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The impact of COVID-19 on reducing carbon emissions: From the angle of international student mobility

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HIGHLIGHTS

• During the COVID-19, 1326 Gg of carbon emissions were reduced due to decreased international student mobility.
• The amount of reduced carbon emissions is equivalent to two-thirds of the UK’s annual agricultural emissions.
• Online education helps avoid the negative impacts of excessive international student mobility on climate change.

ARTICLE INFO

Keywords:
Aviation carbon emissions
International student mobility
Carbon footprint
Air travel

ABSTRACT

Global carbon emissions have been rapidly increasing in recent years, negatively influencing the global climate. Therefore, it is urgent to reduce carbon emissions and achieve carbon neutrality. During the COVID-19 pandemic, strict quarantine plans have led to a sharp decline in the number of international student flights, which will, in turn, decrease aviation carbon emissions. This study predicts the carbon emission reduction caused by the decrease in international student mobility during the COVID-19. The result shows that the carbon emission was about 1326 Gg, a staggering value equivalent to two-thirds of the carbon emissions of the UK’s agriculture sector in a year. Furthermore, this study analyzes the implications of current mitigation policies and makes recommendations for future strategies.

1. Introduction

Aviation is an essential contributor to the global economy, satisfying society’s mobility needs. However, it contributes to climate change through CO2 and non-CO2 effects, including contrail cirrus and ozone formation. There is currently significant interest in policies, regulations, and research aiming to reduce aviation’s climate impact. Here we model the effect of these measures on global warming and perform a bottom-up analysis of potential technical improvements, challenging the assumptions of the targets for the sector with several scenarios up to 2100. We show that although the emissions targets for aviation are in line with the overall goals of the Paris Agreement, there is a high likelihood that the climate impact of aviation will not meet these goals. Our assessment includes feasible technological advancements and the availability of sustainable aviation fuels. This conclusion is robust for several COVID-19 recovery scenarios, including changes in travel behavior.

Air travel accounts for 2% of global CO2 emissions, and this proportion is set to grow in the future. There are currently no large-scale solutions to drastically reduce the industry’s dependence on oil. Therefore, airlines are looking to use a basket of measures to reduce fuel consumption. Optimization of cost index (CI) could be a valuable addition to this. By balancing time-dependent costs with the cost of fuel, it controls the aircraft’s speed to achieve the most economic flight time. This directly impacts the CO2 emissions from the aircraft, with higher speeds resulting in higher fuel consumption. This study aims to assess CI’s impact on CO2 emissions for six different aircraft models on a flight-by-flight basis and to evaluate how the CI could be affected by future impacts on the industry for a representative aircraft. Results show a range of representative CI values for different aircraft models exist and suggest that the maximum benefit for optimizing CI values occurs for long-range flights.

The average saving in CO2 emissions is 1%. Results show that time-
related costs have the greatest effect on the optimum CI values, particularly delay costs. On the fuel side of the equation, it is notable that a carbon price resulting from implementing a market-based mechanism has little impact on the optimum CI and only reduces CO\textsubscript{2} emissions by 0.01% in this case. The largest savings in CO\textsubscript{2} emissions resulted from biofuels, with reductions of between 9% and 44% for 10% and 50% blends, respectively. This study also highlights the need for further research into crew and maintenance costs, cumulative costs and delays induced by congestion and climate change events, and policy considerations to ensure a reduction in CO\textsubscript{2} emissions. Finally, the study concludes that CI should be seen as a valuable tool in both helping to reduce CO\textsubscript{2} emissions as well to assess the impact of future events on the industry.

The Paris Agreement states that the parties will strengthen the global response to the threat of climate change by limiting the increase in global average temperature to 2°C compared to the pre-industrial temperature levels[1]. As a result, the world is projected to reach the peak greenhouse gas (GHG) emissions level as soon as possible and achieve net-zero GHG emissions by the second half of this century. However, CO\textsubscript{2} emissions were climbing and rose to the highest record in 2018, and it slightly decreased to 33Gt in 2019[2]. The carbon emissions of the air transport sector accounted for 10% of the total transport sector’s emissions in 2019[2] and developed an upward trend year on year because of international student mobility. The International Civil Aviation Organization (ICAO) states that from 2013 to 2019, global carbon emissions from civil aviation transport have already exceeded 70% of ICAO’s predicted values. With various policies in social blockade and air transport controls, 2020 witnessed a significant reduction in global aviation carbon emissions[3]. As a result, global carbon emissions fell by 2.4 billion tonnes in 2020[4], the most significant decline since World War II. However, if embargoes are lifted, the carbon emission level is expected to rebound, causing a severe issue in climate change. Therefore, the situation is of great urgency.

A significant gap still exists between the current carbon emission level and the 2030 emission target. Besides, current policies are insufficient to achieve the greenhouse gas reduction goals[5,6]. International aviation carbon emissions have been exempted from the global legal framework such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol for a long time. However, there is a growing global call to add the international aviation policies in the Kyoto Protocol in recent years[7,13]. As international student mobility expands and the number of students moving increases, and as international student mobility is a major contributor to aviation emissions, it is increasingly relevant to take some measures to reduce aviation emissions from international student mobility. According to the Organization for Economic Cooperation and Development’s (OECD) Education, the total number of highly-educated international student mobility exceeded 2 million in 2000. Later on, the number surpassed 4 million in 2010 and reached 5.6 million in 2018[7]. Flights are the dominant choice for international students. According to Aarsenault et al.[8] 87.4% of international students choose to travel by air, with air travel accounting for 96.9% of the total distance they have ever traveled. Prior research shows that 1% of the world’s population generates 50% of total aviation emissions[9]. Meanwhile, although the higher education sector does not possess a large proportion of the total population, the carbon emission from higher education cannot be overlooked, especially considering scholars who frequently attend academic conferences around the world and international student mobility[10]. Therefore, a significant reduction in aviation emissions from long-distance travel of international students and academics is an important component of a successful response to climate change[11]. Carbon emissions associated with international student mobility were between 14.01 and 38.54 MT (megatons) of CO\textsubscript{2} equivalent in 2014, increasing from 7.24 and 18.96 MT in 1999. In the context of these figures, the lowest estimates are comparable to the annual national emissions of Latvia (13.94 MT) or Jamaica (15.47 MT). In comparison, the highest estimates are comparable to the annual national emissions of Croatia (30.42 MT) or Tunisia (39.72 Mt)[12]. Prior literature states that international students’ mobility harms the environment and suggests that it is time to reduce the carbon footprint of international education[14]. There has been much criticism of the aviation carbon emission generated by academic air travel, considering its harm to the environment. Universities in Europe, Northern America, and Oceania have addressed this criticism[15]. For example, ETH Zurich proposed a project in 2017 to reduce emissions from air travel, which made it the first university in the world to take practical actions to reduce aviation carbon emissions[16]. International exchanges in higher education produce significant carbon emissions, which have often been ignored due to the significant benefits generated from higher education. Unlike the previous situation, international educators are increasingly concerned about sustainability and the climate crisis in the 2020s. This may even become one of the critical themes of the internationalization agenda in the coming years.

The academic research for the impact of international students on carbon emission is scarce. This paper presents a quantitative case study using the U.K. Department of Environment, Food and Rural Affairs (DEFRA) metrics, a procedure developed by the U.N. department responsible for environmental protection for calculating carbon emissions. It calculates the GHG emission contribution of international students arriving in the U.S. on flights and analyzes the social reality of this reduction in a multidimensional way. This calculated value’s spatial and temporal dynamics are described, and the changing trends and policy implications affecting the Chinese students studying in the U.S. that lie behind this value are explored. Further, the paper explores the applicable carbon emission reduction from international student mobility based on current feasible programs on Sino-foreign cooperation and energy efficiency measures and the policy implications of these programs and recommendations for future strategies. It also investigates how the aviation industries meet the growing demand for flights for international students and progressively reduce emissions. Finally, it is meaningful to compare the emission levels (including historical trends) and explore possible options for reducing carbon emissions from a legal perspective.

2. Background

2.1. Student international travel generates a significant proportion of carbon emissions in higher education institutions

With the rapid development of society, climate change has become the most severe and threatening issue to human survival today[17,18]. The Intergovernmental Panel on Climate Change (IPCC) suggests that current society will have to make rapid and dramatic changes to limit global warming to 1.5°C[19]. One of the most critical influences on global temperature is GHG [20]. Human pollution and GHG emissions are the main causes of global warming and climate change[21]. The increasing levels of GHG in the earth’s atmosphere will have an unprecedented impact on the global environment, society, and economy. Over the last decade, GHG emissions have increased by an average of 1.5% per year, with the top 20 economies accounting for the largest share of global carbon emissions: 78% of the global total[22]. At the same time, UNEP claims that although all countries have met their commitments under the Paris Agreement, global temperatures are still trending up to 3.2°C, a situation that will have irreversible ecological consequences[23].

In recent years, research on climate change and global warming has increasingly emphasized the concept of carbon footprint. A carbon footprint collects GHG emissions caused by business establishments, activities, products, or individuals through transport, food production and consumption, and various production processes[23]. It describes the impact of energy awareness and behavior on the natural world and calls on people to take action. With global warming and natural resources diminishing, it is crucial to increase one’s awareness of energy saving
and emission reduction to reduce carbon footprint[24]. In particular, carbon emissions from cross-border air travel should be given more attention[25]. Because at a time when global carbon emissions from all sectors are in urgent need of reduction, carbon emissions from the transport sector are still increasing, with civil aviation transport, as a resource-intensive sector, accounting for a larger share of total carbon emissions. International Energy Agency (IEA) data shows that the total CO₂ emissions generated in 2019 will be 918 million tonnes, an increase of 29% from 2013, accounting for about 2% of global emissions[2]. Air travel is the most environmentally polluting mode of transport in climate change[9,26]. Aviation emissions are far more harmful than ground transport emissions[27]. 85% of global air transport CO₂ emissions in 2019 come from passenger transport, amounting to 785 million tonnes, an increase of 33% in total between 2013 and 2019[2]. The transit element is recognized as the most significant carbon contributor to the GHG emissions from, for example, holiday tours[28] and pilgrimage travel[29].

As globalization accelerates, more and more transnational air travel is being undertaken for academic conferences or abroad studies[30]. Reducing cross-border travel is of paramount importance for higher education institutions due to environmental concerns. Especially in countries with advanced levels of higher education, who already rely heavily on flying, flying becomes a significant part of the carbon footprint of higher education institutions[31]. For example, according to Arsenault et al.[8], the University of Montreux accounts for 30% of the institution’s total carbon emissions due to academic air travel. Reducing carbon emissions from air travel would be the most effective and quickest way for higher education to reduce carbon emissions[32].

2.2. COVID-19 influences student mobility and reduces carbon emissions

Before COVID-19, with the increasing scale and scope of student mobility worldwide, the global carbon emissions rise. In the 19th century, countries promoted their talents to study abroad for national interests. People were more likely to choose nearby countries or regions by train or ship during this period. Considering the small scale of student mobility and the transportation they chose, the carbon emission was not much. After the Second World War, people who were influenced by the idea of peace and development began to organize large-scale international student exchange programs. The end of the Cold War in the 1990s and the rapid development of the telecommunication and computer industries stimulated globalization. In this case, a growing number of students were involved in various forms of study abroad exchange programs. International students show higher preferences for airplanes because of convenience. The scientific community investigated the issues of climate change in depth. The IPCC has released five assessment reports, each more certain than the last that anthropogenic activities are the main cause of global climate change[33,34]. Since international student mobility, as an anthropogenic activity, is more and more frequent, its impact on climate change should not be underestimated.

According to OECD, the U.S. has always been the destination with the highest number of students studying abroad. According to the U.S. Open Doors Report published by the Institute of International Education, the U.S. accepted a total of 514,723 international students in the 1999–2000 academic year. By the 2019–2020, this number increased 108.95% to 1,075,496[35]. Thereby, this paper mainly focuses on U.S. international student mobility. Fig. 1 shows the trend in the number of international students in the U.S. since 2009. The data source is the U.S. Open Doors Report.

The sudden outbreak of the COVID-19 limits international student mobility at the end of 2019, adding much uncertainty to global politics and economics. This makes an unpredictable international situation in 2020 and impacts the international education market. According to the World Health Organization (WHO), by August 2021, the cumulative number of confirmed infections worldwide will exceed 200.84 million, and the cumulative number of deaths will be nearly 4.26 million[36]. In addition to vaccination, restrictions on the mobility of people have been shown to be one of the most effective measures to deal with COVID-19. With the reduction of international flights and various measures to restrict people’s cross-border movement, such as the suspension of student visas and the implementation of language qualification and proficiency exams. This has led to a sharp decrease in the number of international travelers. According to the U.S. Immigration and Customs Enforcement (ICE)’s Student and Exchange Visitor Program (SEVP), the total number of registered F-1 and M-1 students in 2020 was 125,569, a decrease of 17.86% from 2019[37]. China and India are the main sources of international students in the U.S. There is a gradually decreasing trend for the number of international students studying in the U.S. due to the COVID-19. The Trump administration has introduced a series of anti-globalization policies, unilaterally curtailing international exchange and cooperation channels between China and the U.S., causing the largest decline of Chinese international students. International student travel is strictly restricted, leading to a sharp decrease in international flights and further reduction of carbon emissions. Statistics from the International Air Transport Association (IATA) show an 80% decline in global flights from January to April in 2020 and predict that the global air passenger demand will be 48% lower in 2020 than in 2019. The amount demanded is projected to be lower than 2019 until 2023[38].

The emergence of mutations of the COVID-19 and the normalization of the COVID-19 have had a significant negative impact on international student mobility, which indirectly reduced the aviation carbon footprint of international student mobility. The global anti-epidemic process faces a prolonged and difficult situation, which has disturbed the traveling plan of international students. Scientists argue that the epidemic will have a longer-term impact on people’s travel behavior[39]. The spread of the COVID-19 is likely to bring a long period of economic depression. The ability of international students’ study plans and their families’ abilities to pay for their studies will be affected. While the COVID-19 will eventually end, the impact of the pandemic on international student mobility and aviation carbon emissions is likely to be prolonged for some time.
2.3. Aviation emission reductions during the COVID-19 explore new paths for carbon emissions and help energy reform

According to the International Civil Aviation Organization (ICAO) 2016 Environmental Report[40], global aviation’s GHG emissions will increase significantly by the mid-21st century, with annual international aviation CO2 emissions put likely to increase from about 700 million tonnes at present to around 2.6 billion tonnes by 2050. Global aviation will emit around 56 billion tonnes of CO2 over 2016–2050. A report published by the IATA, the Aviation & Climate Change Fact Sheet, shows that in 2019, civil aviation as a whole emitted around 915 million tonnes of CO2[41]. The total potential GHG emissions from international aviation achieved zero growth in 2020. It is estimated to reach 14.4 billion between 2020 and 2040, with a reduction of approximately 7.8 billion tonnes of CO2.

The global pandemic of the COVID-19 has had limited visa processing and international air access and significantly impacted air travel and the aviation industry. Neither the 9/11 Terrorist Attacks nor the 2007–2008 global financial crisis had a more dramatic impact on the airline industry than the COVID-19. The IATA counted a 66% drop in global revenue passenger kilometers (RPKs) in 2020[42]. In the short term, this will reduce aviation CO2 emissions significantly, but this phenomenon is only temporary, and aviation carbon emissions will eventually rebound. The air transport industry is under enormous pressure to reduce emissions on the one hand and is suffering significant losses due to COVID-19 on the other. In this context, a growing number of airlines have committed to plans to achieve net-zero carbon emissions and use sustainable aviation fuels by 2050, with 13 Oneworld member airlines such as American Airlines, British Airways, Cathay Pacific, and Finnair. Opportunities and challenges exist to achieve carbon-neutral growth in the aviation industry. The solutions such as producing more efficient engines, consuming less fuel, developing biotechnology, and investing in sustainable aviation fuels are crucial to enhancing aviation industries’ sustainability.

3. Method and data

Extensive previous research work has shown that carbon emissions from international air travel can be calculated in four main ways[34]:

1. Calculation based on fuel: emissions are calculated by counting the aircraft fuel used in each country.

2. Calculation based on passenger: emissions are calculated for the number of passengers and travel distances. This method is recommended by the DEFRA and is the main methodology we adopt in this paper.

3. Calculation based on the plane: emissions are calculated for specific aircraft types and flight distances.

4. Calculation based on freight and passenger: emissions are calculated by counting the number of freight and passenger traffic.

In response to several of these methods, there has been previous literature on calculating carbon emissions from flights, and they give different values for the radiative forcing index. Radiative Forcing (RF) is the metric used to compare climate perturbations among different aviation scenarios and total anthropogenic climate change. RF is the global, annual mean radiative imbalance to the earth’s climate system caused by human activities. It predicts changes to the global mean surface temperature. Whereas the Radiative Forcing Index (RFI) is the ratio of total radiative forcing to that from CO2 emissions alone and measures the importance of aircraft-induced climate change other than that from the release of fossil carbon alone[43].

Although it is not considered that RFI is an appropriate indicator for measuring aviation carbon emissions, it is still considered that aviation emissions are much greater than CO2 emissions alone[44]. The methodology in this study uses the RFI used by Sausen et al.[45]. Nevertheless, we acknowledge the conservative nature of this approach. The RFI factor used in this method is only equivalent to what Brand and Boardman[46] have classed as a low to moderate Aviation Impacts Multiplier.

This paper aims to measure aviation carbon emissions from international student mobility and explore possible policy measures to reduce this value. Unlike other countries, the full database on international students traveling to the U.S. is publicly available, and therefore these data can support this study. Furthermore, because of the ability to obtain the number of passengers and the distance flown, that calculation based on passengers appears to be the most appropriate and meaningful approach. The calculation process for this study is divided into three steps. The first step is to obtain the total number of passenger flights for international students traveling to the U.S. from each country, then calculate the flight distance, and the last is to calculate the carbon emissions of these flights.

3.1. Counting the total number of passenger flights to the U.S. By international students from each country

The number of international students flowing from countries around the world to study in the U.S. is provided by the U.S. Immigration and Customs Enforcement (ICE)’s Student and Exchange Visitor Program (SEVP). The SEVP is a part of the US ICE’s Homeland Security Investigations within the U.S. Department of Homeland Security (DHS).

According to the U.S. Immigration and Customs Enforcement (ICE)’s Student and Exchange Visitor Program (SEVP), the total number of registered F-1 and M–1 students in 2020 was 125,569, a decrease of 17.86% from 2019[37].

SEVP is a program that administers the Student and Exchange Visitor Information System (SEVIS). It ensures that government agencies have essential data about nonimmigrant students and exchange visitors to preserve national security. This data is updated annually. This paper uses the database updated for 2019 and 2020[37]. This data includes the number of F-1 and M–1 nonimmigrant students enrolled in U.S. schools and covers 225 countries and regions.

Specific international airports are designated as points of departure for each of these 225 source countries. Domestic transportation was omitted for both outbound and inbound countries because carbon emissions from domestic transportation are included in the national GHG emissions liability, while international air travel was not.

To calculate the aviation emissions from international student travel to the U.S., we assume that these international students going to school in the U.S. go home once a year to visit family or take a holiday. Therefore, the round-trip aviation emissions are twice as large as possible from a single flight. This is obviously a very conservative assumption, as many other students travel multiple times during the year. Therefore, the actual aviation carbon emissions generated may be much higher than our assumptions.

3.2. Calculating the flight distance

Flight distances were calculated for flights from each designated outbound country airport to the U.S. The airport for international students arriving in the U.S. we designated as John F. Kennedy International Airport (JFK), which has the highest passenger traffic, and using the WGS-84 Ellipsoid[47] (assuming a Great Circle Distance (GCD) for this path. The GCD is defined as the shortest distance between two points, with coordinates (lat1, lon1) and (lat2, lon2), on the surface of a sphere. It is given by:

\[
GCD = \cos^{-1}\left(\sin(lat1) \sin(lat2) + \cos(lat1) \cos(lat2) \cos(lon1 - lon2)\right)
\]

Where R is the mean radius of the earth, R = 6371.01 km, as recommended in the IPCC Special Report Aviation and the Global Atmosphere[48], the distance of the path is increased by 9% when non-direct (i.e., not along a straight line between destinations) routes and delays and circling are taken into account. We have adopted this suggestion and
set the loading factor to 9%. The suggested changes to this figure, such as using 6% instead of 9%, are small compared to the uncertainty associated with the RFI used. The statistics show that the total distance traveled by international students to the U.S. in 2019 is 17.7 billion km, with an average travel distance of 11,612 km. The total distance traveled by international students in 2020 is 14.5 billion km, with an average travel distance of 11,581.25 km, a reduction of 30.52 km in the average travel distance per capita to the U.S.

The climate change impact of each international student traveling to the U.S. is determined by the aviation carbon emissions generated during the trip, weighted to include changes in radiative forcing other than carbon dioxide itself, as detailed below. This paper expresses the carbon dioxide equivalents \((\text{CO}_2-e)\) calculations.

### 3.3. Calculating aviation carbon emissions from international student travel

The \(\text{CO}_2\) emission factors were calculated following the methodology provided by the U.K. Department for Environment, Food and Rural Affairs[49]. The data contains international student flights to the U.S. from 225 countries and regions. 17 of these, including Canada and Mexico, have flights to the U.S. between 425 and 3700 km, which is considered a 'Short-haul flights' in the DEFRA methodology, where \(\text{CO}_2\) emissions are calculated at 95.2 g/km. All other flight routes have a journey distance that meets the DEFRA methodology for 'Long-haul flights', in which case \(\text{CO}_2\) emissions are calculated at 109 g/km. Table 1 shows DEFRA’s GHG conversion factors.

The amount of space taken up by a premium cabin varies in different airlines and aircraft types for 'Long-haul flights' travel, with first-class taking up the most space, typically three to six times more than economy class. Table 2 shows the typical proportions of different classes for different types of flights and the emission factors based on the class of seats used in the calculations. The level of spending by international students is related to their families’ financial situation. Flights for international students contain various classes of seats and are dominated by long-haul travel. Therefore, we use the average carbon emission factors for the different seats in long-haul trips as the per capita emission factors.

We needed to convert \(\text{CO}_2\) emissions to \(\text{CO}_2-e\) so that we could include the effects on tropospheric ozone and methane from NOx emissions, water vapor, particle emissions, and the formation of high-altitude contrails[34], and we applied the RFI according to standard methods [48], which means that the RFI value of 1.9 was used. This calculation includes the effect of contrail radiative forcing but excludes the increased RFI effects of enhanced cirrus cloudiness, which significantly impacts aviation carbon emissions[34]. Therefore, the \(\text{CO}_2-e\) for each international student departing from a designated airport in the outbound country to JFK in the U.S. has been determined. The value of \(\text{CO}_2-e\) is given in metric tonnes. The formula for the long-haul travel is:

\[
\text{CO}_2-e = 109 \times \text{greatcirclepathflightdistance} \times 1.09 \times 2 \times 1.9
\]

We use Gg (the standard unit for carbon emission inventories) as a unit to express the results of our calculations. A gigagram (Gg) is identical to a kilotonne. It is worth noting that the calculations in this study are conservative measurements as we have used an RFI of 1.9, whereas the maximum value of RFI can reach 4. For example, Brand and Boardman[46] use an RFI factor between 1.5 and 4 in their study.

### 4. Results

#### 4.1. Spatial dynamics of carbon emissions from reduced international student mobility

Because the impact of the COVID-19 varied by region, the decreases in international student mobility from different countries in 2019 and 2020 were also differential. This resulted in significant variation in the change in aviation carbon emissions. The study results show that in 2019, the top five countries in terms of the number of students coming to the U.S. are China, India, the Republic of Korea, Saudi Arabia, and Brazil, which account for 31.1%, 16.36%, 5.52%, 3.5%, and 2.7% of the total number of students coming to the U.S., respectively. In 2020, the top five countries are China, India, the Republic of Korea, Saudi Arabia, and Canada, with 30.57%, 16.58%, 5.45%, 3.03%, and 2.8%, respectively. Fig. 2 shows the number of international students traveling to the U.S. from different countries before and after the COVID-19. The number of students from each country traveling to the U.S. has declined to

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**Table 1**

| Air Passenger Model | Seating Class | \(\text{CO}_2\) (gCO\(_2\)/pkm) | \(\text{CH}_4\) (g\text{CO}_2 e/pkm) | \(\text{N}_2\text{O}\) (g\text{CO}_2 e/pkm) | Total GHG (g\text{CO}_2 e/pkm) |
|---------------------|--------------|-----------------|----------------|----------------|----------------|
| Domestic flights    | Average      | 165.1           | 0.10           | 1.61           | 166.9          |
| Short-haul flights  | Average      | 94.3            | 0.01           | 0.93           | 95.2           |
|                     | Economy Class| 89.9            | 0.01           | 0.88           | 90.7           |
|                     | First/ Business Class | 134.8          | 0.01           | 1.33           | 136.1          |
| Long-haul flights   | Average      | 107.9           | 0.01           | 1.06           | 109.0          |
|                     | Economy Class| 78.8            | 0.00           | 0.78           | 79.5           |
|                     | First Class  | 126.0           | 0.01           | 1.24           | 127.3          |
|                     | Business Class | 228.4          | 0.01           | 2.25           | 230.7          |
|                     | First Class  | 315.0           | 0.02           | 3.10           | 318.2          |

Note. Table 1 is derived from ‘2012 Guidelines to Defra/DECC’s GHG Conversion Factors for Company Reporting: Methology Paper for Emission Factors’.

**Table 2**

| Flight type       | Size       | Load factor (%) | \(\text{gCO}_2\)/pkm | Number of economy seats | % of average \(\text{gCO}_2\)/pkm | % Total seats |
|-------------------|------------|-----------------|----------------------|-------------------------|-------------------------------|---------------|
| Domestic Short-haul flights | Average | 66.40%         | 165.1               | 1.00                    | 100%                           | 100%          |
|                   | Average   | 85.40%         | 94.3                | 1.05                    | 100%                           | 100%          |
| Long-haul flights | Economy class | 83.40%     | 89.9                | 1.00                    | 95%                            | 90%           |
|                   | First/ Business class | 83.40%   | 134.8               | 1.50                    | 143%                           | 10%           |
|                   | Average   | 81.90%         | 107.9               | 1.37                    | 100%                           | 100%          |
|                   | Economy class | 81.90%     | 78.8                | 1.00                    | 73%                            | 80%           |
|                   | First class | 81.90%        | 315.0               | 4.00                    | 292%                           | 5%            |

1. Note. Table 2 is derived from ‘2012 Guidelines to Defra/DECC’s GHG Conversion Factors for Company Reporting: Methology Paper for Emission Factors’.
The analysis calculates that the total global carbon emissions from flights to study in the U.S. in 2019 are about 7329 GgCO₂, and the emissions in 2020 after the COVID-19 are about 6004 GgCO₂. The carbon emissions from flights reduced by the COVID-19 are 1326 GgCO₂, which is a decrease of about 18.3%. The top 9 countries in terms of carbon emissions from flights to the U.S. in 2019 are China, India, the Republic of Korea, Saudi Arabia, Vietnam, Japan, Brazil, Nepal, and Nigeria. This ranking will remain almost unchanged in 2020. The statistics show that China, India, and Saudi Arabia had the largest decrease in aviation carbon emissions from international student mobility in 2019. These three countries accounted for nearly half (57%) of the global reduction in aviation carbon emissions from international students. Fig. 3 illustrates the comparison of aviation carbon emissions generated by international students traveling to the U.S. from representative countries before and after the COVID-19. China is the largest emitter of carbon emissions from student flights to the U.S. in 2019, at 2,450 GgCO₂, accounting for 33.4% of the total data. In the post-epidemic year 2020, China generates 1,975 GgCO₂ of flight emissions from study abroad to the U.S., accounting for 32.9% globally. Compared to the same period in 2019, the aviation carbon emissions due to China’s international student mobility to the U.S. reduced by 474.77 Gg, contributing 35.8% of the reduction. This was followed by India, which ranked second in the number of students studying in the U.S., decreasing from 249,221 in 2019 to 207,460 in 2020, a decrease of 16.76%. India generated 1,465 Gg of carbon emissions from flights to the U.S. for study in 2019, with a global share of 19.9 percent. After the COVID-19, the same is true for the number of Indian students studying in the U.S., which dropped significantly.

Moreover, the carbon emissions from Indian flights to the U.S. for study in 2020 is 1220 Gg, with a global share of 20.3%. Before and after the COVID-19, the emission reduction is 245.54 Gg, with a global share of 18.5% of the emission reduction contribution. The next reduction in-flight emissions from Saudi Arabia due to the COVID-19 is also extremely significant, falling from 286 Gg in 2019 to 204 Gg in 2020, with an emission reduction contribution of about 6.1%. The international student mobility aviation carbon emissions of the Republic of Korea, Japan, Vietnam, Brazil, and Thailand have reduced, with 77 GgCO₂, 48 GgCO₂, 27 GgCO₂, 25 GgCO₂, 22 GgCO₂, and 16 GgCO₂, respectively. And their emission reduction contributions are 5.8%, 3.6%, 2%, 1.8%, 1.6%, and 1.1%, respectively. Fig. 4 shows the global contribution of countries to reduce aviation carbon emissions from international students traveling to the U.S. due to the COVID-19. However, very few countries such as Monaco and Dominica have a slight increase in the number of students to the U.S. after COVID-19, which caused more aviation carbon emissions than the same period in 2019.

4.2. Temporal dynamics of carbon emissions from flights with reduced international student mobility

Due to data availability limitations, this paper collects country’s carbon emissions published by the IEA for 2000 (Table 3) and 2018 (Table 4), and compares CO₂ emissions by sector and energy source.

4.2.1. Comparison of CO₂ emissions by sector

According to the data provided by the International Energy Agency (IEA)[50], the total carbon emissions of all sectors in the world were 23,241 MT in 2000. Fig. 5 shows the CO₂ emissions of different countries measured by different indicators, according to the IEA in 2000, Fig. 6 shows the CO₂ emissions of different countries measured by different indicators in 2018. There is significant variability in each sector’s carbon emission quantity and share. Specifically, the carbon emissions of the electricity and heat supply sector accounted for 41% of the overall carbon emissions share, with a carbon emissions volume of 9358 MT.
The carbon emissions of transportation were 5770 MT, accounting for 14.1%. The rest of the countries all had different degrees of increase.

Table 5 shows the reduction in aviation carbon emissions from international students traveling to the U.S. due to the COVID-19 compared to carbon emissions from representative countries. A description of the icon is provided below.

Electricity and heat suppliers: China’s electricity and heat suppliers emitted 1,427 MT of CO₂ in 2000, with average daily emissions of 3.9 MT. The reduction in aviation carbon emissions from international students traveling to the U.S. worldwide due to the COVID-19 is equivalent to 0.34 days of electricity and heat supplier emissions in China in 2000. The sector emitted 4,896 MT of CO₂ in 2018, with average daily emissions of 13.41 MT of CO₂ in 2018, with a reduction in aviation carbon emissions equivalent to 0.09 days of electricity and heat supplier emissions in China in 2018. Therefore, the reduction in aviation carbon emissions is equivalent to 0.09 days of emissions from electricity and heat suppliers in China in 2018. This value is also equivalent to 0.19 days in 2000 and 0.26 days of emissions in 2018 in the U.S.; 1 day in 2000 and 0.4 days of emissions in 2018 in India; 0.6 days of emissions in 2000 and 0.6 days of emissions in 2018 in Russia; 2.6 days in 2000 and 6 days of emissions in 2018 in the U.K.; and 1.1 days in 2000 and 0.9 days in 2018 in Japan.

In the other energy sector, reducing aviation carbon emissions from international student travel to the U.S. worldwide due to the COVID-19 is equivalent to 3.3 days of emissions in 2000 and 1.5 days of emissions in 2018 in China. This value is also equivalent to 1.9 days of emissions in 2000 and 1.9 days of emissions in 2018 in the U.S.; 15 days of emissions in 2000 and 8.2 days of emissions in 2018 in India; 8.6 days of emissions in 2000 and 11.3 days of emissions in 2018 in Russia; 13 days of emissions in 2000 and 11.3 days of emissions in 2018 in Japan.

The carbon emissions of transportation were 5770 MT, accounting for 25%. The industrial, residential, and other energy sectors accounted for 17%, 8%, and 5%, respectively. The commercial and agricultural sectors have the lowest carbon emissions, just 696 and 340 MT, accounting for 6% and 1% of the overall carbon emission share of the industry in 2000.

Between 2000 and 2018, the rapid global development led to a 44.2% increase in world CO₂ emissions by 10,272.1 MT CO₂ compared to 2000. The electricity and heat production sector and the industrial sector are still the main sources of carbon emissions in all countries around the world, with total carbon emissions of 13,978 MT, accounting for 42% of the overall carbon emissions, an increase of 49% compared to the same year in 2000. The share of carbon emissions from transportation and industry remains unchanged at 25% and 18%, respectively, with an increase of 43.1% and 58.9% compared to the same year in 2000. The industries with the smallest carbon emissions are still commerce and agriculture, with a total carbon emission of 1278 MT, accounting for 4%. Comparing and analyzing the carbon emission of each industry in 2000 and 2018, we can find that each industry’s ranking of carbon emission share has continuity in time.

The amount of carbon emission change in China is the most significant. With the rapid industrial development in China, a lot of environmental problems have emerged. China is currently the most carbon emission country in the world. The carbon dioxide emission of China reached 9809.3 MT in 2018, and China’s total carbon emissions in 2018 increased by 6709.5 MT or 216.4% compared to 2000. India’s carbon emissions rose from 889.8 MT in 2000 to 2307.8 MT in 2018, increasing about 159%, making the country the second-highest increase in global carbon emissions after China. The total carbon emissions of the U.S. decreased in 18 years compared with 20 years, from 5729.9 MT to 4921.1 MT, and the carbon emissions decreased by 808.8 MT, about 14.1%. The rest of the countries all had different degrees of increase.

Table 3 shows the reduction in aviation carbon emissions from international students traveling to the U.S. due to the COVID-19 compared to carbon emissions from representative countries. A description of the icon is provided below.

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In the other energy sector, reducing aviation carbon emissions from international student travel to the U.S. worldwide due to the COVID-19 is equivalent to 3.3 days of emissions in 2000 and 1.5 days of emissions in 2018 in China. This value is also equivalent to 1.9 days of emissions in 2000 and 1.9 days of emissions in 2018 in the U.S.; 15 days of emissions in 2000 and 8.2 days of emissions in 2018 in India; 8.6 days of emissions in 2000 and 11.3 days of emissions in 2018 in Russia; 13 days of emissions in 2000 and 11.3 days of emissions in 2018 in Japan.

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In the other energy sector, reducing aviation carbon emissions from international student travel to the U.S. worldwide due to the COVID-19 is equivalent to 3.3 days of emissions in 2000 and 1.5 days of emissions in 2018 in China. This value is also equivalent to 1.9 days of emissions in 2000 and 1.9 days of emissions in 2018 in the U.S.; 15 days of emissions in 2000 and 8.2 days of emissions in 2018 in India; 8.6 days of emissions in 2000 and 11.3 days of emissions in 2018 in Russia; 13 days of emissions in 2000 and 11.3 days of emissions in 2018 in Japan.
emissions in 2000 and 18.6 days of emissions in 2018 in Japan.  

Industry: The reduction in aviation carbon emissions due to the COVID-19 is equivalent to China’s 0.53 days of emissions in 2000 and 0.18 days of emissions in 2018; the U.S.’s 0.86 days of emissions in 2000 and 1 day of emissions in 2018; India’s 2.5 days of emissions in 2000 and 0.94 days of emissions in 2018; Russia’s 2.91 days of emissions in 2000 and 1.87 days of emissions; the U.K.’s 7.8 days of emissions in 2000 and 15.1 days of emissions in 2018, Japan’s 2 days of emissions in 2000 and 2.5 days of emissions in 2018.  

Transport: The reduction in aviation carbon emissions due to the COVID-19 is equivalent to 1.95 days of emissions in China in 2000 and 0.53 days of emissions in 2018; this value is also equivalent to 0.3 days of emissions in the U.S., 1.6 days of emissions in India, 1.9 days of emissions in Russia, 4 days of emissions in the U.K. and 2.4 days of emissions in Japan in 2018.  

Residential: this value is equivalent to 1.2 days of emissions in China, 1.5 days of emissions in the U.S., 5.4 days of emissions in India, 2.4 days of emissions in Russia, 7.4 days of emissions in the U.K., and 9.3 days of emissions in Japan in 2018.  

Commercial and public services: this value is equivalent to 3.2 days of emissions in China, 2.1 days of emissions in the U.S., 16.1 days of emissions in India, 30 days of emissions in Russia, 22 days of emissions in the U.K., and 9 days of emissions in Japan in 2018.  

Agriculture: this value corresponds to 4.3 days of emissions in China, 10.5 days of emissions in the U.S., 14.2 days of emissions in India, 37.2 days of emissions in Russia, 241 days of emissions in the U.K., and 48.4 days of emissions in Japan in 2018.

4.2.2. Comparison of CO₂ emissions by energy sources

Coal: The amount of reduction in aviation carbon emissions caused by international students traveling to the U.S. worldwide due to the COVID-19 is equivalent to 0.19 days of emissions in China, 0.22 days in the U.S., 0.86 days in India, 1.1 days in Russia, 3.38 days in the U.K., and 1.4 days in Japan in 2000. This value is also equivalent to 0.06 days in China, 0.38 days in the U.S., 0.3 days in India, 1.18 days in Russia, 15.6 days in the U.K. and 1.12 days in Japan in 2018.

Oil: This value is also equivalent to 0.91 days of emissions in China, 0.21 days in the U.S., 1.75 days in India, 1.52 days in Russia, 2.7 days in the U.K. and 0.76 days in Japan in 2000. This value is also equivalent to 0.35 days in China, 0.24 days in the U.S., 0.81 days in India, 1.6 days in Russia, 3.06 days in the U.K. and 1.26 days in Japan emissions in 2018.

Natural gas: equivalent to 13.44 days in China, 0.39 days in the U.S., 11.8 days in India, 0.7 days in Russia, 2.44 days in the U.K. and 3 days in Japan emissions in 2000. This value is also equivalent to 0.93 days in China, 0.3 days in the U.S., 5.83 days in India, 0.58 days in Russia, 3.06 days in the U.K. and 2.12 days in Japan emissions in 2018.

4.2.3. Comparison of CO₂ emissions from electricity and heat by energy source

Coal electricity and heat generation emissions: The amount of reduction in aviation carbon emissions caused by international students traveling to the U.S. worldwide due to the COVID-19 outbreak is equivalent to 0.35 days of coal electricity and heat generation emissions in China, 0.24 days in the U.S., 0.81 days in India, 1.6 days in Russia, 3.06 days in the U.K. and 1.26 days in Japan emissions in 2018.

Natural gas: equivalent to 13.44 days in China, 0.39 days in the U.S., 11.8 days in India, 0.7 days in Russia, 2.44 days in the U.K. and 3 days in Japan emissions in 2000. This value is also equivalent to 0.93 days in China, 0.3 days in the U.S., 5.83 days in India, 0.58 days in Russia, 3.06 days in the U.K. and 2.12 days in Japan emissions in 2018.

Fig. 5. CO₂ emissions of different countries in 2000.
Oil electricity and heat generation emissions: The amount of reduction in aviation carbon emissions caused by international students traveling to the U.S. worldwide due to the COVID-19 is equivalent to 8.72 days of oil electricity and heat generation emissions in China, 2.62 days in the U.S., 17.28 days in India, 6.64 days in Russia, 79.32 days in the U.K., and 5.29 days in Japan in 2000. This value is also equivalent to 20.16 days in China, 15.64 days in the U.S., 37.21 days in India, 17.28 days in Russia, 372.2 days in the U.K., and 14.06 days in Japan for oil-fired electricity and heat emissions in 2018.

Gas electricity and heat generation emissions: the reduction in aviation carbon emissions caused by international students traveling to the U.S. worldwide as a result of the New Crown outbreak is equivalent to 41.7 days in China, 1.5 days in the U.S., 22.3 days in India, 1.1 days in Russia, 7.62 days in the U.K. and 4.3 days in Japan for gas electricity and heat generation emissions in 2000. This value is also equivalent to 4.29 days in China, 0.78 days in the U.S., 13.33 days in India, 1.01 days in Russia, 8.78 days in the U.K. and 3.06 days in Japan for gas electricity and heat generation emissions in 2018.

4.3. Changes in Chinese study abroad to the U.S. Before and after the COVID-19

From 2019 to 2020, the number of international students studying in the U.S. worldwide has dropped from 1,523,700 to 1,251,600, a 17.86% decrease. From the country’s perspective, with the most significant number of international students, Chinese students studying in the U.S.
dropped by 19.4% after the COVID-19. With a decrease of 91,936 students and a reduction of 229,246 TCO₂ in aviation carbon emissions, with a global contribution of 35.8% in emission reduction, ranking first in the world. The increasing number of Chinese students studying in the U.S. and the significance of reducing carbon emissions due to the COVID-19 are also significant. This paper collected the annual average carbon emissions of the four major municipalities in China in 2018 and compared them with the reduced aviation carbon emissions due to the international study in the U.S. It found that they are equivalent to 2.6 days of CO₂ emissions in Beijing, 1.2 days of CO₂ emissions in Shanghai, 1.5 days of CO₂ emissions in Tianjin, and 1.4 days of CO₂ emissions in Chongqing in 2018.

The global political and economic situation in 2020 is increasingly uncertain due to the COVID-19. While the U.S. has the highest number of diagnoses and deaths in the world in this COVID-19, the Trump administration has declared that the U.S. will withdraw from the World Health Organization. The COVID-19 will significantly impact the U.S. trade in higher education services. The U.S. position as a global center for higher education may be shaken. First, the increasingly conservative and self-serving policy orientation of the U.S. could dismantle the status of the U.S. as a center of higher education. In early June 2020, the Trump administration issued a ban on Chinese students pursuing graduate studies in Science, Technology, Engineering, and Mathematics (STEM) and international students with graduate degrees or higher, especially those in technology-related fields of interest, to the U.S. government. It may be placed on “priority watch.” The Trump administration will impose the ban. The restrictive measures taken by the U.S. against Chinese students, combined with the negative impact of its policy to restrict Chinese students from entering science fields, resulted in only 808 visas being granted to Chinese applicants to the U.S. from April to the end of September 2020, compared to 90,410 in the same period last year. At the same time, there is a general trend of fewer international students traveling to the U.S. to study due to the outbreak. However, China has experienced the largest decline, above the average of 88%. The Trump administration has successively introduced a series of anti-globalization policies in recent years, unilaterally curtailing international exchange and cooperation channels between China and the U.S. This is not conducive to the exchange and cooperation of higher education in the world and the cultivation of internationalized faculty and talents, not to mention the international mobility and rational allocation of human and financial resources in higher education.

With the evolution of US-China relations and the impact of the COVID-19, the number of Chinese students applying to the U.K. schools is on the rise, with a 23% increase in applications for 2020 in particular. According to the National Study Abroad Report 2020 published by Industrial Bank, the number of students applying for undergraduate studies through UCAS (Universities and Colleges Admissions Service) in 2020 is up 23% compared to 2019. At the master’s level, the distribution of study abroad is more diversified, with the U.K. leading with 33.16%, followed by the U.S. with 25.61%, followed by Australia, Japan, Germany, and other countries. In 2020, influenced by the COVID-19, the visa entry policies of various countries are in constant change, and there are many questionable voices about the future development of international education. China-US education exchange does have a great change at present, mainly for the following three aspects. Firstly, the country orientation of Chinese students studying abroad will change greatly in the next year or two; the ratio of country orientation will not be only the most popular among Chinese students will choose Europe, Southeast Asia, including Singapore. The second is that the U.S. will step up the issuance of visas for Chinese students to study in sensitive majors. However, the restrictions on the so-called sensitive majors are still mainly restricted to graduate students, Ph.D. students, in-state and unit public schools, with little impact on undergraduate students. The third area of change is that the U.S. will intensify its review of internship visas and work visas for Chinese students. However, in Cen Jianjun’s opinion, it is necessary to look at the problem dialectically, and the basic trend will not change under the globalization of education. The disruption or impact of international education is only a pause button, not a permanent one. With the globalization of the economy and the implementation and promotion of China’s “One Belt, One Road,” the country’s demand for international talents is increasing year by year; in addition, the stability of the future COVID-19 and the introduction of vaccines will make the peak of international education come again.

5. Discussion

Although the pneumonia COVID-19 has blocked worldwide international student mobility and contributed to reducing aviation carbon emissions, in economic globalization, the COVID-19 cannot significantly reduce the amount of international student mobility. The IEA states that low economic growth will not lower carbon emissions, and the aviation carbon reductions caused by the COVID-19 are temporary. Under the current situation, carbon emissions will rebound in 2021 and exceed 2019 levels in 2027. This has led to the increasing number of international scholars to reflect on the issues in international mobility and promote us to propose new solutions to reduce aviation carbon emissions from international student mobility. In addition, changes are needed in traditional approaches to international education and student management models. This section will discuss the different solutions and make recommendations.

5.1. Strengthen Sino-foreign cooperative education and online education

First and foremost, strengthening Sino-foreign cooperative education and online education is a new option for studying abroad in the home country. In 2020, the COVID-19 will be rampant overseas, and the uncertainty of international relations has caused the hesitance of some students who originally intended to study abroad, and Sino-foreign cooperative education has become the ideal alternative. For this reason, the Chinese Ministry of Education issued the “Notice on the Approval of Sino-foreign Cooperative School Programs for the Second Half of 2020” on March 26, 2021. In general, the students in the Chinese-foreign cooperative education are taught by foreign education models and foreign teachers to enjoy the foreign education model without traveling abroad. Chinese Ministry of Education released a survey report about the data of Sino-foreign cooperative education at the undergraduate level, showing that the development of Sino-foreign cooperative education has entered the improvement stage, and the employment rate is continuously improving. In the future, the scale of Sino-foreign cooperative education should be expanded so that the quality of talent cultivation can be significantly developed [51].

While focusing on the Sino-foreign cooperative education, the quality and quantity of online education should also be strengthened. According to the research, the overall market value of online education is expected to reach $350 billion by 2025 [52]. With the improvement and standardization of online education intellectual property protection, content regulations, and market access, universities and colleges gradually incorporate high-quality online learning resources into their education system.

5.2. Eliminate unnecessary short-term international exchange study programs

Secondly, the short-term study abroad programs can be eliminated for higher world sustainability. In-person interaction is extremely effective in exchanging ideas, so it is impractical to end all mobility forms. In this case, to significantly reduce the negative environmental impact of international study, the academic researchers suggest that education institutions eliminate the short-term international programs. More than 60 percent of international programs in the U.S. are short-term programs, and other countries also have abundant short-term programs. Although short-term study abroad programs (8 weeks or
less) can positively affect cross-cultural exchange, the environmental burdens caused by short-term study abroad programs are meant to be thought-provoking.

Students and teaching and administrative staff can choose to participate in a large number of short-term international programs to expand their field of vision. In fact, the quality of these programs varies, and most of the students attend the international programs for educational background exaltation rather than gathering knowledge. A practice worthy of emulation would be that the Japan Student Services Organization (JASSO) has decided not to fund short-term exchange programs since 2021 for environmental reasons, although they account for 60% of international programs in Japan.

5.3. Reduce offline international conferences and academic activities

Another suggestion would be to cut the unnecessary offline communication and exchange meetings. In addition to reducing the mobility of international students, we cannot ignore the negative impact of the intensive movement of officials, organizations, and researchers on the environment due to the huge number of flights for meetings, seminars, conferences, and other forms of communication. Therefore, we should launch more online meetings, presentations, and other forms of communication than having them in person. Although online interaction cannot completely replace face-to-face interaction, it helps to ease the climate crisis.

5.4. Accelerate research and development of clean energy

The following recommendation would be to promote the research and development in clean energy and low-carbon technology and accelerate the development of new sustainable aviation fuels. Structural changes are needed to break the traditional carbon emissions pathway. The governmental incentives and coordination are critical to achieving the E.U.’s Sustainable Aviation Fuels (SAF) targets. The government should invest more in SAF research, integration of R&D resources, cooperation between academia, research, and application, promoting technical communication and exchange, and providing financial incentives to aviation energy companies with leading sustainable technology. The U.S. Environmental Protection Association and Rocky Mountain Institute (RMI) announced the Aviation Buyers Alliance (SABA) and is supported by companies including Boeing, Poston Consulting, Deloitte, JP Morgan Chase, Microsoft, Netflix, and Salesforce. The organization’s mission is to promote the production and technological innovation in sustainable aviation fuels by relevant investments and support the participation of institutional members in developing policies that accelerate the achievement of net-zero emissions from aviation activities.

5.5. Build an international inter-airline intelligent transportation system

Last but not least, it is critical to build the international inter-airline intelligent transportation system and guide the international students to travel in an environmentally friendly way. The development of information and communication technology has promoted an international inter-airline intelligent transportation system. It will further improve the accessibility of global urban transportation and facilitate people’s traveling. Under the background of global consensus to address the issues in climate change and carbon emissions, it is crucial to mitigate the increased carbon emissions from flight transit by continuously improving urban transportation accessibility, guaranteeing the effective operation of the air transportation system, and improving the efficiency of international student mobility. The focus of the international aviation plan should be shifted from the facility constructions to international student travel demand management and from physical space planning to people-oriented planning regarding the students’ needs. International students should also be guided to travel in a low-carbon and intelligent way, avoiding unnecessary flights by taking eco-friendly transportations such as trains instead.

6. Conclusion

Using DEFRA metrics as our indicator, we assessed the contribution of international student mobility to aviation emissions. The results show that international student travel constitutes a significant proportion of international aviation emissions, equivalent to two-thirds of the U.K.’s annual agricultural emissions and China’s 41-day Gas-fired generation and thermal emissions. In recent years, the internationalization of higher education has made it difficult to ignore the significant negative environmental impact of transport, particularly air travel. Many universities are actively working to reduce emissions associated with the daily commute to campus, but little attempt has been made to develop new policies to reduce the greater impact of long-distance travel. This study identifies ways to reduce the environmental impact of potential international student mobility through policy changes and new technologies, such as adopting Sino-foreign partnerships, enhanced online education, and the development of cleaner fuels for aircraft.

CRediT authorship contribution statement

Jin Liu: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Project administration. Jiayu Tian: Methodology, Visualization, Data curation, Formal analysis, Writing – original draft. Wenjing Lyu: Conceptualization, Investigation, Supervision, Data curation, Writing – original draft, Writing – review & editing, Project administration. Yitian Yu: Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This research is supported by the National Natural Science Foundation of China [grant numbers: 71974012, 71774015, 71941026].

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