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Jet-setting during COVID-19: Environmental implications of the pandemic induced private aviation boom

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1. Introduction

The ongoing COVID-19 pandemic has significantly impacted travel behavior on a global scale. Demand for travel declined as meetings were moved to virtual format, countries implemented quarantine mandates, and people became reluctant to travel due to concerns about health risks (Wild et al., 2021). In March 2020, worldwide air travel began a period of sharp decline (Jacus et al., 2020; Monmousseau et al., 2020; Sun-Sanchez et al., 2020). By April 2020, international air travel had declined by 90% (Sun-Sanchez et al., 2020). Within the United States (U.S.), the Bureau of Transportation Statistics reported that the pandemic-related decline in domestic passenger traffic is the largest ever recorded, with a 96% decline in year-over-year traffic recorded in May 2020 (BTS, 2020a). In response to the drop in travel demand, airlines reduced capacity (Fuellhart et al., 2021). In May 2020, U.S. flight departures decreased by 71.5% as compared to the previous year, and airlines ceased service in 32.1% of their domestic routes (Hotle and Mumbower, 2021). Airline employment was also impacted as airlines reduced their workforce in response to the drop in demand and reduced capacity (Sobieralski, 2020; BTS, 2020a).

While the pandemic caused a large decrease in travel, it also altered travel mode preferences. Due to the infectious nature of COVID-19, people viewed shared modes of travel, such as transit and car sharing, as more risky than individual modes of travel, such as driving alone, biking, or walking (Ozbilen et al., 2021). Changes in risk perception led to significant travel mode changes as people shifted from using public transportation to using private transportation in order to limit contact with other people (Abdallah et al., 2020; Bucsky, 2020; Shamshiripour et al., 2020). A shift from travel by air to travel by car was also documented as people reported feeling uncomfortable sharing close space with strangers (Shamshiripour et al., 2020). Within the U.S. aviation sector, there was a shift from commercial aviation to private aviation. Even as commercial air travel was at an all-time low, media outlets reported surprising news: “the private jet industry is booming with inquiries” (PR Newswire, 2020a) and “interest in private jet service is surging” (Sullivan, 2020).

Private jet operators have reported that although business travel remains low, there has been an increase in first-time users of private aviation looking to reduce touch points at airports and minimize contact with the traveling public (French, 2020; Georgiadis and Hancock, 2020; Powley and Bushey, 2020; PR Newswire, 2020a, 2020b). These first-time users include groups of friends and family members traveling on vacations, as well as passengers who feel their health is more at-risk during the pandemic, such as older passengers or those with...
weakened immune systems (French, 2020; Powley and Bushey, 2020). Some of the demand for private flights is also reported to come from passengers who are looking to fly non-stop on routes that have been dropped by commercial airlines who reduced their networks during the pandemic (Powley and Bushey, 2020; Paramount Business Jets, 2021). Although replacing a commercial flight with a private flight is expensive (e.g., a one-way charter flight between New York and Miami can cost around $15,000 for an aircraft with four seats), the passengers who have shifted from commercial to private aviation are reported to be passengers who could have afforded to fly private prior to the pandemic but opted to fly first class on commercial flights instead (French, 2020; The Economist, 2021). Some media outlets have coined these passengers as a “new class of private traveler” (The Economist, 2021).

Private aviation offers the benefit of minimizing contact during the COVID-19 pandemic, but it comes with drawbacks too. Emissions per passenger are much higher for a private jet flight as compared to a commercial flight (Gössling, 2019). Also, high altitude emissions have a greater impact on the environment than ground-based emissions (Teoh et al., 2020). Because changes in fleet deployment can have an impact on total emissions for the aviation sector (Sobieralski, 2021), it is important to quantify how this shift toward private aviation has impacted aviation emissions, which is currently unknown. Even as media accounts have reported an increase in private aviation usage during the ongoing pandemic, this trend has not yet been documented in the academic literature. Most papers in the literature do not address emissions from private aviation, and none to date have quantified the shift to private aviation that has recently happened due to the pandemic. This paper fills that gap in the literature by answering the question: What are the environmental implications of the COVID-19 induced shift toward private aviation in the U.S.? To answer this question, first we will determine the extent of the change in the growth rate of private jet operations. Then we will estimate the total emissions from these private jet operations, and finally provide a scenario based long-term environmental assessment of these changes.

In Section 2 that follows, the literature is reviewed. Next, in Section 3 the methodology and data are presented. Section 4 presents the results, and Section 5 concludes with a discussion and ideas for future research.

2. Literature review

2.1. Aviation emissions

Recent research has shown that the global pandemic caused total aviation emissions to drop as airlines significantly reduced their flight frequencies (Le Quéré et al., 2020; Arora et al., 2021; Calderon-Tellez and Herrera, 2021). It is estimated that global emissions for commercial aviation dropped by 46.7% during the first seven months of 2020 as compared to the previous year (Liu et al., 2020). Although air travel demand declined during the COVID-19 pandemic, it is currently rebounding and expected to eventually return to pre-pandemic levels (Chokshi, 2021; Hotle and Mumbower, 2021). Global air travel demand is forecasted to increase drastically in the future (IATA, 2018) and global emissions from commercial aviation are projected to triple by 2050 (Gössling and Humpe, 2020). Aviation emissions vary widely across different regions within the world, with some regions contributing much larger shares than others; Asia-Pacific, North America, and Europe alone accounted for over 80% of emissions in 2018 (Gössling and Humpe, 2020).

In response to growing concerns about transportation’s impact on the environment (e.g., see Olsthoorn, 2001; Macintosh and Wallace, 2009; Mayor and Tol, 2010; Terrenoire et al., 2019; Klower et al., 2021), various policies and mitigation targets have been set, which aim to curb aviation emissions at the international and national levels. Within the U.S, the Federal Aviation Administration’s (FAA’s) Aviation Greenhouse Gas Emissions Reduction Plan of 2015 set a goal of “achieving carbon–neutral growth for U.S. commercial aviation by 2020, using 2005 emissions as a baseline” (FAA, 2015). The plan assumes that a combination of alternative fuels, airframe and engine improvements, and operational improvements will be used to meet this goal (FAA, 2015). Technology advancements have had some successes in reducing emissions per passenger. As aircraft and air traffic operations became more efficient, emissions from domestic U.S. air travel declined by 40% per passenger between 2001 and 2019 (Sobieralski, 2021). At the same time, total emissions from domestic U.S. air travel declined by 33% between 2001 and 2012, but increased by 19% between 2012 and 2019 as demand for air travel grew during the recovery period after the Great Recession (Sobieralski, 2021). Growth in demand for aviation remains a challenging issue in curbing emissions (Macintosh and Wallace, 2009).

To better quantify what aviation emissions might look like in the future, studies in the literature forecast aviation emissions using differing scenarios of alternative fuel utilization (Winchester et al., 2015; Staples et al., 2018), as well as improvements in aircraft and operation efficiency (Hileman and Stratton, 2014). Although advances in alternative fuels and aircraft efficiency have the potential to decrease aviation emissions in the future, many challenges remain that limit their feasibility, such as difficulties in producing alternative jet fuels on a large-scale (Chiaromonti et al., 2014; Hileman and Stratton, 2014; Kousoulidou and Lonza, 2016). Based on an analysis of air travel in China, Zhou et al. (2016) conclude that ambitious targets for curbing aviation emissions are unlikely to be met unless there is a “disruptive technological breakthrough” in the near future.

2.2. Private aviation

Gössling and Humpe (2020) estimate that commercial passenger aviation makes up 71% of the global proportion of total aviation fuel use, whereas commercial freight aviation accounts for 17%, military aviation 8%, and private aviation 4%. Even though private aviation makes up only a small portion of the total aviation fuel use, private aviation is the most energy-intensive form of air travel (Gössling and Humpe, 2020). Estimates of average fuel use per passenger hour for private jets vary but are estimated to be on the order of 10 to 20 times higher than the average fuel use per passenger hour for a commercial flight (Gössling, 2019; Transport and Environment, 2021). Some studies show that a small number of people make up a large portion of total aviation emissions. Gössling and Humpe (2020) estimate that 1% of the world population accounts for over half of the emissions for passenger air travel. Private aviation is often associated with luxury travel of ultra-high-net-worth individuals who place a high value on the time savings of flying private (e.g., see Klaus et al., 2021; Veloutsou et al., 2021). However, private aviation is also used for many other purposes, including humanitarian efforts after disasters and transport of patients for medical purposes (Alliance for Aviation Across America, 2010; NBAA, 2021). Within the U.S, private aviation flights are also heavily used in Alaska, a state with extreme terrain where some areas are only accessible by air (Detwiler et al., 2006).

In general, there is a lack of literature on the operations and emissions of private aviation. This is because data on private aviation are limited. Most studies are based on airline flight schedules datasets that only include scheduled air traffic; private service is excluded as it is mostly unscheduled service. For example, some authors use scheduled flights data to study the reduction in commercial flight frequencies after the pandemic (Hotle and Mumbower, 2021), along with its impact on aviation emissions (Le Quéré et al., 2020; Arora et al., 2021). However, trends based on private aviation are not included. Kim et al. (2007) describe a computer model built to assess global aviation emissions. The authors note that they are not able to model unscheduled flights due to data limitations; however, they incorporate airport-based scaling factors to account for unscheduled flights, which was accomplished by comparing flight schedules data to radar and flight plans data. Using scheduled flights data, Simone et al. (2013) develop a tool to calculate aircraft emissions, but the authors acknowledge that unscheduled flights...
are missing from the data, leaving it for future research.

3. Data and methodology

To address the environmental implications of the reported COVID-19 induced shift toward private aviation we first examine the validity of the so-called “boom” (i.e., whether there was a sharp increase in private aviation traffic). A private flight is defined as a flight operated under Parts 91 or 135 of Title 14 of the Code of Federal Regulations (C.F.R.) and not Part 121. Flights operating under Part 91 of 14C.F.R. are general aviation flights operated by private pilots, and flights operated under Part 135 of 14C.F.R. are charter-type services by commercial operators (General Operating and Flight Rules, 2022; Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board such Aircraft, 2022). Part 121 operations include regularly scheduled air carrier service and are not included. Then, we develop estimates of the emissions from private jet operations followed by future scenarios of private jet travel. Although this phenomenon is likely occurring around the globe, the U.S. is used as the focal country of attention because it has more private jets than any other nation accounting for 69% of the global fleet (Gollan, 2021).

Data covering private jet operations (defined as a departure and arrival) is obtained from several sources. First, the FAA’s Enhanced Traffic Management System Counts (ETMSC) records are used to obtain daily data on private jet operations, aircraft type, and operation type in the U.S. from January 2014 to October 2021 (FAA, 2021a). These data are then aggregated to monthly and quarterly levels. The FAA Operations Network (OPSNET) database is also used and contains air traffic data for U.S. airports from January 2014 to October 2021 (FAA, 2021b). These traffic data include aircraft type, arrival and departure numbers, and frequency. To supplement these databases, the FAA General Aviation Activity Survey dataset from 2019 is used to provide additional information on flight hours and fuel consumed prior to the pandemic (FAA, 2019). Also, Cirium’s air-taxi dataset is used to provide a more detailed examination of travel time, aircraft, and distance flown for air-taxi flights not operating as general aviation flights; Cirium is a data analytics firm that specializes in aviation data and is part of LexisNexis Risk Solutions (Cirium, 2021). Finally, to provide a more precise estimation of the total emissions from private jet travel, automatic dependent surveillance-broadcast (ADS-B) data from FlightAware is used (FlightAware, 2021). These data provide exact routing, distance, and aircraft information to assist in accurately estimating aircraft emissions. These datasets are summarized in Table 1.

### Table 1
Summary of databases used.

| Database Description                              | Date Range         | Data Frequency | Number of Aircraft Types | Number of Observations |
|--------------------------------------------------|--------------------|---------------|--------------------------|------------------------|
| Cirium                                           | Q1 2014 – Q3 2021  | Quarterly     | 61                       | 3,368                  |
| FAA General Aviation Activity Survey             | Calendar Year 2019 | Annually      | NA                       | 1                      |
| FAA Enhanced Traffic Management System Counts     | 01 Jan 2014 – 31 Oct 2021 | Daily     | 74                       | 662,279,565            |
| FAA Operations Network (ETMSC)                    | 01 Jan 2014 – 31 Oct 2021 | Daily     | NA                       | 109,520,203            |
| FlightAware (ADS-B)                              | 01 Jan 2020 – 31 Oct 2021 | Daily     | 70                       | 30,584                 |

Note: NA indicates not applicable.

3.1. Pandemic induced boom in private jet travel

As previously discussed, media outlets have reported that the pandemic has resulted in an increase in the use of private jets in the U.S. This increase in private jet usage is highlighted in Fig. 1, which shows the trend of private jet operations (defined as total monthly flights) from January 2014 to October 2021. The shaded area represents the impacts of the pandemic, which begins March 2020 in the figure as this is the first month where a decrease in operations is observed. Private jet operations decreased by 14.2% in March 2020 as compared to March 2019, and commercial operations decreased by 29.5%. In April 2020, private jet operations hit its lowest point with a year-over-year decrease of 74.9%. Commercial operations for the same time decreased by 69.6%. This illustrates the sharp decline in travel that was similarly experienced by all aviation travel in the U.S. and globally. Unlike commercial air service though, the cost to fly on these small private jets is quite high and for most Americans this type of luxury is out of reach (Pitrelli, 2021). Despite this higher cost, private aviation rebounded faster than commercial aviation, as can also be seen in Fig. 1. By June 2020, the year-over-year decrease in private jet operations was only 24.0% whereas the decrease in commercial operations was 64.1%.

Examining the year-over-year differences further can aid in understanding how the pandemic has resulted in increased usage of private jets in the U.S. and ultimately to provide an accounting of the additional emissions. Fig. 2 displays the monthly trends in private jet usage for each year from 2014 to 2021. In 2020, the year of the pandemic, a steep decline is exhibited with the lowest point being April 2020. The trend for 2021 exhibits a steep rise in private jet usage that is higher than any previous years for March 2021 through October 2021. These figures corroborate the media reported boom in private jet travel, but further investigation is necessary.

To further substantiate the change in the growth rate of private jet operations in the U.S. following the pandemic, an unobserved components model is used (Dresner et al., 2015; Pelagatti, 2015). This model will provide further evidence of the structural break in private jet usage following the pandemic. Using monthly data, the model is defined as:

\[
P_{tj} = \alpha + \beta m + \delta \text{Pandemic} + \gamma (m\Delta \text{Pandemic}) + \sum_{i=1}^{n-1} \mu_i \text{Time}_i + \epsilon_t
\]

where \(P_{tj}\) is private jet traffic in time \(t\), \(m\) is the time trend, Pandemic is an indicator variable equal to one after 01 March 2020, and Time\(i\) is a set of monthly fixed effects. The coefficient \(\delta\) captures the growth of private jet travel, \(\delta\) captures the change in the intercept \(\alpha\) following the pandemic, \(\gamma\) captures the change in the growth rate following the pandemic, and \(\mu\) captures the seasonality of travel. We test the change in the level and growth by examining the coefficients \(\delta\) and \(\gamma\). Once the structural breaks are validated, we estimate the emissions from these private jet flights relative to the pre-pandemic levels.

3.2. Emissions from private jets

Two primary techniques are used to estimate the emissions from private jet operations in the U.S. The technical data requirements to accurately estimate aircraft fuel burn can be extensive and the first technique provides an accurate estimation without aircraft technical data. The reduced order model known as the Fuel Estimation in Air Transportation or FEAT model is the first technique used to estimate aircraft fuel burn and ultimately emissions (Seymour et al., 2020). The model uses great circle distance to provide accurate aircraft specific fuel consumption estimates. To measure the great circle distance in kilometers for private jet flights, we use the Jeppesen FliteDeck tool, which is a flight charting application (Jeppesen, 2021). Each flight will use the following model with specific aircraft inputs:

\[
F_t = \alpha + \beta_1 \text{GC} + \beta_2 \text{GC}^2
\]
where $F_i$ is the fuel burn for aircraft type $i$, $GC$ is the great circle distance between the arrival and departure airports, $\alpha_i$, $\beta_{1,i}$, and $\beta_{2,i}$ are aircraft specific coefficients for each aircraft type $i$. These coefficients can be found in the appendix in Seymour et al. (2020).

These estimates will be compared to the ICAO emissions calculator tool (ICAO, 2016). The ICAO calculator uses origin and destination pairs to derive an estimate of aircraft emissions. The aircraft used in the calculations are typical aircraft operating on the route given the distance traveled. One drawback is that the ICAO emissions calculator does not provide emissions specific to private jet aircraft; however, the tool does provide calculations for smaller regional jets that share similar engine configurations to private jet aircraft. For example, the Challenger 650 private jet is produced with a similar engine (General Electric GE CF34 turbofan) to the Bombardier CRJ 200 series regional jet. Therefore, fuel burn approximations based on comparable aircraft engine configurations are used with the ICAO calculator although it is expected that the aggregation of aircraft in the ICAO tool will result in larger fuel burn estimates.

Emissions are calculated by using emissions factors to convert aircraft fuel burn. The emissions that are calculated are the primary contributors to global climate change: carbon dioxide ($CO_2$), Methane ($CH_4$), and Nitrous oxide ($N_2O$). When jet fuel is burned, then a specific resultant mass of each emission are produced. The specific mass is calculated from the emissions factors for 1 kg of fuel burned. The emissions factors are: 3.15 kg $CO_2$, 0.13 g $CH_4$, and 0.026 g $N_2O$ per 1 kg of jet fuel burned (Sobieralski, 2021). When examining global climate change, $CO_2$-equivalents are an important criterion to consider. Each of these gases absorb energy and remain in the atmosphere for a specified period which contributes to the warming of the planet (EPA, n.d.-a). $CO_2$ is the baseline measure for a gas’ warming potential with $CH_4$ and $N_2O$ having a significantly greater energy absorption and atmospheric lifespan. Therefore, we convert each pollutant by using 1-, 84-, and 298-times carbon dioxide, methane, and nitrous oxide, respectively (IPCC, 2007). These estimates of emissions will be evaluated across the pandemic through 2021.

### 3.3. Example long-term scenarios of private jet emissions

Finally, to better understand the future emissions of the pandemic induced private jet boom, three hypothetical scenarios are built and resultant emissions calculated. These scenarios are used to provide an understanding of the potential future environmental impact of U.S. private jet travel on global climate change. The first scenario assumes that private jet travel will return to pre-pandemic levels by 2024 as travel on commercial airlines returns to normal. The year 2024 is chosen due to numerous forecasts of commercial aviation (Josephs, 2021). This decline back to pre-pandemic levels could be caused by factors such as improved business and first-class commercial travel options as commercial airlines implement recovery strategies (Singh, 2021) or shifting consumer attitudes towards the adverse environmental impacts of private aviation (Mkono, 2020). In our first scenario, we assume that the return to pre-pandemic levels will follow a path similar to straight line depreciation. The second scenario assumes that the level of private jet travel will remain unchanged through 2024. This scenario could be plausible if private jet travelers do not increase their travel demand and do not find better commercial airline alternatives. The scenario smooths the seasonality of air travel but assumes that the demand for private jet travel continues to remain at current levels. The final scenario assumes that private jet travel will continue to grow over the next three years. A time series forecast is used to provide a scenario using data from September 2020 forward. This scenario assumes that tastes of these wealthier travelers has continued to shift away from commercial air travel and the share of wealth has continued to shift. These hypothetical scenarios are depicted in Fig. 3 and will be used to illustrate the longer-term emissions outcomes.

### 4. Results

The boom in private jet usage has been documented in media accounts as previously discussed. This boom has repercussions for the environment as greenhouse gas emissions increase with this growth in flights. To test whether the pandemic has resulted in a change in the
level and growth rate of private jet flights, we used an unobserved components model to verify the structural break. Table 2 provides the results of the maximum likelihood estimation. Private jet travel exhibits seasonality throughout the time period studied. The change in the level of private jet flights following the pandemic is found to be statistically significant as measured by the coefficient on the Pandemic variable in column one. The growth rate of private jet operations is also found to have experienced both an increase in the level and growth rate of private jet flights following the pandemic is found to be statistically significant as measured by the coefficient on the Pandemic variable in column two. These results suggest that the U.S. has experienced both an increase in the level and growth rate of private jet usage following the pandemic.

The estimates of the emissions from January 2019 through October 2021 are provided in Fig. 4. The FEAT model and ICAO calculator fuel burn and resultant emissions estimates varied by approximately 4.3% on average. The ICAO calculator estimates are greater on average than the FEAT model estimates likely due to the aggregation of aircraft types used.

The total emissions for each of the hypothetical long-term scenarios are provided in Table 3. Over the next three years, these scenarios provide an understanding of the plausible trajectory of emissions from private jet travel. In scenario one, private jet travel returns to pre-pandemic levels by Q3 2024 which results in a cumulative production of 770 megatons of CO₂-equivalents. For comparison, these emissions are equivalent to over 53 million cars travelling 11,500 miles per year with a fuel economy of 22 miles per gallon (EPA, n.d.-b). With regard to environmental concerns, this would be considered the best-case scenario. In the second scenario, private jet travel remains unchanged and cumulatively emits 850 megatons of CO₂-equivalents. Similarly, this compares to the emissions from over 59 million cars driving over that time period. Finally, the last scenario assumes private jet travel to increase over the next three years resulting in over 940 megatons of CO₂-equivalents emitted. This level of emissions equals the share produced by nearly 65 million cars or over one fifth of all cars in the U.S. driving over that time period. These long-term scenarios underscore the requirement of policymakers to better understand the environmental footprint of private jet travel.

5. Discussion and conclusions

To summarize, this paper analyzed the environmental implications of the COVID-19 induced shift toward private aviation in the U.S. We find that there has in fact been a boom in private jet travel as reported by media outlets. The number of private aviation flights has increased by approximately 20% resulting in an increase of private jet emissions by over 23%. These emissions are significant given that the total CO₂-equivalent emissions from private aviation account for 1.3% of all transportation emissions in the U.S. Further, we found that private aviation’s share of aviation related emissions has increased since the pandemic began. Finally, we explored several long-term scenarios through 2024 finding a range of cumulative emissions of between 770 and 940 megatons. The substantial environmental implications of the eventual path of private aviation travel must be weighed by policymakers in the U.S. and other nations experiencing a boom. This study aims to build a clearer picture of the environmental impact of these flights to assist in building awareness and policy development. Policy implications of these findings highlight the need to develop tools to curb these emissions. Private aviation user fees could serve this purpose as could tailored jet fuel taxes (Gossling et al., 2017; Sobieralski and Hubbard, 2020).

As far as future research goes, there are several avenues that could be explored further. This study is one of the first studies to focus on private aviation emissions in the transportation literature. Future studies could
also help fill this gap in literature by incorporating private aviation into their emissions analysis. Currently, many of the international greenhouse gas mitigation plans for aviation (such as the Kyoto Protocol and the Paris Agreement) address commercial flights for international travel, leaving out all military and private flights as well as the domestic commercial flights of some nations (Gössling and Humpe, 2020). As more research on private aviation emissions is conducted, it could be better incorporated into current policies and emissions targets. Transport and Environment (2021) note that private aviation has an opportunity to “supercharge zero-emission aviation” by using greener aircraft. Measuring the potential decrease in emission as the fleet shifts to greener aircraft could be a productive avenue of research too. Additionally, lessons from the U.S. private aviation boom can be used to guide policy in other regions such as Asia and Latin America that may be experiencing a rise in private aviation usage. These regions already rank as leading operators of private aircraft and continued economic growth is likely to further propel private aircraft usage and emissions (Gollan, 2021). Future work should incorporate flight data from these regions to provide a more comprehensive examination of private aviation’s impact on the global environment. Similarly, as the growth of private aviation emissions increases across the globe then researchers should more closely examine the populations impacted. In general, populations most impacted by climate change tend to be least responsible for the production of these emissions (University of Colorado Boulder Environmental Center, 2017). This inequity could be further explored through the lens of environmental justice and aviation sustainability.

Although this study documented a growth in private aviation due to
Table 3
Emissions comparison for each scenario.

| Scenario | Total CO₂ equivalents by Q3 2024 | Equivalent Number of Cars driving from Q3 2021 to Q3 2024 |
|----------|----------------------------------|----------------------------------------------------------|
| (1) Return to pre-pandemic levels | 770 Megatons | 53.3 million |
| (2) Remain unchanged from current (Q3 2021) levels | 850 Megatons | 59 million |
| (3) Continue to grow at pandemic-induced boom levels | 940 Megatons | 64.7 million |

Notes: Assumes traveling 11,500 miles per year with a vehicular fuel economy of 22 miles per gallon.

The pandemic and analyzed three scenarios of plausible future private jet travel, it is currently unknown how travel behavior may change after the end of the global pandemic or which scenario may be observed to happen. Those passengers who switched to private air travel during the pandemic may continue to fly private, or they may switch back to flying commercial. Future research could measure passenger attitudes towards private aviation as the pandemic wains in order to better measure and forecast demand for private aviation in the future. The growth of private aviation in the short term will be limited to some extent by capacity constraints. Future research could examine the share of commercial passengers relative to private aviation passengers if these data could be estimated. Plane and pilot shortages have recently been reported for private aviation (Frank, 2021; Sullivan, 2021), and factors such as this could be incorporated into forecasts of private aviation demand and emissions in future research. The growth of private aviation may also be limited to some extent by customer willingness to pay. However, the sharing economy has already disrupted ground transportation (e.g., Uber) and it could potentially disrupt aviation in the future as well. For example, a Dutch charter company began operations in summer of 2021 and is creating an “Uber-style network for luxury travel” where passengers can share the cost of a private flight (Paton, 2021). Commercial air travelers have shown an interest and willingness to pay for flying on a shared private aircraft (Sarlay and Neuhofer, 2020), and it would be informative to research how a big disruption within the sharing economy would impact aviation emissions.

CRediT authorship contribution statement

Joseph B. Sobieralski: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. Stacey Mumbower: Conceptualization, Methodology, Writing – original draft, Writing – review & editing.

Declarations 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.

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