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Flying along the supply chain: accounting for emissions from student air travel in the higher education sector

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Abstract: Higher education institutions (HEIs) can play a key role in facilitating the transition to a low-carbon economy, where greenhouse gas emissions reporting is a vital first step in this process. While most UK HEIs are now required to report their estates emissions, a robust approach requires consideration of all significant emission sources, where engagement with voluntary reporting of supply chain emissions has been inconsistent. This research examined the potential significance of emissions arising from the air travel of international and study abroad students and their associated visiting friends and relatives (VFR). Based on a survey, we found that average student flight frequencies were substantially higher than the values assumed in sector guidance. Using our estimates of flight frequencies, along with publicly reported emissions and international student numbers for a sample of 25 HEIs, we found student and VFR emissions to be highly significant, each being greater than all other Scope 3 travel emissions and comparable to Scope 2 emissions. Scenario analysis suggests that by 2020/21 increases in student and VFR flight emissions are likely to exceed reductions in estates emissions unless HEIs reinvigorate efforts to achieve their ambitious reduction targets, and/or there is close to zero annual growth in inbound and outbound student numbers. Furthermore, we highlight the potential for rebound type effects, where if HEIs took action to encourage fewer student flights, the number of VFR flights may increase to maintain a similar degree of student-VFR contact. We therefore argue that it is imperative that UK HEIs develop an accurate picture of these emissions in order to identify effective reduction options and inform both their carbon management and internationalisation strategies.

Keywords: Scope 3, higher education, student air travel, visiting friends and relatives, rebound

1. Introduction

Globally, the Higher Education (HE) sector can play a key role in facilitating the transition to a low-carbon economy. As organisations, HE institutions (HEIs) can be considered analogous to small cities with significant environmental impacts (Klein-Banai and Theis 2011), where in recent years, many have started to embed sustainable practices into their systems (Lozano et al. 2015). While campus greening is often an area of focus (Muller-Christ et al. 2014), the potential contribution of HEIs is not limited to the operation of their estates, but extends to a wider sphere of influence through their role as educators, researchers, and community leaders (UNESCO 2012). Although a number of tools have been developed for sustainability assessment across core HEI activities (operations, education, research, outreach), sustainability management remains in its early stages with few HEIs producing sustainability reports (Lozano

2011; Ceulemans, Molderez, and Van Liedekerke 2015). However, HEIs are increasingly reporting their carbon footprint (the GHG emissions arising from their activities) as a measure of sustainability (Klein-Banai and Theis 2013). While taking action on climate change is only one aspect of the sustainable development agenda, it is widely recognised that the two are intrinsically linked (Pinkse and Kolk 2012), thus GHG emissions reporting can be viewed as an important first step for HEIs that enables identification of sustainability initiatives and ultimately improved performance (Townsend and Barrett 2015). Here we focus on carbon management in the UK HE sector, examining the significance of student air travel in the context of GHG emissions reporting.

1.1 UK HE sector GHG emissions reporting

All UK HEIs are expected to contribute to the ambitious national targets to reduce emissions, although specific requirements vary across the funding councils and devolved governments (Table 1). Robust approaches for the measurement of GHG emissions are thus needed to identify the best options to reduce emissions, for target setting, and to assess the impact of mitigation measures (Wright, Kemp, and Williams 2011).

[Table 1 near here]

The GHG Protocol provides some of the most widely used guidance in GHG accounting, where the Corporate Standard (WBCSD/WRI 2004) introduces the concept of 'Scopes' to assist in defining operational boundaries. Scope 1 (direct) emissions arise from sources owned or controlled by an organisation, Scope 2 (energy indirect) emissions arise from the generation of purchased energy, and Scope 3 (other indirect) emissions are all other supply chain emissions that arise as a consequence of the activities of an organisation. Under the Corporate Standard, the minimum reporting boundary includes all Scope 1 and 2 emissions, while under the supplemental Scope 3 Standard, the boundary should be extended to include all significant Scope 3 emissions (WBCSD/WRI 2011a). Evaluating these Scope 3 emissions is recognised as a sizeable challenge due to issues relating to boundary setting, data availability, and calculation reliability (Schaltegger and Csutora 2012; Williams et al. 2012). With specific reference to the HE sector, a number of studies have highlighted the importance of sector level guidance to help address these issues (thus ensuring consistency and enabling comparability) by setting clearly defined boundaries and identifying appropriate calculation methodologies (Ozawa-Meida et al. 2013; Robinson et al. 2015; Townsend and Barrett 2015).

In terms of sector reporting, HEIs in England, Wales and Northern Ireland are required to make an environmental management record (EMR) return to the Higher Education Statistics Agency (HESA). Making an EMR return is optional for Scottish HEIs, although in practice the majority choose to do so. Within the EMR return, it is mandatory to report all Scope 1 and 2 emissions, along with Scope 3 emissions from water supply and wastewater treatment (HESA 2014a). Introduced in the 2013/14 reporting year, HEIs can also voluntarily submit data for Scope 3 emissions sources associated with waste, travel and procurement (HESA 2014a), where guidance has been produced to assist in the consistent calculation of these emissions (HEFCE 2012a; 2012b; 2012c). The Higher Education Funding Council for England (HEFCE) recommends reporting against all of these Scope 3 sources, and has signalled that mandatory reporting may be extended to include these sources in the future (HEFCE 2015).

In the 2013/14 EMR return (HESA 2014b), only 27 of 159 HEIs reported against all available Scope 3 sources, where the emissions reported by two HEIs appeared erroneous (Appendix 1, available as supplemental material). For the remaining 25 institutions, the voluntarily reported emissions accounted for 71% of total reported emissions (51% to 88% on an institutional basis). This clearly illustrates the significance of Scope 3 sources, where narrowly set boundaries can significantly underestimate emissions and thus provide a misleading picture of an organisations carbon footprint (Matthews, Hendrickson, and Weber 2008; Williams et al. 2012).

1.2 Extending the reporting boundary – the case for accounting for student air travel

Whilst extending mandatory reporting across all current EMR Scope 3 categories would clearly represent an improvement in UK HE sector reporting, there are other potentially significant emission sources that fall outside of this boundary. Specifically, student travel emissions are presently limited to commuting, defined as travel between the term-time address and the HEI (HESA 2014c). Thus, emissions associated with student travel between home and term-time addresses, or to participate in study abroad programmes are not included. Although not part of the EMR return, HEFCE good practice guidance does include accounting for international and study abroad student air travel (HEFCE 2010b), likely the most significant component of these additional emissions. However, according to the People and Planet University League (PPUL), only nine HEIs have included these emissions in their carbon management plans (PPUL 2015).

Extending the reporting boundary to account for student air travel may prove challenging for (or be challenged by) HEIs for a number of reasons. Firstly, given that there are minimal alternatives to air transport, these emissions will likely increase in line with the continued internationalisation of the sector and the drive to increase inbound and outbound student numbers (Long, Vogelaar and Hale 2014; Townsend and Barrett 2015). Secondly, questions can be asked regarding responsibility for the associated emissions, where the guidance provided by the GHG Protocol is potentially open to interpretation regarding whether or not they are attributable to the HEIs.

According to the Scope 3 Standard (WBCSD/WRI 2011a), organisations should report downstream emissions resulting from the use of sold products, where the critical issue in setting boundaries is to consider the purpose that the service fulfils, and service delivery "encompasses all operations required to complete a service" (WBCSD/WRI 2011b:40). We argue that HEIs are explicitly providing education for overseas students and study abroad opportunities as service offerings, where students are required to travel in order to access these services. Thus, at a minimum, travel between the UK and the overseas country at the start and end of the study period should be included in an HEIs Scope 3 emissions. Whether or not any additional flights that students elect to make are attributable to the HEI is more questionable. It could be argued that these emissions form part of the service-use profile (and are therefore attributable), or that as non-essential travel, the students bear responsibility for any additional flights. We suggest that when offering a service of overseas education that is delivered over an extended period, it is not reasonable to expect that students would not travel home during that period, and as such, additional flights form part of the service-use profile.

Following similar reasoning, we question whether the reporting boundary should be extended further to include emissions arising from the flights of visiting friends and relatives (VFR). VFR trip generation has been identified as a key socio-economic benefit associated with the UK international student population, where according to Bischoff and Koenig-Lewis (2007), for 73% of VFR the sole motivation for travel was a wish to see the student concerned (with 27% holding joint motivations, combining a student visit with a holiday or event in the area). Thus if action were taken to encourage fewer student flights, it is conceivable that the number of VFR flights might increase, decreasing or negating any expected reduction in economy-wide emissions (c.f. rebound and backfire effects; Druckman et al. 2011). Thus, although VFR travel may be considered a leakage or secondary market effect, and to fall outside of an HEIs 'Scopes' (WBCSD/WRI 2004), we suggest that the significance of VFR travel should be evaluated, and potentially acknowledged under 'Other' emissions.

1.3 Accounting for student air travel – calculation reliability

Notwithstanding the arguments presented above, in order to have an informed debate regarding responsibility for student and VFR travel emissions, and the efficacy of potential mitigation measures, it is necessary to understand the significance of those emissions, where this requires robust accounting practices.

While HEFCE guidance includes a methodology for estimating emissions from student air travel (HEFCE 2010b), we question the robustness of the assumptions regarding trip distance and flight frequency. Following a standard approach, student flight emissions (F_S) can be estimated as:

$$F_S = [D \times (1 + A)] \times CF$$

Where D is the return flight trip distance, (1+A) is the number of return flights per year, where 1 represents the flight at the start and end of the study period and A is the number of additional flights, and CF is the appropriate conversion factor (short-haul or long-haul) as published by the UK Government (DEFRA/DECC 2014a).

In the HEFCE guidance, D is estimated as twice the great circle distance (GCD) between London Heathrow (LHR) and the capital city of the overseas country (HEFCE 2010b). However, if the overseas country is unknown, the GCD is assumed to be 400 miles for short-haul flights and 4000 miles for long-haul (HEFCE, 2010b). With regard to flight frequency, A is assumed to be one for inbound (international) students from the European Union (EU), and zero for other inbound and all outbound (study abroad) students (HEFCE 2010b). However, there is no prior research on which to base these assumptions (SQW Consulting/SQW Energy 2009) where there may or may not be differences between the travel behaviour of different student groups, and average trip distances and flight frequencies may be substantially different, particularly if both student and VFR flights are considered.

This paper seeks to address these issues and to assess the significance of student air travel emissions. In Section 2 we report the results of a survey examining student and VFR travel behaviour. Section 3 then presents a sensitivity analysis of the HEFCE (2010b) methodology to assess the appropriateness of the recommended assumptions. Following this, Section 4 contextualises student and VFR flight emissions by examining their significance in comparison to GHG emissions for those HEIs who reported against all available categories in the 2013/14 EMR return. In section 5, we evaluate the magnitude of these emissions for the UK HE sector in 2013/14 and examine the potential future significance in 2020/21 under a range of scenarios. Finally, we make recommendations regarding reporting of student air travel emissions and identify areas for future research.

2. Student travel behaviour

The survey instrument was an online, self-administered questionnaire targeting international (inbound) and study abroad (outbound) students registered at UK HEIs. In addition to demographic questions, respondents were asked to identify their overseas airport, their flight frequency, and the flight frequency of VFR. A copy of the questionnaire is provided in Appendix 2, available as supplemental material.

In total, 673 useable responses were received from students registered at 26 UK HEIs between December 2014 and February 2015. Table 2 presents a breakdown of respondents by study group and region in which the UK HEI of enrolment is located. An analysis of student and VFR flight frequency is provided below, and both the overseas airport and flight frequency are utilised in the sensitivity analysis presented in Section 3.

[Table 2 near here]

2.1 Student flight frequency

Inbound students

Table 3 presents the average number of additional flights made by inbound students by region of domicile and level of study. A Kruskal-Wallis test revealed some significant differences between world regions for all students (n=498, H=138.954, p<.001), for undergraduates (n=142, H=26.011, p=.001) and for postgraduates (n=324, H=95.464, p=.001). Follow up pairwise comparisons indicated significant differences between European regions (EU-28 and Other Europe) and North America, Asia and the Middle East, Africa, South America, and Oceania. Conversely, the European regions were not statistically different to each other, nor were there any significant differences between the other world regions. We therefore suggest that average flight frequency can be well described using domicile groups of 'Europe' and 'Rest of the World' (RoW).

[Table 3 near here]

For RoW nationals there were no significant differences in the average number of flights according to level of study. However, for European nationals, postgraduates made more flights than undergraduates (n=179, U=3814.000, p=.006), where this most likely reflects the difference in typical academic year length (postgraduates 12 months; undergraduates 9 months), with both groups displaying a similar flight frequency of ~0.2 flights per month. As the proportion of undergraduate and postgraduate students in the survey sample differed from that in the UK student population, a weighted average of flight frequency was calculated, where European students made 2.1 additional flights per year, and RoW students made 1.0 additional flight per year (Table 3).

Outbound students

Table 4 presents the average number of additional flights made by outbound students by period of study and region of destination (no significant differences according to level of study, data not shown). For those studying abroad for one year, a Kruskal-Wallis test revealed some significant differences between world regions (n=107, H=28.791, p=.001). Follow up pairwise comparisons indicated significant differences between EU-28 and Oceania (p=.001) and North America (p=.007). No significant differences between world regions were found for students studying abroad for less than a year. However, we found nothing to contradict the European and RoW groupings identified for inbound students, and when these were applied, significant differences were found (one year: n=107, U=2191.000, p<.001; less than a year: n=68, U=582.000, p=.011). Thus using these destination groupings, on average students studying abroad for one year made 2.4 additional flights if studying in Europe and 0.9 additional flights if studying in the RoW, while students studying abroad for less than 1 year made 1.1 additional flights if studying in Europe and 0.4 additional flights if studying in the RoW.

[Table 4 near here]

2.2 VFR flight frequency

This section considers the total number of flights made by VFR, as all VFR flights can be considered additional to the return flight made by the student at the start and end of the study period.

Table 5 presents descriptive statistics for the number of VFR flights by study group and the domicile/destination groupings identified above (no significant differences according to level of study, data not shown). For inbound students, 77% of Europeans and 56% of RoW nationals received at least one visitor, with averages of 2.9 and 1.4 respectively (n=498, U=38,920.500, p=.001), where these results are comparable to previously reported values (Bischoff and Koenig-Lewis 2007). For outbound students studying abroad for one year, 78% of those studying in Europe and 65% of those studying in the RoW received at least one visitor with averages of 4.0 and 2.2 respectively (n=107, U=1859.000, p=.006). For those studying abroad for less than a year, the number of visitors is considerably lower where only 43% of students received at least one visitor with an average of 1.0 (with no significant difference between students visiting Europe and the RoW).

[Table 5 near here]

3. Sensitivity analysis of the HEFCE assumptions

This section presents a sensitivity analysis of the HEFCE (2010b) methodology for estimating GHG emissions from student air travel, where the appropriateness of the recommended assumptions relating to trip distance and flight frequency were tested against the results of the student survey. For completeness, assumptions incorporated in the conversion factors were also tested. In each test, the parameter in question was changed whilst keeping all other parameters fixed. The test parameters and results of the sensitivity analysis are presented in Table 6 and discussed below, where differences in estimated GHG emissions are expressed relative to the standard HEFCE estimate for the student survey sample of 1,222 tCO_2e.

[Table 6 near here]

3.1 Trip distance

All UK HEIs hold data on the country of domicile or destination of their students, thus for the standard HEFCE estimate we adopted a GCD between LHR and the overseas capital city (HEFCE 2010b). However, we also tested the GCDs recommended by HEFCE (2010b) in cases where the overseas country is not known (UK-Europe = 400 miles; UK-RoW = 4,000 miles; Table 6, simple HEFCE estimate). It can be seen that these simplifying assumptions result in a significantly lower estimate of emissions and are thus not only unnecessary but also inappropriate. In comparison, the average GCDs for our sample were 725 miles for UK-Europe flights and 5,285 miles for UK-RoW flights.

In the sensitivity analysis, we tested the impact of using the GCD between LHR and the actual overseas airport identified by each student in the survey. While a significant proportion (46% of inbound and 65% of outbound) of students did not fly to or from the capital city in their country of domicile or destination, the sensitivity of estimated emissions to this parameter was low, with a revised estimate only 2% higher than the standard HEFCE estimate at 1,247 tCO_2e.

3.2 Flight frequency

In the standard HEFCE estimate we applied the recommended assumptions that inbound EU students make two return trips during the academic year (one additional flight), while all other students make one return trip (no additional flights).

In the sensitivity analysis, we tested the impact of using the actual number of additional flights reported in the survey by each student, where this resulted in estimated emissions of 2,249 tCO_2e, 84% higher than the standard HEFCE estimate. We also tested using the average number of additional flights made by students (by study group and domicile/destination group) as reported in Section 2 above. This gave excellent agreement (within 2%) to the estimate based on the actual number of flights, thus lending confidence to the use of these revised average flight frequencies in calculating emissions.

3.3 Conversion factor assumptions

In the standard HEFCE estimate we applied the recommended DEFRA/DECC (2014a) conversion factors which incorporate a distance uplift of 8% to compensate for lateral inefficiencies in flight tracks (deviations away from the GCD due to stacking, flying around military air space etc.) and a 'best-estimate' multiplier of 1.9 to account for the additional impacts of aviation emissions.

A recent analysis suggests that lateral inefficiencies as a percentage of GCD may differ substantially depending on flight route with average values of 14% for flights within Europe, 7% for flights departing Asia and arriving in Europe, and 5% for North Atlantic flights (Reynolds 2014). Thus in the sensitivity analysis we applied an uplift factor of 14% for UK-Europe flights and 6% for UK-RoW flights. Estimated emissions were 1,213 tCO_2e, only 1% less than the standard HEFCE estimate.

As noted in DEFRA/DECC (2014a), there is significant uncertainty regarding the magnitude of the additional impacts of aviation emissions. The current recommended multiplier of 1.9 is based on the radiative forcing (RF) index (the ratio of total RF to the RF from CO_2 alone) for all aviation emissions to the year 2000, and does not include aviation induced cloudiness (AIC) (DEFRA/DECC 2014b; Sausen, et al. 2005). Notwithstanding that this estimate excludes AIC and is now somewhat dated, the RF index represents a backward looking perspective that considers the present day impact of historical aviation emissions. As such, this conflicts with the forward-looking perspective typically adopted in GHG emissions accounting (and all UK conversion factors), which considers the present and future global warming potential of emissions over a 100 year time horizon (GWP_{100}). Recent estimates of an alternative multiplier including AIC and based on the GWP_{100} metric are in broad agreement, with Lee et al. (2010) reporting a range of 1.9-2.0, and Azar and Johansson (2012) reporting a range of 1.3-2.6. In the sensitivity analysis we adopted the full range of these reported values, with a central estimate of 1.95. Thus while accounting for the uncertainty in the additional impacts of aviation emissions at altitude results in estimated emissions ranging from 32% less to 37% more than the standard HEFCE estimate, the central estimate results in only a small increase of 3%.

3.4 Recommended assumptions

The sensitivity of estimated emissions to the choice of overseas airport is low (2%), thus given the additional complexity introduced by accounting for differences in flight route, we find that the HEFCE assumption of a flight route between LHR and the capital city of the overseas country is reasonable. Similarly, the sensitivity of estimated emissions to assumptions regarding uplift factor (1%) and the additional impacts of aviation emissions at altitude (central estimate 3%) is also low, thus we recommend use of the standard UK Government conversion factors in order to align with the national reporting framework. However, we find that the HEFCE assumptions regarding flight frequency are not appropriate, where utilising the actual number of flights increases the estimated emissions by 84%. We therefore recommend that HEIs should base emissions estimates on actual flight frequency as determined by a student travel survey, or employ our revised estimates of average flight frequency.

4. The significance of inbound student air travel emissions

This section contextualises student flight emissions by examining their significance in comparison to the emissions for 25 UK HEIs who reported against all available categories in the 2013/14 EMR return (HESA 2014b). This analysis was limited to inbound students as outbound student data by country of destination was not available at an institutional level.

The reporting HEIs spanned the continuum from research intensive to teaching-led universities, one of the key determinants of HEI emissions (Klein-Banai and Theis 2013; Robinson et al. 2015). Collectively, these HEIs accounted for 27% of mandatorily reported emissions, and had a moderately higher mandatory emissions intensity (1.2 tCO_2e/student) and slightly higher proportion of international students (21%) than the sector as a whole (1.04 tCO_2e/student and 19%). With respect to carbon management and reduction, the range in scores awarded to these HEIs by the PPUL (2015) was comparable to the UK average (see Appendix 1). Thus, while we make no claims that this sample is statistically representative, we believe it provides a reasonable picture of the UK HE sector.

For each institution, emissions from student flights were calculated from inbound student data by country of domicile (HESA 2015a) and the average flight frequencies (by domicile group) presented in Section 2. Results are presented in Figure 1 and Appendix 1.

[Figure 1 near here]

Overall, estimated inbound student flight emissions were equivalent to 65% of mandatorily, 27% of voluntarily, and 19% of total reported emissions. If VFR flights were included, this increased to 113%, 47%, and 33% respectively. This analysis clearly demonstrates the significance of student air travel in comparison to all emissions categories reported in the EMR, where student flights and VFR flights were the third and fourth most significant sources of emissions, after other procurement and Scope 2 emissions (Figure 1). Furthermore, emissions within all current EMR reporting categories could realistically be expected to decrease over time given both the potential to reduce emissions and sector reduction targets. Conversely, international and study abroad student numbers are expected in increase (DBIS 2013), and there are extremely limited options to decrease the associated travel emissions through increased efficiency of aviation or substitution of flying with alternative modes of travel (Townsend and Barrett 2015). As such, it is important to evaluate the current and potential future emissions associated with student and VFR air travel for the HE sector as a whole in order to inform debate and identify appropriate approached to emissions reductions.

5 The potential significance of student air travel for UK HE Sector GHG Emissions to 2020/21

In this section we consider the current and potential future emissions from student and VFR flights in comparison to mandatorily reported emissions (HESA 2014b) for the UK HE sector. We first estimate emissions for 2013/14 based on inbound and outbound student data by country of domicile (HESA 2015a) and the average flight frequencies presented in Section 2 above. We then estimate emissions in 2020/21 based on 3 forecasts for growth in student air travel and 3 storylines for GHG reduction.

For forecasts of student air travel, we used low (0.7%), medium (3.7%) and high (6.7%) annual growth rates based on projected growth in international student enrolments (DBIS 2013) and assuming a similar growth in study abroad student numbers. As a first order estimate, we assumed no change in student demographics or student and VFR travel behaviours.

For forecasts of GHG reduction, the no reduction storyline holds HEI estates emissions and aviation fuel efficiency at 2013/14 levels. In the aspirational storyline, HEIs achieve Scope 1 and 2 targets (institutional targets against the 2005/6 baseline where reported in HESA (2014b), otherwise a 3% annual reduction assumed in line with national targets) and emissions from water supply and wastewater treatment decrease by 3% per year (in line with national targets). In the realistic storyline, HEI estates reductions are equivalent to 50% of the targets, in line with a recent report assessing current progress (BriteGreen 2015). For aviation fuel efficiency, the realistic and aspirational storylines reflect the industry target and aspirational goal respectively (1.5% and 2.0% improvement per year; ICAO 2013).

Figure 2 presents average student flight emissions in 2013/14 on a per student basis. Figure 3 illustrates the change in sector emissions from 2013/14 to the 2020/21 central scenario (realistic GHG reduction and medium growth in student air travel), and emissions in all future scenarios are shown in Figure 4.

[Figure 2 near here]

[Figure 3 near here]

[Figure 4 near here]

Inbound students and their VFRs account for 95% of estimated total air travel emissions (Figure 3), reflecting the much higher number of students in this group. However, if emissions are considered on a per student basis (Figure 2), then the highest impact is associated with outbound students studying abroad for 1 year in RoW destinations. While the emissions from student flights for this group are broadly comparable to those associated with inbound students from the RoW, the VFR emissions are much greater. This difference is mainly driven by a higher average flight frequency (as opposed to differences in average trip distance), which may reflect the relative wealth of outbound VFRs when compared to inbound VFRs.

Considering absolute emissions (Figure 3), in 2013/14, student flight emissions slightly exceeded Scope 2 emissions and were equivalent to 68% of all estates emissions. If VFR flights are included, then total student air travel emissions exceeded estates emissions by 0.45 $MtCO_2e$, or ~19%. From 2013/14 to the 2020/21 central scenario, estates emissions decreased by 0.32 $MtCO_2e$ to 2.08 $MtCO_2e$, while student flight emissions increased by 0.26 $MtCO_2e$ to 1.89 $MtCO_2e$ (equivalent to 91% of estates emissions). Thus in this scenario, estates emissions reductions compensate for the growth in student flights. However, if estates emissions reductions are used to offset the growth in flights, then the net estates emissions reduction is only 0.05 $MtCO_2e$ (equivalent to a 2.5% reduction below the 2005/6 Scope 1 and 2 baseline). Furthermore, if emissions from VFR flights are included, then overall emissions increase by 0.14 $MtCO_2e$.

In all 2020/21 scenarios the relative significance of student flight emissions increases over time, ranging from 72% (no reduction-low growth) to 136% (aspirational-high growth) of estates emissions (Figure 4). Reductions in estates emissions compensate for the growth in emissions from student flights in all of the aspirational scenarios and the realistic-low and –medium growth scenarios. For the remaining scenarios, the growth in student flight emissions outstrips the estates reductions, where in the realistic-high growth scenario, emissions from student flights could reach ~2.31 $MtCO_2e$ by 2020/21 (equivalent to 111% of estates emissions). If VFR flights are included, then reductions in estates emissions only compensate for the growth in student numbers in the aspirational-low and –medium and realistic-low growth scenarios, with a net increase in all other cases.

6. Conclusions and Recommendations

This research has clearly demonstrated the current and potential future significance of GHG emissions arising from the air travel of international and study abroad students and their associated VFRs when compared to other components of the carbon footprint for UK HEIs. Indeed, scenario analysis suggests that by 2020/21 increases in student and VFR flight emissions are likely to exceed the reductions achieved in estates emissions unless HEIs reinvigorate efforts to achieve their ambitious reduction targets, and/or there is close to zero annual growth in inbound and outbound student numbers.

We acknowledge that HEI responsibility for these emissions can be questioned. However, the flight made by the student at the start and end of the study period is clearly induced by HEI service offerings, and should therefore be included within Scope 3 emissions. With respect to additional flights, we argue that when offering overseas education over an extended period, it is reasonable to expect that students may travel home during that period, and therefore additional flights should be evaluated. We also highlight that if HEIs took action to encourage fewer student flights, it is conceivable that a behavioural rebound-type effect might occur, where the number of VFR flights increases to maintain a similar degree of student-VFR contact. Indeed, a backfire effect, where the increase in VFR emissions exceeds the decrease in student flight emissions, would be plausible.

Given the significance of student and VFR flights and the potential for rebound and backfire effects, we consider it imperative that UK HEIs develop an accurate picture of these emissions in order to identify effective reduction options (that deliver a net reduction in global emissions) and inform both their carbon management and internationalisation strategies. We therefore recommend that funding bodies and devolved governments should encourage HEIs to estimate and report these emissions based on a survey of student travel behaviour or our estimates of average flight frequencies.

We acknowledge that by arguing that all student flights are induced by HEI service offerings, we adopted a particular perspective on accounting for student travel emissions. Further work examining alternative approaches to determining attributable emissions would make a valuable contribution to the responsibility debate, and would help define the extent to which the HE sector should (or could) mitigate or compensate for these emissions. In particular, evaluating incremental emissions (based on a comparison of flight frequency, including leisure trips, between those who do and do not study overseas), and examining perceived responsibility and potential approaches to allocating emissions amongst the various beneficiaries (students, UK and overseas partner HEIs, airports, airlines) may prove helpful.

Perhaps most importantly, there is a need to identify and examine alternative internationalisation strategies that have the potential to offer a reduced carbon footprint while providing equivalent access to and quality of tertiary education and opportunities to experience other cultures. In theory, the provision of transnational education through branch campuses and collaborative delivery mechanisms may offer such an alternative. However, whether these initiatives result in a net decrease in travel emissions is questionable and requires evaluating, where they may even result in a net increase (c.f. Wilkins and Huisman, 2010).

Even if all reasonable options for reducing the carbon consequences of the internationalisation agenda were considered and implemented, it seems virtually certain that substantial student and VFR flight emissions will remain. Thus if HEIs are to deliver a significant reduction in total emissions, offsetting will likely prove necessary. Thus, further work should also be undertaken to examine the acceptability of offsetting emissions from the perspective of both the HEI and the students.

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References

Azar, C. and Johansson, D. J. A. 2012. "Valuing the non-CO_2 impacts of aviation." *Climatic Change* 111 (3-4): 559-579. doi:10.1007/s10584-011-0168-8.

Bischoff, E. E. and Koenig-Lewis, N. 2007. "VFR tourism: the importance of university students as hosts." *International Journal of Tourism Research* 9 (6): 465-484. doi:10.1002/jtr.618.

BriteGreen 2015. "Higher Education Carbon Report." http://www.brite-green.co.uk/index.php/our-work/reports-and-publications/university-carbon-targets

Ceulemans, K., Molderez, I., and Van Liedekerke, L. 2015. "Sustainability reporting in higher education: a comprehensive review of the recent literature and paths for further research." *Journal of Cleaner Production* 106 (Nov.): 127-143. doi:10.1016/j.jclepro.2014.09.052.

DBIS (Department for Business, Innovation and Skills). 2013. "International education - global growth and prosperity: An accompanying analytical narrative." https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/340601/bis-13-1082-international-education-accompanying-analytical-narrative-revised.pdf

DEFRA/DECC (Department for Environment, Food and Rural Affairs and Department of Energy and Climate Change). 2014a. "UK Government conversion factors for Company Reporting." http://www.ukconversionfactorscarbonsmart.co.uk/

DEFRA/DECC (Department for Environment, Food and Rural Affairs and Department of Energy and Climate Change). 2014b. "2014 Government GHG Conversion Factors for Company Reporting: Methodology Paper for Emission Factors." http://www.ukconversionfactorscarbonsmart.co.uk/Documents/Emission%20Factor%20Methodology%20Paper%20-%202014.pdf

DOE (Department of Environment). 2011. "Northern Ireland Greenhouse Gas Emissions Reduction Action Plan." http://www.doeni.gov.uk/northern_ireland_action_plan_on_greenhouse_gas_emissions_reductions.pdf

Druckman, A., Chitnis, M., Sorrell, S., and Jackson, T. (2011). "Missing carbon reductions? Exploring rebound and backfire effects in UK households." *Energy Policy* 39 (6): 3572-3581. doi:10.1016/j.enpol.2011.03.058

HEFCE (Higher Education Funding Council for England). 2010a. "Carbon reduction target and strategy for higher education in England." January 2010/01. http://www.hefce.ac.uk/pubs/year/2010/201001/

HEFCE (Higher Education Funding Council for England). 2010b. "Carbon Management Strategies and Plans, a Guide to Good Practice." http://www.hefce.ac.uk/pubs/year/2010/201002/

HEFCE (Higher Education Funding Council for England). 2012a. "Measuring Scope 3 Carbon Emissions – Transport, a Guide to Good Practice."http://www.hefce.ac.uk/media/hefce/content/pubs/2012/201202/12_02.pdf

HEFCE (Higher Education Funding Council for England). 2012b. "Measuring Scope 3 Carbon Emissions – Supply Chain (Procurement)." http://www.hefce.ac.uk/media/hefce/content/pubs/indirreports/2012/Measuring,scope,3,carbon,emissions/supplysectoremissions.pdf

HEFCE (Higher Education Funding Council for England).. 2012c. "Measuring Scope 3 Carbon Emissions – Water and Waste, a Guide to Good Practice." http://www.hefce.ac.uk/media/hefce/content/pubs/2012/201201/12_01.pdf

HEFCE (Higher Education Funding Council for England). 2015. "Reducing carbon emissions." Accessed June 22nd 2015. http://www.hefce.ac.uk/workprovide/carbon/carbonfaq/

HEFCW (Higher Education Funding Council for Wales). 2014. "Carbon Management Policy Ref. W14/09HE."

https://www.hefcw.ac.uk/documents/publications/circulars/circulars_2014/W14%2009HE%20Carbon%20Management%20Policy.pdf

HMSO (Her Majesty's Stationary Office). 2008. Climate Change Act (2008). London, UK.

HMSO (Her Majesty's Stationary Office). 2009. Climate Change (Scotland) Act (2009). London, UK.

HESA (Higher Education Statistics Agency). 2014a. "Estates Management Record 2013/14 - Environment, energy, emissions and waste." https://www.hesa.ac.uk/index.php?option=com_studrec&task=show_file&mnl=13042&href=a^_^EnvironmentEnergyEmissionsandWaste.html

HESA (Higher Education Statistics Agency). 2014b. "Estates Management Statistics – Environmental Information 2013/14." https://www.hesa.ac.uk/index.php?option=com_content&view=article&id=2093&Itemid=634

HESA (Higher Education Statistics Agency). 2014c. "Estates Management Record 2013/14 – Scope 3 Emissions from Student Commuting." *Higher Education Statistics Agency.* https://www.hesa.ac.uk/index.php?option=com_studrec&task=show_file&mnl=13042&href=a^_^Scope3CarbonEmissionsFromStudentCommuting.html

HESA (Higher Education Statistics Agency). 2015a. "Bespoke data request – inbound and outbound student numbers 2013/14." *Higher Education Statistics Agency.* https://www.hesa.ac.uk/component/infoprov/

HESA (Higher Education Statistics Agency). 2015b. "Students in Higher Education: 2013/14 Students." *Higher Education Statistics Agency.* https://www.hesa.ac.uk/content/view/1973/239/

ICAO (International Civil Aviation Organization). 2013. "Resolution A38-18, Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change. Resolutions Adopted at the 38th Session of the Assembly (November 2013)." http://www.icao.int/Meetings/a38/Documents/Resolutions/a38_res_prov_en.pdf

Klein-Banai, C. and Theis, T. L. 2011. "An urban university's ecological footprint and the effect of climate change." *Ecological Indicators* 11 (3): 857-860. doi:10.1016/j.ecolind.2010.11.002.

Klein-Banai, C. and Theis, T. L. 2013. "Quantitative analysis of factors affecting greenhouse gas emissions at institutions of higher education." *Journal of Cleaner Production* 48: 29-38. doi:10.1016/j.jclepro.2011.06.004

Lee, D. S., Pitari, G., Grewe, V., Gierens, K., Penner, J. E., Petzold, A., Prather, M. J., Schumann. U., Bais, A., Bernsten, T. Iachetti, D., Lim, L. L. and Sausen, R. 2010. "Transport impacts on atmosphere and climate: Aviation." *Atmospheric Environment* 44 (37): 4678-4734. doi:10.1016/j.atmosenv.2009.06.005.

Long, J., Vogelaar. A. and Hale, B. W. 2014. “Towards sustainable educational travel.” *Journal of Sustainable Tourism* 22 (3): 421-439. doi:10.1080/09669582.2013.819877.

Lozano, R. 2011. “The state of sustainability reporting in universities.” *International Journal of Sustainability in Higher Education* 12 (1): 67-78. doi:10.1108/14676371111098311.

Lozano, R., Ceulemans, K., Alonso-Almeida, M., Huisingh, D., Lozano, F. J., Waas, T., Lambrechts, W., Lukman, R. and Huge, J. 2015. “A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey.” *Journal of Cleaner Production* 108, part A (Dec.). doi:10.1016/j.jclepro.2014.09.048.

Matthews, H. S., Hendrickson, C. T. and Weber, C. L. 2008. “The importance of carbon footprint estimation boundaries.” *Environmental Science and Technology* 42 (16): 5839-5842. doi:10.1021/es703112w.

Müller-Christ, G., Sterling, S., van Dam-Mieras, R., Adomßentd, M., Fischer, D. and Rieckmann, M. 2014. “The role of campus, curriculum, and community in higher education for sustainable development - a conference report.” *Journal of Cleaner Production* 62 (Jan.): 134-137. doi:10.1016/j.jclepro.2013.02.029.

Northern Ireland Executive. 2011. “Programme for Government 2011-2015.” http://www.northernireland.gov.uk/pfg-2011-2015-final-report.pdf

Ozawa-Meida, L., Brockway, P., Letten, K., Davies, J. and Fleming, P. 2013. “Measuring carbon performance in a UK University through a consumption-based carbon footprint: De Montfort University case study.” *Journal of Cleaner Production* 56 (Oct.): 185-198. doi: doi:10.1016/j.jclepro.2011.09.028

Paling. C., Hooper, P. and Thomas, C. 2014. “The Sustainability of Air Transport.” In Goetz, A. R. and Budd, L. (Ed.), The Geographies of Air Transport (pp. 125-140). UK:Ashgate.

Pinkse, J. and Kolk, A. 2012. “Addressing the climate change sustainable development nexus: the role of multi-stakeholder partnerships.” *Business and Society* 51 (1): 176-210. doi:10.1177/0007650311427426.

PPUL (People and Planet University League). 2015. “2015 League Tables”. https://peopleandplanet.org/university-league/2015/tables

Reynolds, T. 2014. “Air traffic management performance assessment using flight inefficiency metrics.” *Transport Policy* 34: 63-74. doi:10.1016/j.tranpol.2014.02.019.

Robinson, O., Kemp, S. and Williams, I. 2015. “Carbon management at universities: a reality check”. *Journal of Cleaner Production* 106 (Nov.): 109-118. doi:10.1016/j.jclepro.2014.06.095.

Sausen, R., Isaksen, I., Grewe, V., Hauglustaine, D., Lee, D.S., Myhre, G., Kohler, M.O., Pitari, G., Schumann, U., Stordal, F. and Zerefos, C. 2005. “Aviation radiative forcing in

2000: an update of IPCC (1999).” *Meteorologische Zeitschrift* 14 (4): 555-561. doi:http://dx.doi.org/10.1127/0941-2948/2005/0049.

Schaltegger, S. and Csutora, M. 2012. “Carbon accounting for sustainability and management. Status quo and challenges.” *Journal of Cleaner Production* 36 (Nov.): 1-16. doi:10.1016/j.jclepro.2012.06.024.

SFC (Scottish Funding Council). 2015. “Outcome Agreements.” http://www.sfc.ac.uk/funding/OutcomeAgreements/OutcomeAgreementsOverview.aspx

SQW Consulting/SQW Energy. 2009. “Research into a carbon reduction target and strategy for Higher Education in England. A report to HEFCE.” http://www.hefce.ac.uk/media/hefce/content/pubs/2009/rd1609/rd16_09.pdf

Townsend, J. and Barrett, J. 2015. Exploring the applications of carbon footprinting towards sustainability at a UK university: reporting and decision making. *Journal of Cleaner Production* 107 (Nov.): 164-176. doi:10.1016/j.jclepro.2013.11.004.

UNESCO. 2012. “Shaping the Education of Tomorrow.” *United Nations Educational, Scientific and Cultural Organization.* http://unesdoc.unesco.org/images/0021/002166/216606e.pdf

WBCSD/WRI (World Business Council for Sustainable Development and World Resources Institute Geneva). 2004. The Greenhouse Gas Protocol Corporate Standard. http://www.ghgprotocol.org/files/ghgp/public/ghg-protocol-revised.pdf

WBCSD/WRI (World Business Council for Sustainable Development and World Resources Institute Geneva). 2011a. Corporate Value Chain (Scope 3) Accounting and Reporting Standard. http://www.ghgprotocol.org/files/ghgp/public/Corporate-Value-Chain-Accounting-Reporing-Standard_041613.pdf

WBCSD/WRI (World Business Council for Sustainable Development and World Resources Institute Geneva). 2011b. Product Life Cycle Accounting and Reporting Standard. http://www.ghgprotocol.org/files/ghgp/public/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf

Welsh Assembly Government. 2010. “Climate Change strategy for Wales.” http://gov.wales/docs/desh/publications/101006ccstratfinalen.pdf

Williams, I., Kemp, S., Coello, J., Turner, D. A. and Wright, L. A. 2012. “A beginner’s guide to carbon footprinting.” *Carbon Management* 3 (1): 55-67. doi:10.4155/cmt.11.80.

Wilkins, S. and Huisman, J. (2011). “International student destination choice: the influence of home campus experience on the decision to consider branch campuses.” *Journal of Marketing for Higher Education*, 21 (1): 61-83. doi:10.1080/08841241.2011.5735

Wright, L. A., Kemp, S. and Williams, I. 2011. “‘Carbon footprinting’: towards a universally accepted definition.” *Carbon Management* 2 (1): 61-72. doi:10.4155/cmt.10.39.

Table 1. Summary of the size of the UK Higher Education sector and GHG emissions in 2013/14, and 2020 GHG reduction targets, for the four countries of the United Kingdom.

Country	**HEIs**		**Total students**		**International students**		**Mandatorily Reported GHG Emissions ($ktCO_2e/yr$)**				
	#	*(% UK)*	#	*(% UK)*	#	*(% UK)*	**Scope 1**	**Scope 2**	**Scope 3**	**Total**	*(% UK)*
United Kingdom	**159**		**2,299,355**		**435,500**		**862.0**	**1,505.3**	**25.2**	**2,392.6**	
GHG target:	The UK Climate Change Act (2008) sets a national 2020 target of a 34% reduction in GHG emissions against a 1990 baseline (HMSO 2008). The higher education funding bodies are required by the UK and devolved governments to contribute to these reduction targets.										
England	**130**	*(82%)*	**1,875,020**	*(82%)*	**355,585**	*(82%)*	**661.9**	**1,232.7**	**20.7**	**1,915.3**	*(80%)*
GHG target:	The Higher Education Funding Council for England (HEFCE) has set a sector wide target for academic year 2020/21 of a 34% reduction in Scope 1 and 2 GHG emissions against a 1990/91 baseline, re-expressed as a 43% reduction against 2005/6 (HEFCE, 2010a). HEIs are required to individually set targets for Scope 1 and 2 emission reductions, but are not required to individually meet the sector target (HEFCE, 2010a). In 2013/14, reported HEI commitments for 2020/21 were equivalent to a 38% reduction below the 2005/6 baseline (HESA, 2014b).										
Scotland	**17**	*(11%)*	**230,805**	*(10%)*	**48,360**	*(11%)*	**142.3**	**176.3**	**2.8**	**321.4**	*(13%)*
GHG targets:	The Climate Change Scotland Act (2009) sets a more stringent Scottish 2020 target of a 42% reduction in GHG emissions against a 1990 baseline (HMSO 2009). The Act also places duties on public bodies to act in the way best calculated to contribute to the delivery of this target, where HEIs are identified as 'major players' and are required to develop carbon management plans to measure and reduce their impact. The Scottish Funding Council (SFC) Outcome Agreements, which set out what HEIs plan to deliver in return for their funding, include carbon reduction targets, however, the baseline year, target year, and level of ambition, vary by HEI (SFC, 2015).										
Wales	**8**	*(5%)*	**137,135**	*(6%)*	**25,605**	*(6%)*	**38.5**	**71.8**	**1.2**	**111.5**	*(5%)*
GHG targets:	The Welsh Assembly Government (2010) Climate Change Strategy for Wales aims to reduce carbon emissions by 3% per annum from 2011 across all devolved areas based on a baseline of average carbon emissions between 2006-2010. The Higher Education Funding Council for Wales (HECFW) Carbon Management Policy requires HEIs to publish a carbon management strategy, including an identified target for Scope 1 and 2 emissions (HEFCW, 2014). However, the level of ambition in terms of carbon reduction and choice of baseline year are considered matters for individual institutions to establish, although in setting targets HEIs should reflect upon national policy (HEFCW, 2014).										
Northern Ireland	**4**	*(3%)*	**56,395**	*(2%)*	**5,950**	*(1%)*	**19.4**	**24.5**	**0.5**	**44.4**	*(2%)*
GHG targets:	The Northern Ireland Executive's Programme for Government commits to working towards a reduction in GHG emissions of at least 35% by 2025 against a 1990 baseline. The Executive's Greenhouse Gas Action Plan, which outlines how each department will contribute towards meeting the 2025 target, states that the HEIs have targets to reduce GHG emissions by at least 34% by 2020 (DOE, 2011).										

Table 2. Survey respondents by region of institution with a comparison to the 2013/14 UK international student population (HESA 2015a).

Region	Inbound[a]			Outbound[b c]	
	n	% Respondents	% All inbound students	*n*	% Respondents
North East	39	8%	5%	6	3%
North West	62	12%	8%	5	3%
Yorkshire & The Humber	53	11%	8%	25	14%
East Midlands	14	3%	6%	2	1%
West Midlands	4	1%	8%	0	0%
East of England	75	15%	7%	70	40%
London	59	12%	23%	16	9%
South East	9	2%	11%	3	2%
South West	124	25%	6%	42	24%
Scotland	24	5%	11%	2	1%
Wales	2	0%	6%	0	0%
Northern Ireland	0	0%	1%	0	0%
Did not specify	33	7%	-	4	2%
TOTAL	**498**			**175**	

(a) Inbound students refers to all overseas students studying in the UK for a minimum of one year; (b) Outbound students refers to all UK registered students on study abroad schemes; (c) Institutional level data on study abroad numbers was not available, thus there is no comparison to the UK sector data

Table 3. Average number of additional return flights made by inbound students during the academic year by region of domicile and level of study.

Region of Domicile	All Students[a]			Undergraduates			Postgraduates			All Students Weighted Average[d]			
	n	Ave. ± Std. Dev.		*n*	Ave. ± Std. Dev.		*n*	Ave. ± Std. Dev.		*n*	%UG	%PG	W.Ave.
All Europe	***193***	**2.4 ± 1.4**		***45***	**1.8 ± 1.2**		***134***	**2.5 ± 1.5**		***193***	***62%***	***38%***	**2.1**
EU-28[b]	*181*	2.3 ± 1.4		*43*	1.8 ± 1.2		*125*	2.5 ± 1.5		*181*	*63%*	*37%*	*2.1*
Other Europe[c]	*12*	2.9 ± 1.2		*2*	2.0 ± 0.0		*9*	3.2 ± 1.3		*12*	*58%*	*42%*	*2.5*
Rest of the World	***305***	**1.0 ± 1.1**		***97***	**0.9 ± 1.0**		***190***	**1.0 ± 1.1**		***305***	***49%***	***51%***	**1.0**
Central America	*5*	2.0 ± 1.0		*0*	-		*5*	2.0 ± 1.0		*5*	*43%*	*57%*	*1.1*
North America	*51*	1.4 ± 1.1	†,‡	*10*	1.5 ± 1.4		*39*	1.3 ± 1.1	†,‡	*51*	*43%*	*57%*	*1.4*
Asia and the Middle East	*206*	0.9 ± 1.1	†,‡	*81*	0.9 ± 1.0	†	*113*	1.0 ± 1.1	†,‡	*206*	*51%*	*49%*	*0.9*
Africa	*23*	0.9 ± 1.1	†,‡	*3*	1.3 ± 1.2		*18*	0.8 ± 1.2	†,‡	*23*	*42%*	*58%*	*1.0*
South America	*14*	0.6 ± 0.6	†,‡	*3*	0.3 ± 0.6		*11*	0.7 ± 0.6	†,‡	*14*	*35%*	*65%*	*0.6*
Oceania	*6*	0.2 ± 0.4	†,‡	*0*	-		*4*	0.3 ± 0.5	†,‡	*6*	*32%*	*68%*	*0.2*

(a) The sum of undergraduate and postgaduate students does not equal the total as some respondents did not specify degree level; (b) EU-28 refers to the 28 member states of the European Union and includes the Canary Islands, the Åland Islands and Gibraltar. Although officially part of the EU, the Overseas Departments of the French Republic have been classed here on a geographic rather than politicial basis and are included in the RoW category. (c) In line with HESA definitions, 'Other Europe' includes the European Economic Area countries of Iceland, Liechenstein and Norway in addition to Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Cyprus (Non-European-Union), Faroe Islands, Georgia, Kosovo, Macedonia, Moldova, Monaco, Montenegro, Russia, San Marino, Serbia, Svalbard and Jan Mayen, Switzerland, Turkey, Ukraine, and Vatican Ciy; (d) Here the number of additional flights was calculated as a weighted average of the number of additional flights made by postgraduates and undergraduates based on the overall proportion of inbound students for the sector (HESA 2015b); † indicates a significant difference to EU-28 and ‡ indicates a significant difference to Other Europe ($p < 0.03$). No other significant differences were observed.

Table 4. Average number of additional return flights per year or within the study period for outbound students by region of destination and duration of study period.

Region of Domicile	1 year			<1 year		
	n	**Ave. ± Std. Dev.**		***n***	**Ave. ± Std. Dev.**	
All Students	**107**	**1.6 ± 1.6**		**68**	**0.6 ± 1.2**	
All Europe	**50**	**2.4 ± 1.7**		**18**	**1.1 ± 1.4**	
EU-28	49	2.4 ± 1.6		16	1.2 ± 1.5	
Other Europe	1	5.0		2	0.0 ± 0.0	
Rest of the World	**57**	**0.9 ± 1.3**		**50**	**0.4 ± 1.1**	
Central America	0	-		2	0.5 ± 0.7	
North America	26	0.9 ± 1.2	†	9	0.9 ± 1.8	
Asia and the Middle East	8	0.8 ± 0.7		12	0.0 ± 0.0	
Africa	5	1.6 ± 1.5		8	0.1 ± 0.4	
South America	3	1.3 ± 2.3		4	0.0 ± 0.0	
Oceania	15	0.5 ± 1.3	†	15	0.7 ± 1.5	

† indicates a significant difference to EU-28 ($p < 0.007$)

Table 5. Descriptive statistics for the number of return flights made by visiting friends and relatives (VFR) during the academic year.

Student Group	*n*	# of VFR flights (%)						Ave. ± Std. Dev.
		0	1	2	3	4	5+	
Inbound								
All Europe	*193*	22.8	15.0	18.7	13.0	7.3	23.3 [a]	2.9 ± 2.9
Rest of the World	*305*	43.9	18.0	17.4	6.2	8.9	5.6 [a]	1.4 ± 1.9
Outbound (1 year)								
All Europe	*50*	22.0	4.0	10.0	10.0	20.0	34.0 [a]	4.0 ± 3.4
Rest of the World	*57*	35.1	7.0	21.1	12.3	5.3	19.3 [b]	2.2 ± 2.2
Outbound (<1 year)								
All Regions	*68*	57.4	16.2	11.8	7.4	4.4	2.9 [c]	1.0 ± 1.4

(a) maximum = 11; (b) maximum = 7; (c) maximum = 6

Table 6. Table 6. Sensitivity analysis of assumptions within the HEFCE methodology for estimating student flight emissions (HEFCE 2010b).

		Standard HEFCE estimate	Simple HEFCE estimate	Sensitivity Tests						
				Trip Distance	Flight Frequency		Conversion Factor Assumptions			
					Actual no. of flights	Average no. of flights	Uplift factor	Impact of emissions at altitude		
								Low	Central	High
Calculation Parameters										
Trip Distance:	**Great circle distance (one-way)**	LHR-overseas capital city	**SH = 400 miles LH = 4000 miles**	LHR-actual						
	Uplift factor multiplier	All regions = 1.08					**SH = 1.14 LH = 1.06**			
Flight frequency:	**Inbound**	EU-28 = 2				**Europe = 3.1**				
		non-EU = 1				**RoW = 2.0**				
	Outbound (1 year)	EU-28 = 1			**Actual # of flights**	**Europe = 3.4**				
		non-EU = 1				**RoW = 1.9**				
	Outbound (<1 year)	EU-28 = 1				**Europe = 2.2**				
		non-EU = 1				**RoW = 1.4**				
Effects of emissions at altitude multiplier		1.90						**1.30**	**1.95**	**2.60**
Estimated GHG Emissions (tCO_2e)										
Inbound		883	668	899	1,678	1,703	878	604	906	1,208
Outbound (1 year)		178	121	184	337	360	176	122	183	244
Outbound (<1year)		161	101	164	234	229	159	110	165	221
Total		1,222	889	1,247	2,249	2,292	1,213	836	1,254	1,673
% change from standard HEFCE estimate		**-**	**-27%**	**2%**	**84%**	**87%**	**-1%**	**-32%**	**3%**	**37%**

NOTE: All UK-Europe flights are short-haul (SH), while all UK-RoW flights are long-haul (LH).

Figure 1. Inbound student air travel emissions in comparison to emissions reported in the 2013/14 EMR return for 25 UK HEIs.

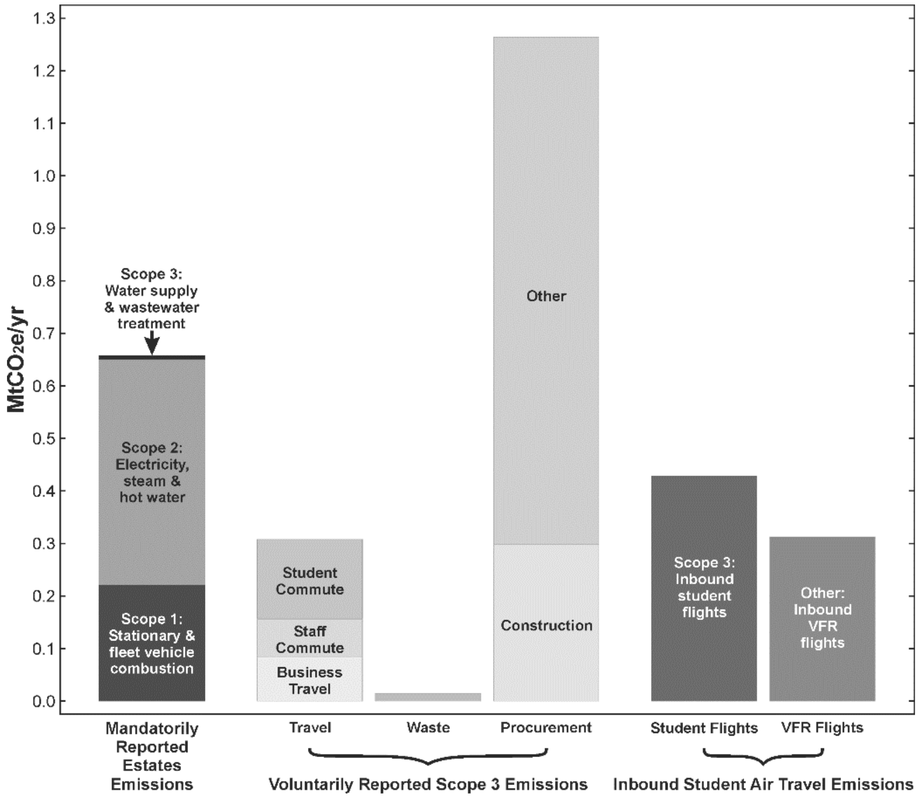


Figure 2. Average air travel emissions for inbound and outbound students.

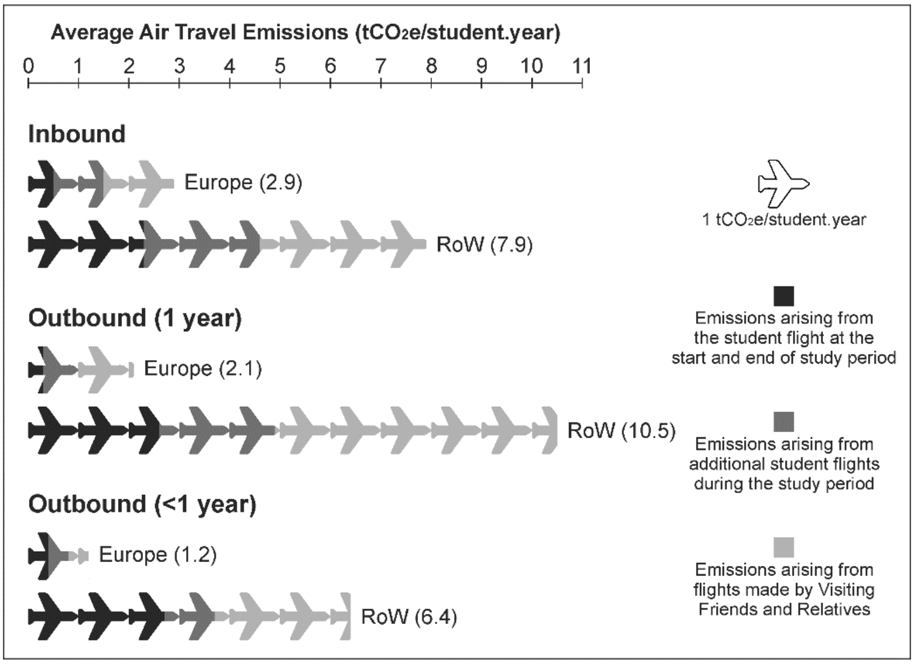


Figure 3. Change in HE estates emissions and student air travel emissions from 2013/14 to 2020/21 based on realistic reductions in GHG emissions and medium growth in inbound and outbound student numbers (central scenario).

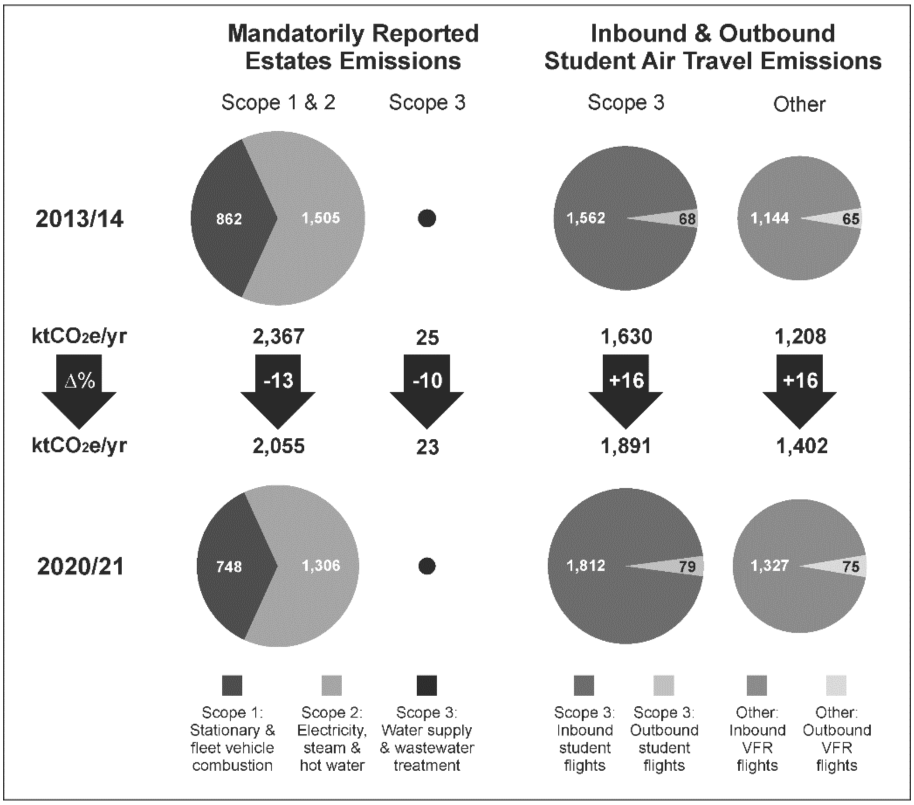
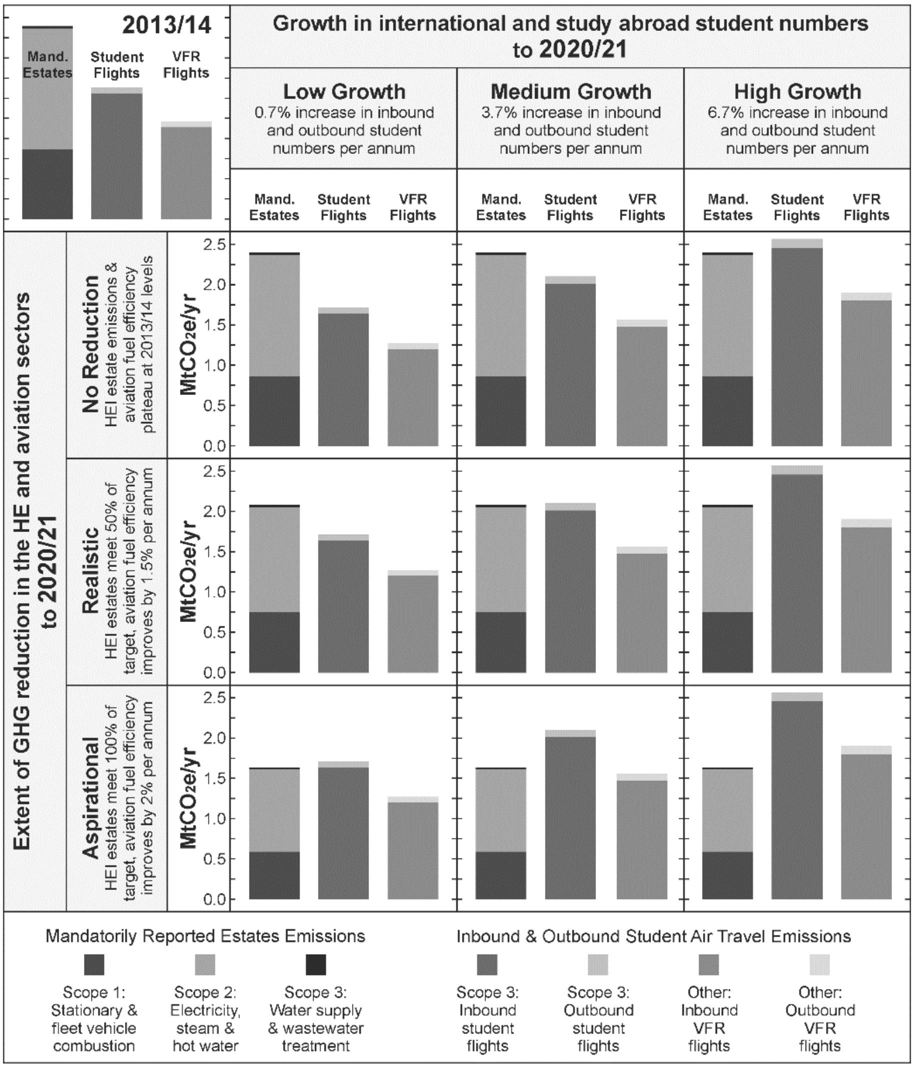


Figure 4. Nine scenarios illustrating the potential change in HE sector emissions from 2013/14 to 2020/21 based on the extent of GHG reduction in the HE and aviation sectors and growth in inbound and outbound student numbers.



Appendix 1: GHG emissions associated with inbound student and VFR flights in comparison to mandatorily and voluntarily reported GHG emissions in the EMR return

NOTE 1: While 27 institutions reported against all EMR reporting categories, the voluntarily reported emissions appeared anomalously high for 1 institution (27.6 tCO_2e/student.yr), and anomalously low (0.3 tCO_2e/student.yr) for another, when compared to the remaining 25 institutions (range 1.2-6.4 tCO_2e/student.yr, average 2.7±1.3 tCO_2e/student.yr, weighted average 2.9 tCO_2e/student.yr) and were therefore excluded from the analysis. For the University of the Arts, London, there are indications that both staff commuting and student commuting have been erroneously entered in $kgCO_2e$ (as opposed to the reporting unit of tCO_2e), being 3 orders of magnitude greater (on a per student basis) than the average at other institutions. At the UAL, student commuting is dominated by public transport via rail (328,527 tCO_2e), bus (17,536 tCO_2e) and underground (5,895 tCO_2e). The reported emissions via these travel modes (assuming all buses are London local buses) are equivalent to 422,681 km travelled per student per year. If it is assumed that all students travel to university 5 days a week for 2 x 10 week terms, this would be equivalent to a daily journey of 4,227 km – or ca. 3 times the distance from Land's End to John O'Groats (a journey which traverses the whole length of the island of Great Britain from the extreme southwest to northeast). Rose Bruford College is one of the smallest UK HEIs, being a specialist drama school with 770 registered students in 2013/4. While the mandatorily reported emissions fall within the range reported by other institutions (on a per student basis), the voluntarily reported emissions are an order of magnitude lower. In particular, procurement emissions appear anomalously low, being ~48 times lower than the weighted average across the 25 institutions included in the analysis (between 1 to 2 orders of magnitude). While these reported emissions may reflect the small size and specialist nature of the institution, they do not appear to be representative of the UK HE sector as a whole, and are excluded from the analysis presented in the paper.

NOTE 2: Procurement emissions reported in the table below are based on the 'Scope 3 carbon emissions from supply chain' reported in the EMR Return (HESA 2014b), which are estimated from HEI procurement data (HEFCE 2012b). Scope 3 carbon emissions from supply chain waste and water have been excluded to avoid double counting with the separately reported water supply and waste water treatment and waste categories (HEFCE 2012b). Construction procurement is shown separately as this is the single largest component of procurement emissions. Included in 'Other' procurement are Scope 3 supply chain emissions associated with procurement of business services, paper products, other manufactured products, manufactured fuels, chemicals, and gases, food and catering, information and communication technologies, medical and precision instruments, and other and unclassified procurement (HESA 2014b).

NOTE 3: We note the significant variation in waste emissions reported by these institutions, which vary over 4-5 orders of magnitude on an absolute and per student basis. We suspect that a significant proportion of this variation is due to differences in data quality and the completeness of the estimate. However, no clear relationship was found between reported emissions and the calculation methodology employed (HEIs can elect one of three calculation methodologies of increasing complexity). Thus the data has been included in the analysis presented in the paper, where we note that actual waste emissions may be substantially different to the total reported here.

Data for institutions included in the analysis presented in the paper

UK Higher Education Institution	Mission Group / Association[a]	Student Population[b]			People & Planet University League Scores[c]			GHG Emissions Reported in the 2013/14 EMR Return (tCO_2e/yr)												Inbound Student Air Travel Emissions (tCO_2e/yr)[e]		
								Mandatorily Reported Estates Emissions				Voluntarily Reported Scope 3 Emissions							Total Reported Emissions			
												Travel				Procurement						
		Total #	International #	(%)	C Man-agement	C Red-uction	Total	Scope 1	Scope 2	Scope 3	Total Mand.	Business travel	Staff commute	Student commute	Waste	Construc-tion	Other	Total Volun.		Scope 3 Student	Other VFR	Total Inbound
University of Bedfordshire	Million+	17,835	4,470	(25%)	65	10	67.1	1,878	5,515	63	7,456	689	71	1,579	22	8,601	19,675	30,637	38,093	16,464	11,785	28,249
The University of Birmingham	Russell Group	32,335	7,717	(24%)	10	35	35.1	28,702	18,823	529	48,053	4,588	5,698	7,514	330	18,476	33,834	70,441	118,494	31,428	22,589	54,016
The University of Bradford	University Alliance	12,505	2,062	(16%)	65	90	64.9	5,179	2,685	48	7,911	1,308	1,294	2,138	9	4,231	17,498	26,477	34,388	6,962	5,224	12,186
The University of Brighton		20,700	2,938	(14%)	85	0	65.0	4,152	7,263	116	11,531	4,859	1,411	5,861	19	10,391	17,448	39,988	51,519	8,956	6,848	15,804
Brunel University London		14,330	4,423	(31%)	60	35	44.0	6,683	12,007	445	19,136	228	3,218	1,257	28	3,112	22,161	30,004	49,140	16,693	12,117	28,810
De Montfort University	University Alliance	19,645	2,504	(13%)	60	38	67.7	2,511	7,146	77	9,734	2,138	2,001	7,140	887	1,487	13,751	27,403	37,137	9,358	6,911	16,268
The University of Greenwich	Million+	21,950	4,375	(20%)	60	60	66.5	2,814	5,921	70	8,804	2,946	661	1,232	21	13,892	46,635	65,387	74,191	15,279	11,184	26,463
University of Hertfordshire	University Alliance	25,295	4,343	(17%)	35	13	47.6	10,771	11,152	276	22,199	1,822	6,850	46,903	3,566	3,362	18,329	80,832	103,031	16,694	12,023	28,717
Kingston University	University Alliance	23,055	4,364	(19%)	0	20	34.2	4,044	9,520	203	13,768	2,883	3,190	3,726	528	5,803	67,294	83,424	97,192	13,036	9,921	22,956
The University of Leeds	Russell Group	30,975	5,855	(19%)	45	75	60.3	5,409	48,990	733	55,132	8,152	4,106	2,288	282	16,452	54,715	85,995	141,127	23,319	16,764	40,083
The University of Lincoln	University Alliance	13,400	1,634	(12%)	35	25	34.6	2,578	5,647	102	8,327	590	1,560	3,262	68	6,914	28,095	40,489	48,816	6,636	4,752	11,387
Liverpool Hope University	Cathedrals Group	6,240	271	(4%)	50	45	30.0	1,959	2,808	81	4,848	295	473	1,844	592	1,544	5,408	10,156	15,004	744	541	1,285
Loughborough University		15,965	3,213	(20%)	50	25	42.3	15,881	7,912	372	24,164	4,137	2,140	611	62	12,239	34,797	53,986	78,151	12,398	8,979	21,377
Manchester Metropolitan University	University Alliance	32,160	2,179	(7%)	90	35	73.1	4,786	12,770	168	17,724	1,250	2,303	12,607	33	13,412	24,445	54,050	71,774	7,132	5,451	12,584
The University of Manchester	Russell Group	37,925	11,604	(31%)	0	33	29.8	25,989	50,989	899	77,877	15,677	9,828	4,823	6,510	65,915	138,646	241,399	319,277	47,811	34,589	82,399
Middlesex University	Million+	19,880	4,863	(24%)	45	100	62.9	1,450	4,573	49	6,072	1,462	1,859	5,876	9	4,043	19,664	32,913	38,985	15,188	11,407	26,594
University of Newcastle-upon-Tyne	Russell Group	22,410	6,361	(28%)	90	33	67.5	11,672	32,293	408	44,374	4,103	2,401	479	78	7,697	31,664	46,421	90,795	26,534	19,123	45,657
University of Nottingham	Russell Group	33,270	7,510	(23%)	25	53	53.1	16,841	45,881	852	63,573	4,296	4,697	3,452	0	24,884	56,685	94,014	157,587	30,425	22,044	52,469
The Nottingham Trent University	University Alliance	26,845	3,706	(14%)	60	48	72.6	3,928	13,022	131	17,080	1,945	3,702	5,880	18	3,296	30,573	45,414	62,495	13,809	9,986	23,795
The University of Reading		13,595	3,369	(25%)	60	50	47.6	5,010	11,251	267	16,527	6,222	2,448	2,293	26	8,810	38,179	57,978	74,506	13,114	9,593	22,707
The University of Sheffield	Russell Group	26,600	7,897	(30%)	50	0	37.2	7,028	36,813	535	44,376	1,465	3,359	3,837	76	37,571	79,988	126,296	170,672	34,128	24,489	58,617
The University of Westminster		20,200	5,737	(28%)	35	33	35.3	4,620	8,075	122	12,818	1,187	306	1,778	102	2,882	28,396	34,650	47,468	17,520	13,205	30,725
University of Worcester		10,295	617	(6%)	60	40	76.7	1,729	2,907	44	4,680	230	928	3,970	48	1,027	6,608	12,811	17,491	1,614	1,300	2,914
The University of Edinburgh	Russell Group	27,625	9,461	(34%)	55	20	51.6	34,649	46,881	696	82,226	9,609	5,156	4,302	306	20,389	83,972	123,734	205,959	32,208	23,771	55,979
The University of Strathclyde		19,960	3,203	(16%)	60	43	33.9	9,793	19,520	176	29,489	2,993	1,635	16,806	1,241	2,498	46,394	71,567	101,056	10,795	8,058	18,853
SAMPLE TOTAL / AVERAGE		544,995	114,676	(21%)	50±24	38±24	52±16	220,054	430,365	7,460	657,879	85,073	71,295	151,459	14,860	298,927	964,854	1,586,468	2,244,347	428,243	312,654	740,897
UK TOTAL / AVERAGE		2,299,355	435,500	(19%)	41±24	38±26	44±16	862,043	1,505,325	25,184	2,392,552									1,561,837	1,143,967	2,705,804

(a) see www.millionplus.ac.uk, www.russellgroup.ac.uk, www.unialliance.ac.uk and cathedralsgroup.org.uk (b) student population data obtained from HESA (2015a; 2015b) (c) see peopleandplanet.org/university-league/2015/tables (d) footprint data obtained from HESA (2014b), (e) Emissions from student flights were calculated from inbound student data by country of domicile (HESA 2015a) and the average flight frequencies for students from Europe and the RoW, and their associated VFR, as discussed in this paper.

Appendix 2. Student air travel survey instrument.

Student Air Travel Survey Instrument

Note: The survey instrument was part of a larger study investigating the attitudes of students registered at UK Higher Education Institutions towards environmental and carbon management. Only those questions relating to the focus of this paper (student demographics, airport of departure or arrival, student flight frequency, visiting friends and relatives flight frequency) are reproduced here.

Qualification Question

Are you currently studying at a UK university for your degree or as a visiting student? *If you are registered at a UK university and currently studying abroad, please answer Yes.*
[Multiple Choice (only one answer)]

- ○ Yes *[skip to Study Group]*
- ○ No *[End of Survey]*

Study Group

Please tell us your current level of study. *[Multiple Choice (only one answer)]*

- ○ Undergraduate
- ○ Postgraduate

To help us direct you to the right part of the survey, please tell us if you are...
[Multiple Choice (only one answer)]

- ○ ...a UK citizen studying at a UK university (including UK citizens on study abroad) *[skip to Home Students: Opportunity to Study Abroad]*
- ○ ...a non-UK citizen studying at a UK university *[skip to International Students]*

Home Students: Opportunity to Study Abroad

Is there an opportunity for you to undertake a period of study abroad within your course? *[Multiple Choice (only one answer)]*

- ○ Yes - I have already participated in a study abroad program *[skip to Home Students Studying Abroad]*
- ○ Yes - I am currently studying abroad *[skip to Home Students Studying Abroad]*
- ○ Yes - I have arranged a period of study abroad *[skip to Home Students Studying Abroad]*
- ○ Yes - and I am thinking about studying abroad in the future *[End of Survey]*
- ○ Yes - but I do not plan to study abroad *[End of Survey]*
- ○ No *[End of Survey]*
- ○ Don't know / unsure *[End of Survey]*

Home Students Studying Abroad

Please indicate your study abroad region. *[Multiple Choice (only one answer)]*

- ○ Africa
- ○ Caribbean
- ○ Central America
- ○ South America
- ○ Asia
- ○ Europe
- ○ North America
- ○ Oceania

Please select your study abroad destination from the drop-down list.
[Drop-down list of countries, filtered by world region.]

Home Students Studying Abroad Cont.

Please state which airport you arrived to (or plan to arrive to) in your study abroad destination *[Text Box (50 characters)]*

How long is (or was) your period of study at an overseas university?
[Multiple Choice (only one answer)]

- ◯ Less than one academic year *[skip to Studying Abroad for < 1 Year: Number of Flights]*
- ◯ One academic year or longer *[skip to Studying Abroad for 1+ Years: Number of Flights]*

Studying Abroad for <1 Year: Number of Flights

Not including travelling from and to the UK at the start and end of your study visit, how many additional return flights home did you make (or do you plan to make) during your period of study at an overseas university? *For example, if you did not fly home during your study visit that would be 0 additional flights. Alternatively, if you flew home once for a weekend break that would be 1 additional flight. [Multiple Choice (only one answer)]*

◯ 0	◯ 2	◯ 4
◯ 1	◯ 3	◯ 5+

How many flights did friends and family from home make (or do they plan to make) to visit you during your period of study at an overseas university? Please count each person and each visit. *For example, if 4 family members visited you at the same time that would be 4 flights. Alternatively, if 2 family members visited you at one time, and 3 friends visited you on another occasion, that would be 5 flights. [Multiple Choice (only one answer)]*

◯ 0	◯ 4	◯ 8
◯ 1	◯ 5	◯ 9
◯ 2	◯ 6	◯ 10
◯ 3	◯ 7	◯ 11+

[End of Survey]

Studying Abroad for 1+ Years: Number of Flights

Not including travelling from and to the UK at the start and end of the academic year, how many additional return flights home did you make (or do you plan to make) during 1 academic year at your overseas university? *For example, if you did not fly home for a visit during the academic year that would be 0 additional flights. Alternatively, if you flew home once during the Christmas vacation and once during the Easter vacation that would be 2 additional flights. [Multiple Choice (only one answer)]*

◯ 0	◯ 2	◯ 4
◯ 1	◯ 3	◯ 5+

How many flights did friends and family from home make (or do they plan to make) to visit you during 1 academic year at your overseas university? Please count each person and each visit. *For example, if 4 family members visited you during the Christmas vacation that would be 4 flights. Alternatively, if 2 family members visited you during the Christmas vacation and 3 friends visited you during the Easter vacation that would be 5 flights.*
[Multiple Choice (only one answer)]

◯ 0	◯ 4	◯ 8
◯ 1	◯ 5	◯ 9
◯ 2	◯ 6	◯ 10
◯ 3	◯ 7	◯ 11+

[End of Survey]

International Students

Please indicate which region of the world you are from. *[Multiple Choice (only one answer)]*

- ○ Africa
- ○ Caribbean
- ○ Central America
- ○ South America
- ○ Asia
- ○ Europe
- ○ North America
- ○ Oceania

Please select your home country from the drop-down list.
[Drop-down list of countries, filtered by world region.]

Please state which airport in your home country you usually fly from when travelling to your UK university *[Text Box (50 characters)]*

How long is your period of study at a UK university?
[Multiple Choice (only one answer)]

- ○ Less than one academic year *[End of Survey*]*
- ○ One academic year or longer *[skip to International Students: Number of Flights]*

International Students: Number of Flights

Not including travelling from and to the UK at the start and end of the academic year, how many additional return flights home did you make (or do you plan to make) during this academic year at your overseas university? *For example, if you did not fly home for a visit during the academic year that would be 0 additional flights. Alternatively, if you flew home once during the Christmas vacation and once during the Easter vacation that would be 2 additional flights. [Multiple Choice (only one answer)]*

- ○ 0
- ○ 2
- ○ 4
- ○ 1
- ○ 3
- ○ 5+

How many flights did friends and family from home make (or do they plan to make) to visit you during this academic year at your overseas university? Please count each person and each visit. *For example, if 4 family members visited you during the Christmas vacation that would be 4 flights. Alternatively, if 2 family members visited you during the Christmas vacation and 3 friends visited you during the Easter vacation that would be 5 flights. [Multiple Choice (only one answer)]*

- ○ 0
- ○ 4
- ○ 8
- ○ 1
- ○ 5
- ○ 9
- ○ 2
- ○ 6
- ○ 10
- ○ 3
- ○ 7
- ○ 11+

[End of Survey]

** International students studying in the UK for less than 1 year were excluded from the analysis presented in this paper due to the low numbers in this response group (n=19).*