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Trends in air travel inequality in the UK: From the few to the many?

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ABSTRACT

Aviation is responsible for at least 3.5% of global warming, and demand is predicted to rise rapidly over the next few decades. To reverse this trend, air travel demand will need to be managed. An important question is: 'who would be affected by air travel demand reduction policies'? The answer to that question largely depends on who is participating in air travel, and how unequally it is distributed. Existing analysis suggests that participation in air travel in the UK is highly unequal and driven by richer, highly educated and urban households. However, so far little is known about how these patterns of inequality have changed over time – has air travel participation increased among low income households, e.g. due to the rise of low-cost carriers and 'normalisation' of air travel as a social practice? Would these groups therefore now be more affected by flight taxes or frequent flyer levies? To address these questions, this paper examines trends in air travel inequality between 2001 and 2018 in the UK based on two representative surveys, providing the first micro-level analysis of air travel inequality over time for this country. We find that while disadvantaged groups have contributed to the expansion of air travel over the past two decades, they remain far less likely to be affected by air travel demand management policies because air travel inequality is still at a very high level. These findings challenge common discourses that present air travel as a widespread norm, and demand management policies as socially unfair.

1. Introduction

Air travel and related greenhouse gas emissions (GHG) have increased rapidly in the last few decades – according to a recent study by a factor of 6.8 between 1960 and 2018 (Lee et al., 2021). When non-carbon emissions and other climate forcing impacts are taken into account, passenger air travel accounts for at least 3.5% of global warming (ibid.). In countries in the Global North, air travel makes up a high proportion of transport emissions (Aamaas and Peters, 2017; Reichert et al., 2016), as well as a large share of emissions for those individuals who fly (Büchs and Schnepf, 2013; Wynes and Nicholas, 2017).

At least until the COVID-19 crisis, air travel emissions were predicted to triple between 2020 and 2050 (Gössling and Humpe, 2020; ICAO, 2019). This, in conjunction with the fact that aviation technology is particularly difficult to decarbonize (Peeters et al., 2016; Schäfer et al., 2019), makes the sector hard to fit into a zero-carbon budget (Allwood et al., 2019; CCC, 2019) unless demand management policies are implemented (Bows-Larkin et al., 2016; Higham et al., 2016; Lenzen et al., 2018).

An important question in this context is how 'fair' policies that seek to reduce demand for air travel would be. Answers to that question largely depend on who is participating in air travel, and how unequally it is distributed. Prior research has demonstrated that air travel is highly unequally distributed, but so far little is known about how air travel inequality has developed over time. Has air travel increased among low income and other disadvantaged groups which would make them more vulnerable to flight taxes or frequent flyer levies? In this paper, we examine how air travel inequality has changed in the UK between 2001 and 2018.

Assumptions regarding air travel inequality are highly relevant for public acceptability of policies that seek to reduce air travel demand. Two examples demonstrate this: UK Treasury Minister Robert Jenrick declared in 2019 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). This statement reflects the existence of a public discourse, promoted by aviation organisations, whereby "air travel is a 'norm', involving large parts of the global population" (Gössling et al., 2019: 2). On the other hand, the French 'Yellow Vest' movement of 2018–2019 advocated the introduction of an aviation fuel tax, which it regarded as a more progressive alternative to the motor fuel tax increases that sparked the protest (Atkin, 2018).

Existing research has indeed shown that the distribution of air travel

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is very skewed, with a minority of high-mobility individuals responsible for the large majority of trips, travel distance and emissions, even in countries where flying is most common (Gössling and Humpe, 2020; Ivanova and Wood, 2020). In the UK, roughly 50% of the population does not participate in air travel in any given year, with 15% of the population responsible for 70% of all flights (Hopkinson and Cairns, 2021). In many, especially poorer countries, the share of the population who takes a plane in any one year is even lower than that (ibid.: 18–19).

Previous research has also found a strong correlation between air travel and income, with the more affluent sectors of the population responsible for a disproportionate share of trips. Besides high income, other factors associated with higher air travel activity include high education, smaller household size, urban location, accessibility to airports, good health, migration background and spatial dispersion of personal social networks (Büchs et al., 2018; Czepkiewicz et al., 2018; Mattioli et al., 2021). The strong association between air travel and income means that a carbon tax on flight emissions would be progressively distributed, i.e. the tax burden would be greater for higher income groups (Büchs et al., 2014). Despite this evidence, as Gössling and Cohen (2014: 199) note, the fact that "a minor share of highly mobile travellers, mostly from higher income classes, are responsible for a significant share of the overall distances travelled, as well as emissions associated with this transport" remains remarkably absent from the public debate, constituting a sort of 'taboo' in sustainable transport policy.

While there is much evidence about the inequality of air travel, an open question is how air travel inequality has changed over time. Has air travel among less well-situated people increased and air travel inequality hence been declining over time, putting less well-situated groups at risk if demand reduction policies were introduced? The participation of low-income households in air travel may well have increased over time due to greater availability of low cost air travel (Dobruszkes and Mondou, 2013), the aspirational nature of air travel as a social practice (Cohen and Gössling, 2015; Gössling and Stavrinidi, 2016), and the increasing global dispersion of social networks (Dobruszkes et al., 2019; Mattioli, 2020; Mattioli et al., 2021). Given these various trends, we address these questions by examining trends of air travel inequality between 2001 and 2018.

To date, relatively few studies have examined the development of air travel inequality over time. Demoli and Subtil (2019) investigate trends in the inequality of air travel in France between 1974 and 2008. They find that, while the increase in participation in air travel was similar across different social groups, the association between socio-economic characteristics (e.g. income, education) and air travel did not change much over time. Banister (2018) finds that participation in air travel was rather stable between 2002 and 2012 in Great Britain, while the distribution of trips remained highly skewed throughout the period, with a strong income effect on the propensity to fly. These studies suggest that the general increase in air travel participation was fairly evenly shared among different social groups, with little effect on overall air travel inequality. In this paper, we investigate whether these assumptions hold for England and the UK, or whether there is evidence for a larger increase in air travel participation among disadvantaged groups, and a decrease in air travel inequality between 2001 and 2018.

To investigate this question, the article has two main objectives. First, to examine the development of air travel inequality over time for the period 2001–2018, based on participation and trip rates. This period includes the global financial crisis of 2007/8, which could be instructive for anticipating possible impacts of the economic contraction following the COVID-19 pandemic on flight inequality. Second, we build on this analysis to reflect on the fairness implications for policies that target air travel emissions. This is an important question as perceptions of fairness are key determinants of public support for climate policy measures in the aviation sector (Larsson et al., 2020).

We investigate these questions about trends in air travel inequality based on two UK datasets, the Living Costs and Food Survey (LCF) and the National Travel Survey (NTS). We use both datasets because this approach provides us with the best possible data coverage that is currently available in terms of time span, geography, and types of flights. The LCF only covers personal (non-business) flights while the NTS includes business flights, which is an important reason to compare data from these two sources. Furthermore, the LCF provides data for a longer time period (2001–2018) and greater geographical reach (UK) compared to the NTS which only covers air travel by individuals in England from 2006 to 2017. Exploiting both surveys thus acts as an important robustness check of our findings. While the aim of this article is not to compare the suitability of the two datasets for tracking trends in air travel, we comment on the quality of existing data in Section 2.

The main argument that emerges from our findings is that while disadvantaged groups have contributed to the expansion of air travel over the past two decades, and while this has reduced air travel inequality, disadvantaged groups remain far less likely to be affected by air travel demand management policies. This is because, in absolute terms, levels of air travel inequality remain very high. We also find that air travel inequality increased substantially during the 2008–2013 economic crisis, when air travel activity reduced. We argue that we might see a similar pattern in the aftermath of the COVID-19 crisis given that job losses and financial implications of the pandemic were more prevalent among disadvantaged groups.

The article is structured as follows: in Section 2 we introduce the datasets and methods on which our analysis is based. The findings are presented in Section 3 and discussed in Section 4.

2. Material and methods

2.1. Data

Our analysis is based on two representative surveys, the Living Costs and Food Survey (LCF) and the National Travel Survey (NTS). To the best of our knowledge, these are the only UK datasets providing representative data on air travel behaviour (both domestic and international), along with household and individual characteristics, on an annual basis.

Up until 2007, the LCF was called the Expenditure and Food Survey, but for simplicity we refer to the survey as LCF for the whole period in this paper. Both the LCF and the NTS collect data on the number of flights per year but with some differences which are important to examine. The LCF collects information at the household level in the UK while the NTS collects information at the individual level for each household in the sample for England. The LCF explicitly only asks about personal (non-business) flights while the NTS does not specify the type of flight. We can therefore assume that business flights are included in the NTS. The two surveys also cover different time periods: The LCF started collecting data on the number of personal flights per year in 2001, while the NTS started collecting data on internal flights in the UK in 2003, and international flights in 2006. For both surveys we use all available years for flights, up to 2017/2018.

2.1.1. LCF

The LCF is an annual survey that is representative at the household level in the UK. Each sample contains around 6000 households, and our combined dataset from 2001 to 2018 includes 102,981 households. The LCF collects household data on expenditure and household characteristics. Most expenditure items are collected through two-week diaries, but information on a range of less frequent expenditures is collected through a household survey completed by the household representative. This includes information on flights. The household survey asks whether anyone in the household has taken a flight in the past 12 months and collects information on whether the flight was to a UK destination or abroad. Until 2010, the latter differentiated between destinations in the EU and outside the EU. For flights within the UK, the survey also asks whether it was a single or a return flight, and since 2013 the survey distinguishes return flights and other flights for destinations outside the UK. Furthermore, for international flights only, the survey asks how many members of the household took part in the flight. All these questions are asked for up to 10 (until 2011) or 16 (from 2012) destinations per year.

2.1.2. NTS

The NTS is a continuous survey aimed primarily at capturing the travel of English residents within Great Britain (which includes England, Wales and Scotland, but not Northern Ireland). The annual survey sample includes approximately 7000 English households (ca. 18,000 individuals) and our combined sample has 90,324 households (216,104 individuals). While most travel information in the NTS is collected through a one-week travel diary, recent waves also include bespoke questions on air travel, for which the reference period is 12 months. The individual survey asks "How frequently do you take an internal air flight within Great Britain?", and instructs respondents to "only include travel within Great Britain, over the last year or so" and to "count each single trip as one journey and each return trip as two". Seven response categories are provided: "3 or more times a week"; "Once or twice a week"; "Less than that but more than twice a month"; "Once or twice a month"; "Less than that but more than twice a year"; "Once or twice a year"; "Less than that" (Comick et al., 2018: 86). We recoded this categorical variable as continuous, assigning values corresponding to the lower bound of each category (i.e. 156, 52, 24, 12, 2, 1, and 0 flights per year respectively). Since 2006, respondents are also asked "How many times have you left the country by plane in the last 12 months?", with interviewers instructed to "only include outward journeys going abroad" and "do not include internal flights within Great Britain or flights originating in other countries" (Comick et al., 2018: 112). In our analysis, we multiplied the number of outward international flights by two, based on the assumption that each of them was followed by a return flight. This might lead to an overestimation of flights (if return journeys were made by other modes) and/or to an underestimation (if travellers made further flights while abroad (Larsson et al., 2018)).

2.1.3. LCF – NTS harmonisation

Since the NTS only collects data from English residents since 2013, the main analysis is presented for England, but we also draw comparisons to the UK where relevant, using LCF data. The two surveys differ in recording flights to Northern Ireland (excluded from the NTS but included in the LCF), but this is unlikely to make a significant difference to our analysis since domestic flights are only a relatively small proportion of all flights (3.6% in the LCF and 14.8% in the NTS).

For both surveys, we define one flight as a one-way flight, i.e. return flights are counted as two flights. If not specified, flights to destinations outside the UK are assumed to be return flights.

To estimate trip rates (average number of flights per person) we total up household flights and divide this by the totalled up household members for the groups of interest. Since the LCF does not capture the number of household members who took part in UK flights, these trip rates further underestimate average numbers of flights. Since the NTS has information on individual flights, we simply calculate averages of trip rates for the different groups in question.

Household weights provided by the LCF and NTS are applied throughout. Analysis of participation rates, Gini coefficients, income shares and regressions are conducted at the household level for both surveys. While this is not ideal, it is the only practical way to compare the two surveys.

We also harmonised a range of household characteristics across the two surveys because information is collected in slightly different ways. While this limits our analysis to some extent (e.g. resulting in less fine-grained independent variables), being able to triangulate between two datasets increases the robustness of our findings, and data harmonization is essential to that end.

The LCF collects normal disposable household income while the NTS only provides quintiles of equivalised gross household income. For the LCF, we create variables with equivalised household income quintiles and deciles for the descriptive analysis, and use the log of normal disposable household income in the regression analysis. The restriction to income quintiles inevitably reduces information, but is unavoidable if we want to compare data from the two surveys. The NTS asks about the highest educational qualification of each household member while the LCF only collects information about the age at which each household member left full time education. To harmonise this, we create a household level dummy variable for the LCF that is coded 1 for "higher education" if at least one member of the household completed continuous full time education at the age of 21 or above, and 0 otherwise. We use age and ethnicity of the household representative in both surveys. The NTS collects information on whether respondents experience difficulties travelling by foot, bus or car, which we summarise in a dummy variable for "mobility difficulties". For the LCF, we create a dummy variable that is coded 1 for households that receive a council tax discount if at least one member of the family has a disability. We also create a variable based on the employment status of the household representative, distinguishing "in employment/self-employed", "retired", and "out-of-work but of working age". The LCF does not have a rural/urban variable for all years in the standard access dataset, we therefore just control for Greater London vs. all other regions in the regression analysis.

Despite harmonisation, we find considerable differences between the LCF and the NTS in air travel participation and trip rates: According to the LCF, an average of 40.6% of households in England (39.9% in the UK) had at least one flight, and the average person had 1.03 flights each year between 2006 and 2017/8 in England (1.01 in the UK) compared to 54.3% and 2.57 flights in the NTS for England. The higher figures in the NTS could be due to several factors: the NTS includes business flights while the LCF only covers personal flights. Business flights are estimated to account for an average of around 12% of all flights for UK residents for the period of 2009–2019 (ONS, 2020) (but note this figure is much higher for UK internal flights – around 48% of which are business flights according to the NTS (DfT, 2020)). We thus assume that the exclusion of business flights in the LCF explains some of the difference in participation and trip rates between the two surveys.

There are other possible reasons for the differences between the two surveys, although we can only support the first of them with evidence. First, the LCF only asks for up to 10 destinations (until 2011) or 16 destinations (from 2012) at the household level per year which automatically caps the number of flights reported. Additional data exploration (not included here for the sake of brevity) showed that top-coding flights in the NTS reduces the difference in trip rates between the two surveys. Second, the LCF does not ask how many household members took part in UK flights, possibly leading to an underestimation of UK passenger trips. Third, the LCF asks participants several follow-up questions per destination as described above. If participants do not have all that information handy or 'get tired' of answering these questions, they might underreport flights. The NTS only asks respondents to state the number of flights, with no follow-up questions which makes the question less onerous but fails to collect important information such as price, destination, and the number of persons who participated in the flight.

While the differences in air travel participation that the two surveys report complicate the analysis and interpretation, they are consistent with well-known methodological challenges in capturing infrequent, long-distance travel data (Dowds et al., 2018; van Goeverden et al., 2016). When it comes to patterns in air travel participation and trends over time, we find strong similarities however, supporting the general robustness of the data.

A limitation of both surveys is that respondents are asked to recall the flights they have taken over the last 12 months which can affect the accuracy of data. The way in which the LCF collects information on flights has changed slightly over the years, e.g. collapsing EU and other international flights into one category from 2010 onwards, and switching the survey period (financial year from 2001 to 2006 and from 2015 onwards, and calendar years in between). However, we do not believe this will make a significant difference to the results because it does not affect the number of flights recorded through the survey.

Overall, our analysis highlights that further efforts need to be made to improve the data basis on air travel in the UK, which is currently far from ideal. While this partly reflects broader methodological challenges surrounding the measurement of long-distance travel (e.g. Dowds et al., 2018), it is increasingly out of step with the significant and growing importance of long-distance and air travel in terms of travel distance and associated emissions.

2.2. Methods

We examine changes in air travel inequality over time in a number of steps. First, we estimate average household-level participation rates in air travel and average number of trips per person over time. The development of participation and trip rates over time is then examined for different groups, including by income quintile, age group (over/under 65 years or under 35, 36–64, 65–74 and >75 and ethnicity (white vs. others).

Second, we assess inequality of air travel through inequality measures such as the Gini coefficient and income shares. Gini coefficients are estimated in relation to the distribution of number of flights across households (with both datasets) as well as across the income distribution in each available year (for the LCF data), based on concentration curves (Jann, 2016). We also estimate the share of the total number of flights for each income quintile.

Third, we estimate multivariate count regression models to evaluate the conditional effect of different household characteristics on air travel. Count regression models are better suited than ordinary least squares models to estimate count outcomes (like the number of flights taken) because count data are often not normally distributed. For instance, there is a high proportion of households or individuals who have not flown during the past 12 months (59% in the LCF and 46% in the NTS for 2006–2017/8). At the same time, some households or individuals have much higher than average numbers of flights. The 'number of flights' variables are therefore highly overdispersed, with a much higher variance than the mean. We have therefore chosen to model the number of flights with a zero-inflated negative binomial regression model (using the "zinb" command in Stata). This technique separately models the participation in air travel (zero flights vs. all others) and the number of flights ($\geq$1). Since air travel is a relatively infrequent activity for most people, we cannot be sure whether people without flights in the dataset never fly, or whether they just happened not to have flown in the past 12 months. The "zero inflation" part of the model takes these two processes into account and estimates the probability that the respondent is a more permanent non-flyer, rather than someone who just happened not to have travelled by plane in the past 12 months. A logit model is being used for the "zero inflation" part of the model. The zero-inflated negative binomial model also takes overdispersion of the data into account. Preference for a zero-inflated negative binomial model over a zero-inflated Poisson regression which would assume data are not overdispersed is estimated with a dispersion coefficient alpha. The probability of alpha being zero was <0.0001 in both datasets, confirming the suitability of the negative binomial model. The negative binomial count part of the regression estimates the expected change in the log count in response to a unit change of the independent variables. We express results as changes in the percent of number of flights by exponentialising the coefficients. We apply probability weights which automatically estimates robust standard errors.

Underlying factors that influence participation in air travel, and air travel inequality, such as changes in real incomes, education levels and population ageing have of course occurred over the period of study, but we are not able to test their relevance at the macro-level due to the micro-level nature of the survey data applied here. However, the first step of our analysis controls for these broader trends to some extent, by investigating how participation in and frequency of air travel have changed among specific social groups (e.g. education groups, age bands). In the third step of our analysis, we include survey year predictors in the regression models, along with a range of socio-economic variables. This enables us to disentangle the impact of changing population composition from 'year effects' to some extent.

3. Results

3.1. Inequality in air travel

Participation in air travel and number of flights are extremely unequally distributed in England and the UK. LCF data show that on average between 2006 and 2017/8, only 20% of households are responsible for 76% of all flights, 10% of households for 51%, and 1% for 10% of flights (very similar for England and the UK). NTS figures for the period 2006–2017 are similar (with 20% of households responsible for 75% of all flights, and 10% for 57%) but show an even stronger concentration among the top 1% of frequent flyers (responsible for 21% of all flights), possibly because the NTS does not cap the number of flights and as it includes business flights. Fig. 1 shows the Lorenz curve for the distribution of flights in England and the corresponding Gini coefficient of 0.75 (0.76 for the UK) from both surveys.

Participation in air travel differs strongly by income. LCF data (Fig. 2) show that in the lowest income decile, only an average 17.5% (LCF) or 37% (NTS) of all households have at least one flight per year across all years, while 71.6% (LCF) or 81% (NTS) of households in the top income decile have at least one flight per year in England (figures are not significantly different for the UK). The higher participation rates in the NTS likely reflect the inclusion of business travel and other methodological differences in the NTS survey as explained in Section 2.1.

Participation in air travel also differs widely across other social groups. In both the LCF and the NTS, households with reference persons who are over 65, female or white, or in which no household member has a degree, all have significantly lower participation rates than their counterparts (Table 1). All of these groups also have significantly lower household income than the comparator groups, indicating relationships between characteristics of social disadvantage (except for households with white household representatives who have a significantly higher mean household income that those with non-white representatives) (SM Tables 1–5).

Similar inequalities apply to trip rates of different social groups. The average person in the lowest income decile in England has 0.35 (LCF) or 1.25 (NTS) flights per year, while the average person in the top income decile has 2.54 (LCF) or 6.80 (NTS) flights per year (Fig. 3). Interestingly, households with non-white representatives have a lower average number of flights per year (0.85 (LCF) or 2.11 (NTS)) as compared to other households (1.06 (LCF) or 2.64 (NTS)), despite being characterised by higher participation rates (as discussed above). This suggests that they are more likely to fly at least once per year, but on average make fewer flights.

The population in the bottom income quintile is responsible for only 6% (LCF) or 10% (NTS) of all flights, while the top income quintile is responsible for 42% (LCF) or 40% (NTS) of all flights.

Inequality of the distribution of the number of flights by *income* can also be expressed with concentration curves, which "illustrate how one variable is distributed across the population, ranked by another variable" (Jann, 2016: 860) – a sort of bivariate equivalent of the simple Lorenz curve, with its own Gini coefficient. The concentration curve in Fig. 4 depicts the cumulative distribution of flights over the income distribution. The associated Gini coefficient for this concentration curve over income is 0.34 for England (0.35 for the UK).

3.2. Air travel over time

LCF data show that participation in flights in England has risen between 2001 and 2017/8 from 38.3% of all households to 46% (Fig. 5).

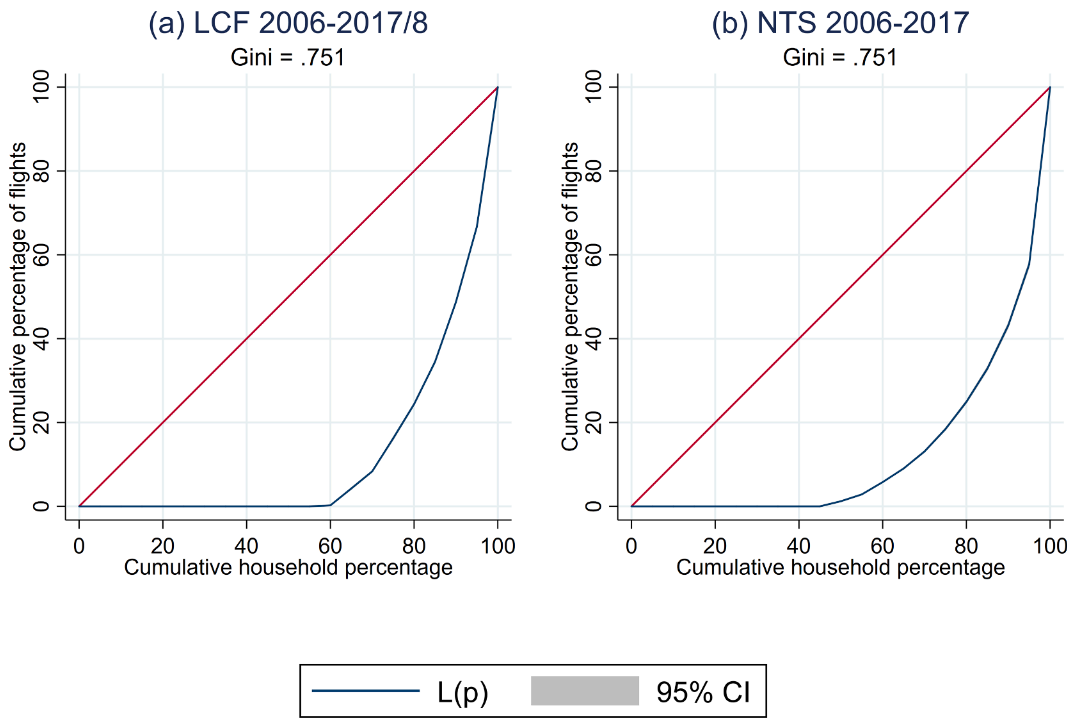

Fig. 1. Lorenz curves for the distribution of household flights.

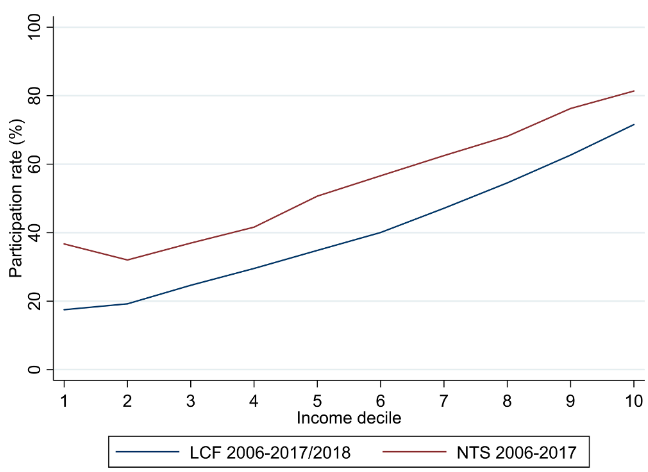

Fig. 2. Participation rate in air travel, by income decile (based on LCF 2006–2017/8 and NTS 2006–2017).

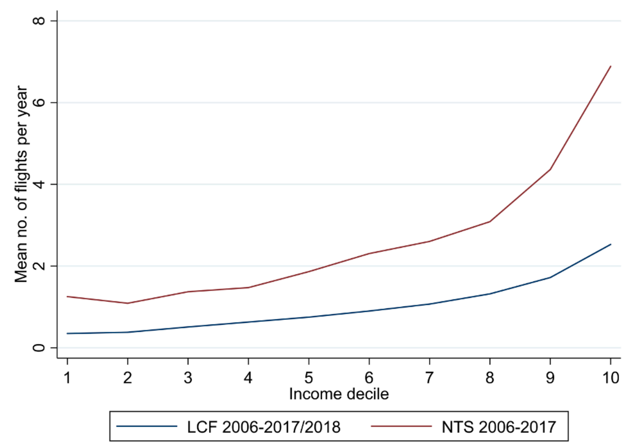

Fig. 3. Individual air trip rates by income decile (based on LCF 2006–2017/8 and NTS 2006–2017).

Table 1
Participation in air travel (LCF 2006–2017/8, NTS 2006–2017).

	LCF %	Standard error	NTS %	Standard error
Age <65	45.69	0.25	61.44%	0.24
Age 65+	26.84	0.36	34.74%	0.31
Female	35.72	0.33	49.12%	0.30
Male	43.57	0.27	57.48%	0.25
No degree	36.60	0.27	44.52%	0.23
Degree	60.02	0.42	75.00%	0.28
Non-white	46.33	0.73	60.91%	0.61
White	39.92	0.22	53.56%	0.22

During the recession, flight participation fell with its lowest point in 2011 when only 35.1% of all households took at least one personal flight per year. This pattern is very similar for the whole of the UK just that the average air travel participation rate across all years is 0.6% lower there compared to England (significant at the 5% level). The analysis of NTS data, albeit covering a shorter period, shows a similar trend (Fig. 5).

The trajectory of trip rates over time displays a similar pattern. Based on the LCF, average flights per person in England increased from 0.95 per year in 2001/2 to 1.26 per year in 2017/8 (with a low of 0.72 flights per year in 2012 during the recession). The trajectory for the NTS is similar with an increase of flights per person from 2.81 in 2006/7 to 2.92 in 2017 (with a low of 2.12 in 2011) (see SM Figs. 1 and 2).

When we examine the development of inequality in air travel over time, there are three things to note. Firstly, participation in air travel by people on low incomes and in other less privileged groups has increased over the whole time period. This is consistent with the expansion of low cost air travel and social normalisation of air travel more generally. For instance, while only 15% of households in the lowest income decile participated in air travel in 2001–3, nearly 23% of households in that income bracket participated in air travel in 2016–8 (LCF, England and

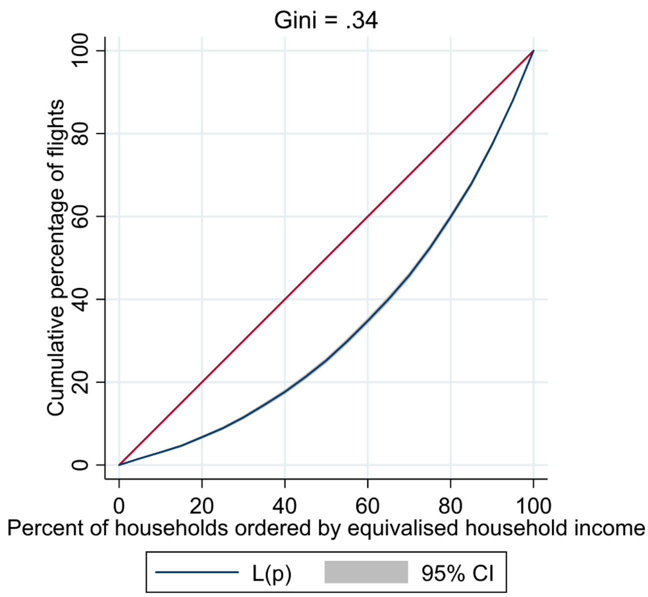

Fig. 4. Concentration curve of household flights over equivalised income, LCF 2006–2017/8.

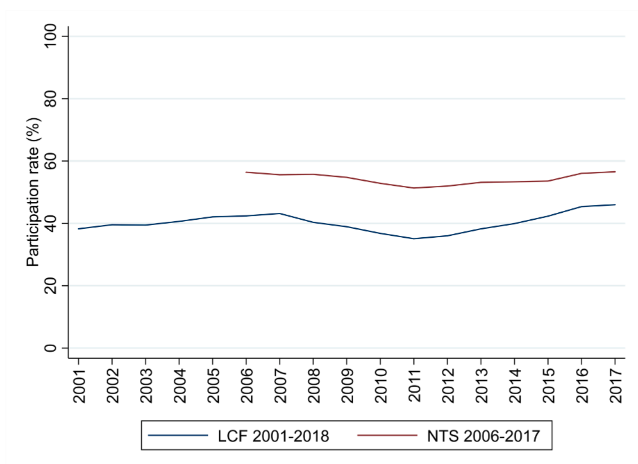

Fig. 5. Participation in air travel, households in England (based on LCF 2001–2017/8 and NTS 2006–2017).

UK). Similarly, 34% of households in which no-one has a degree had a flight in 2001–3, but this rises to 38% in 2016–8 (LCF, England and UK).

Secondly, our data confirms that air travel is highly income elastic – reducing considerably when incomes fall as during the 2008–2013 economic crisis, and resurging again following this period. In *absolute* terms, these changes are much larger among high income compared to low income groups: the estimated total number of flights taken by people in the highest income quintile in the UK declined by around 4.1 million between 2007 and 2021, but only by around 1 million among people in the lowest income quintile (LCF). Conversely, the total number of flights taken by people in the highest income quintile increased by around 10.9 million between 2012 and 2017/8, but only by about 2.7 million by people in the lowest income quintile.

Thirdly however, in *relative* terms, income elasticity was stronger among low income and other disadvantaged groups. In relative terms, their participation in flights as well as numbers of flights decreased more during the recession compared to higher income groups, and increased more strongly in its aftermath. For instance, between 2012 and 2017/8, the volume of flights increased by 62% for the lowest income quintile and 39% for the highest income quintile.

This means that flight inequality increased during the recession and reduced afterwards when air travel was expanding again. Based on the LCF, the participation rate of the top income quintile in England falls by 7.3 points between 2006/7 and 2011/12 and by 5.4 points in the bottom income quintile. In relative terms however, the decrease is much greater for the bottom income quintile than for the top quintile with a decrease of 26% (28% in the UK) of the initial participation rate compared to only 9% (10% UK) for the top income quintile. Conversely, the participation rate of the bottom income quintile rises by 56% in England (58% for the UK) and by 10% (same for the UK) for the top income quintile between 2011/12 and 2017/18). Fig. 6, panel a) also confirms that the proportion of all flights taken by households in the highest income quintile rose during the recession, and dropped again towards the end of the period. The NTS analysis for England (Fig. 6, panel b) shows a roughly similar pattern.

Similar trends apply to other groups such as older, less educated and non-white households. For instance, the LCF analysis shows that while the air travel participation rate decreased more in relative terms during the recession for households with representatives aged under 65 compared to those over 65, the participation rate increases more for the over 65 year olds compared to those under 65 following the recession, by 34% (33% UK) compared to 29% respectively. For households in which no-one has a degree, air travel participation decreased by 22% during the recession, compared to 15% (14% UK) among households in which at least one person has a degree. Conversely, air travel participation increased by 31% for households in which no-one has a degree following the recession, compared to only 15% (14% in the UK) for those with a degree following the recession. Results for ethnicity are also interesting – while the air travel participation rate fell much less for households with non-white representatives compared to those with white representatives (2% compared to 18% (19% UK)), it increased more after the recession for households with non-white representatives compared to their counterparts (35% (34% UK) versus 27% respectively). The NTS analysis shows broadly similar results, with the only substantial difference being that the participation rate increased less among those aged 65 or more (+8%) than for the rest of the population (+11%) between 2011 and 2017.

The LCF analysis shows similar patterns for the number of flights, as trip rates increase substantially more in relative terms for the bottom income quintile compared to the top income quintile following the recession (88% vs. 35% in England, 92% vs. 35% in the UK). The same applies to other less well situated groups, for instance, we see higher relative increases in trip rates for households with representatives aged 65 or over following the recession compared to younger households (73% vs. 52% in England, 70% vs. 51% in the UK); households in which no-one has a degree compared to those with a degree (56% vs. 38% in England, 56% vs. 37% in the UK); as well as for households with non-white representatives compared to others (66% vs. 55% in England, 65% vs. 54% in the UK). The NTS analysis shows broadly similar results, with the only substantial difference being that trip rates have increased slightly more rapidly among households with representatives younger than 65 (+28.2%) than for those over 65 (+26.9%) between 2011 and 2017.

Examining the Gini coefficient of the distribution of the number of flights over time confirms that inequality increased during the recession and eased again since 2013 both at the household (LCF) and individual (NTS) level (Fig. 7).

Based on the LCF, air travel inequality also increased during the recession when we examine the distribution of flights over the income distribution. As discussed in Section 3.1, the “income based” distribution of flights can also be expressed as a ‘concentration curve’ with its own Gini coefficient. Fig. 8 displays the evolution of the *income*-based Gini coefficient for air travel inequality between 2001 and 2018. It shows a longer-term decline, as well as a rapid increase during the recession.

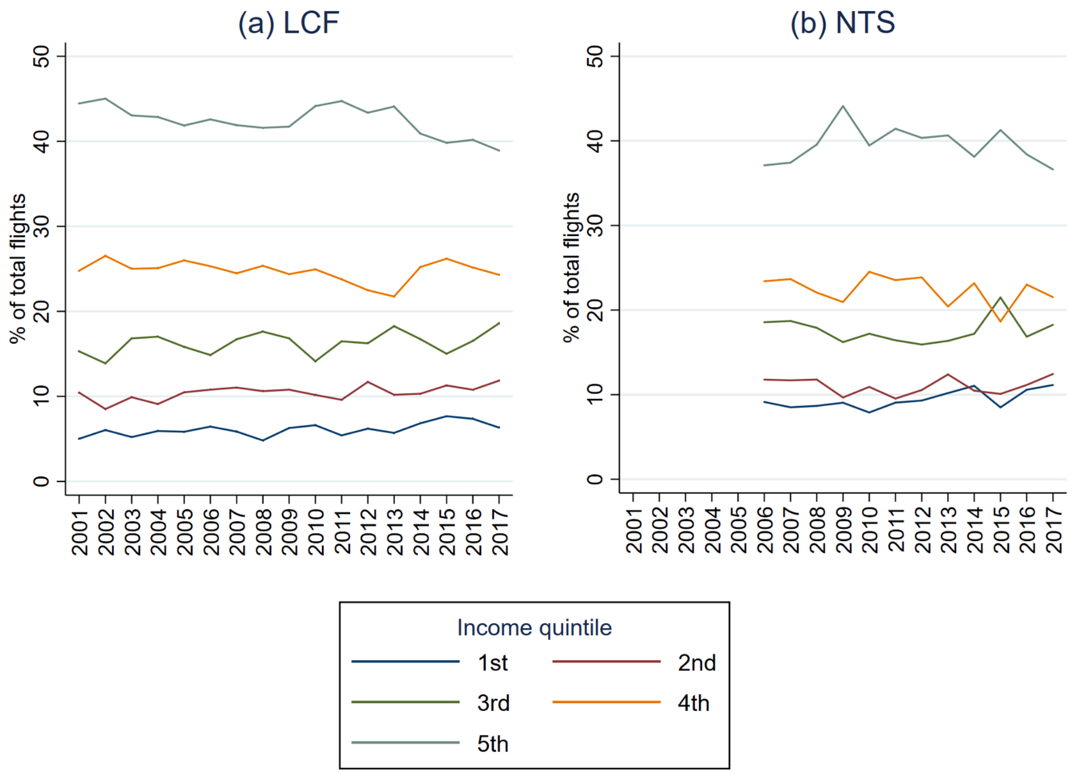

Fig. 6. Share of total flights by income quintile in England (based on LCF 2001–2017/8 and NTS 2006–2017).

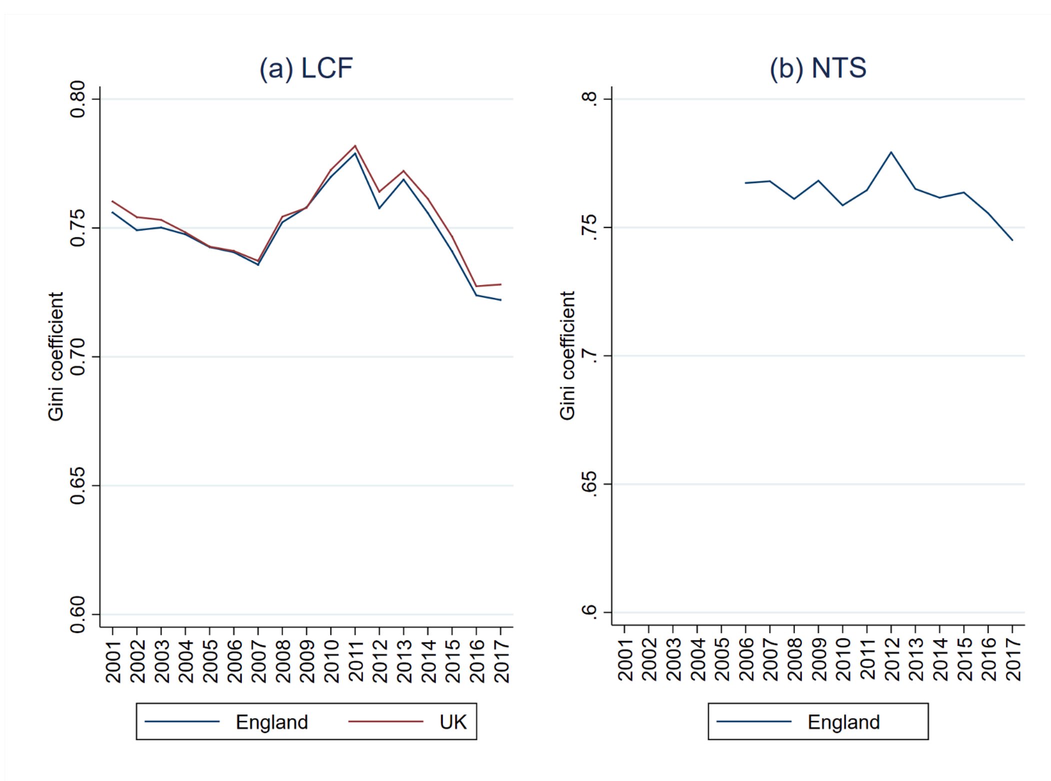

Fig. 7. Changes in the Gini coefficient of the distribution of flights over time. Note: LCF analysis (panel a) based on household-level data, NTS analysis based on individual-level data (panel b).

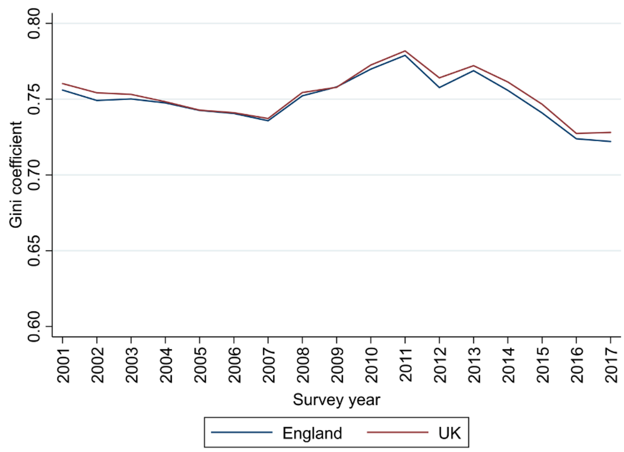

Fig. 8. Gini coefficient for the distribution of flights over the income distribution, LCF 2001/2–2017/8.

3.3. Count regression analysis

In this section, we discuss which household characteristics are related to high numbers of flights, holding other factors constant. For the analysis, we use a zero-inflated negative binomial regression model which not only estimates the number of flights but also non-participation in air travel (zero flights). Results based on the LCF sample for England for 2006–2017/8 show that holding everything else constant, income, household size, high education, being retired, and being located in London have significant positive effects on the number of flights taken per year (Fig. 9 panel b). Results confirm that the number of flights is highly income elastic: a 1% increase in household income increases the number of flights by 3%. An increase of household size by one member increases the number of flights by 15%,[1] having at least one member in the household with a degree by 14%, being retired (compared to being in employment) by 17%, and being located in London by 13%. Conversely, having a female household representative reduces the number of flights by 8%, having a non-white household representative by 20%, and having a person with mobility difficulties in the household by 11%.

These characteristics are also strong predictors for the probability of non-participation in air travel. A 1% rise in income decreases the odds of non-participation by 1%, having at least one household member with a degree by 36%, having a non-white household representative by 21%, and being located in London by 27%. Conversely, an increase in the household size by one person increases the odds of non-participation by 17%, having at least one child increases the odds by 47%, having a household representative who is out of work by 80%, and having at least one person with mobility difficulties in the household increases the odds by 39% (Fig. 9 panel a). Full results for the zero-inflated negative binomial model covering 2001/2 to 2017/8 are displayed in SM Table 6.

Results for a similar zero-inflated negative binomial regression model based on NTS 2006–2017 data (Fig. 10) show broadly consistent results, with some minor differences concerning the effect of having children on the number of flights, and the impact of household size on non-participation. This difference could be due to the fact that the LCF is a household survey and the NTS an individual survey. The LCF relies on the household representative to mention all flights that have been taken by the household, and all household members who have taken the flights, which could lead to an underreporting of participation in flights that rises with household size. The opposite is true for the NTS where the probability of taking a plane might increase per household with rising household size. The regression models include survey year predictors (depicted in SM Figs. 3 and 4). The corresponding coefficients can be interpreted as capturing the 'year effects', net of changes in socio-economic composition of the population. Comparing those coefficients with the corresponding descriptive figures (Fig. 5, SM Fig. 1, SM Fig. 2) shows very similar trends over time. This suggests that much of the change in participation in and frequency of air travel between 2006 and 2018 is due to factors other than changes in the socio-economic make-up of the English population.[2]

4. Discussion and conclusions

Our analysis of the evolution of inequality in air travel participation and the number of flights in England and the UK over the past two decades provides several new insights. In the previous literature, it was unclear whether well-situated and disadvantaged groups have contributed to the rise in air travel over the past two decades to a similar extent or not. We find that less privileged groups (low income, low education, non-white) have contributed more to the increase in air travel in relative, but less in absolute terms compared to well-situated groups. The greater relative contribution to the expansion of air travel by disadvantaged groups could be explained with the further expansion of the low-budget airline industry (Dobruszkes and Mondou, 2013), a continuing social normalisation of air travel (Gössling et al., 2019; Gössling and Stavrinidi, 2016), and acceleration of the global dispersion of social networks (Dobruszkes et al., 2019; Mattioli, 2020). In absolute terms, however, well-situated groups have contributed a much larger volume to the expansion of air travel than disadvantaged groups. These results provide greater nuance to findings by Demoli and Subtil (2019) according to which the increase in participation in air travel was similar across different social groups between 1974 and 2008 in France.

We also find that inequality in air travel reduces if overall participation in air travel in society increases, and vice versa. While our study shows that air travel is highly income elastic – dropping sharply during the 2008–13 economic crisis in the UK and rising again since then – low income and other less privileged groups have cut down more on air travel in relative terms during the recession than richer households. Our examination of direct inequality measures such as the Gini coefficient for the flight distribution and the income based Gini coefficient (Figs. 7 and 8) for this period confirms that inequality of air travel rose during the recession and has reduced again since. While there is no data available yet for the period following the COVID-19 pandemic, our findings suggest that inequality in air travel might increase again following the economic downturn and reduction in overall air travel triggered by the pandemic. While many governments restricted air travel for everyone during the pandemic, and while we may see a pronounced economic bounce-back once restrictions are lifted worldwide, the pandemic has hit disadvantaged groups harder in terms of job and income losses. This means better situated groups may be more likely to contribute to a post-pandemic recovery of air travel, and inequality in air travel participation may increase again for a while (as also suggested by a recent modelling study (Santos et al., 2021)).

On the whole, air travel remains extremely unequally distributed in England and the UK. People on high incomes and with high education,

[1] Note that the per cent figures for all coefficients (b) except log income are calculated as follows: (exp(b)-1)*100. The coefficient for log income in the LCF regression can simply be multiplied by 100 to get per cent.

[2] It must be noted that the regression model based on NTS data (Fig. 10, SM Table 7, SM Table 4) includes an 'income decile' predictor that is based on the income distribution within each survey wave. As such, the model does not control for changes in income levels between 2006 and 2017. This is not the case for the model based on LCF data (Fig. 9, SM Table 6, SM Fig. 3), which includes a continuous income predictor.

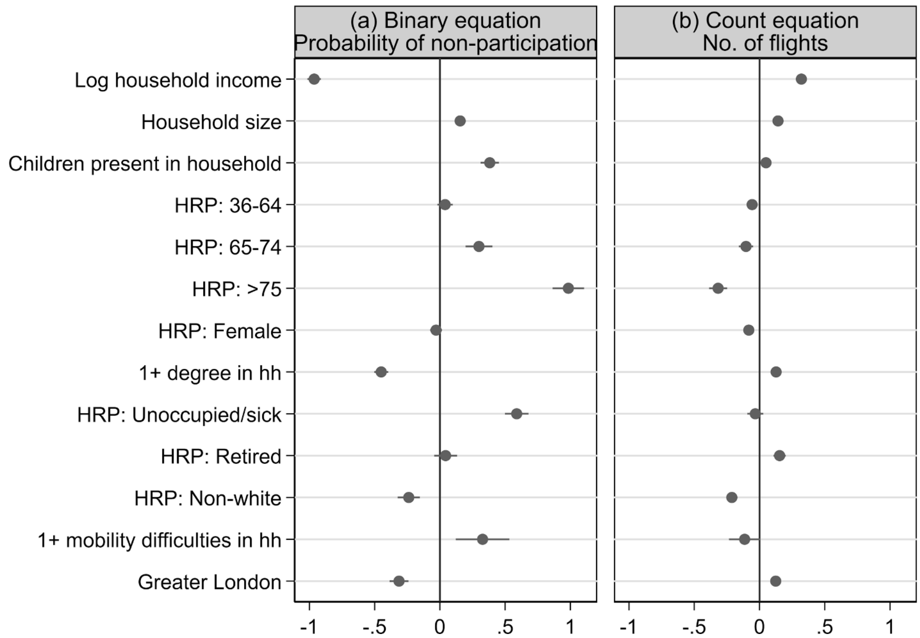

Fig. 9. Coefficients for a zero-inflated negative binomial regression on the number of flights per household in England, LCF 2006–2017/8. The model also controls for survey year dummies (reported in SM Fig. 3). Predictors prefixed by "HRP" refer to the household reference person.

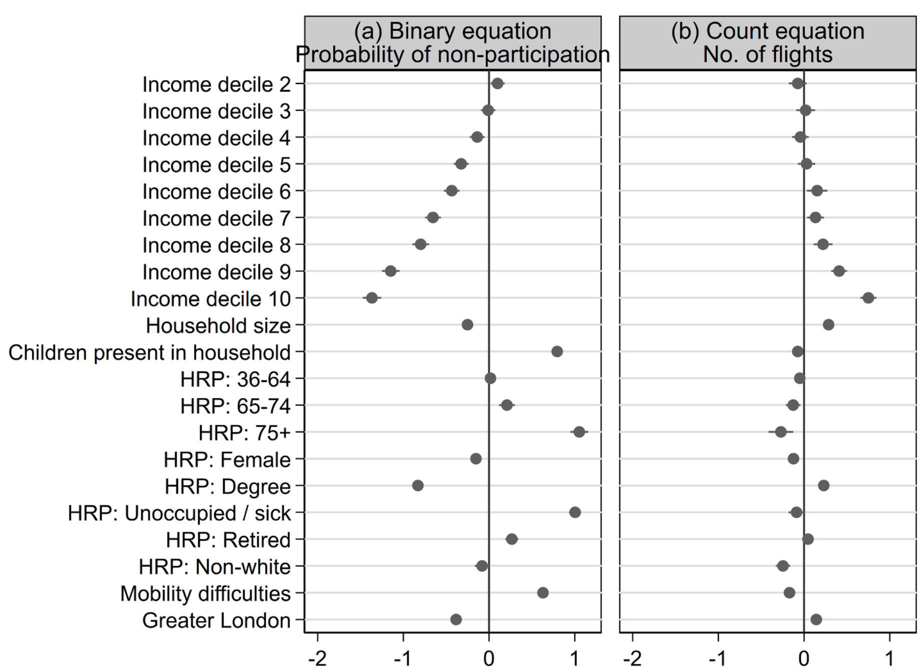

Fig. 10. Coefficients for a zero-inflated negative binomial regression model on the number of flights per household, NTS 2006–2017. The model also controls for survey year dummies (reported in SM Fig. 4). Predictors prefixed by "HRP" refer to the household reference person.

younger people and those based in Greater London are significantly more likely to participate in air travel, and fly significantly more often than their counterparts. Inequality of air travel exceeds inequality of travel as a whole: while Brand and Preston (2010) found that the top 20% of emitters were responsible for 60% of emissions from all travel (air travel, vehicles and public transport), we find that the top 20% of flyers are responsible for 75–76% of all flights. If we had been able to consider emissions, this figure could be even higher if longer flights are also more concentrated at the top of the distribution of flights (e.g. as suggested by the analyses of Demoli and Subtil, 2019).

Our main conclusion is that while disadvantaged groups have indeed contributed to the expansion of air travel over the past two decades, their contribution is much smaller compared to that of well-situated groups in absolute terms. Since air travel inequality remains very high, disadvantaged groups are also far less likely to be affected by air travel demand management policies. While an overall expansion of air travel enables more people from low income and disadvantaged groups to participate in air travel, and thus slightly reduces inequality of air travel, this comes at a high price from a climate change perspective and it does not change the underlying, very extensive inequality of air travel. We therefore argue that policies that target air travel emissions are defendable from a fairness point of view as they will mainly burden well-situated groups in society. In this context, claims that air travel demand management policies would disproportionately burden low-income groups appear highly questionable, and may reflect an attempt to exploit social justice concerns in order to delay climate action (Lamb et al., 2020). In this light, the UK Government proposal to reduce Air Passenger Duty on domestic flights (HM Treasury, 2021) is questionable from a climate change and social fairness perspective. Instead, proposals for a frequent flyer tax or levy that have been put forward by various organisations, including the Committee on Climate Change (Carmichael, 2019) should be duly considered as far more beneficial from an environmental and justice perspective.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tbs.2021.05.008.

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