The impact of migration background and social network dispersion on air and car travel in the UK

Dr Giulio Mattioli
Research Fellow
Department of Transport Planning, TU Dortmund University (Germany)

Prof Joachim Scheiner
Professor
Department of Transport Planning, TU Dortmund University (Germany)

Abstract
While there is a saturation of car mileage per head in developed countries, international air travel is growing rapidly, making it crucial to better understand its drivers. An often-overlooked factor here is migration. Individuals with a migration background tend to have more environmentally sustainable everyday travel patterns, due to lower car use. Yet there is evidence suggesting that their air travel-related emissions are higher than average, possibly due to visits to the home country and the trips required to maintain spatially distant social ties. However, migration background and social network attributes are typically not included in quantitative studies of air travel. In this paper, we analyse data from the 2011-2013 UKHLS survey, which provides information on annual car mileage and air travel frequency, allowing us to derive rough estimates of GHG emissions. We estimate regression models for these outcomes, including migration background and social network predictors. We find broad support for three hypotheses: i) ‘first generation’ migrants have lower than average car mileage but higher levels of air travel, with this contrast being less pronounced for subsequent generations; ii) the relationship between migration background and air travel is moderated by the extent of social networks abroad; iii) migration background and social network dispersion partly explain greater air travel in large cities.

1. Introduction

Climate change is setting out to be one of the most important issues of the 21st century, with passenger transport one of the most challenging sectors for mitigation. Notably, while car mileage per head is saturating in developed countries, air travel is growing rapidly, with e.g. a 117% increase in EU international aviation greenhouse gas (GHG) emissions over 1990-2017 (EEA, 2018). Another defining trend of early 21st century is a growth in the cross-border mobility of persons, with forecasts predicting e.g. a growth in the share of EU population with migration background from 10-15% in 2011 to 25-35% in 2061 (Lanzieri, 2011). The relationship between migration background and travel behaviour has attracted only limited attention in transport studies, and the studies that exist mostly focus on daily mobility (e.g. Welsch et al., 2018). The main message from this literature is that individuals with a migration background may have more environmentally sustainable travel patterns in daily life, due to lower car use (Klocker et al., 2015). This has led e.g. the International Transport Forum to assume that increases in the foreign-born population in Europe will contribute to a reduction in car travel demand (OECD/ITF, 2013).

The long-distance travel behaviour of these groups has received less attention, particularly within transport studies. Yet there is evidence to suggest that migrants are more likely to be international tourists, to undertake air travel, and thus to have higher aviation emissions (Bouffard-Savary, 2010; Dwyer et al., 2014; Hunecke & Toprak, 2014). Therefore, it has been suggested that the growing share of persons with foreign background in Europe will drive increases in long-distance travel and related emissions (EEA, 2014; IFMO, 2014).

A possible explanation for greater air travel among people with migration background has to do with the greater geographical dispersion of their personal social networks. Studies have found associations between social network dispersion and long-distance and air travel (e.g. Howerter et al., 2019; Wall et al., 2014). Migrants typically maintain contact with friends and relatives in the country of origin, as well as with other diaspora member, which tends to result in greater spatial dispersion of their social networks (e.g. Chua et al., 2018), and much of migrants' international tourism is motivated by visits to friends and relatives (Dwyer et al., 2014).

Migration and social network dispersion may also help explain spatial differences in levels of air travel and related emissions across different types of area. While there is a robust literature supporting the finding that these are higher in large and dense urban areas, even after controlling for other factors (Czepkiewicz et al., 2018), the reasons for this association have remained unclear to date. It has been posited that urbanites tend to have more spatially dispersed social networks, and travel more to maintain them (Czepkiewicz et al., 2018; Reichert et al., 2016), but this hypothesis has not been empirically tested to date. Similarly, the possible role of migration background has barely been discussed, which is surprising given that urban populations are typically more diverse in terms of origin.

This paper uses unique data from the UK to investigate the nexus between migration background, social network dispersion, and air and car travel. Specifically, we test the following three hypotheses, derived from the literature: i) 'first generation' migrants have lower than average car mileage but higher levels of air travel, with this contrast being less pronounced for subsequent generations; ii) the relationship between migration background and air travel is moderated by the extent of social networks abroad; iii) migration background and social network dispersion partly explain greater air travel in large cities.

2. Data preparation

We use survey data from *Understanding Society,* the UK Household Longitudinal Study (UKHLS) (University of Essex et al., 2018). UKHLS provides information on a variety of subjects, with questionnaire modules that change year-on-year. While in this study we combine data from Wave 3 (2011-2012) and Wave 4 (2012-2013), our analysis is cross-sectional, as we do not model changes over time. The full sample size for Wave 4 is 47,066 individuals. UKHLS is an excellent source for migration-related research, as it includes dedicated questions and oversamples the main ethnic minority groups. While we do not discuss other aspects of the complex survey design of UKHLS here, we weighted our analysis as appropriate to adjust for differences in sample selection probability.

The two dependent variables in our analysis are drawn from Wave 4. With regard to car use, respondents reported the approximate number of miles they had driven in the twelve months prior to the interview. They also reported the number of flights that they had taken over the same period "for leisure, holidays or visiting friends or family", distinguishing between flights within the UK, to other European countries and to countries outside of Europe. Air travel "for work or business purposes" was explicitly excluded, which is arguably appropriate for our study, as we expect migration background and social network dispersion to have greater impact on personal travel. Yet this means that there is a discrepancy between our measure of car travel (which includes business travel), and the air travel variable (which excludes it). We comment on this issue in the conclusions.

In order to compare air and car travel on the same scale, and to get a sense of their environmental impact, we computed rough estimates of GHG emissions for both types of travel, as illustrated in Table 1. We impute flight distance for the three destination categories using the average estimates proposed in a study that used the same data (Alcock et al., 2017)[1]. For each destination category, we multiply the number of flights taken by the individual by the imputed average distance, and by the appropriate UK Government GHG conversion factors for domestic, short-haul international and long haul international flights (DEFRA & DECC, 2015). These include direct CO_2, CH_4 and N_2O emissions, as well as indirect emissions from production and distribution of fuels, and further 'radiative forcing' (e.g. contrails, water vapour, NOx), which accounts for a large share of the climate impact of aviation (Reichert et al., 2016). The factors are presented as CO_2 equivalents (CO_2e) for global warming potential over a 100-year time horizon (GWP_{100}). The aviation emission factors are on a passenger km basis, so they consider UK-specific loading factors. For car travel, in the absence of information on vehicle characteristics, we multiply distance

[1] Alcock et al. (2017) derive their estimates combining data on passenger traffic between airports and on the proportion of traffic flying for non-work reasons, with reference to the years 2008-2009.

(converted to kms) by the UK government GHG vehicle/km conversion factor for 'average car, fuel unknown' (reflecting average values of the UK car fleet). As information about vehicle occupancy and car passenger use is not available in UKHLS, we assign all vehicle emissions to the driver. In a final step, we sum estimates of air- and car-related emissions to obtain a rough proxy of total annual transport-related emissions for individual respondents[2]. Given the numerous limitations of our GHG estimates, the main focus of our analysis is on the original variables (number of flights and car mileage). We use GHG estimates to complement these findings, and do not test specific hypotheses for this part of the analysis.

Table 1 – Imputed distance and GHG conversion factors used for emission estimates.

Type of travel		Imputed distance (km)	GHG conversion factor (kg CO_2e per km)
Car		-	0.23394
Flight	within the UK	857	0.37826
	to other European countries	3,181	0.215939
	outside of Europe	13,518	0.247076

We consider four sets of independent variables. First, migration generation background, which distinguishes between 'first generation' (born abroad), and second (UK-born, at least one foreign-born parent), third (at least one foreign-born grandparent) and 'fourth' generation (all others - referred to as 'natives' in the following). 6.6% of respondents in our analysis sample were UK-born but did not provide sufficient information on the country of birth of relatives, and are classed in a separate category ('unclassifiable'). The second set of independent variables assesses the geographical dispersion of social networks, based on information collected in Wave 3 (i.e. one year earlier than the other variables). These include: i) the share of the respondent's friends living outside of the 'local area' (with the meaning of 'local area' left to the respondent's interpretation); ii) a dummy indicating whether at least one of three "closest friends" was living abroad at the time of the survey; iii) a dummy indicating whether at least one close family member (child, mother or father) lives abroad.

To test our third hypothesis, we include spatial variables in the analysis. Here the information available in the 'end user licence' version of UKHLS is limited, so we use two rather coarse measures: i) a dichotomous 'urban vs. rural' area classification; ii) a variable distinguishing 'government office regions' and other devolved administrations. Since exploratory analysis showed little differences between English regions outside of London, we aggregate these in a single category. We test the hypothesis that air travel is higher in urban areas, and notably in London (as the largest, densest city-region and main airport hub), and that this association is partly explained by migration background and social network dispersion factors.

While the focus of our analysis is on the three sets of independent variables listed above, we include socio-economic control variables (income, education, economic status, household composition, age, gender, and disability), as these have been found to be associated with air travel in previous research (e.g. Alcock et al., 2017; Reichert et al., 2016). As such in Section 4 we comment only briefly on the association between these factors and travel behaviour.

We exclude from the analysis individuals with missing information on any of the variables listed above, as well as six implausible outliers for car mileage (reporting more than 300,000 annual miles). Further exclusions are due to the complex survey design of the UKHLS, resulting in an analysis sample of 20,120 individuals, (all aged 16 or older). By applying the appropriate weights, we ensure that the results are representative of adults who lived continuously in the UK from 2009-2010 to 2012-2013.

3. Analysis and methods

We start by presenting crosstabulations and means to show the association between dependent and independent variables at the bivariate level (Table 2). We then present multivariate regression models, organised in three steps (Table 3 to 5). First, to test

[2] GHGs from the use of other modes have been shown to account for a very small share of passenger transport emissions in the UK (Brand & Boardman, 2008).

hypotheses i) and ii), we estimate regression models for both outcomes (number of flights and car mileage), starting with a non-adjusted model including a single predictor (migration background), and then progressively adjusting for socio-economic and spatial, and social network variables (Table 3). To predict the number of flights, we estimate negative binomial regression (NBR) models. This is appropriate in light of the count nature of the variable, and in presence of overdispersion. To predict car mileage, we estimate ordinary least square (OLS) models. This is not strictly appropriate considering the high share of individuals in our sample with zero mileage (32.5%), and the skewed distribution of mileage for the rest of the sample. This calls for the estimation of Heckman Sample Selection models, possibly with a log-transformed variable. We present OLS results for two reasons: i) they allow us to present a more succinct and easily interpretable set of coefficients; ii) as part of the data analysis, we have estimated Heckman models (both with and without long-transformed variables), and they deliver results that are broadly consistent with the OLS models.

To test hypothesis iii), we adopt a similar approach, estimating regression models with spatial variables as predictors, and then progressively adjusting for other sets of independent variables (Table 4). While our main interest here is for predicting air travel frequency (NBR models), we carry out the same analysis for car mileage (again with OLS models). The goal is to test whether the association between spatial variables and car travel is similarly moderated by migration background and social network variables (although we expect this not to be the case).

Our third and final step is to estimate models for annual GHG emissions for air and car travel, and both sources combined, using maximally adjusted models (Table 5). We aim to: i) compare the effects of independent variables of interest on the two outcomes on the same scale; ii) to explore their effects on 'total' emissions. Again, for ease of exposition, we present OLS models. We have checked the main findings against corresponding Heckman models, which give broadly consistent results (not reported here for the sake of brevity).

4. Results

Table 2 presents descriptive statistics for the two main dependent variables of our analysis at different levels of the independent variables, providing initial support for our hypotheses. First generation migrants are overrepresented among those who took at least one flight, and notably among 'frequent flyers' (with four or more flights), while second and third generation migrants behave more like 'natives'. Conversely, average annual car mileage is lowest among first generation migrants, but on similar (higher) levels for other generations. The association of all three social network variables with air travel frequency is in the expected direction, with higher frequency for those who have best friends or close family abroad, as well as for people with at least one friend living outside of the local area.

Spatial variables are associated in the expected way with car travel, with mileage higher in rural areas and outside of London. While there are no statistically significant differences between urban and rural areas in terms of flight frequency[3], both participation in and frequency of air travel are higher in London. However, similarly high levels of air travel frequency are observed for Scotland and Northern Ireland. Socio-economic control variables show the expected bivariate associations with both outcomes. Notably all characteristics associated with greater car mileage (high income, high education, employment, middle-adulthood, cohabiting with a partner or spouse, male gender, not having children, lack of disability) are also associated with greater air travel frequency.

[3] For all other crosstabulations nested in Table 2, the association between the two variables is statistically significant at the p<0.001 level (Chi-square tests). All independent variables show differences between means of car mileage that are statistically significant at the p<0.001 level (t-tests), except for the share of friends living outside of the local area.

Table 2 – Descriptive statistics for the main dependent variables of our analysis, by level of independent variables (N=20,120) [continued overleaf].

Variable	*Level*	No. of flights (%) 0	1	2	3	4+	Car miles (mean)
Household income decile (after housing costs)	*1-2*	75.8	13.5	6.4	1.8	2.5	2747
	3-4	68.0	17.8	8.0	2.6	3.6	4310
	5-6	59.7	22.6	9.8	3.2	4.7	5772
	7-8	49.2	25.8	12.8	4.7	7.6	7073
	9	39.7	26.6	16.8	5.9	10.9	7102
	10	30.0	25.9	18.8	8.3	17.0	7704
Tertiary education qualification	*No*	64.4	19.6	8.8	3.0	4.1	4833
	Yes	43.9	24.4	15.1	5.6	11.1	6703
Economic status	*In paid employment*	49.0	24.9	13.2	4.6	8.4	7330
	Retired	67.9	15.9	8.5	3.3	4.4	2967
	Other	71.1	16.2	7.0	2.4	3.3	2647
Age	*16-29*	57.5	23.7	11.4	2.8	4.6	3508
	30-49	54.6	23.0	11.2	3.8	7.4	7089
	50-64	52.7	21.4	12.4	5.0	8.6	6578
	65-74	59.2	19.6	10.3	5.1	5.7	4201
	75+	78.1	11.2	6.3	1.9	2.5	2180
In a cohabiting couple	*No*	64.9	18.2	9.5	2.7	4.7	3595
	Yes	52.8	23.0	11.9	4.6	7.6	6602
Gender	*Male*	57.0	20.8	10.9	3.9	7.5	7285
	Female	57.7	21.6	11.1	3.9	5.6	3806
Responsible for children <16 years old	*No*	56.6	21.1	11.2	4.1	7.0	5590
	Yes	61.5	22.1	9.8	2.9	3.8	4854
Long-standing illness or disability	*No*	52.6	23.4	12.2	4.4	7.4	5981
	Yes	66.2	17.3	8.7	3.1	4.8	4533
Type of area	*Urban*	57.6	21.0	11.0	3.7	6.8	7252
	Rural	57.3	21.3	11.0	4.0	6.4	4949
Region	*England (outside of London)*	58.9	21.4	10.3	3.8	5.6	5817
	London	47.1	22.5	14.6	5.2	10.6	3197
	Wales	64.2	18.0	11.2	1.8	4.8	5787
	Scotland	54.1	20.0	12.0	4.4	9.6	4981
	Northern Ireland	53.8	17.5	12.4	4.2	12.2	6625

Table 2 [continued from page 5]

Variable	*Category*	No. of flights (%) 0	1	2	3	4+	Car miles (mean) 0
Migration generation	*4th+*	59.5	20.4	10.3	3.9	5.8	5825
	3rd	56.9	20.9	10.3	4.4	7.6	5865
	2nd	55.3	21.3	12.1	4.6	6.7	5411
	1st	45.5	24.7	14.4	4.2	11.2	4418
	Unclassifiable	58.2	24.0	11.4	1.9	4.5	3550
Share of friends living outside of local area	*None*	68.9	17.9	7.3	2.7	3.1	3975
	Less than half	55.4	22.3	11.6	4.2	6.5	5586
	Half or more	55.3	21.2	11.7	4.1	7.8	5912
Best friends abroad	*No*	58.7	21.1	10.5	3.8	5.9	5441
	Yes	41.0	22.5	16.8	5.7	14.0	5903
Close family abroad	*No*	58.6	20.9	10.7	3.9	5.9	5529
	Yes	40.6	25.4	15.0	4.6	14.3	4740

Table 3 tests our first hypothesis concerning the impact of migration generation on air and car travel. For each outcome, we present three regression models: a non-adjusted model, including migration generation as the sole predictor (A1, C1); a partially-adjusted model, controlling for socio-economic and spatial predictors (A2, C2); and a maximally-adjusted model, including control variables as well as variables measuring social network dispersion (A3, C3). The goal is to test whether the association between migration generation and the two types of travel is accounted for by other intervening variables.

Regarding air travel, we find a positive association between first (and, to a lesser extent, second and third) migration generation background in the non-adjusted model (A1). When controlling for socio-economic and spatial factors (A2), the coefficients associated with second and third generation become non-significant. This suggests that the higher levels of air travel observed among people with foreign-born parents or grandparents are largely due to compositional differences. The coefficient associated with the first generation is slightly reduced in magnitude, but remains statistically significant, suggesting that this is not the case for people who were themselves born abroad. In the maximally-adjusted model (A3), all migration generation coefficients are statistically non-significant. All social network variables are significantly associated with air travel frequency in the expected direction, and their inclusion improves model quality according to the AIC (not reported because of space constraints). This confirms that the higher levels of air travel observed among first generation migrants are largely due to greater geographical dispersion of their social networks. Incidence-rate ratios (IRR) estimated from the partially-adjusted model (A2) show that first migration generation background increases the expected number of flights by 38.4% as compared to ‘natives’, holding other variables constant. IRRs derived from the maximally-adjusted model (A3) show that having best friends abroad increases the expected number of flights by 51.5%, and close family abroad by 34.6%. The increase associated with having friends outside of the local area is roughly +28%.

Models C1-C3 apply the same analysis approach to car mileage. We find a statistically significant, negative effect of first-generation migration background on car driving distance in the non-adjusted model (C1), accounting for a reduction of approximately 1,400 miles per year as compared to ‘natives’. This effect is reduced in magnitude but remains statistically significant in both the partially- and maximally-adjusted models (C2-C3). This suggests that lower levels of car travel among first-generation immigrants are partly, but not entirely, due to different composition in terms of socio-demographics (e.g. age) and residential location.

The effect of social network variables on car mileage deserves detailed comment. Having friends outside of the local area is associated with a rather large increase in car travel, even after controlling for socio-demographic, spatial and migration background variables. Conversely, if close family members live abroad, car travel decreases. This suggests the existence of a 'substitution effect' whereby people with family members abroad tend to fly to visit them, rather than travelling by car. Having best friends abroad does not appear to have a significant association with car mileage, after controlling for other variables.

Table 4 applies a similar approach to test our third hypothesis, namely that migration background and social network dispersion partly explain greater air travel in large cities (models A4-A6). For comparison, we provide results for models predicting car mileage based on the same predictors (C4-C6). The non-adjusted model (A4) includes only the two spatial predictors. We find no statistically significant association between urbanity and air travel frequency when controlling for the region of residence. Living in London, however, is associated with more flights as compared to the rest of England, as does living in the (relatively remote) regions of Scotland and Northern Ireland. The negative coefficient associated with London is reduced in magnitude when controlling for socio-economic characteristics (A5), and migration background and social network variables (A6). In the maximally-adjusted model (A6), we find a positive relationship between all social network dispersion variables and air travel.

Overall, this suggests that higher levels of air travel in London are partly (but not entirely) due to the different socio-economic make-up of the UK capital, notably the greater share of people with (first generation) migration background, who tend to have more spatially dispersed social networks. Note that this is not the case for Scotland and Northern Ireland, whose coefficients slightly *increase* in magnitude when going from the non-adjusted (A4) to the maximally-adjusted model (A6). This suggests that higher levels of air travel in these regions are due to other factors, e.g. their peripheral location within the UK and Europe.

With regard to car mileage (C4-C6), as expected we find a large negative effect of urban location (up to 2,000 miles less per year as compared to rural areas) and residence in London (up to 2,500 miles less as compared to the rest of England), which is robust to controlling for the socio-economic, migration background and social network characteristics of the respondents.

Table 5 shows results for OLS models predicting GHG emissions from annual air travel (A7), car travel (C7), and both combined (T7). The models include all predictors, as in the maximally-adjusted models in Table 2 and 3. The results for air travel GHG (A7) again highlight emission increases associated with spatial dispersion of social networks and migration background. An interesting difference concerns the impact of residential location. NBR models (Table 4) suggest that the increase in air travel frequency for London residents is smaller than for the inhabitants of Scotland and Northern Ireland, when controlling for intervening factors. The opposite is the case when GHG is modelled. Further analysis (not reported here) shows that this is because of a higher share of intra-UK flights originating from Scotland and Northern Ireland, while the flights of Londoners are more often oriented to foreign (and notably extra-European) destinations, thus accounting for greater emissions.

The car GHG model (C7) does not deviate from the results presented in the maximally-adjusted models in Table 3 and 4, as GHG estimates are merely car distance figures multiplied by a fixed per-km emission factor. More interesting are the results for 'total' transport emissions (T7). These suggest that the net impact of migration background on travel emissions is negative (but small), as the increase in air travel emissions is more than compensated by the reduction in car-related emissions[4]. Similarly, the increase in air travel GHG associated with having close family abroad is partly compensated by a reduction in emissions from car travel, although the residual effect is still positive. Something different happens with the presence of friends outside of the local area and of best friends abroad, both of which have relatively large net effects on total GHG, as a result of the cumulation of positive effects for both modes.

[4] Similar conclusions can be drawn from the non-adjusted OLS model, and the corresponding Heckman models (not reported here for the sake of brevity).

Table 3 – Parameter estimates for regression models of air and car travel (N=20,120)

Variable	Level	No. of flights (NBR)			Car miles (OLS)		
		A1	A2	A3	C1	C2	C3
Migration generation (ref.cat: 4th+)	*3rd*	.15*	.085	.068	40	244	209
	2nd	.14*	.038	.015	-414	-141	-169
	1st	.43***	.33***	.07	-1407***	-1114***	-882***
	Unclassifiable	-.14*	-.098	-.087	-2274***	-1280***	-1258***
Household income decile (ref.cat.: 1-2)	*3-4*		.24***	.23***		519***	493**
	5-6		.37***	.36***		974***	942***
	7-8		.67***	.67***		1902***	1851***
	9		.88***	.86***		1807***	1751***
	10		1.2***	1.2***		2343***	2284***
Tertiary education (D)			.48***	.42***		730***	639***
Economic status (ref.cat.: employed)	*Retired*		-.14*	-.13*		-2842***	-2850***
	Other		-.41***	-.41***		-3068***	-3051***
Age (ref.cat: 16-29)	*30-49*		.11	.074		2393***	2426***
	50-64		.22***	.21***		2274***	2303***
	65-74		.21**	.2*		1641***	1691***
	75+		-.31**	-.3**		606*	713*
Part of cohabiting couple (D)			.021	.016		667***	681***
Female (D)			-.026	-.03		-3251***	-3242***
Has children <16yo (D)			-.43***	-.41***		138	195
Disability (D)			-.27***	-.26***		-557***	-559***
Urban area (D)			.025	.031		-1835***	-1814***
Region (ref.cat.: England outside of London)	*London*		.19**	.18**		-2404***	-2454***
	Wales		-.098	-.077		-37	14
	Scotland		.31***	.31***		-991***	-1009***
	Northern Ireland		.52***	.51***		545	563
Friends outside of local area (ref.cat.:0)	*half or less*			.25***			706***
	more than half			.25***			1019***
Best friends abroad (D)				.42***			54
Close family abroad (D)				.3***			-752*
Constant		-.077**	-.77***	-.99***	5825***	7080***	6377***
Alpha		2.07	1.44	1.40	-	-	-
R^2		-	-	-	.0071	.17	.17

*Notes: * p<0.05, ** p<0.01, *** p<0.001; (D): dummy variable*

Table 4 – Parameter estimates for regression models of air and car travel (N=20,120)

		No. of flights (NBR)			Car miles (OLS)		
Variable	***Level***	**A4**	**A5**	**A6**	**C4**	**C5**	**C6**
	Urban area (D)	-.05	.038	.031	-2056***	-1853***	-1814***
Region (ref.cat.: England outside of London)	*London*	.43***	.26***	.18**	-2136***	-2630***	-2454***
	Wales	-.12	-.11	-.077	-300	-34	14
	Scotland	.28***	.3***	.31***	-1107***	-1012***	-1009***
	Northern Ireland	.46***	.54***	.51***	154	484	563
Household income deciles (ref.cat.: 1-2)	*3-4*		.22***	.23***		502***	493**
	5-6		.35***	.36***		964***	942***
	7-8		.64***	.67***		1882***	1851***
	9		.85***	.86***		1771***	1751***
	10		1.1***	1.2***		2314***	2284***
	Tertiary education (D)		.51***	.42***		723***	639***
Economic status (ref.cat.: employed)	*Retired*		-.15*	-.13*		-2831***	-2850***
	Other		-.41***	-.41***		-3150***	-3051***
Age (ref.cat.: 16-29)	*30-49*		.14*	.074		2554***	2426***
	50-64		.23***	.21***		2526***	2303***
	65-74		.22**	.2*		1868***	1691***
	75+		-.3**	-.3**		847**	713*
	Part of cohabiting couple (D)		.039	.016		692***	681***
	Female (D)		-.025	-.03		-3237***	-3242***
	Has children <16yo (D)		-.42***	-.41***		205	195
	Disability (D)		-.27***	-.26***		-502***	-559***
Friends outside of local area (ref.cat.:0)	*half or less*			.25***			706***
	more than half			.25***			1019***
	Best friends abroad (D)			.42***			54
	Close family abroad (D)			.3***			-752*
Migration generation (ref.cat.: 4th+)	*3rd*			.068			209
	2nd			.015			-169
	1st			.07			-882***
	Unclassifiable			-.087			-1258***
	Constant	-.053	-.76***	-.99***	7387***	6729***	6377***
	Alpha	2.06	1.46	1.40	-	-	-
	R^2	-	-	-	.021	.17	.17

*Notes: * p<0.05, ** p<0.01, *** p<0.001; (D): dummy variable*

Table 5 – Parameter estimates for OLS regression models of GHG emissions from air and car travel (N=20,120)

Variable	*Level*	A7 kgCO_2e for air travel	C7 kgCO_2e for car travel	T7 Total kgCO_2e (air + car)
Migration generation (ref.cat.: 4^{th}+)	*3rd*	100	79	179
	2nd	180	-64	116
	1st	243*	-332***	-89
	Unclassifiable	-117	-474***	-590***
Household income decile (ref.cat.: 1-2)	*3-4*	136	186**	322***
	5-6	244**	355***	599***
	7-8	602***	697***	1299***
	9	1008***	659***	1667***
	10	1791***	860***	2651***
	Tertiary education (D)	495***	241***	735***
Economic status (ref.cat.: employed)	*Retired*	-200	-1073***	-1273***
	Other	-192**	-1149***	-1341***
Age (ref.cat.: 16-29)	*30-49*	144	913***	1058***
	50-64	239**	867***	1106***
	65-74	382**	637***	1019***
	75+	-34	268*	235
	Part of cohabiting couple (D)	67	256***	323***
	Female (D)	18	-1221***	-1203***
	Responsible for children <16yo (D)	-575***	73	-502***
	Disability (D)	-314***	-211***	-525***
	Urban area (D)	58	-683***	-625***
Region (ref.cat.: England outside of London)	*London*	340**	-924***	-583***
	Wales	-37	5	-32
	Scotland	59	-380***	-321**
	Northern Ireland	-118	212	94
Friends outside of local area (ref.cat.:0)	*half or less*	148**	266***	414***
	more than half	234***	384***	617***
	Best friends abroad (D)	689**	20	710***
	Close family abroad (D)	711**	-283*	428*
	Constant	359***	2401***	2760***
	R^2	.072	.17	.16

*Notes: * p<0.05, ** p<0.01, *** p<0.001; (D): dummy variable*

With regard to spatial variables, the net effect of London residence is a reduction in total travel GHG, as the positive effect on air emissions is more than compensated by the large reduction in car GHG. The same is true for urban location, which is associated with a reduction in total emissions, mainly as a result of much lower emissions from cars.

5. Discussion and conclusions

Overall, the results provide support for our hypotheses: a ‘first generation’ migration background is associated with less car use and more air travel, both in bivariate and multivariate analysis, although such effect does not extend to further generations. This is suggestive of an intergenerational assimilation process whereby, starting from the second generation, people adopt the travel patterns that are prevalent in their country of residence.

Our results also suggest that a large part (and possibly all) of the increase in air travel associated with migration background is due to the geographical dispersion of their social networks. In other words, if foreign-born people fly more than the rest of the population, this is largely because they have relationships with friends and families abroad, which they need to maintain. By contrast, the association between migration background and lower levels of car use seems to be largely due to other factors, which our analysis was not able to identify.

Overall, our study shows that the geographical dispersion of friendship and family networks tends to increase both car and air travel, and related GHG emissions. The exception here is the presence of close family members abroad, for which there is suggestive evidence of a ‘substitution effect’, whereby higher levels of international air travel are compensated by lower levels of car travel in the host country. Overall, these findings contrast with the relative lack of attention that sustainable transport research and surveys have paid to social networks as a driver of transport activity, and strongly suggest that more research on this nexus is needed.

With regard to our third hypothesis, while we do not find an association between urbanity and air travel, we do observe more frequent flying among London residents. Part, but not all of this association is accounted for by the different socio-demographic makeup of the capital’s population, as well as by the overrepresentation of people with migration background and dispersed social networks there. Note that this is not the case for car travel, whose (negative) association with urbanity and London residence is not greatly diminished when controlling for other intervening factors. Overall, this suggests that the association between large city residence and air travel is more spurious than that with car travel (although our analysis does not consider possible residential self-selection effects). Overall, our findings provide initial support for the hypothesis that higher levels of air travel among urbanites are explained by migration background and social network factors, although more research is required on this point.

Our analysis of GHG emissions suggests that, while migration background and London residence are associated with higher aviation emissions, this is more than compensated by a corresponding reduction in car-related emissions, so that their net impact on total transport emissions is neutral or negative. However, our estimates of the climate impact of air travel are conservative, because of the exclusion of business travel (which is included in the estimates of car GHG). Also, the air travel emission factors adopted here consider global warming potential over a 100-year horizon. Studies adopting a shorter (20-year) time horizon (Reichert et al., 2016), which magnifies the short-term climate impact of aviation, have concluded that the climate impacts of air travel can more than compensate reductions in other sources of transport emissions, as e.g. in large urban areas.

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