UK Treasury Minister that any further increase to the air passenger duty would "hammer hardworking families and prevent them from enjoying their chance to go abroad" (Woodling 2019). Partly in response to fairness considerations, several organisations in the UK have proposed an alternative Frequent Flyer Levy (e.g. Carmichael 2019, Green Party 2019, Liberal Democrats 2019) which would exclude the first return flight a person makes. Some regard this as fairer on people who only take one or few return flights per year. However, this approach would not take the environmental impact of the first flight, and differences in flight distance, into account.

While there are no existing peer reviewed studies on the distributional impacts of different types of air travel taxes (but see the working paper by Fouquet and O'Garra (2020) which finds progressive impacts of a frequent flyer levy and an aviation carbon tax), a review of the literature on inequalities of all air travel, and of frequent flights specifically, can help to inform hypotheses about the distributional impacts of air travel taxes.

Inequalities in air travel and frequent air travel

How the distributional impacts of different flight taxes such as a flat tax per flight or a frequent flyer levy vary, will partly depend on how unequally all flights and frequent flights are distributed in the population. For instance, it is often assumed that a frequent flyer levy which excludes the first return flight is less regressive than a carbon tax on air travel emissions because it is predominantly richer and more privileged people who fly frequently (e.g. Carmichael 2019: 34, Büchs & Mattioli 2021).

Several studies demonstrate the statistical association between income and frequency of air travel at the individual level (e.g. Schubert, Sohre et al. 2020, Kim & Mokhtarian 2021), and show aggregate patterns of inequality of air travel over income groups (e.g. Banister 2018, Gössling & Humpe 2020, Büchs & Mattioli 2021). However, to the best of our knowledge, there are no peer-reviewed studies yet that *compare* inequality of all air travel and 'frequent air travel' over income groups. This is key to understanding possible differences in the distributional impact of frequent flyer levies as compared to other flight tax models.

A similar gap in research exists regarding which social groups would be most affected by taxes on flights or frequent flights, which depends on who takes part in air travel and frequent air travel. The few studies that examine social characteristics of frequent flyers find that they tend to be people with high incomes, high education and high occupational positions, singles or couples without children (Gössling, Ceron et al. 2009, Castillo-Manzano & López-Valpuesta 2014, Zuskáčová & Seidenglanz 2019). This is consistent with the broader literature on the determinants of air travel, which finds positive associations with income, employment, education and absence of children (Alcock, White et al. 2017, Czepkiewicz, Ottelin et al. 2018, Schubert, Sohre et al. 2020, Falk & Hagsten 2021, Kim & Mokhtarian 2021). However, to our knowledge there are no studies comparing the characteristics of those who fly more generally with those who take 'frequent flights'.

Some have argued that people with migration background or geographically dispersed social networks might be particularly likely to fly and therefore be adversely affected by frequent flyer levies. For instance, according to proponents of the frequent flyer levy, one of the reasons for exempting the first return flight in each year is to "ensure that immigrants … are not unduly burdened" (Murray 2015: 10). Stay Grounded (2019), a global activist network which aims to "reduce air travel in a just way", has made very similar arguments. Yet to the best of our knowledge no study has investigated how migration background, ethnicity and social network dispersion impact on the probability of being affected by air travel taxes, and frequent flyer levies specifically. Migrants and other people with family abroad are important contributors to 'visiting friends and relatives' (VFR) travel. VFR constitutes an important and rapidly growing segment of international tourism but has been chronically overlooked within tourism research (Zentveld, Labas et al. 2022). By including these variables in the analysis, we also gain insights into how the environmental taxes required to achieve sustainable tourism would impact the VFR segment.

This paper addresses these various gaps in the literature, providing for the first time a comparison of the inequality and social characteristics of flyers and frequent flyers, as well as an analysis of the distributional impacts of different types of flight taxes as well as taxes on home energy and motor fuels in the UK.

Materials and methods

Data

To examine the inequality of air travel and frequent air travel, we use data from the Understanding Society (The UK Household Longitudinal Study) survey (US) (University of Essex & Institute for Social & Economic Research 2021), and from the Living Costs and Food Survey 2006-2018 Secure Access dataset (LCF) (DEFRA/ONS 2019). US is employed to examine inequality of the number of flights and frequent flights and characteristics associated with flying and 'frequent flying'. The LCF is employed to examine the inequality of emissions associated with flights and frequent flights, and distributional impacts of air travel taxes.

Understanding society survey

Understanding Society (US) is a nationally representative, general-purpose survey. In this study, 'frequent flights' are defined as all flights above the first return flight, i.e. flights that would be subject to the UK proposal for a Frequent Flyer Levy which exempts the first return flight (Chapman, Murray et al. 2021). The analysis utilises US wave 10 (2018-2019) which has a sample size of 34,318 individuals. Respondents reported the number of return flights they had taken over the last 12 months "for leisure, holidays or visiting friends or family"; the survey question explicitly excludes air travel "for work or business purposes" (see the next section for a justification for focusing on personal air travel). A limitation of the US survey is that respondents were instructed to "count the outward and return flight and any transfers as one flight", which could lead to an underestimation of the number of flights in the case of long-haul flights with multiple legs (see e.g. Larsson, Kamb et al. 2018).

The US dataset includes a range of variables that are potentially associated with air travel frequency. We investigate these patterns of association with bivariate and multivariate analysis. Besides basic socio-economic characteristics, we consider ethnicity and migration background. Here we distinguish between first-generation (born abroad), second- (parents born abroad), and third-generation (grandparents born abroad). All other respondents (including those with missing information) were assigned to the “fourth generation or more” category. We further distinguish between ‘recent’ first generation migrants (arrived 10 years or less before the interview) and others[1]. Other unique predictors used in our analysis include: population density at the Lower Layer Super Output Area (LSOA) level from the 2011 Census; and a dummy assessing whether the individual is the responsible adult for cohabiting children (which in households with two parents it is often still the mother) (University of Essex & Institute for Social & Economic Research 2021).

While our analysis is cross-sectional, we additionally use variables collected in Wave 9 (2017-18), i.e., one year before the air travel interview, for information on the geographical dispersion of respondents’ social networks. This includes the share of friends who live outside of the ‘local area’ (as defined by the respondent) and whether any close relative (parents or children) was living abroad at the time of the interview.

For the analysis of air travel inequality, we use the full sample for wave 10, minus cases with missing information on air travel frequency and/or household income. For the analysis of the determinants of (frequent) flying, we further restrict our sample to respondents who participated in both waves 9 and 10 and provided complete information on all dependent and independent variables (listwise deletion). We applied appropriate weights provided by US to adjust for differences in sample selection probability and respondent drop-off, while also considering other aspects of survey design (sampling clusters and strata).

Living costs and food survey

The Living Costs and Food Survey 2006-2018 Secure Access dataset (LCF) (DEFRA/ONS 2019) is utilised for analysing inequality of flight emissions and the distributional impacts of different types of air travel taxes and carbon taxes on home energy, motor fuels and total household emissions. The LCF is an annual survey that is representative at the household level in the UK. The LCF collects information about flights through a household survey completed by the household representative. Survey participants are asked whether the household purchased a flight for “holiday or leisure” purposes in the past 12 months, i.e. excluding business flights. For the distributional analysis of flight tax burdens conducted in this paper, using leisure flights is appropriate, as the costs for business flights are generally not borne by private individuals. Furthermore, around 81% of all flights in the UK are conducted for leisure purposes (Statistica 2022). We note, however, that the exclusion of business flights potentially underestimates flight tax burdens related to leisure flights because some customers might combine business and leisure trips. While we believe that survey designs should be improved to better capture the blurring of business and leisure travel, there is currently no UK survey available that collects information on leisure and business air travel, as well as flight distance.

For up to 16 flights, the LCF interview protocol checks whether the flight was domestic or international, and for international flights only, information is collected on the destination country and how many household members took the flight. Since destination country information is only available in the Secure Access version of the dataset from 2014 onwards, we utilise years 2014-2017/8 for this analysis. To our knowledge, this is the first paper that utilises the destination country information to estimate flight emissions, emission distribution, and the distribution of air travel tax burdens.

The LCF distinguishes between single and return flights for UK destinations, but not for international flights. We assume flights from the UK to international destinations to be return flights, and “other” international flights to be single flights, e.g. connecting flights from one international destination to another. This may lead to slight inaccuracies and underestimate emissions for “other” international flights, but since they only make up 3% of all flights this should not have a large impact on overall results. While the UK Air Passenger Duty does not cover flights that start overseas, we include “other” international flights in the flight tax calculations to get a fuller

Table 1. Utilisation of the living costs and food survey and understanding society survey in the analysis.

Analysis	LCF	US
Air travel emissions	✓	
Number of flights		✓
Distributional impacts of flight taxes	✓	
Social characteristics of participation in air travel and frequent air travel		✓

picture of air travel behaviour and resulting flight taxes. This decision is also informed by the view that international coordination on aviation taxes would be an important policy development to create a level playing field across countries. Each LCF survey round includes around 5,000 households, creating a total sample size for our analysis of 20,502 households.

To estimate GHG emissions associated with air travel, we estimate the flight distance for international flights based on the online "Distance From To" calculator using capital cities of destination countries as start and end points.[2] For UK flights, we apply an average distance of 622 km per single flight, based on the average UK flight distance derived from International Passenger and National Travel Survey as previously applied in Büchs and Schnepf (2013). We then apply UK Government conversion factors for air travel in kg CO_2 equivalent (CO_2e) per passenger km, including radiative forcing and indirect "well-to-tank" emissions for aviation fuels, separately for each year. We apply different factors for domestic, short-haul ("other" international flights) and long-haul (international return) flights, and use the values for "average passengers" which represent a mean for different flight classes (BEIS 2013-2021).

To estimate emissions from home energy, motor fuels and all other consumption (including public transport), we apply GHG conversion factors from DEFRA/The University of Leeds based on Multi-Regional Input-Output Analysis (DEFRA 2021). The conversion factors are expressed in kg CO_2e per £ expenditure, and are applied to household expenditure from the LCF to estimate household emissions.

Methods

Due to the different ways in which the LCF and US collect data on flights, each of the datasets is used for different parts of the analysis to harness their advantages (Table 1).

Both datasets are used to provide descriptive analysis of inequality of air travel and frequent air travel, including distributional measures like Lorenz curves, the Gini coefficient, and distribution over income deciles. The LCF is utilised to examine inequality of emissions, and US is used to analyse inequality of the number of flights. To examine the distribution and inequality of frequent flights, we create a variable in US that is set to zero for 0-1 return flights per individual, while reporting the actual number of flights (minus one exempted flight) for individuals with two return flights or more.

We employ regression based on the US data to examine how the probability of individuals not to fly, to take one return flight, and to fly more than that in one year is associated with individual characteristics. The dependent variable is ordinal, but here we are particularly interested in how the predictors may have different effects on the probability of taking just one return flight per year (and thus being exempt from a 'frequent flyer levy') as opposed to flying more frequently than that (and being affected by it). As such, we estimate a generalised ordered logit model (Long & Freese 2013: 371-374), which relaxes the 'parallel regression assumption' built into the more stringent ordinal logit model, which is rejected for our data. We tested alternative modelling approaches, including multinomial and ordinal logit, obtaining very similar results.

Since the coefficients of regression models for categorical dependent variables are difficult to interpret, we present Average Marginal Effects (AME) and predicted probabilities in the main text. AMEs measure the change in the probability of the outcome for a change in the predictor, while holding other independent variables constant. They are averaged across the sample and sum to zero for the categories of the dependent variable. AMEs provide "the best summary of the effect of a variable" and "can be interpreted as the average size of the effect in the sample" (Long & Freese, 2013: 245). We use the generalised ordered logit model results to estimate predicted probabilities for combinations of predictor values that are of substantive interest, e.g. to illustrate the combined effect of income and migration background on the probability of being a 'frequent flyer'. The full results of the generalised ordered logit model, including multiplicative coefficients (relative risk ratios) and goodness-of-fit measures, are included in the Supplementary Information.

Air travel tax models

We examine the distributional implications of four different types of air travel taxes based on LCF data: The UK Air Passenger Duty (2021 version); a tax per tonne of CO_2 ('flight emissions tax'); a 'frequent flyer levy', and a 'frequent air miles tax' that takes both emissions and the number of flights into account. Tax burdens as a percentage of disposable household income and the distribution of tax burdens over equivalised disposable income deciles are calculated. The top and bottom 1% of the income distribution are excluded from this analysis because income outliers may bias the results. We also calculate the tax burden ratio of the first (lowest) and fifth (highest) income quintile, and differences of average tax burdens across social groups, to examine whether the distributional impacts of the different types of taxes are progressive, regressive or neutral.

For each of the four tax models, two versions are estimated where one excludes the first return flight, and the other includes all flights. The distribution of tax burdens is conducted as a "day after" analysis, i.e. we do not take possible behaviour changes in response to taxes into account (e.g. based on price or income elasticities).

Since the LCF is a household survey which collects data on flights at the household level (aggregating information from all household members), the distributional analysis of flight taxes refers to the household level. To exclude the first return flight in the first variant of the tax models, flights for all household members who participated in the first household flight are excluded. Similarly, to identify frequent flights and estimate associated emissions, we include all flights made by any household members who participated in any second or subsequent flight purchased by the household during the survey year. It needs to be noted that the tax models that exclude the first return flight do include a small number of first return flights for instances in which only one member of a multi-person household participates in the first household flight, but additional household members participate in a subsequent household flight. We cannot exclude these subsequent flights from the analysis because exemptions can only be applied at the household level, not at the individual level. However, it is unlikely that this has any significant impact on the analysis as it only affects around 4% of frequent flights.

The four air travel tax models are defined as follows, where one variant excludes the first return flight (reported in the main paper), while the other includes all flights (reported in the Supplementary Information):

1. *Air Passenger Duty* – based on the version proposed by the UK Government in 2021 (HM Treasury 2021). UK Air Passenger Duty is a charge per flight paid by airline carriers. For our analysis, we assume that this charge is passed on to consumers via the ticket price. The Air Passenger Duty varies by distance and seat class. Band A rates are charged on flights under 2,000 miles, band B rates on flights over 2,000 miles, and band C rates on flights of over 5,500 miles. Since the LCF only includes personal flights we apply the lowest charge for economy class: £6.50 per single UK flight, £13 for UK return flights and flights to international destinations of under 2,000 miles per leg, £87 for flights to international destinations of between 2,000 and 5,500 miles per leg, and £91 for flights of over 5,500 miles per leg.

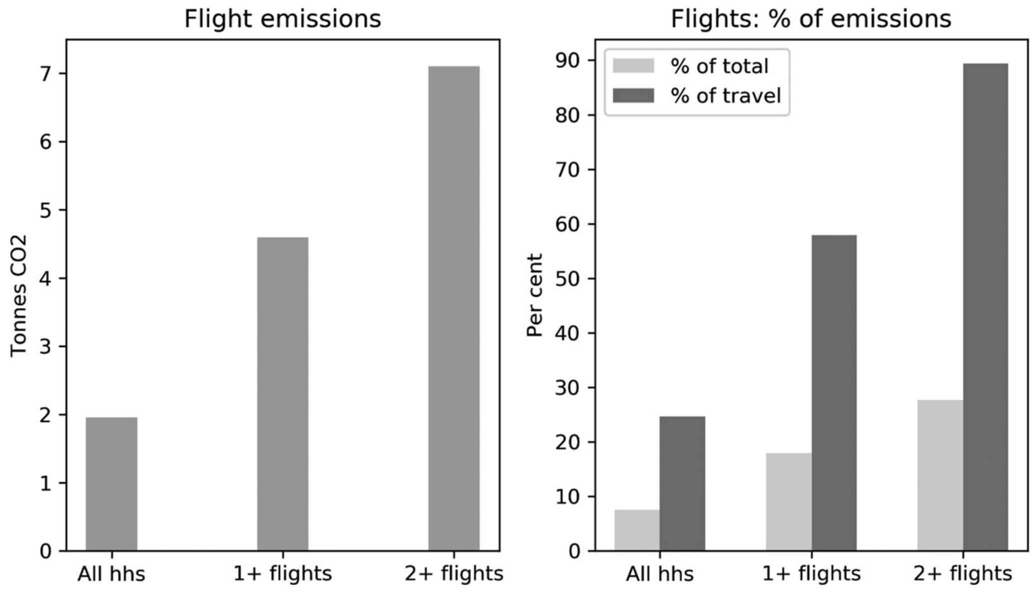

Figure 1. Air travel emissions, and air travel emissions in per cent of average total and average travel emissions for all households, households with at least one, and households with two or more return flights. Data: LCF Secure Access 2014-19.

2. *Flight Emissions Tax* - a tax of £50 per tonne of CO_2e associated with air travel.
3. *Frequent Flyer Levy* - based on the proposal by the New Economics Foundation/We Are Possible (Chapman, Murray et al. 2021). This model applies a levy per flight starting with £25 for the second return flight which then increases by £10 per additional flight. In the model that includes the first return flight, we assume a charge of £10 for the first return flight (see Supplementary Information).
4. *Frequent Air Miles Tax* - based on the proposal by Fouquet and O'Garra (2020) to combine a tax on emissions with the number of flights. Here, £50 are charged per tonne of CO_2e, and an additional £50 per tonne for each additional flight.

Results

Air travel emissions

The analysis of LCF data shows that emissions from air travel can make a significant contribution to total household emissions. Across all households, average air travel emissions per year are around 2.0 tonnes of CO_2e. Average total emissions per household per year are 25.7 tonnes of CO_2e and total travel emissions are 7.9 tonnes of CO_2e. This means that, on average, air travel emissions make up 7.6% of total household emissions and 24.7% of travel emissions for all households. However, these figures are considerably higher for households that fly. Households that have at least one flight per year have average air travel emissions of 4.6t CO_2e per year, equating to 17.9% of average total and 57.9% of average travel emissions. Households with two or more flights per year have air travel emissions of 7.1t CO_2e per year, or 27.7% of average total and 89.4% of average travel emissions (Figure 1). However, there are no significant differences in the average emissions per flight for households with only one return flight compared to those with frequent flights (0.75 tonnes per flight for each group). This means that on average, frequent flyers do not fly significantly shorter or longer distances than non-frequent flyers, and that the distributional impacts of taxes on flight emissions and of taxes on the number of flights should be similar (confirmed in our analysis below).

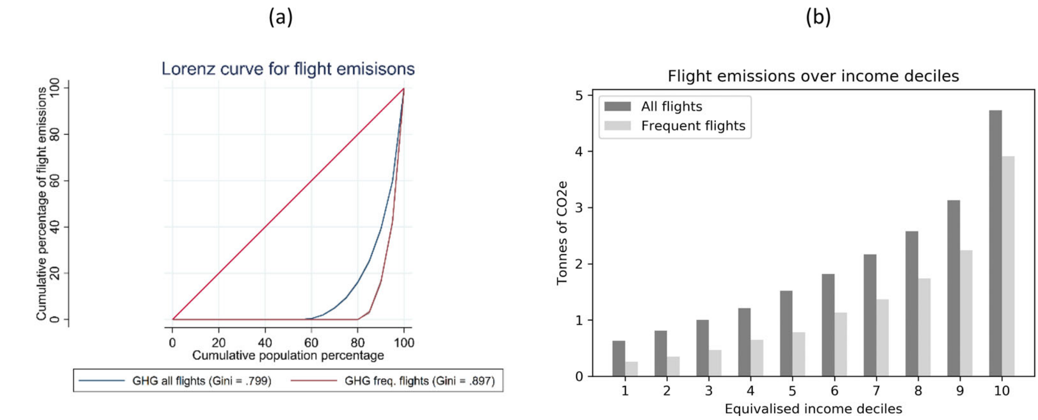

Figure 2. Distribution of annual flight emissions Data: LCF Secure Access 2014-2017/8, n = 20,502 households.

Inequality of flight emissions, flights and frequent flights

Flight emissions are very unequally distributed in the UK. Based on LCF data, the top 5% of flight GHG emitters are responsible for 40.2% of flight emissions and the top 10% for 60.8% of flight emissions, while the bottom 80% of flight GHG emitters only generate 16.1% of all flight emissions (Figure 2, panel a). The Gini coefficient for the inequality of flight emissions is 0.8 (on a scale from 0 to 1 where 1 is complete inequality). The distribution is even more unequal for frequent flyers: the top 5% of frequent flyers generate 57.8% and the top 10% emit 83.7% of all frequent flight emissions.

Flight emissions are also highly unequally distributed over income groups (Figure 2, panel b). While households in the lowest income decile have mean annual flight emissions of 0.63 tonnes of CO_2e, households in the top income decile have 7.5 times as many emissions with an average of 4.73 tonnes of CO_2e per year. Emissions from frequent flights are even more unequally distributed, with an average of 0.26 tonnes CO_2e per year for the bottom income decile, and 3.91 tonnes of CO_2e for the top income decile which is 15 times as much.

Another way of assessing the relationship between flight emissions and income is to plot the distribution of emissions over the income distribution in a 'concentration curve' which "illustrate[s] how one variable is distributed across the population, ranked by another variable" (Jann 2016: 860). The concentration curve shown in Supplementary Figure 1 depicts the cumulative distribution of flight emissions over the equivalised disposable income distribution: the top 5% of earners emit 13.6% of flight emissions; the top 10% of earners emit 23.8% of flight emissions; while the bottom 50% of earners only emit 26.2% of all flight emissions. The Gini coefficient for inequality of flight emissions over equivalised disposable income is 0.3. Inequality is even higher for frequent flights where the top 5% of earners emit 17.6% of frequent flight emissions, and the top 10% of earners emit 29.9% of frequent flight emissions while the bottom 50% of earners only emit 19.2% of frequent flight emissions.

The analysis of air travel frequency based on US data also finds high levels of inequality, although slightly less pronounced compared to flight emissions (Figure 3, panel a). The top 5% of flyers is responsible for 35.1% of total flights, and the top 10% for 51.2%, while the bottom 80% only make 28.6% of all air trips. When only flights that would be subject to a frequent flyer levy are included in the analysis, inequality patterns are even more pronounced: 70% of the population do not have any 'frequent flights', while the top 5% are responsible for 49.4% (the top 10% for 68.8%) of frequent flights. The Gini coefficient is 0.72 for all flights, and 0.84 for 'frequent flights', indicating that 'frequent flights' are even more unequally distributed among the population than all flights.

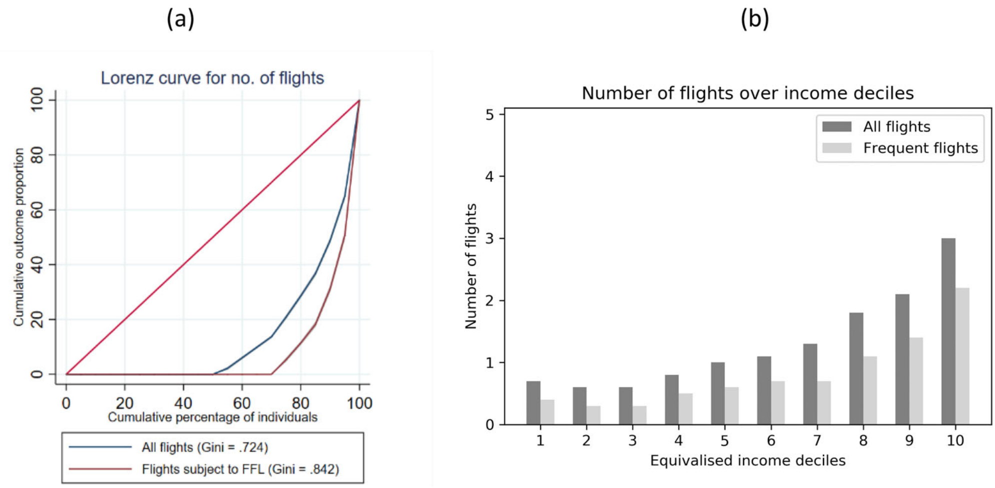

Figure 3. Distribution of the number of return flights. Data: Understanding Society 2018-2019. n = 24,152 individuals.

The number of flights that individuals take is again unequally distributed over equivalised income deciles. On average, individuals in the lowest income decile take 0.7 single flights per year, while individuals in the top income decile take 3 single flights per year, 4.4 times as many (Figure 3, panel b). Inequality of the number of flights is more pronounced for frequent flights, where individuals in the lowest income decile have 0.4 frequent flights per year, but individuals in the top income decile have 2.2 frequent flights per year on average, 5.9 times as many (Figure 3, panel b). The concentration curve in Supplementary Figure 2 shows patterns of inequality in the distribution of flights by income. The top 5% of earners are responsible for 13.0% of flights and 15.7% of 'frequent flights', while the richest top 10% takes 22.9% of all flight and 27.0% of 'frequent flights'. The lower half of the income distribution is responsible for just 28.8% of flights and 25.0% of 'frequent flights'. The bottom 10% of earners is responsible for 5.1% of all flights and 4.4% of frequent flights.

Distribution of tax burdens

The analysis of LCF data shows that all taxes on flights are broadly progressive as they burden higher income households more than lower income households relative to income, especially if the first return flight is excluded. However, households in the lowest income decile bear slightly higher burdens than households in the 2nd and 3rd decile, especially in the frequent flyer levy and the frequent air miles tax models (Figure 4). Including the first return flight increases the burden on lower income deciles, especially the bottom one. However, all tax models remain progressive or neutral overall (Supplementary Figure 3, Supplementary Table 3).

Furthermore, an analysis of household characteristics in the lowest income decile suggests that higher tax burdens for the lowest income decile are partly driven by households that are actually better situated, i.e. by households who record low levels of income but are likely to have high levels of wealth. Around 5.3% of households in the bottom income decile state that their main source of income comes from investments or "other sources" that are not wages, salaries or social security benefits (compared to 2.6% for the whole sample), and nearly 4% of households in the lowest income decile identify "annuities and pensions" as their main income source (compared to 10.4% in the whole sample). Households in the lowest income decile whose main income comes from either of these three sources have by far the highest number of flights and flight emissions, e.g. 1.8t CO_2e for those with investment incomes and 1.1t for those with pensions and annuities, compared to only 0.4t for those who receive their main

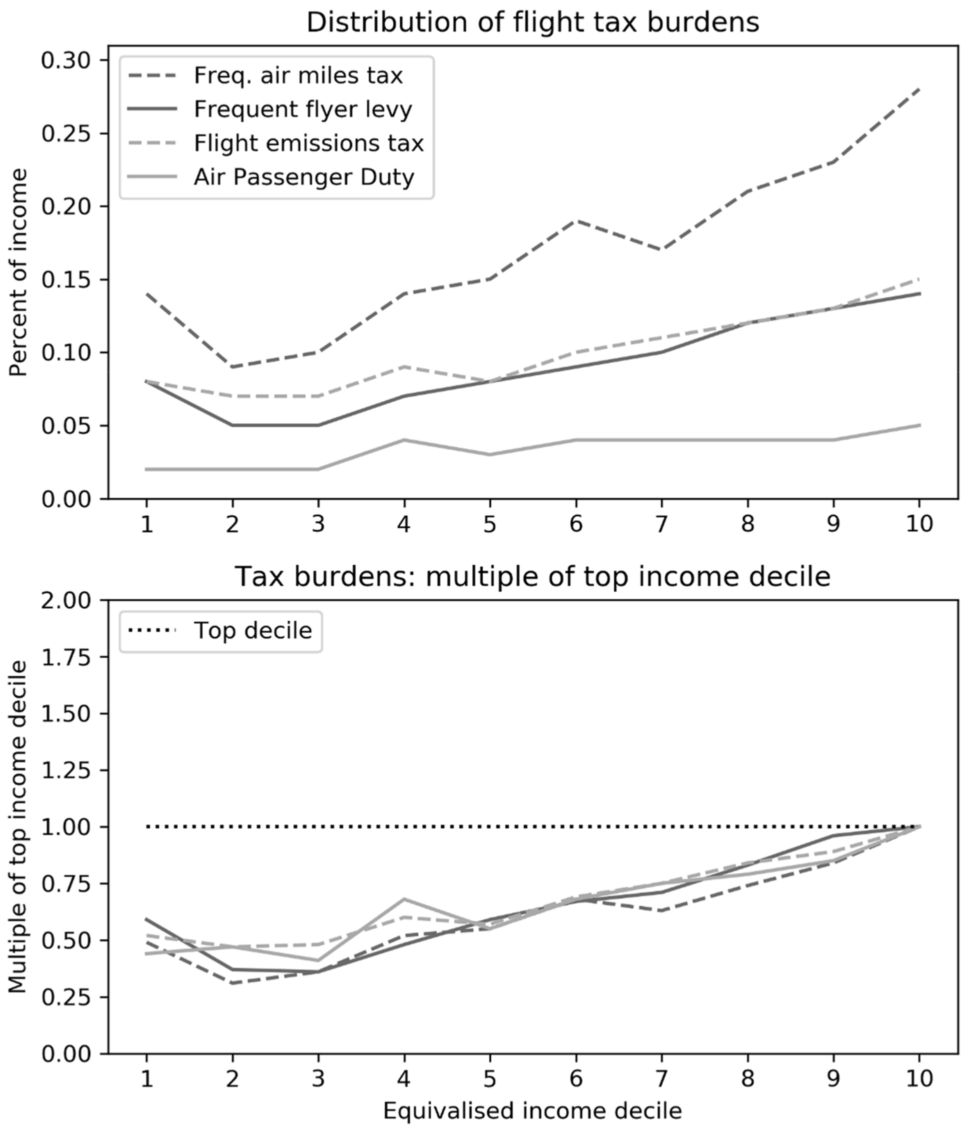

Figure 4. Distribution of burdens from taxes on flights excluding the first return flight. Per cent of income and multiple of the top income decile. Data: LCF Secure Access 2014-19. See section "Air travel tax models" for a description of the models.

income from social security benefits (70.2% of households in the lowest income decile). Since households with investment and "other" main income sources in the lowest income decile are likely to actually be quite wealthy, higher flight tax burdens are less of a concern for these groups from a justice perspective. If households whose main income source are investments, annuities and pensions, or "other" are removed from the analysis, the tax burdens from all models are lower or equal for the bottom income decile compared to the 2nd and 3rd income deciles (see Supplementary Table 2).

An analysis of mean tax burdens for households with different socio-economic characteristics confirms the overall progressive distributional impacts of flight taxes. Households with low income, children, household representatives aged 75 and over, low education, located in rural areas, unemployed, and those with long-term health problems tend to have significantly lower tax burdens than their counterparts for several tax models (Supplementary Table 4). However,

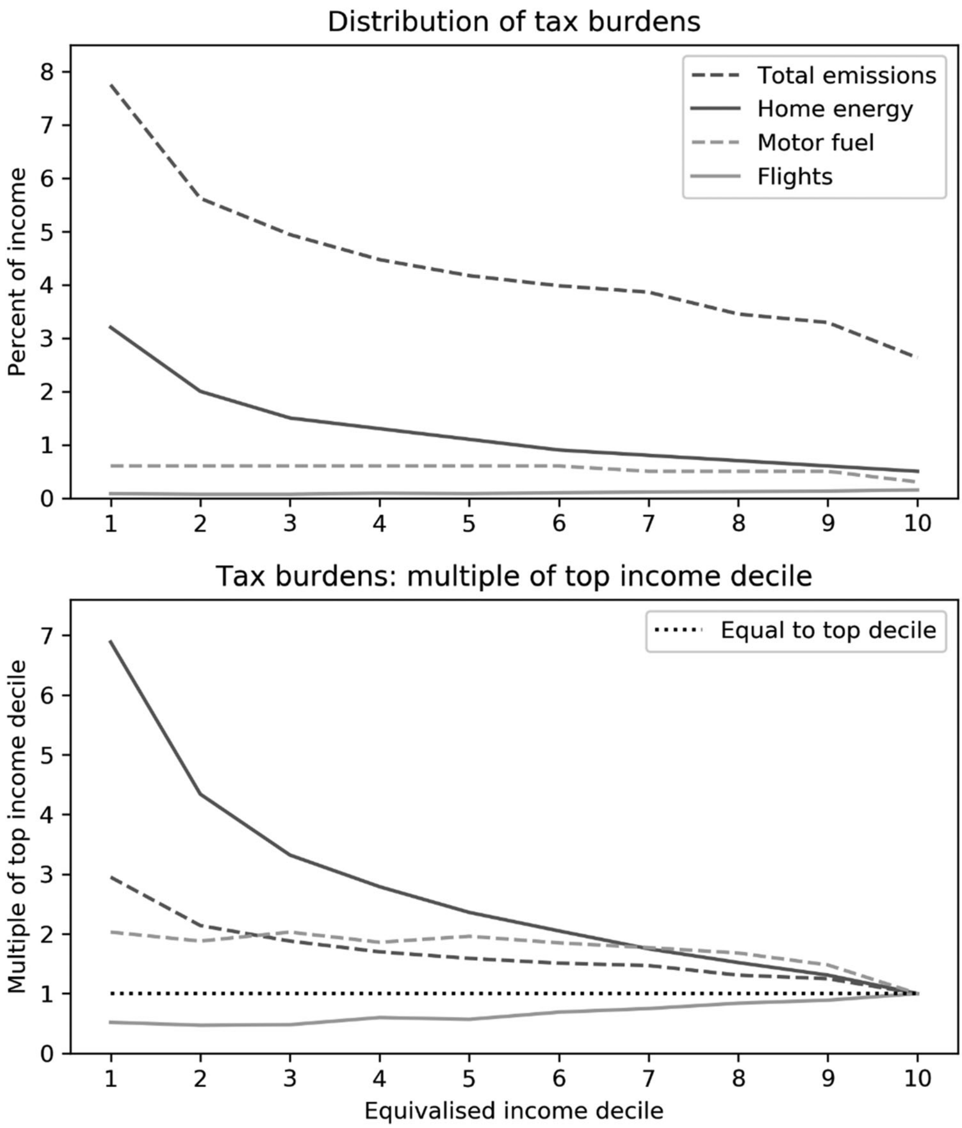

Figure 5. Distribution of burdens from a £50 per tonne of CO2e tax (for flights, the first return flight is excluded from the tax), per cent of income and multiple of the top income decile. Data: LCF Secure Access 2014-19.

households with household representatives of colour[3] bear significantly higher tax burdens than households with white representatives in both versions of the Air Passenger Duty and flight emissions tax models, and in the Frequent Air Miles Tax model if the first flight is included (Supplementary Table 4). Further analysis of the LCF data (not reported here for the sake of brevity) shows that households with representatives of colour have lower incomes, but a higher number of international flights and total air travel emissions than households with white representatives. These factors are likely to explain the higher tax burdens for households with representatives of colour.

A comparison with hypothetical carbon taxes in other consumption domains also demonstrates that taxes on flights are the only progressive type of carbon tax. We compare here a £50 per tonne of CO_2e tax on home energy, motor fuel and total household emissions with one on flights (excluding the first return flight). Figure 5 demonstrates that taxes on home energy are especially regressive, putting significantly higher burdens on low-income households compared to richer households. While taxes on motor fuels are still regressive on average as they generate higher burdens for low-income households, the burdens are more evenly distributed across equivalised income deciles compared to taxes on home energy.

Social characteristics of air travel and frequent air travel

In this section, we use US data to provide further detail on the inequality of air travel and on who would be most affected by flight taxes, investigating how a range of social characteristics are associated with participation in air travel and with being a frequent flyer. We first examine the proportion of different social groups that take part in flights and that are 'frequent flyers'. Second, we conduct a multivariate generalised ordered logit regression to examine how social characteristics are associated with the number of flights taken, holding other factors constant.

In the analysis sample, we find that 50.9% reported no flight over the last 12 months, 18.8% reported one return flight (hereafter referred to as 'infrequent flyers'), and 30.3% more than that ('frequent flyers'). The bivariate analysis (Table 2) shows that some of the groups that are overrepresented among those who have one return flight per year are also overrepresented among frequent flyers. This includes the top two income quintiles, university graduates, employed individuals, young and middle-aged adults, residents of London, as well as first and second-generation migrants. Other groups are overrepresented among infrequent flyers, but not among frequent flyers. This includes adults primarily responsible for children, residents of rural Wales, and individuals living in households with four or more members. Residents of Scotland and Northern Ireland, recent first-generation migrants as well as some ethnic minority groups (non-British white people (i.e. people who likely have a migration background), Asians and 'others'), and people with friends outside of the local area or close relatives abroad are overrepresented among frequent flyers, but not (or to a much lesser extent) among infrequent flyers. Overall, the groups with the highest rates of frequent flying (over 40%) are those in the top income quintile, the university-educated, recent migrants, non-British white people, people with close relatives abroad, and residents of London and Northern Ireland. These groups are likely to be among those affected by flight taxes, especially frequent flyer levies or 'frequent air miles taxes'. However, based on the LCF data, we found that households in Scotland and Northern Ireland did not have significantly different or even lower flight tax burdens (for three models that included all flights) than households in other government regions. Additional analysis shows that while households in Northern Ireland and Scotland have significantly higher numbers of UK flights than households in other regions, they are less likely to fly internationally and have lower air travel emissions overall than their counterparts which may explain this result.

Table 3 shows the Average Marginal Effects (AME) of the same independent variables on the probability of taking no flight, 1 return flight, and 2 or more return flights in the 12 months prior to the interview. The AMEs are derived from a generalised ordered logit model reported in full in Supplementary Table 5. Taken together, the findings of the multivariate analysis confirm the positive association of air travel frequency with income, education, employment, young age, migration background, social network dispersion and car ownership. Being in a cohabiting relationship, being female, and living in London, rural Scotland or Northern Ireland are also associated with more air travel, while responsibility for children, disability, and identifying as Asian or Black tend to decrease it.

Here, we are particularly interested in how certain predictors affect the probability of being a 'frequent flyer' (rightmost column in Table 3) differently than the probability of being an 'infrequent flyer' (middle column), as this is relevant for plans to introduce a frequent flyer levy. The AMEs show that several factors tend to significantly increase the probability of being a 'frequent flyer', but not that of being an 'infrequent flyer'. This is the case for most predictors including higher income, education, residence in London, (rural) Scotland and Northern Ireland,

Table 2. Percentage of individuals with zero, one and two or more return flights for private purposes over last 12 months, by independent variables (n = 15,603).

Variable	Value	None	1 flight	2 + flights
Income quintile (after housing costs, equivalised)	1st	70	15	15
	2nd	65	17	18
	3rd	52	21	28
	4th	41	22	37
	5th	29	20	52
Tertiary education	No	58	17	25
	Yes	39	21	40
Employment status	In paid employment	43	22	36
	Retired	65	13	22
	Other (non-employed, non-retired)	60	16	24
Age	16-29 years old	46	21	33
	30-59 years old	47	20	33
	60-74 years old	52	17	31
	75+ years old	76	11	14
Household size	1	64	13	23
	2	48	18	34
	3	47	20	33
	4+	49	22	29
In a cohabiting couple	No	58	17	25
	Yes	46	20	34
Sex	Male	[51]	[18]	[31]
	Female	[51]	[19]	[30]
Responsible for children	No	51	18	31
	Yes	53	23	24
Long-standing illness or disability	No	44	21	35
	Yes	63	16	22
Type of area	England: London metropolitan area	41	20	40
	England: other urban	54	19	28
	England: Rural	51	18	31
	Wales: Urban	56	16	28
	Wales: Rural	57	22	21
	Scotland: Urban	48	19	33
	Scotland: Rural	48	16	36
	Northern Ireland: Urban	41	18	41
	Northern Ireland: Rural	40	18	42
Population density	Low	[49]	[19]	[32]
	Medium	[51]	[19]	[30]
	High	[52]	[18]	[30]
Migration generation	4th+	52	19	29
	3rd	53	18	30
	2nd	45	21	34
	1st (10+ years)	42	20	39
	1st (less than 10 years)	33	19	48
Ethnicity	White British	52	19	30
	Other White	34	20	46
	Asian or Asian British	49	20	31
	Black or Black British	57	20	23
	Other + Mixed	48	20	33
Friends outside of local area	None	65	17	19
	Half or less	47	20	33
	More than half	50	18	32
Close family abroad	No	52	19	29
	Yes	30	21	49
Cars in household	No	75	11	14
	Yes	47	20	33

Note: values are reported between square brackets if there is no statistically significant difference between the categories of the independent variable (Chi-square and t-tests at $p < 0.05$). All other differences between categories of independent variables are significant.at the indicated level.

first-generation migration background, having friends outside of the local area or close family abroad, being in a cohabiting relationship, not having primary responsibility for children, female gender, and car ownership. This can be partly explained by the intermediate nature of the

Table 3. Results from a generalised ordered logit regression model for different categories of air travel frequency (no. of return flights): Average marginal effects.

	None	1 flight	2+ flights
Household Income, equivalised after housing costs (ref. cat.: 1st income quintile / bottom)			
2nd	−0.040*	−0.003	0.043*
3rd	−0.118***	0.002	0.116***
4th	−0.176***	−0.011	0.187***
5th – top	−0.254***	−0.028*	0.283***
Tertiary education qualification (dummy)	−0.062***	0.015	0.047***
Employment status (ref. cat.: In employment)			
Retired	0.076***	−0.041**	−0.034*
Other (non-employed, non-retired)	0.048***	−0.031**	−0.017
Age (ref.cat. 16-29 years old)			
30-59 years old	0.104***	−0.031**	−0.073***
60-74 years old	0.112***	−0.024	−0.088***
75+ years old	0.230***	−0.058***	−0.172***
Household size *	0.026***	0.006	−0.032***
Cohabiting couple (dummy)	−0.079***	0.011	0.069***
Female (dummy)	−0.041***	0.014	0.027**
Responsible for children <16 years old (dummy)	0.061***	0.019	−0.080***
Long-standing illness or disability (dummy)	0.091***	−0.018*	−0.073***
Type of area (Ref.cat: England: other urban)			
England: London metropolitan area	−0.095***	0.013	0.083***
England: Rural	0.011	−0.008	−0.004
Wales: Urban	0.049*	−0.031	−0.017
Wales: Rural	0.050	0.020	−0.070*
Scotland: Urban	−0.043	0.007	0.036
Scotland: Rural	−0.040	−0.030	0.070***
Northern Ireland: Urban	−0.114***	−0.015	0.129***
Northern Ireland: Rural	−0.098**	−0.027	0.125***
Population density in LSOA (10 s persons per hectare)*	−0.002	−0.001	0.003
Migration generation (ref. cat.: 4th+)			
3rd	0.012	−0.007	−0.005
2nd	−0.044*	0.014	0.030
1st (10+ years)	−0.052*	−0.003	0.055*
1st (less than 10 years)	−0.102	−0.041	0.142*
Ethnic group (ref. cat.: White British)			
Other White	−0.047	0.009	0.038
Asian or Asian British	0.086**	−0.021	−0.066**
Black or Black British	0.116**	−0.012	−0.105***
Other + Mixed	0.025	−0.005	−0.020
Friends outside of local area (ref.cat.: none)			
half or less	−0.072***	0.003	0.069***
more than half	−0.036**	−0.019	0.055***
Close family abroad (dummy)	−0.141***	0.022	0.118***
Cars in household (dummy)	−0.144***	0.017	0.128***

Note: Significance levels: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. For corresponding regression coefficients and goodness-of-fit statistics see Supplementary Table 5. Data: Understanding Society 2018-2019 (n = 15,603). For continuous variables (marked with *) the AMEs refer to a + SD change. For categorical variables they refer to a contrast with the reference category.

'infrequent flyer' category, so that e.g., as income increases, the probability of taking no flights decreases, and the probability of taking two or more flights increases, while the probability of taking exactly one flight does not change much (as shown in Table 2).

Overall, the regression findings suggest that, while frequent flying is strongly associated with higher income, several other factors can contribute to increasing the propensity to fly frequently. For example, on average, holding other variables at their observed values, increasing household income from the first to the third quintile is expected to increase the probability of frequent flying by 12 percentage points (Table 3). This is close in magnitude to the AMEs for frequent flying associated with residence in Northern Ireland (vs. English urban areas) and with being a recent first-generation migrant (vs. no migration background).

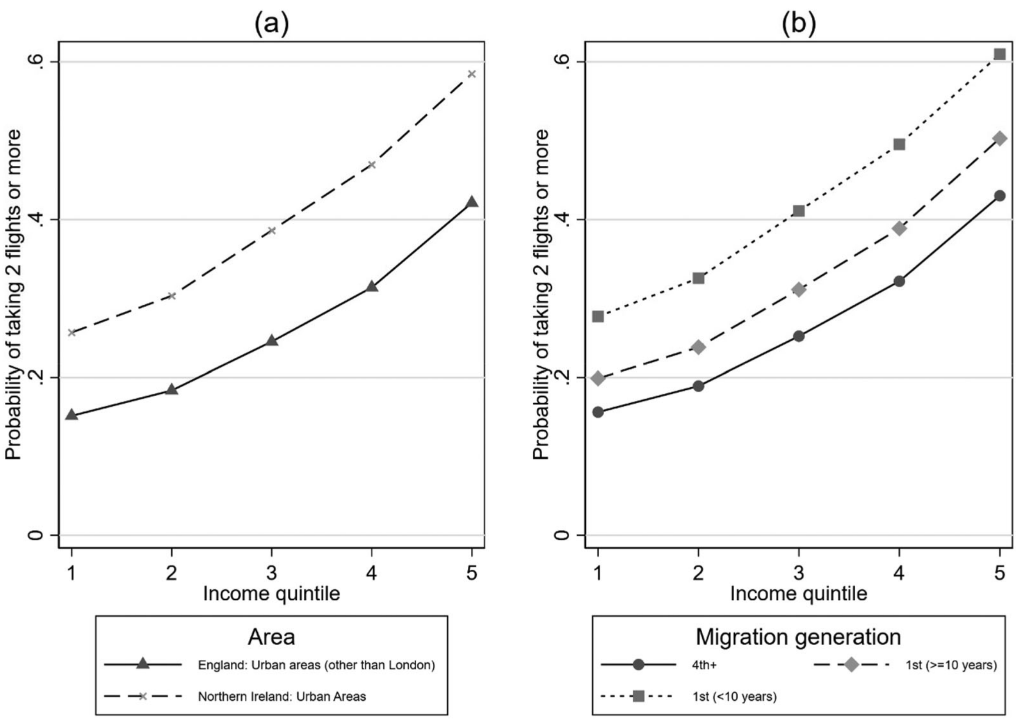

Figure 6. Predicted probability of being a 'frequent flyer': a) for selected types of area, by income (other predictors held at their mean value); b) for selected migration generation categories, by income (other predictors held at their mean value). The predicted probability values are estimated based on the generalised ordered logit model in Supplementary Table 5.

To illustrate this point, Figure 6 shows predicted probabilities estimated from the generalised ordered logit model (Supplementary Table 5). These show that, holding other factors equal, urban residents in Northern Ireland in the lowest income quintile have a probability of being a 'frequent flyer' (0.26) higher than residents of English urban areas other than London in the middle-income quintile (0.24). A similar pattern is observed for migration background, with recent migrants in the first income quintile having a probability of being a 'frequent flyer' (0.28) nearly as high as that of people without migration background in the fourth income quintile (0.32) (Figure 6a). Note that this is an underestimate of the full effect of migration background as recent migrants tend to have more dispersed social networks than assumed in this model where social network (and other) variables are held at the mean. Supplementary Figure 4 compares the examples of a recent migrant with dispersed social networks vs. a person without migration background and localised social networks. It finds that the former's probability of being a frequent flyer ranges from over 0.4 to over 0.7 depending on income level, while for the latter the estimated probability is lower than 0.4 even at the highest levels of income (while other variables are held at their mean).

Overall, our findings suggest that individuals with migration background and/or with dispersed social networks are relatively likely to be frequent flyers even when on low incomes. While we can hypothesise that these groups would be disproportionately affected by frequent flyer levies, we cannot estimate tax burdens for these groups because the LCF, on which the tax burden analysis is based, lacks these variables. Our US analysis also suggests that residents of Northern Ireland are more likely to be frequent flyers even when low incomes – although the LCF analysis suggests that this does not result in a higher tax burden from the tax models considered here (except for the Air Passenger Duty model that excludes the first flight, please refer to Supplementary Table 4 for mean tax burdens for different social groups in the LCF).

Discussion and conclusion

This paper offers a first analysis of distributional impacts of different types of flight taxes in the UK. It also provides a first comparison of the unequal distribution of air travel and frequent air travel, and the social characteristics associated with 'infrequent' and frequent flights. This analysis helps to understand which socio-economic characteristics might be associated with higher burdens from flight taxes and frequent flyer levies. In this section, we summarise the main findings, compare them to the previous literature, and discuss research contribution and policy implications.

The main finding from this paper is that carbon taxes on air travel are distributionally neutral or even progressive, especially if the first return flight is excluded (Figure 4). Distributional impacts from air travel therefore stand in stark contrast to carbon taxes on domestic energy, motor fuel or total household consumption which are all distributionally regressive, burdening low-income households more than high-income households relative to income (Figure 5). Taxes on home energy have the most regressive distributional impact of the taxes modelled here. Motor fuel taxes are slightly regressive, but the burdens are less steeply distributed compared to home energy taxes (Figure 5), confirming previous results (Büchs, Ivanova et al. 2021).

Based on notions of distributional justice, and discussions about climate justice more generally (e.g. Schlosberg & Collins 2014, Newell, Srivastava et al. 2021), we therefore conclude that carbon taxes on air travel can be defended from a justice perspective. They generally put the burden on those who most contribute to GHG emissions and have the greatest capacity to mitigate emissions, based on their social status. While previous research demonstrated that air travel emissions are more unequally distributed than emissions from domestic energy, motor fuels or all consumption (Büchs & Schnepf 2013, Ivanova & Wood 2020), and that carbon or energy taxes on these consumption domains tend to be regressive (e.g. Büchs, Ivanova et al. 2021, Preuss, Reuter et al. 2021), this is the first study which directly compares the distributional impacts of carbon taxes across these domains.

A second key finding of this study is that the distributional impacts of taxes on air travel differ depending on the design of the tax. No prior peer-reviewed studies have been conducted on this question. We find that the most progressive tax on air travel is the 'frequent air miles tax' which takes both flight emissions and number of flights into account. Frequent flyer levies were the second most progressive type of tax. The UK Air Passenger Duty is progressive if the first return flight is excluded and distributionally neutral when it is included. Outcomes for a flight emissions tax are similar to the Air Passenger Duty (Supplementary Table 3).

To facilitate a more detailed interpretation and analysis of these distributional results, this study also provided a comparison of the underlying distribution of all air travel and frequent air travel in the UK population. Several previous studies have detailed the unequal distribution of all air travel across income and other social groups, but a comparison of inequalities between all and frequent air travel was still lacking. Our results confirm findings from previous research that air travel is highly unequally distributed and that high income, high education, being London-based, young and in employment significantly increase the probability to take part in air travel. Our comparison of inequality of all and frequent air travel shows that these characteristics are even more strongly associated with frequent air travel. This means that people with these characteristics tend to be more affected than their counterparts by flight taxes, especially by taxes that take the number of flights into account.

Our analysis also advances the state-of-the-art by showing that there are some lower-income people who have a higher probability to take part in air travel and frequent air travel and are thus more likely to be affected by air travel taxes. This includes migrants, especially recent migrants who still have extended social networks abroad, and other people with close family abroad (see Figure 6). However, the analysis of the two datasets also delivers some mixed findings regarding ethnicity which are complex to interpret. Based on the US dataset, we find that people of colour are equally or less likely to fly (frequently) as compared to white British people when other factors are controlled for, confirming previous research (Mattioli & Scheiner, 2022). This suggests that they would be less affected by flight taxes if the first flight was exempted. At the same time, the LCF analysis finds higher tax burdens for households with representatives of colour from the Air Passenger Duty and Flight Emissions Tax models even if the first return flight is excluded, as well as the Frequent Air Miles model that includes the first flight (see Supplementary Table 4). A likely reason for this finding is that these tax models penalise long-haul flights, and households with representatives of colour are more likely to fly long-haul and have higher flight emissions, while on average also having lower incomes, compared to households with white representatives. Overall, this suggests that the impact of air travel taxes on people of colour will vary considerably depending on the tax model that is adopted – a novel finding. We also find that people living in more remote regions of the UK (Northern Ireland and Scotland) travel more often by air within the UK. However, our findings suggest that they have lower air travel emissions overall and are equally or even less affected by air travel taxes in most models, despite lower average incomes compared to other regions (Supplementary Table 4).

We also find a rather strong association between (frequent) flying and young adulthood. This finding is consistent with previous studies (e.g., Falk & Hagsten, 2021) and can be interpreted as a 'life course effect', whereby younger adults travel more during that life stage (to 'explore the world') but then reduce air travel at later life stages. However, previous research also provides evidence of 'socialisation' effects, whereby higher rates of international travel among younger adults today are partly explained by greater experience of international travel during childhood (e.g. Frändberg 2009, Gössling, Hanna et al. 2019, Mattioli, Scheiner et al. 2022). It is thus possible that this socialisation effect will continue, leading this cohort to fly more even at later life stages. This would strengthen the case for increasing air travel taxes sooner rather than later, as new generations might take cheap air travel for granted and build their lifestyles around it, possibly leading them to oppose future tax increases.

Our findings are for the UK, which is characterised by comparatively high levels of air travel among the population. We believe that our findings regarding the highly unequal distribution of 'frequent flights' and the progressivity of air travel taxes and frequent flyer levies likely also apply to countries with lower levels of participation in air travel (Hopkinson & Cairns 2021) because previous research shows that air travel inequality is higher at lower participation rates (Büchs & Mattioli 2021). With regards to the patterns of association between social characteristics, frequent flying and burdens from air travel taxes, future research may explore to what extent these differ across countries.

Our study's contribution to sustainable tourism research is threefold. First, we provide evidence on the distributional impact of one of the main policy measures required for advancing the net zero tourism agenda, which is gaining prominence within the field (Higham, Font et al. 2022, Scott & Gössling 2022). Second, our findings are of interest for the nascent literature on justice and tourism (Guia 2021, Jamal & Higham 2021), as they show that air travel taxes can be defended from a justice perspective, as far as their distributional impacts on travellers is concerned. While air travel demand management measures may have implications for other actors involved in tourism systems, these are beyond the scope of this article, and are for future research to explore. Finally, by showing the impact that air travel taxes would have on migrants and others with dispersed social networks, we provide insights on how air travel demand management would impact VFR travel, an important and growing tourism segment, which has not yet received the attention that it deserves (Zentveld, Labas et al. 2022).

From a policy perspective, we draw two main conclusions and recommendations. First, the fairer distributional outcomes of carbon taxes on flights (as compared to home energy and motor fuels) are also likely to make them more acceptable to the population as has been suggested in previous studies (Carmichael 2019). Carbon taxes on air travel could hence be a promising avenue for reducing emissions in the UK more generally, and specifically within the tourism sector. At the same time, our analysis identifies groups who might experience high burdens while being on a low income. Policy-makers might want to consider tax exemptions or other provisions for these groups, as suggested by organisations like Stay Grounded (2019). For instance, the revenue from flight taxes could be used to increase benefits or reduce income taxes for low-income households (ibid.). Partial exemptions or rebates to the frequent flyer levy could be introduced for more peripheral regions (such as Scotland and Northern Ireland), as our analysis finds that their residents tend to travel more frequently, but over shorter distances, which results in fewer overall emissions. Reducing tax impacts on migrants is more challenging because checking nationality and presence of family ties in other countries could prove administratively challenging and intrusive. Stay Grounded acknowledges these difficulties but proposes that migrants could be allowed to apply for higher contingents for tax free flights or for tax free flights in emergency situations (e.g. related to a family crisis) (ibid.).

Notes

1. Note that the median value of the length of stay in the UK for respondents in the 'recent first-generation migrant' category in our analysis sample is 9 years. This is due to the panel nature of the US sample, whereby many respondents have been in the sample (and thus in the UK) since Wave 1. As such, our analysis tends to underestimate the impact of recent migration background on (frequent) air travel.
2. https://www.distancefromto.net/
3. We use the term "people of colour" or "household representatives of colour" throughout the paper, based on Eddo-Lodge's (2018) book "Why I No Longer Talk To White People About Race" which prefers this term over several alternatives.

Disclosure statement

No potential conflict of interest was reported by the authors.

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