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SYMPOSIUM: CORPORATE SUSTAINABILITY IN THE ERA OF SHIFTING FEDERAL PRIORITIES

Private Governance Responses to Climate Change: The Case of Global Civil Aviation

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PRIVATE GOVERNANCE RESPONSES TO CLIMATE CHANGE: THE CASE OF GLOBAL CIVIL AVIATION

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ABSTRACT

This Article explores how private governance can reduce the climate effects of global civil aviation. The civil aviation sector is a major contributor to climate change, accounting for emissions comparable to a top ten emitting country. National and international governmental bodies have taken important steps to address civil aviation, but the measures adopted to date are widely acknowledged to be inadequate. Civil aviation poses particularly difficult challenges for government climate mitigation efforts. Many civil aviation firms operate globally, emissions often occur outside of national boundaries, nations differ on their respective responsibilities, and demand is growing rapidly. Although promising new technologies are emerging, they will take

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time to develop and adopt. This Article argues that private initiatives can overcome many of these barriers. Private initiatives can motivate civil aviation firms to act absent government pressure at the national level and can create pressure for mitigation that transcends national boundaries. The Article argues that it is time to develop a private climate governance agenda for civil aviation and identifies examples of the types of existing and new initiatives that could be included in the effort. If public and private policymakers can overcome the tendency to focus almost exclusively on public governance, private initiatives can yield large and prompt emissions reductions from global civil aviation, buy time for more comprehensive government measures, and complement the government measures when they occur.

INTRODUCTION

Fuel use accounts for roughly a third of an airline's operating costs, so it is fair to assume that airlines are motivated to achieve high levels of fuel efficiency.[1] Yet it was not until Virgin Atlantic Airlines began studying its carbon footprint with the help of a non-profit group and several University of Chicago economists that its managers realized how simply providing fuel use information to pilots could reduce fuel use and carbon emissions while saving large amounts of money.[2] What motivated Virgin Atlantic to act after overlooking this major cost savings for decades? Although Virgin Atlantic may have been anticipating government regulatory limits on aircraft carbon emissions in the distant future, it was also subject to pressure for carbon emissions reductions from advocacy groups, investors pushing for disclosure of carbon emissions, and the public climate statements of its founder, Sir Richard Branson.[3]

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1. Greer K. Gosnell et al., *A New Approach to an Age-Old Problem: Solving Externalities by Incenting Workers Directly* 1 (Nat'l Bureau of Econ. Research, Working Paper No. 22316, 2016) (2–3%), https://www.nber.org/papers/w22316 [https://perma.cc/X647-2VES] ("[F]uel use in the industry affects profits—fuel represents an average 33% of [airlines'] operating costs").

2. *See id.*

3. Fiona Harvey, *Richard Branson leads call to free global economy from carbon emissions*, THE GUARDIAN (Feb. 5, 2015), https://www.theguardian.com/environment/2015/feb/05/richard-branson-net-zero-emissions-target-businesses [https://perma.cc/M7UN-L4KC]. For example, in 2015 Branson was quoted saying that "[s]etting a net-zero GHG emissions target by 2050 will drive innovation, grow

This symposium focuses on the growing importance of private environmental governance.[4] In recent years, private governance initiatives have begun to focus on climate change,[5] and in this Article we explore how private initiatives can address the carbon emissions of civil aviation firms such as Virgin Atlantic.[6] Civil aviation is a significant contributor to climate change. The sector accounts for roughly two percent of global greenhouse gas emissions, an amount comparable to one of the highest-emitting nations, and its contribution is expected to grow. Although existing and new technologies can reduce the sector's emissions, a number of barriers prevent rapid uptake of these technologies.[7] In addition, government measures face substantial barriers.[8] Much of civil aviation is international, which leaves national and subnational governments ill-suited to reduce its effects. Intergovernmental organizations are attempting to respond, but these organizations face collective action problems and have limited capacity to enforce environmental standards against non-compliant actors. Their efforts have resulted in the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which is an important achievement for the international process. The goal of

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jobs, build prosperity and secure a better world for what will soon be 9 billion people. Why would we wait any longer to do that?" *Id.* at 2.

4. *See* Michael P. Vandenbergh, *Private Environmental Governance*, 99 CORNELL L. REV. 129, 146 (2013) (defining private environmental governance as "actions taken by non-governmental entities that are designed to achieve traditionally governmental ends such as managing the exploitation of common pool resources, increasing the provisions of public goods, reducing environmental externalities, or more justly distributing environmental amenities."); Sarah E. Light & Eric W. Orts, *Parallels in Public and Private Environmental Governance*, 5 MICH. J. ENVTL. & ADMIN. L. 1, 3 (2015) (defining private environmental governance as "the traditionally 'governmental' functions of environmental standard setting and enforcement that private actors, including business firms and non-governmental organizations (NGOs), adopt to address environmental concerns.").

5. *See* MICHAEL P. VANDENBERGH & JONATHAN M. GILLIGAN, BEYOND POLITICS: THE PRIVATE GOVERNANCE RESPONSE TO CLIMATE CHANGE (2017).

6. In this Article, we refer to the carbon emissions from civil aviation as a shorthand way to refer to not only the greenhouse gas emissions attributable to the civil aviation sector, but also the other ways in which the sector contributes to increases in global average temperature, such as through the creation of contrails. *See* discussion *infra* Part I.B. The Effect of Climate Change on Civil Aviation.

7. *See infra* Part II.A. Challenges to International Public Governance.

8. *See infra* Part II.B. International Initiatives.

CORSIA, however, is modest: to freeze net emissions at 2020 levels, largely through the use of carbon offsets.

Private environmental governance initiatives—non-governmental actions that pursue traditionally governmental objectives like managing consumption of common resources, increasing public goods, and reducing negative externalities—often use private forms of common governmental instruments (e.g., information disclosure requirements, performance requirements, carbon taxes, and others)[9] and are tackling many of the same subject matter areas as government environmental regulatory programs.[10] These private initiatives can play an important role in reducing civil aviation's carbon emissions, buying time for more substantial efforts to become politically viable and complementing government regulatory efforts when they do.

Rather than depending on the coercive power or resources of any nation, group of nations, or subnational government, private initiatives can harness the support for climate mitigation among investors, lenders, retail and corporate customers, employees, managers, and others.[11] As the Virgin Atlantic experience suggests, private actors can motivate civil aviation firms to act and provide the expertise necessary for firms to do so in an effective way. These efforts are often facilitated by organizational self-interest, since many climate mitigation initiatives will not only respond to demands from stakeholders, but also will yield lower energy and other costs. Maximizing fuel efficiency, for example, is often in an airline's self-interest. Of course, unobserved costs may be a barrier,[12] and the motivations of corporations and other private sector organizations are complex, but the literature on private ordering provides reason for optimism. Greenwashing—a false claim of pro-environmental action—is a risk, but private initiatives that target civil aviation's carbon emissions also

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9. *See* Light & Orts, *supra* note 4, at 23–52 (noting parallel instruments).

10. Vandenbergh, *Private Environmental Governance*, *supra* note 4, at 146; *see also* Sarah E. Light & Michael P. Vandenbergh, *Private Environmental Governance*, *in* ENVIRONMENTAL DECISION MAKING, ENCYCLOPEDIA OF ENVIRONMENTAL LAW (Robert Glicksman & LeRoy Paddock eds., 2016) (noting parallel instruments and subject matters).

11. *See* Michael P. Vandenbergh & Jonathan Gilligan, *Beyond Gridlock*, 41 COLUM. J. ENVTL L. 217 (2015).

12. *See* Gosnell et al., *supra* note 1, at 1; Michael P. Vandenbergh, *The Drivers of Corporate Climate Mitigation*, ENVTL. F. 29 (Jan.–Feb. 2018), at 29.

can exceed expectations and can have positive spillover effects on government programs, building support for and reducing the cost of public governance.[13]

Part I provides context about the climate effects of civil aviation by describing the sector's current contributions to climate forcing, expected growth, and the options for reducing those contributions. Part II analyzes challenges that stand in the way of government civil aviation climate efforts and describes existing government efforts. Part III explains why private governance initiatives can bypass some of the obstacles that discourage government action, suggests development of a private climate governance agenda for civil aviation, and provides examples of specific private initiatives that can reduce the sector's carbon emissions.

I. BACKGROUND

A. The Contributions of Civil Aviation to Climate Change

Following guidance from the Intergovernmental Panel on Climate Change (IPCC), the Environmental Protection Agency distinguishes between civil, military, and general aviation.[14] Civil aviation includes "[e]missions from international and domestic civil aviation, including take-offs and landings . . . [and c]omprises civil commercial use of airplanes, including: scheduled and charter traffic for passengers and freight, air taxiing, and general aviation," military aviation is comprised of all aircraft under control of the armed forces, and general aviation refers to recreational and small corporate aircraft.[15] In 2015, civil aviation accounted for 119 out of a national total of 157.7 million

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13. For a discussion of an example of private governance initiative that exceeded expectations, see discussion *infra* at note 189 (discussing Walmart's reduction of 28 million tons of carbon emissions following a commitment to achieve 20 million tons).

14. ENVIRONMENTAL PROTECTION AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2015 3–94 (2017), https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf [https://perma.cc/PFY4-BWRG] [hereinafter U.S. GREENHOUSE GAS INVENTORY].

15. *See* IPCC, 2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES (Vol.1 at 8.12) (2006), https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8_Ch8_Reporting_Guidance.pdf; *see also id.*

tons of jet fuel consumed in the United States.[16] During the same year military aircraft consumed 14.7 million tons of jet fuel and general aviation used roughly 24 million tons.[17]

In this Article we focus on global civil aviation, and we focus in particular on passenger travel rather than freight transport in our discussion of private initiatives in Part III.[18] Civil aviation as a whole plays a critical role in the global economy. On a global basis, three and a half billion passengers travelled across a distance of nearly four trillion miles in 2015.[19] Sixty percent of these passengers flew internationally.[20] The fleet that transports these passengers is made up of over twenty-six thousand aircraft operated by more than one thousand commercial airlines.[21] The availability of rapid, reliable air transport facilitates economic activity worldwide and is supported by nearly four thousand airports serving commercial flights.[22] Although industry groups rightly point out that civil aviation is "essential for global business" and that it "plays a vital role in facilitating economic growth, particularly in developing countries," the industry also acknowledges its significant and complex contribution to climate change.[23]

In 2015, civil aviation worldwide emitted around 781 million tons of carbon dioxide, representing about 2% of all human carbon dioxide emissions.[24] As we mentioned at the outset, if civil aviation were a

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16. U.S. GREENHOUSE GAS INVENTORY, *supra* note 14, at 3–24.

17. *Id.*

18. *See supra* notes 14–17 and accompanying text. Although civil aviation is not responsible for all aircraft emissions, it represents the most significant component of the aviation total. Later in this Article we discuss options that can reduce carbon emissions from aircraft themselves as well as from ground infrastructure, and we use the term civil aviation to refer to both portions of the sector together. Where this Article discusses carbon mitigation options that are available only to firms that transport freight and passengers by aircraft, we refer to those firms as airlines, as opposed to, for example, ground services or renewable fuel manufacturing firms.

19. AIR TRANSPORT ACTION GROUP (ATAG), AVIATION: BENEFITS BEYOND BORDERS 5 (2016) [hereinafter AVIATION: BENEFITS BEYOND BORDERS].

20. *Id.* at 5.

21. *Id.* at 6.

22. *Id.*

23. *Id.* at 5, 7.

24. *Id.* at 7. Estimates of aviation's total global emissions vary, but are typically in the range of 1.5 to 3%. *See, e.g.*, Janina D. Scheelhaase & Wolfgang G. Grimme, *Emissions Trading for International Aviation—An Estimation of the Economic*

nation, it would be a top-ten carbon dioxide emitter, roughly equal to all of Germany's carbon emissions from fuel combustion.[25] Within the European Union, civil aviation emissions constitute 3% of greenhouse gas emissions.[26] In 2013, civil aviation wholly within, or originating within in the United States comprised 29% of global civil aviation emissions and 3% of the country's total greenhouse gas emissions.[27] Although three percent may seem like a small percentage, the climate problem is caused by many types of sources, most of which can claim to be small contributors on their own, yet achieving carbon mitigation targets will require emissions reductions from many of these sources.[28]

Mitigating carbon emissions is particularly important because even though a significant portion of the emissions from civil aviation are absorbed into the ocean and taken up by plants,[29] the carbon that

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Impact on Selected European Airlines, 13 J. AIR TRANSP. MGMT. 253 (2007) ("[B]etween 2.5 and 3%."); ROB BAILIS, DERIK BROEKHOFF & CARRIE M. LEE, STOCKHOLM ENVTL. INST., SUPPLY AND SUSTAINABILITY OF CARBON OFFSETS AND ALTERNATIVE FUELS FOR INTERNATIONAL AVIATION 1 (2016) ("International aviation produced . . . in 2013, about 1.5% of global CO_2 emissions from fossil fuel combustion . . . ."); Gosnell et al., *supra* note 1, at 1.

25. *Each Country's Share of CO2 Emissions*, UNION OF CONCERNED SCIENTISTS (Nov. 20, 2017), https://www.ucsusa.org/global-warming/science-and-impacts/science/each-countrys-share-of-co2.html#.WO4o24jyuUk [https://perma.cc/EA9X-ECVQ]; AVIATION: BENEFITS BEYOND BORDERS, *supra* note 19. These figures compare carbon dioxide emitted by civil aviation with national totals for fuel consumption. *See infra* Appendix A, p. 97.

26. STEVAN TRUXAL, ECONOMIC AND ENVIRONMENTAL REGULATION OF INTERNATIONAL AVIATION 126 (2017). The European Environmental Agency reported that civil aviation in the European Union in 2014 emitted 15,379 kilotons of carbon dioxide. EUROPEAN ENVIRONMENTAL AGENCY, ANNUAL EUROPEAN UNION GREENHOUSE GAS INVENTORY 1990–2014 AND INVENTORY REPORT 2016 at xi (2016), http://www.eea.europa.eu/publications/annual-european-union-greenhouse-gas/at_download/file [https://perma.cc/KAH2-QBXW].

27. *Reducing Carbon Dioxide Emissions from Aircraft*, CENTER FOR CLIMATE AND ENERGY SOLUTIONS, https://www.c2es.org/content/reducing-carbon-dioxide-emissions-from-aircraft/ [http://perma.cc/7TZH-3FU3] (last visited July 10, 2018).

28. *See, e.g.*, Kevin M. Stack & Michael P. Vandenbergh, *The One Percent Problem*, 111 COLUM. L. REV. 1385, 1388 (2011) (examining how climate change's global scale renders most individual sources small percentages of the whole; accordingly, climate mitigation efforts will need to address many individually-minor contributors).

29. David W. Fahey & David S. Lee, *Aviation and Climate Change: A Scientific Perspective*, 10 CARBON & CLIMATE L. REV. 97, 98 (2016).

remains in the atmosphere can linger for thousands of years.[30] Further, these emissions are not limited to carbon dioxide. High temperature combustion in jet engines creates nitric oxide and nitrogen dioxide, primarily at cruising altitude.[31] In the presence of sunlight, these nitrogen compounds react in ways that increase atmospheric ozone but decrease the presence of methane.[32] Less methane results in less warming, but the increase in ozone outweighs this benefit, resulting in a net warming effect.[33] Aviation injects sulfur compounds into the atmosphere as well, since sulfur is typically present in aviation fuels at around 400–600ppm.[34] Further, aviation emissions are distinctive relative to the same compounds emitted from other industries. Unlike nearly every other anthropogenic source of carbon, most aviation emissions are emitted directly into the atmosphere high above the earth's surface.[35] Aviation emissions are more damaging than they would be at sea level because nitrogen compounds are converted to ozone more efficiently at high altitudes, and because aircraft produce contrails.[36]

Contrails are formed when warm water vapor in a jet's plume of exhaust is emitted into cold, moist air.[37] As the exhaust expands and cools, water droplets condense and freeze.[38] If the surrounding

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30. *Id.* It should be noted however, that carbon dioxide absorbed into the oceans increases their acidity, which has a significant effect on marine ecosystems worldwide.

31. *See id.* ("[H]igh temperatures of combustion lead to the formation and emission of nitrogen species."); U.S. GREENHOUSE GAS INVENTORY, *supra* note 14, at 3–94 ("In jet engines, N2O is primarily produced by the oxidation of atmospheric nitrogen, and the majority of emissions occur during the cruise phase.").

32. Fahey & Lee, *supra* note 30, at 98

33. *Id.*

34. *Id.*

35. David S. Lee et al., *Aviation and Global Climate Change in the 21st Century*, 43 ATMOSPHERIC ENV'T 3520 (2009) ("[T]he largest fraction of [aviation's] emissions are injected at aircraft cruise altitudes of 8–12 km. At these altitudes, the emissions have increased effectiveness to cause chemical and aerosol effects relevant to climate forcing.").

36. *See* David S. Lee, *Aviation and Climate Change: The Science, in* CLIMATE CHANGE AND AVIATION: ISSUES, CHALLENGES AND SOLUTIONS 27, 41 (Stefan Gössling & Paul Upham eds., 2009).

37. Fahey & Lee, *supra* note 30, at 100.

38. *Id.*

atmosphere is dry, contrails dissipate quickly.[39] But in conditions with enough ambient atmospheric water vapor, background water can condense onto those frozen droplets, resulting in persistent linear clouds that are formed behind each of an aircraft's jet engines.[40] These clouds can persist for hours after formation, eventually blending with existing clouds.[41] High-level clouds like these have both cooling and warming effects: They reflect incoming solar radiation and trap escaping terrestrial radiation, but their effect on the latter is larger over the long term.[42] Consequently, increasing contrail-based clouds increases the heat that is trapped in the atmosphere.[43] In fact, a 1999 special report on civil aviation and climate change by the IPCC noted that aviation's role in cloud formation may have a climate changing effect comparable to all of the industry's carbon emissions.[44] More recent work has supported the assessment that contrails are a significant component of civil aviation's climate impact,[45] and under current projections radiative forcing from contrail-induced cloudiness could increase seven-fold by 2050.[46]

The attacks on the World Trade Center on September 11, 2001 gave scientists an opportunity to shed further light on the effect of civil aviation on climate by allowing them to examine the effect of almost

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39. Hermann Mannstein & Ulrich Schumann, *Aircraft Induced Contrail Cirrus Over Europe*, 14 METEOROLOGISCHE ZEITSCHRIFT 549 (2005).

40. Victoria Williams et al., *Reducing the Climate Change Impacts of Aviation by Restricting Cruise Altitudes*, 7 TRANSP. RES. PART D 451 (2002).

41. Fahey & Lee, *supra* note 30, at 100.

42. Williams et al., *supra* note 41, at 451.

43. *Id.*

44. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, AVIATION AND THE GLOBAL ATMOSPHERE: SUMMARY FOR POLICY MAKERS 7 (1999) (showing nearly equal radiative forcing changes derived carbon dioxide emissions and contrail formation).

45. Fahey & Lee, *supra* note 30, at 101 (concluding, based on data from 2005, that of all of aviation's radiative forcing impacts, increased total cloudiness is the most significant); *see also* Bo Zou et al., *Optimal 4-D Aircraft Trajectories in a Contrail-Sensitive Environment*, 16 NETWORKS & SPATIAL ECON. 415 (2016) ("While a number of studies have examined the climate impact of persistent contrails with varying estimated results, the general conclusion is that the magnitude of contrail climate impact is non-negligible comparable to that of CO2.").

46. Chih-Chieh Chen & Andrew Gettelman, *Simulated 2015 Aviation Radiative Forcing from Contrails and Aerosols*, 16 ATMOSPHERIC CHEMISTRY & PHYSICS 7317 (2016).

entirely halting civil aviation for several days. United States airports handled 38,047 flights on September 10; on the twelfth, 252.[47] Commercial aircraft were grounded for three days following the attack.[48] Early research into the effect of that grounding suggested that the absence of contrails had a predictable influence—because these clouds block some incoming solar radiation in the short term but prevent some energy from escaping over the long term, removing contrails can be expected to increase temperature in the near term.[49] Not surprisingly, during the grounding period daily temperature ranges across the United States increased by about 1.1°C above historic averages.[50] Although subsequent research has pointed out that the specific effects observed during those three days were also explainable by natural variation and other weather factors,[51] the changes observed during that period suggest that even though contrails are not the sole driver of cloud-induced temperature changes, they may play an important role.[52]

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47. THE IMPACT OF SEPTEMBER 11, 2001 ON AVIATION, INTERNATIONAL AIR TRANSPORT ASSOCIATION 2 (2011), http://www.iata.org/pressroom/Documents/impact-9-11-aviation.pdf.

48. David Travis et al., *Contrails Reduce Daily Temperature Range* 418 NATURE 601 (2002).

49. *Air-traffic moratorium opened window on contrails and climate* (August 8, 2002) NATURE.COM, http://www.nature.com/news/2002/020808/full/news020805-7.html [https://perma.cc/J66F-A5M7].

50. Travis et al., *supra* note 49.

51. *See* Gang Hong et al., *Do Contrails Significantly Reduce Daily Temperature Range?* 35 GEOPHYSICAL RES. LETTERS ("While missing contrails may have affected the DTR, their impact is probably too small to detect with a statistical significance."). *But cf.* Simone Dietmüller et al., *Contrails, Natural Clouds, and Diurnal Temperature Range* 21 J. CLIMATE 5061 (2008) ("Although a radiative cooling of contrails during the day and a warming during the night is reproduced by the climate model simulation with enhanced contrails, we could not find any significant decrease in DTR in the multiyear simulations including contrails, even when enhancing the contrail effect to level much higher than expected . . . .").

52. David Travis, the author of one of the earliest studies on climate effects of the September 11 groundings has pointed out that subsequent studies do not disprove this core understanding of how contrails effect climate. The Hong et al. study, for example, studied the effect of high-level cloudiness in general, and did not separate out contrails specifically. *See* Anna Barnett, *Can aircraft trails affect climate?*, (Dec. 31, 2008) NATURE, http://www.nature.com/news/2008/081231/full/news.2008.1335.html [https://perma.cc/YR6Y-23XA] (discussing Hong et al., *supra* note 52). In addition, although longer-term studies show that variations as significant as what

In addition, although estimates vary, the consensus is that civil aviation will continue to grow rapidly. In its 2016–2035 Market Outlook, Boeing forecast that airline traffic will increase 4.8% by 2033, and that long-term demand will call for 39,620 new airplanes.[53] The Federal Aviation Administration forecast that the U.S. commercial fleet will grow at 1% annually, adding over 1,500 new aircrafts by 2036.[54] Rapid growth in the number of passengers and the size of commercial fleets corresponds to large projected increases in emissions. The International Civil Aviation Organization (ICAO) reported in 2009 that by 2050 global civil aviation will consume 880 MT of jet fuel.[55] Thus under a business-as-usual scenario, 2050 emissions could be triple what they are today.[56]

B. The Effect of Climate Change on Civil Aviation

In the previous section we examined several ways in which aviation contributes to climate change. But the relationship between aviation and climate change is further complicated by the ways in which climate change will affect aviation. Climate change will alter the civil aviation industry in many ways, but risks to airports and changes in aircraft performance are among the most salient.[57]

Travis et al. observed can occur through natural processes, those variations are extraordinarily rare and unlikely to account for the 2001 observations. *Id.*

53. BOEING, CURRENT MARKET OUTLOOK 2016–2035 2 (2016), http://www.boeing.com/resources/boeingdotcom/commercial/about-our-market/assets/downloads/cmo_print_2016_final_updated.pdf.

54. FEDERAL AVIATION ADMIN., FAA AEROSPACE FORECAST: FISCAL YEARS 2016–2036 28 (2016), https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2016-36_FAA_Aerospace_Forecast.pdf.

55. Int'l Civil Aviation Org. [ICAO], *Global Aviation CO_2 Emissions Projections to 2050*, ICAO Doc. GIACC/4-IP/1 (May 20, 2009), http://www.icao.int/environmental-protection/GIACC/Giacc-4/Giacc4_ip01_en.pdf.

56. Parth Vaishnav, *ICAO's Market Based Mechanism: Keep it Simple*, 10 CARBON & CLIMATE L. REV. 120, 120 (2016) ("If the impact of alternative fuels is not accounted for, CO_2 emissions from aviation are likely to grow by between 40% and 300% between now and 2050.").

57. For a systematic overview of the distinct ways in which different sectors of aviation industry will be affected, see Terence R. Thompson, *Climate Change Impacts Upon the Commercial Air Transport Industry: An Overview*, 10 CARBON & CLIMATE L. REV. 105 (2016).

Sea-level rise and increased storm frequency threaten low-lying airports by adding to the risk that storm events will cause airports to be modified, shut down, or relocated. A quarter of the largest airports in the United States are already vulnerable to moderate to high storm surge.[58] At least thirty European airports are similarly vulnerable, and many more airports worldwide may be as well.[59] Increased average temperatures also increase the fire hazard of stored aviation fuel, which has a flash point of about 100°F.[60] A comprehensive assessment of climate risks at London's Heathrow Airport determined that temperatures exceeding aviation fuel's flashpoint pose a significant risk in 2020–2050.[61]

Climate change will also have major effects on flight performance. For example, as air temperature increases it becomes less dense, causing a wing traveling through it to generate less lift than it would in cooler, denser air.[62] As a result, takeoff speeds must be increased.[63] Since airport runway lengths vary, aircraft will not always be able to achieve the speed necessary to take off at their maximum weight.[64] These disruptions can also occur even when flights are not cancelled; for example, on a 92°F day at Ronald Reagan Washington National Airport, a Boeing 737-800 will have to reduce its weight to 15,000 pounds below maximum to take off.[65] For a cross-country flight this weight restriction represents a thirty percent reduction in payload capacity[66]—and based on FAA guidelines for average passenger

58. *Id.* at 107 ("[I]n the United States more than 25% of the largest airports have at least one runway with an elevation within the reach of moderate to high storm surge. Sea level rise will pose a threat to low-lying infrastructure . . . .") (citations omitted).

59. *Id.*

60. *Id.* at 108–09.

61. HEATHROW AIRPORT, CLIMATE CHANGE ADAPTATION REPORTING POWER REPORT 88 (2011), http://www.heathrow.com/file_source/Company/Static/PDF/Communityandenvironment/LHR-climate-change-adaptation-report.pdf.

62. *See* E. Coffle & R. Horton, *Climate Change and the Impact of Extreme Temperatures on Aviation*, 7 WEATHER, CLIMATE & SOC'Y 94, 94 (2015).

63. *Id.*

64. *Id.*

65. *Id.* at 95.

66. *Id.* at 97.

weight, this could mean seventy-nine fewer passengers.[67] 2017 saw extreme heat forcing airlines to cancel some flights entirely in the United States.[68] As climate change increases the number of very hot days each summer, weight restrictions will become more common, severe, and disruptive.

In addition, flight times and turbulence are expected to increase. A 2016 study examining flights between New York and London concluded that as carbon dioxide in the atmosphere increases, average flight times increase.[69] Although changes in the jet stream will make eastbound flights shorter, they will lengthen westbound flights at a greater rate, thus increasing the average time and fuel consumed on each trip.[70] A similar phenomenon has been observed in average flight times across the Pacific, where changes in wind speeds widen the time difference between inbound and outbound flights asymmetrically, netting more flying time and more fuel consumed.[71] The intensity of turbulence along the same flight path is expected to increase by ten to

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67. The FAA estimates that the summer weight of an adult passenger, including their carry-on baggage and personal items, is 190lbs—accounting for bulkier winter clothing, winter passengers average 195lbs. FED. AVIATION ADMIN., AIRCRAFT WEIGHT AND BALANCE CONTROL, AC 120-27E tbl. 2-1 (June 10, 2005). https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC120-27E.pdf.

68. Zach Wichter, *Too Hot to Fly? Climate Change May Take a Toll on Air Travel*, N.Y. TIMES (June 20, 2017), https://www.nytimes.com/2017/06/20/business/flying-climate-change.html [https://perma.cc/24TR-H4VB].

69. Paul D. Williams, *Transatlantic Flight Times and Climate Change*, 11 ENVTL. RES. LETTERS 024008 (2016).

70. *Id.*; *see also* Soo Kim, *Climate change 'to increase turbulence, flight times and fares'*, TELEGRAPH (May 12, 2016), http://www.telegraph.co.uk/travel/news/climate-change-to-increase-turbulence-flight-times-and-costs/ [https://perma.cc/6KU7-QCGN] (reporting that Williams' key finding was that "aircraft on transatlantic routes were collectively projected to 'be airborne for an extra 2,000 hours a year, burning an extra 7.2 million gallons of jet fuel' and emit an 'extra 70 million kilograms of carbon dioxide.'").

71. Kristopher B. Karnauskas et al., *Coupling Between Air Travel and* Climate, 5 NAT. CLIMATE CHANGE 1068, 1069 (2015) ("Although the relationship between westbound and eastbound flight times is inverse and strong, a closer look at the total round-trip flying time by route . . . reveals a small but significant round-trip residual."); *see also* Justin Worland, *How Climate Change Could Make Your Flights Longer*, TIME (Jul. 14, 2015), http://time.com/3957203/climate-change-flight-time/ [https://perma.cc/AC8E-P5V6] ("Flights over the Pacific Ocean have gotten longer due to climate change-related changes in wind patterns, a shift that could be mirrored in other regions across the globe . . . .").

forty percent by the middle of the century, and its frequency could increase by 40–170%.[72]

C. Pathways to Reducing the Climate Effects of Aviation

Although civil aviation currently generates contrails and substantial emissions, a range of measures can mitigate its effects. Most of these measures are designed to reduce fuel consumption and thereby reduce the emissions that are produced when aviation fuels are used. Because fuel accounts for about a third of an airline's operating cost, civil aviation firms already have incentives to operate efficiently, but a range of market, organizational, and behavioral barriers may exist.[73] The result, as suggested by the Virgin Atlantic example, is that a surprisingly large gap exists between the current state of the industry and full realization of all cost-effective efficiency measures.[74]

In this Section I.C we describe several possible actions that could reduce civil aviation's contribution to climate change, regardless of whether the actor driving the action is public or private. The purpose of this description is not to calculate the specific extent of each opportunity,[75] but rather to highlight the types of opportunities that exist and demonstrate that fully adopting them would yield a meaningful reduction in emissions. We then turn to the actors who could induce the civil aviation sector to seize these opportunities. We

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72. Paul D. Williams & Manoj M. Joshi, *Intensification of Winter Transatlantic Aviation Turbulence in Response to Climate Change*, 3 NAT. CLIMATE CHANGE 644, 646 (2013).

73. Vaishnav, *supra* note 57, at 121; *See also* Gosnell et al., *supra* note 1, at 1.

74. *See, e.g.*, *infra*, Subsection. III.B.2. (describing a Virgin Atlantic study on pilot behaviors that have an effect on how much fuel is consumed on a given flight).

75. Some of the measures that we describe in this section overlap in technically complex ways which are beyond the scope of this Article. For example, lower cruising altitudes have been suggested as a way to reduce contrail formation. But operating at a lower altitude forces aircraft to travel through a denser portion of the atmosphere, expend more energy doing so, and therefore consume more fuel to obtain that energy. Similarly, travelling north–south at sunrise and sunset can reduce contrail formation, but in many cases would also increase a flight's total distance. *See* Judith Rosenow, *Optical Properties of Condensation Trails* (Oct. 6, 2016) (unpublished Dr.-Ing. dissertation, Technische Universität Dresden), https://www.researchgate.net/profile/Judith_Rosenow/publication/309464261_Optical_Properties_of_Condensation_Trails/links/5811cdd108aec29d99f779fb/Optical-Properties-of-Condensation-Trails.pdf.

discuss public governance responses in Part II and private governance responses in Part III.

1. Efficient Operations

Increasing the efficiency of operational measures is one of the most promising avenues through which civil aviation emissions can be reduced. Operational measures generally work within existing infrastructure and design constraints, and some can be adopted very quickly. The Virgin Atlantic study examined the role that pilot incentives can play on fuel use during flights, finding that pilots have significant control over how efficiently they operate and that they can be incentivized to do so.[76] In the study, researchers observed the behaviors of 335 Virgin Atlantic captains with regard to three behavior modifications through which the pilots could influence fuel efficiency.[77]

The researchers first examined pre-flight decisions about how much fuel an aircraft would carry on its route.[78] Prior to each flight, pilots use their professional judgment to adjust the amount of fuel that the aircraft will ultimately carry, based on the final weight of the aircraft.[79] This allows the pilot to prevent excess fuel from being loaded onto the aircraft, thereby reducing the flight's overall weight, and the energy necessary to transport it to its destination.[80] The study next measured whether pilots are making fuel efficient choices during flight, including obtaining optimum altitudes and any feasible shortcuts from air traffic control, adjusting speed, responding optimally to changing weather, and making efficient choices about flap settings and landing gear. Finally, pilots have control over whether to shut down one or more engines during taxiing, thereby further reducing a flight's total gate-to-gate fuel intensity.[81] The study found that simply having these efficiency behaviors observed combined with a variety of other pilot incentives produced a nearly eight thousand metric ton reduction in

76. Gosnell et al., *supra* note 1.
77. *Id.* at 7.
78. *Id.*
79. *Id.*
80. *Id.*
81. *See* Thomas Schilling, Thomas Rötger & Kai Wicke, *Assessment of the Impact of Radically Climate-Friendly Aviation Technologies* at 8 (2016), http://elib.dlr.de/106658/1/2016_GreenerAviation_Paper_AIRCAT_20160906.pdf.

fuel use during an eight-month period, representing over twenty four thousand metric tons of carbon dioxide not emitted by Virgin Atlantic.[82]

In addition to the actions just described, a wide range of other operational efficiencies can decrease the carbon consequences of civil aviation. Reduced thrust takeoff can lower fuel consumption by up to 23.2%, and can reduce nitric oxide and black carbon emissions to an even greater extent.[83] Traditional flight plans direct a pilot to reduce altitude in steps, requiring engine thrust at each stage of the descent,[84] but a continuous descent can reduce fuel consumption during descent by 27%.[85] New technologies like the NASA's Efficient Descent Advisor enable air traffic controllers to synchronize the descent of incoming aircraft, allowing them to glide through their descent while consuming minimal fuel.[86]

2. Efficient Technologies

New aircraft are being designed in ways that make them, on average, more efficient than the older aircraft they replace. By the time an aircraft is replaced, the new model is typically twenty percent more efficient.[87] Airlines ordinarily operate aircraft for at least twenty years, however.[88] This means that the annual efficiency benefits of regular fleet turnover occur at less than one percent.[89]

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82. Gosnell et al., *supra* note 1, at 3, 25.

83. These figures are based on a study of 3336 takeoff events at London Heathrow airport. George S. Koudis et al., *Airport Emissions Reductions from Reduced Thrust Takeoff Operations*, 52 TRANSP. RES. PART D 17, 27 (2017).

84. *Continuous Descent Approaches*, AIR TRANSPORT ACTION GROUP, http://aviationbenefits.org/case-studies/continuous-descent-approaches/ [https://perma.cc/67VR-DTYW] (last visited Apr. 19, 2017).

85. *Id.*

86. *Efficient Descent Advisor (EDA)*, NAT'L AERONAUTICS AND SPACE ADMIN. (last visited Apr. 19, 2017), https://www.aviationsystemsdivision.arc.nasa.gov/research/tactical/eda.shtml [https://perma.cc/L85L-ESLS].

87. *Id.* at 132.

88. D.I.A. Poll, *21st Century Civil Aviation: Is it On Course or Is It Over-Confident and Complacent?—Thoughts on the Conundrum of Aviation and the Environment*, 121 AERONAUTICAL J. 115, 131–32 (2017).

89. *Id.* at 133

Radically novel design concepts have the potential to vastly improve the rate at which an airline's fleet efficiency increases.[90] Fully electric aircraft would provide the most dramatic decrease in emissions, eliminating the need for nearly all fossil fuel combustion if the electric grid is decarbonized.[91] These aircraft currently exist, but because they use electric power to turn a propeller and carry heavy batteries, electric planes are much slower than their fossil-fueled counterparts.[92] Matching the energy stored in a Boeing 787 Dreamliner's 223,000 pounds of jet fuel would take four and a half million pounds of batteries—so energy storage technologies will need to improve before electric planes become a major component of the world's fleet.[93]

Despite the current need for further technological advancement, it is already evident that electric aircraft and fully solar planes will eventually be a critical part of a sustainable future for civil aviation. In 2016 Solar Impulse created the first fully solar aircraft to fly around the world.[94] That flight averaged only forty-seven miles per hour,[95] but the project's founders claim that passengers will fly in solar planes within the next ten years.[96] Many other firms are actively working to realize fully electric short-range passenger aircraft. For example, Wright Electric is partnering with EasyJet to develop a battery-powered 120-passenger aircraft capable of traveling over 300 miles.[97] Airbus is designing fully-electric, hybrid, and small-scale vertical take-off aircraft that, in addition to reducing carbon emissions, could

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90. *See generally* Schilling et al., *supra* note 82.

91. *Id.* at 7. We say that these designs would nearly, rather than completely, eliminate fossil fuel consumption to acknowledge the use of fossil fuels in the manufacturers supply chains and in the materials from which an aircraft is composed, even for aircraft that are ultimately all-electric.

92. *See* Samantha Masunaga, *No flying Tesla? That's because electric planes are a steeper challenge than electric cars*, L.A. TIMES (Sep. 9, 2016, 6:00AM), http://www.latimes.com/business/la-fi-electric-aircraft-20160830-snap-story.html [https://perma.cc/L2V6-KK2F].

93. *Id.*

94. Victoria Bryan, *Solar Impulse founder sees electric passenger plane in 10 years*, REUTERS (Dec. 8, 2016), http://www.reuters.com/article/us-airlines-tech-solar-impulse-idUSKBN13X0TD [https://perma.cc/3GUS-5F2P].

95. Masunaga, *supra* note 93.

96. Bryan, *supra* note 95.

97. Angela Monaghan, *EasyJet says it could be flying electric planes within a decade*, GUARDIAN (Sept. 27, 2017), https://www.theguardian.com/business/2017/sep/27/easyjet-electric-planes-wright-electric-flights [https://perma.cc/E987-682G].

reduce infrastructure needs on the ground.[98] And Boeing engineers working through a NASA contract are exploring a wide range of alternative aviation fuel concepts, including advanced batteries, hybrid battery-gas turbine propulsion, and many others.[99]

Advanced wing shape designs can offer significant efficiency gains as well, and these opportunities can be realized with or without transitioning to solar power. Two main innovations show substantial promise to increase aircraft efficiency: blended wing body designs and strut-braced wings. Unlike conventional designs that use wings to lift a tube-shaped fuselage, blended wing body designs use the entire body of the aircraft as a lifting surface.[100] These types of designs could reduce the carbon intensity of a given aircraft by nearly fifty percent.[101] The key challenges for widely adopting blended wing body designs are infrastructure constraints that limit wingspan, production systems that are geared toward traditional designs, and ground services that would need to adapt to different aircraft needs.[102]

Strut-braced wing aircraft can also be designed more efficiently than traditional designs, but they would require changes in airport support and may exceed wingspan maximums dictated by ground services.[103] These aircraft use a wider wing to create more lift with less power, supported by a brace that makes up for the added stress of having a longer wing.[104] Airport services would have to be changed to accommodate these aircraft, but they can be twenty-nine to sixty-two percent more efficient than traditional designs.[105]

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98. Airbus, *Future of electric flight*, AIRBUS (June 18, 2017), http://www.airbus.com/newsroom/topics-in-focus/electrification.html [https://perma.cc/ZE2V-TYMW].

99. *See* MARTY K. BRADLEY & CHRISTOPHER K. DRONEY, SUBSONIC ULTRA GREEN AIRCRAFT RESEARCH PHASE II: N+4 ADVANCED CONCEPT DEVELOPMENT, NASA/CR–2012-217556 3 (2012), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20120009038.pdf.

100. *See* Schilling et al., *supra* note 82, at 8.

101. *Id.* at 7.

102. *See id.* at 8.

103. *See id.* at 8.

104. *See id* at 2.

105. *Id.*

3. Renewable Fuels

Alternative fuels derived from renewable sources are another option.[106] The easiest alternative fuels to adopt are those that resemble fossil-derived fuels closely enough to not require major technology or infrastructure changes.[107] Ensuring that production of these fuels does not diminish their net mitigation potential is critical, since even though they are renewable, they have land-use and transportation implications.[108] Acknowledging this problem, governments have set a variety of standards for how significant a biofuel's carbon reduction must be.[109] Further, ASTM International published a standard specifically for aviation fuel containing synthesized standards.[110] As of 2016, five production methods have met its specifications.[111]

The net emissions of biofuels depends on which production method is used and can vary significantly.[112] Still, the opportunity presented by using renewable biofuels in civil aviation is substantial—one recent study suggested that if carbon capture during the fuel production process is credited to the use of biofuels, their use would result in net

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106. In its 2016 environmental report, the ICAO recognized that "[t]he use of sustainable alternative fuels is an important element of the basket of measures for reducing aviation's impact on the global climate and also on air quality." INT'L CIVIL AVIATION ORG, 2016 ENVIRONMENTAL REPORT 153 (2016), http://www.icao.int/environmental-protection/Documents/ICAO%20Environmental%20Report%202016.pdf [hereinafter 2016 ENVIRONMENTAL REPORT].

107. *See generally* BAILIS ET AL., *supra* note 24, at 5–35 (describing methods of producing drop in fuels that resemble kerosene-based jet fuel).

108. *Id.* at 35 ("There is broad consensus that GHG emissions reductions resulting from the use of alternative fuels should be calculated on a life-cycle basis, . . . [which] includes recovery and extraction, transport of raw materials, refining and processing, transport of the finished product, and combustion.").

109. *See id.* at 36 (comparing US, EU, California, and Roundtable on Sustainable Biomaterials standards for biofuel's minimum GHG reductions).

110. *Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons*, ASTM INT'L, https://compass.astm.org/EDIT/html_annot.cgi?D7566+16b [https://perma.cc/N9B2-W8VE] (last visited Apr. 21, 2017)

111. 2016 ENVIRONMENTAL REPORT, *supra* note 107, at 153 ("Today, there are five pathways that have been approved under ASTM D7566 for producing alternative jet fuel and two airports are providing significant quantities of biofuel to their customers . . . .").

112. BAILIS ET AL., *supra* note 24, at 45 ("The magnitude of cumulative emission reductions that could result from the use of [this growing supply] of aviation biofuel between 2020 and 2035 depends on the specific pathways and feedstocks used.").

negative emissions.[113] More conservative estimates are nevertheless optimistic, suggesting that biofuels could reduce an aircraft's emissions from twenty-five to seventy-five percent.[114]

Price is a key barrier to more widespread use of biofuels however. The ICAO recently reported that "[t]he most significant challenge affecting the demand for alternative fuels is the tremendous price gap between conventional fuels and biofuels for civil aviation. Suppressed demand for alternative aviation fuels then, in turn, limits the investment in biorefineries that is needed in order to scale up production."[115]

4. Demand Reduction

The ICAO's preferred avenue for mitigating civil aviation emissions is through new technologies, operational efficiencies, and alternative fuels.[116] But reducing demand for air travel is another way that direct reductions in emissions could occur. Given the profit motives of civil aviation firms, it is not surprising that specific estimates about the extent to which demand reduction can mitigate civil aviation emissions are rare, but emissions reductions will arise if it is possible to reduce demand. Several proposals have argued that demand reduction is in fact the only effective way in the long run to reduce civil aviation emissions enough to meet the climate stabilization goals described in the Paris Agreement.[117]

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113. Marshall Wise, Matteo Muratori & Page Kyle, *Biojet Fuels and Emissions Mitigation in Aviation: An Integrated Assessment Modeling Analysis* 52 TRANSP. RES. PART D 244, 252 (2017) ("In our analysis, the production of biojet fuels with CCS leads to net negative carbon emissions for each unit of fuel produced. The net negative emissions partially offset the carbon emissions from fossil fuel use, and the viability of CCS greatly enhances the mitigation potential of biojet fuels.").

114. BAILIS ET AL., *supra* note 24, at 45 ("using the HEFA pathway with lower-performing soy, rapeseed and jatropha, for example . . . we assume that replacing jet fuel with these fuels reduces CO2 emissions by 25% . . . [using different underlying materials with the same HEFA pathway] yields average CO_2 reductions of 75%.").

115. 2016 ENVIRONMENTAL REPORT, *supra* note 107, at 153.

116. *See* Int'l Civil Aviation Org. [ICAO], Resolution. A39-3, para. 2 (Oct. 2016) [hereinafter Res. A39-3] ("[The ICAO] *affirms* the preference for the use of aircraft technologies, operational improvements and sustainable alternative fuels that provide the environmental benefits within the aviation sector.").

117. *See, e.g.*, Philip Cafaro, *Reducing Consumption to Avert Catastrophic Global Climate Change: the Case of Aviation*, NAT. SCI. 99 (2013) ("[I]n the real world,

II. PUBLIC GOVERNANCE

In light of the substantial contributions of global civil aviation to climate change and the options available to reduce those contributions, an obvious first question is what international, national, and subnational public governance initiatives can do to reduce civil aviation emissions. This Part describes barriers to international public governance efforts, the status of the general international legal framework for addressing climate change, and the specific government regulatory instruments that have targeted civil aviation. Governments face many challenges regulating carbon emissions that are not unique to the civil aviation sector, including economic interests that favor fossil fuel use, domestic collective action problems, and deep worldview differences. These challenges have been fully described in the literature, [118] and we focus here on the particular challenges posed by civil aviation.

A. Challenges to International Public Governance

The transnational character of civil aviation creates several significant challenges for public-governance-based approaches. It almost goes without saying that the jurisdiction of national governments ends at national boundaries, limiting the extent to which nation states can coerce other nations and private actors outside its borders to reduce emissions.[119] In addition, a collective action problem

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right now, people need to fly less, in order to avert catastrophic global climate change."); Andrew Macintosh & Lailey Wallace, *International Aviation Emissions to 2025: Can Emissions be Stabilized Without Restricting Demand?*, 37 ENERGY POL'Y 264, 272 (2009) ("Stabilizing international aviation emissions at level consistent with risk averse climate targets without restricting demand will be extremely difficult."); Benoît Chève et al., *Will Technological Progress be Sufficient to Stabilize CO_2 Emissions from Air Transport in the Mid-Term?*, 28 TRANSP. RES. PART D 91 (2013) (answering the article's titular question in the negative).

118. *See, e.g.*, Richard J. Lazarus, *Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future,* 94 CORNELL L. REV. 1153, 1154–1234 (2009) (discussing challenges of climate change to public governance); Michael P. Vandenbergh & Kaitlin T. Raimi, *Climate Change: Leveraging Legacy*, 42 ECOLOGY L.Q. 139, 145–70 (2014) (discussing worldview-based challenges and the socio-temporal trap).

119. *See* Timothy William Waters, *"The Momentous Gravity of the "State of Things Now Obtaining": Annoying Westphalian Objections to the Idea of Global*

arises at the international level.[120] Emissions from any one country will affect the global climate, so no single national government, however motivated to lead the way, can fully resolve the climate problem.[121] Absent an international agreement that incorporates all major emitters and creates motivations for compliance, a danger exists that free-rider states could decline to impose limits on aircraft that operate within them, while still enjoying a reduced risk of suffering climate harms. These problems are exacerbated by the difficulty of determining which state should be assigned responsibility for flights between countries and over international waters.

Because many states see binding international regulation as an affront to their national sovereignty, an additional barrier stands in the way of reducing civil aviation emissions.[122] The fear that strong

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Governance, 16 IND. J. GLOBAL LEGAL STUD. 25, 33 (2009) ("The remembered Westphalian system was marked by the factual existence of (and normative support for) self-legitimating states, whose people and processes were their own concern."); *see also* Kenneth W. Abbott & Duncan Snidal, *Strengthening International Regulation Through Transnational New Governance: Overcoming the Orchestration Deficit*, 42 VAND. J. TRANSNAT'L L. 501, 534 (2009) ("No global "state" has authority to adopt mandatory regulations or impose sanctions. States are jealous of their sovereignty and freedom of action, and resist delegating authority to international institutions.").

120. Michael P. Vandenbergh, *Reconceptualizing the Future of Environmental Law: The Role of Private Climate Governance*, 32 PACE ENVTL. L. REV. 382, 384–85 (2015) ("As to the problems of today, climate change is simply different from earlier threats. Whether it is 'the mother of all collective action problems' or just the most challenging collective action problem, no environmental threat addressed by the statutory framework erected in 1970–1990 matches climate change in the magnitude and irreversibility of the potential harm . . . .")

121. *See generally* Robert O. Keohane & David G. Victor, *The Regime Complex for Climate Change*, The Harvard Project on International Climate Agreements: Discussion Paper No. 2010–33 ("Climate change is politically a difficult problem for three fundamental reasons. First, it is a global problem, whose solution cannot be achieved through the efforts of any single state or small group of states."); Daniel H. Cole, *From Global to Polycentric Climate Governance*, 2 CLIMATE L. 395, 398 (2011) ("Even when global governance is necessary, institutions established at the international or global level are never sufficient, by themselves, for successfully resolving global problems.").

122. *See* Kenneth W. Abbott, *Strengthening the Transnational Regime Complex for Climate Change*, 88 TRANSNAT'L ENVTL. L. 543 (2012) ("Even voluntary norms addressing private actors can reduce state control of domestic economic activity or

international conventions undermine national autonomy has famously motivated the United States' failure to ratify the Convention on the Law of the Sea.[123] International aviation is, by definition, transport among different nations—each of which enjoys "complete and exclusive sovereignty over the airspace above its territory."[124] Further, "[a]ircraft have the nationality of the State in which they are registered."[125] Thus no individual state can set environmental guidelines for civil aviation generally. And although a national or sub-national government could impose limits on the aircraft in its own registry, or on the aircraft that visit its airports, doing so will come at a political and economic cost.[126]

The challenge to international action is further complicated by the mismatch between when mitigation expenditures may occur and when the benefits will occur. The greatest harms of climate change will not occur in the near-term but will instead be felt by future generations.[127] As a result, there is a tendency to undervalue the importance of those effects, particularly when confronting global disparities in economic development.[128] At the same time, delays in national and international

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be perceived as invading sovereignty; they are sometimes opposed even by governments generally favorable to environmental action.").

123. *See, e.g.*, James L. Malone, *The United States and the Law of the Sea*, 24 VA. J. INT'L L. 785, 785–86 (1984) (arguing that "President [Reagan] correctly viewed the seabed mining provisions in the proposed Convention as clearly inconsistent with vital national interests [and he] was unwilling to compromise those interests for the sake of world opinion or American participation in a global regime . . . .").

124. Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat. 1180, 15 U.N.T.S. 295 art. 1 [hereinafter *Chicago Convention*].

125. *Id.* art 17.

126. To the extent that stricter environmental requirements raise costs for civil aviation, they can provide an incentive not to register in a particular state, to raise passenger fees for flights into an environmentally-restrictive state, or otherwise penalize an outlier jurisdiction.

127. *See* Keohane & Victor, *supra* note 122, at 9 ("[T]he negative effects of climate change are not observable now, but are only expected to occur some years into the future. It is therefore an intergenerational problem: present generations are expected to pay costs for the benefit of their successes two or more generations into the future. . . . [and] costs borne today are in the interests of successor generations.")

128. Vandenbergh, *supra* note 121, at 385 ("Psychologists tell us that near-term, vivid, local events are most likely to affect beliefs, norms and behavior, but the most certain and most severe climate events are far easier to project over a long-term and global scale.")

action are important because current carbon emissions are locking in climate and sea level effects for hundreds or thousands of years. Thus, even though the ultimate costs of mitigating the effects of climate change will be very large and are being locked in now (absent the development of low-cost carbon removal technologies), the bulk of those costs will not arise until well into the future. Even if they use an extremely low discount rate, opponents of near-term action may argue that little present expense is justified in avoiding even very large long-term harms.[129] Coupled with uncertainties about the ultimate cost of public governance, these economic uncertainties complicate international negotiations,[130] and suggest that a dramatic increase in public pressure or political will to undertake public governance is unlikely, at least in the near term.

On a related note, deep differences exist about the distribution of responsibility for civil aviation emissions reductions among nation states. Individual states have varying degrees of willingness and capacity to enforce environmental regulations, and debates about the respective responsibilities of the developed and developing nations have emerged regarding civil aviation as they have regarding other sources of carbon emissions. A recent analysis identified the deep divide between developed and developing countries as an important challenge to action on civil aviation at the international level.[131] Similar collective action, temporal, justice and other problems arise at

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129. *Id.* ("The value of the climate change harms that will be avoided in future centuries is miniscule in the calculus after the application of almost any non-zero discount rate.")

130. Richard B. Stewart, Michael Oppenheimer, & Bryce Rudyk, *Building A More Effective Global Climate Regime Through A Bottom-Up Approach*, 14 THEORETICAL INQUIRIES L. 273, 280 (2013) ("[U]uncertainties regarding mitigation costs and future economic conditions, which together make many governments reluctant or unwilling to make legally binding international treaty commitments to achieve major quantified reductions five to ten years in the future."); Daniel H. Cole, *The Problem of Shared Irresponsibility in International Climate Law, in* DISTRIBUTION OF RESPONSIBILITIES IN INTERNATIONAL LAW 290, 293 (André Nollkaemper & Dov Jacobs, eds. 2015) ("Uneven distribution of costs and benefits expected from moderate climate change reduces incentives for wide sharing of responsibility.").

131. MARKUS W. GEHRING & CAIRO A. R. ROBB, ADDRESSING THE AVIATION AND CLIMATE CHANGE CHALLENGE 11-12 (2013), https://www.ictsd.org/sites/default/files/research/2013/08/addressing-the-aviation-and-climate-change-challenge.pdf. As Gehring & Robb note, the EU acted unilaterally after not being satisfied with the ICAO efforts. *Id*. at 12, 15.

the national and subnational levels, but as we mentioned above these problems have been discussed at length elsewhere.[132]

In total, these challenges make it unlikely that a general international agent or a civil aviation-focused international agent with adequate targets and participation by all major emitting countries will emerge in the next decade.[133] Nevertheless, substantial progress has been made by ICAO as a result of the availability of low-cost carbon offsets. The following overview of existing public governance reflects the challenges that the existing regime has confronted in attempting to reduce carbon emissions from civil aviation.

B. International Initiatives

1. Aviation in International Climate Governance

The negotiation of the 1992 United Nations Framework Convention on Climate Change (UNFCCC) was a watershed moment for international action on climate.[134] But in the decades that have followed, consensus has developed that it has been unsuccessful at "achieving its lofty goal to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system . . . ."[135]

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132. *See* Abbott, *supra* note 123.

133. *See* Kenneth W. Abbott & Duncan Snidal, *The Governance Triangle: Regulatory Standards Institutions and the Shadow of the State, in* THE POLITICS OF GLOBAL REGULATION 44, 57–58 (Walter Mattli and Ngaire Woods, eds. 2009) ("[S]tates as a group vary greatly in their will and capacity to regulate. Some governments are captured or corrupt. Governments in developing countries . . . often view regulation as a tradeoff against economic growth, and lack the information, resources and technical competence to manage complex regulation."); Stewart et al., *supra* note 131, at 280 ("Domestic priorities and political circumstances in many major MEF jurisdictions, together with the difficulties in securing adequate compliance assurance arrangements to deal with free-riding, are major reasons for the lack of progress.")

134. United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107.

135. TRUXAL, *supra* note 26, at 130 ("[T]he consensus view is that to date the UNFCCC process has generally delivered 'inadequate results,' owing to what many consider to be an overly ambitious approach."); Timothy Meyer, *How Local Discrimination Can Promote Global Public Goods*, 95 B.U. L. REV. 1937, 2012 (2015) ("The twenty-first century is one of disillusionment with global institutions. No longer do commentators and politicians hold out hope that the WTO, the

Article 2.2 of the Kyoto Protocol to the UNFCCC directed Annex I parties to address emissions from aviation, but do so through the ICAO: "The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively."[136]

Accordingly, the 2015 Paris Agreement excluded international shipping and civil aviation.[137] Although these omissions were dubbed "conspicuous holes" in the days after the Agreement was negotiated,[138] their exclusion from the Kyoto Protocol more than a decade earlier renders their omission in the Paris Agreement unsurprising. Still, the Paris Agreement did represent some international recommitment to climate goals,[139] and it may facilitate national action on domestic flights where states choose to include action on domestic aviation in their individually determined national commitments.[140]

2. The International Civil Aviation Organization

The core of the international legal system regulating civil aviation is the Chicago System, named for the Convention on International Civil

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UNFCCC, or the UN Security Council will serve as the primary fora in which to resolve global challenges.").

136. Kyoto Protocol to the United Nations Framework Convention on Climate Change, art. 2.2, Dec. 11, 1997, FCCC/CP/1997/L.7/Add.1.

137. Paris Agreement, Dec. 12, 2015, U.N. Doc. No. FCCC/CP/2015/L.9/Rev.

138. Benjamin Hulac, *Rules for ship, airplane emissions left out of Paris deal*, CLIMATEWIRE (Dec. 14, 2015), https://www.eenews.net/climatewire/2015/12/14/stories/1060029447 [https://perma.cc/LB79-ZZFP].

139. Despite being hailed as a significant step toward meaningful international climate action, commenters have severe disappointment about what the Paris Agreement actually accomplished. *See, e.g.*, George Monbiot, *Grand promises of Paris climate deal undermined by squalid retrenchments*, THE GUARDIAN (Dec. 12, 2015), https://www.theguardian.com/environment/georgemonbiot/2015/dec/12/paris-climate-deal-governments-fossil-fuels [https://perma.cc/5XW8-UW72].

140. *Top 3 misconceptions about CORSIA*, ICAO, http://www.icao.int/environmental-protection/Pages/A39_CORSIA_FAQ6.aspx (last visited Apr. 23, 2017) ("Emissions from domestic aviation are considered under the UNFCCC. Therefore, Parties to the UNFCCC have the possibility of addressing these emissions in their Nationally Determined Contributions (NDCs) under the Paris Agreement, as part of their actions aimed at reducing greenhouse gas emissions from domestic sources.").

Aviation ("Chicago Convention" or "Convention"), signed in Chicago in 1944.[141] The Chicago Convention established an international air law, and constituted the ICAO.[142] In its original form, the Chicago Convention contained a number of core principles that remain important today. In Article 12, the signatories agreed that each nation state would adopt measures to ensure that both aircraft registered in the state and foreign aircraft flying within its territory would comply with the state's rules and regulations.[143] In support of this ambition, the parties agreed to endeavor to keep their regulations uniform to the greatest extent possible.[144] In the same article, the parties agreed to extend the Convention's rules to flights over the high seas.[145] Under the original convention, aircraft have the nationality of the state in which they are registered,[146] and must possess a certificate of airworthiness issued by its registering state.[147] The Convention also established the ICAO, one purpose of which was to "[m]eet the needs of the peoples of the world for safe, regular, efficient and economical air transport . . . ."[148]

Each of those provisions has survived to the most recent ninth edition of the Convention.[149] With 190 states now within the Convention, it enjoys nearly universal membership.[150] ICAO addresses civil aviation emissions in a number of ways, including facilitating research, promulgating standards, policies and guidance on aircraft noise, emissions, and operations.[151] The ICAO's most prominent action to address the industry's climate implications is its

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141. *Chicago Convention*, *supra* note 125.
142. *Id.*
143. *Id.* art 12.
144. *Id.*
145. *Id.*
146. *Id.* art 17.
147. *Id.* art 31.
148. *Id.* art 43–44(d).
149. ICAO, *Convention on International Civil Aviation*, ICAO Doc 7300/9 (2006).
150. *Convention on International Civil Aviation – Doc 7300*, ICAO (last visited Apr. 19, 2017), http://www.icao.int/publications/Pages/doc7300.aspx [https://perma.cc/36BG-3S66].
151. *Environmental Protection*, ICAO (last visited Apr. 20, 2017), http://www.icao.int/environmental-protection/Pages/default.aspx [https://perma.cc/S6LE-383U].

Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), adopted in October 2016.[152]

3. CORSIA

CORSIA's target is to freeze carbon dioxide emissions beginning in 2020 levels, and to phase in a system offsetting emissions above those levels, except where special circumstances render the requirement too burdensome.[153] In its initial formulation, CORSIA does not specifically designate which offsets will satisfy the program, but it notes that "emissions units generated from mechanisms established under the UNFCCC and the Paris Agreement are eligible for use in CORSIA."[154] This offsetting scheme will be implemented in stages, beginning with voluntary pilot and first phases that will run from 2021 through 2023,[155] and 2024 to 2027 respectively.[156] The program becomes mandatory for member states in 2027, except for Least Developed Countries, Small Island Developing States, and Landlocked Developing Countries.[157] The United States is currently a signatory to the Chicago Convention and has committed to joining the voluntary first phase of CORSIA.[158] In light of the history of the United States with agreements that acknowledge different

152. Res. A39-3, *supra* note 117.

153. *Id.* para. 5.

154. *Id.* para. 21.

155. *Id.* para. 9(a).

156. *Id.* para. 9(b).

157. *Id.* para. 9(e).

158. LEADERS' STATEMENT ON A NORTH AMERICAN CLIMATE, CLEAN ENERGY, AND ENVIRONMENT PARTNERSHIP (June 29, 2016), https://obamawhitehouse.archives.gov/the-press-office/2016/06/29/leaders-statement-north-american-climate-clean-energy-and-environment [https://perma.cc/5GB3-CZNW] ("We support the adoption by all countries in 2016 of the market-based measure proposed through the International Civil Aviation Organization to allow for carbon-neutral growth from international civil aviation from 2020 onwards and will join the first phase of the measure adopted."). Although the present administration does not appear to have publicly spoken on whether the United States remains committed to joining the first phase of the measure, the Federal Aviation Administration's 2018 Fiscal Year Business Plan, published in March of 2018, includes an activity target that suggests continued work toward domestic implementation of CORSIA: "Initiate domestic implementation of CORSIA Standard and Recommended Practices, once available from ICAO." FAA, FY2018 APL BUSINESS PLAN 17, https://www.faa.gov/about/plans_reports/media/2018/apl_business_plan.pdf.

responsibilities for certain parties, the extent to which the United States will continue to support CORSIA is unclear.[159] Further, since the United States has withdrawn from the Paris Agreement, it has less incentive to meet the CORSIA goals.[160]

In adopting CORSIA, the ICAO acknowledged that new technologies, operational improvements, and alternative fuels—apparently even in light of existing efficiency incentives for airlines—are not delivering sufficient emissions reductions: the environmental benefits from aircraft technologies, operational improvements and sustainable alternative fuels may not deliver sufficient CO_2 emissions reductions to address the growth of international air traffic, in time to achieve the global aspirational goal of keeping the global net CO2 emissions from international aviation from 2020 at the same level.[161]

Thus the function of the CORSIA offset program is "to complement a broader package of measures to achieve the global aspirational goal"[162] of freezing civil aviation emissions at 2020 levels, and to do so without imposing an "inappropriate economic burden on international aviation."[163]

159. This imbalance ultimately led the United States to reject the Kyoto Protocol, based on its inclusion of different requirements for developing country parties. *See* S. Res. 98, 105th Cong. (1998) (enacted) ("[T]he United States should not be a signatory to any protocol [which would] mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties, unless the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for Developing Country Parties within the same compliance period."). President Trump's comments suggest that his administration shares this attitude toward climate commitments. *See* Megan Darby, *Trump complains US share of climate finance is unfair*, CLIMATEHOME (Apr. 28, 2017), http://www.climatechangenews.com/2017/04/28/trump-complains-us-share-climate-finance-unfair/ [https://perma.cc/ZHC7-V9DV].

160. *See* Valerie Volcovici, *U.S. submits formal notice of withdrawal from Paris climate pact*, REUTERS (Aug. 4, 2017), https://www.reuters.com/article/us-un-climate-usa-paris/u-s-submits-formal-notice-of-withdrawal-from-paris-climate-pact-idUSKBN1AK2FM [https://perma.cc/DW5F-3ESK].

161. Res. A39-3, *supra* note 117, para 3.

162. *Id.* para 4

163. *Id.*

4. ICAO and CORSIA Limitations

CORSIA confronts several shortcomings, and commenters have been quick to point out its limitations.[164] The scheme's target of stabilizing emissions at 2020 levels allows emissions to continue to grow until that time and fails to provide an incentive for civil aviation to further reduce its emissions. The scheme's reservations are a further barrier—until 2027 participation is voluntary.[165]

The goal of CORSIA— freezing civil aviation emissions from all participating states at 2020 levels— is valuable, but it is insufficient if the objective is for civil aviation to bear its proportionate share of the reductions necessary to avoid a substantial risk of exceeding the 2 degree goal included in the Paris Agreement, much less than 1.5 degree aspiration.[166] For instance, the 1.5 degree target requires that global emissions peak no later than 2020, but emissions must also decrease steeply in the years following, not stabilize at 2020 levels as provided for in CORSIA.[167] Thus the implicit assumption built into CORSIA is that other sectors will reduce emissions even more significantly than civil aviation, and that civil aviation will comprise an increasingly large portion of total anthropogenic carbon emissions. The decision to use offsetting is therefore only a near-term response that buys time for long-term progress toward a carbon-neutral civil aviation sector.[168]

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164. James Beard, *A global climate deal for aviation! So what next?*, CLIMATEHOME (Nov. 10, 2016), http://www.climatechangenews.com/2016/10/11/a-global-climate-deal-for-aviation-so-what-next/ [https://perma.cc/354B-3PTS] ("Here are the bad points: It's just offsetting. And so it doesn't send a strong price signal to the industry to innovate or to passengers to fly less. It's nice-sounding target of "carbon neutral growth from 2020" (CNG2020) is actually pretty weak, and ICAO is only set to achieve around three quarters of that goal (so far).").

165. CARBON MARKET WATCH, THE CORSIA: ICAO'S MARKET BASED MEASURE AND IMPLICATIONS FOR EUROPE (2016), http://carbonmarketwatch.org/wp-content/uploads/2016/10/Post-Assembly-Policy-Brief-Web-1.pdf [hereinafter CORSIA: IMPLICATIONS FOR EUROPE].

166. *Id.* at 2; Paris Agreement, *supra* note 138, art. 2.

167. Johan Rockström et al., *A Roadmap for Rapid Decarbonization*, 335 SCI. MAG. 1269, 1269 (2017).

168. CORSIA: IMPLICATIONS FOR EUROPE, *supra* note 166, at 2 ("For each additional ton of CO2 emitted, offsetting reduces that ton in another location, a zero-sum exercise that balances out the carbon entering the atmosphere. However, if the reduction lacks environmental integrity . . . there is an overall increase of emissions in the atmosphere.)

Aside from CORSIA's specific limitations, more fundamental limitations hinder the effectiveness of any ICAO action to reduce carbon emissions from civil aviation. The ICAO is the intergovernmental organization tasked in part with reducing emissions from civil aviation,[169] but it lacks enforcement tools. Since an ICAO resolution is not automatically binding, it will have to be implemented through later-promulgated standards.[170] ICAO resolutions are thus difficult to enforce for at least four reasons. First, a state may hesitate to enforce obligations on its own air carriers if other states refuse to follow suit.[171] Second, differences in enforcement capacity may generate different enforcement outcomes even if states intend to apply standards uniformly.[172] Third, a state that determines that it is impracticable to comply with an ICAO standard may simply choose not to do so.[173] And fourth, although the Chicago Convention allows a state to deny an air carrier entry if that carrier has breached an obligation, that extraordinary remedy has never been invoked.[174] In short, although the ICAO represents a step forward by the international public governance regime, it has adopted a goal that is modest at best, is unlikely to be achieved until 2027 at the earliest and will be subject to substantial enforcement challenges along the way.

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169. Kyoto Protocol, *supra* note 137, art. 2.2.

170. Alejandro Piera, *Designing the Legal Form of a Global Aviation Market Based Measure*, 10 CARBON & CLIMATE L. REV. 144, 145 (2016).

171. *Id.* at 145; s*ee also supra* Section III.A.

172. *See* Piera, *supra* note 171, at 145. ("States may exercise different levels of enforcement (e.g. different levels of monetary sanctions), leading to market distortions.").

173. Pamela Campos, *Compliance Tools for a Global Market Based Measure for International Aviation*, 10 CARBON & CLIMATE L. REV. 153, 157 (2016) ("States are not categorically required to follow or implement standards. If a State "finds it is impracticable to comply in all respects," to "bring its own regulations or practices into full accord," or "deems it necessary to adopt regulations or practices differing in any particular respect" from a standard, it can establish differing regulations, as long as it provides notification to ICAO.") (quoting *Chicago Convention*, *supra* note 125, art. 38).

174. Campos, *supra* note 174, at 157.

III. PRIVATE GOVERNANCE OPTIONS

Private governance provides additional options for reducing the climate effects of civil aviation. International governmental organizations can claim authority derived from their association with national governments and international agreements, but they move slowly and have limited capacity to set and enforce adequate standards.[175] Private governance initiatives can bypass many of the barriers that make civil aviation so difficult for public governance. In Part III, we examine several existing and potential new private initiatives and explain why they can motivate climate mitigation efforts despite these barriers. As noted earlier, the term civil aviation refers to the commercial transport of both passengers and freight. We focus here on the opportunity for private governance regarding passenger travel, but air freight has already been the subject of several private initiatives, and we believe that it is worthy of additional efforts.

Although we identify private governance examples here, development of a comprehensive agenda is beyond the scope of this Article. Instead, we recommend formation of a multi-stakeholder panel to develop such an agenda. The panel could include representatives from the civil aviation industry, advocacy and service groups, philanthropists, affected sectors such as finance and travel services, and employee and community groups. It could conduct a rigorous study of the opportunities for private initiatives to achieve emissions reductions, identify gaps in current private initiatives, and propose new initiatives to pursue the most promising opportunities.

A. The Emerging Understanding of Private Ordering

Why is private governance well-situated to fill some of the gaps in public governance regarding civil aviation? In the last several decades, social scientists have demonstrated that private actors sometimes organize in ways that perform governmental functions. For instance, more than a decade ago Thomas Dietz, Elinor Ostrom, and Paul Stern pointed to a large and growing literature suggesting that Garrett Hardin's vision of the tragedy of the commons, which is commonly

175. Piera, *supra* note 171, at 148 ("Just like most international organizations, ICAO has no enforcement authority in a strict legal sense.") (citations omitted).

thought to require a government response, is not inevitable.[176] Research pioneered by Ostrom and others demonstrated that resources can be sustainably managed without traditional government intervention when they can be monitored at low cost, their users are embedded in strong social networks that have effective means of excluding outsiders, and rule enforcement is supported by the users themselves.[177] In many cases, these conditions arise when small groups manage discrete resources, and the most well-known example involves the informal groups that manage the lobster harvest off the coast of Maine.[178]

At first glance, the global civil aviation sector—including airlines, pilots, manufacturers, and airport operators, among others—appears to exhibit few of these characteristics. This might suggest that global civil aviation is a poor candidate for private climate mitigation efforts, but recent research in law, political science, international relations, economics and other fields has expanded the early work on private ordering and has provided insights that explain why a wide range of private actors at the domestic and global levels can make important contributions to environmental protection. This research has demonstrated that private ordering can occur regarding local, regional, and global environmental issues even when one or more of the Ostrom

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176. *See* Thomas Dietz, Elinor Ostrom, and Paul C. Stern, *The Struggle to Govern the Commons*, 302 SCI. 1907, 1907 (2003) (suggesting that Hardin's view was limited by assuming that governmental institutions were the only way to sustain common pool resources, and that users were trapped in the system without the ability to create solutions); *see also* Daniel H. Cole, *Advantages of a Polycentric Approach to Climate Change Policy* 5 NAT. CLIMATE CHANGE 114, 117 (2015) ("That subglobal negotiations and agreements might not reduce GHG emissions rapidly enough to forestall the need for adaptation and/or geoengineering is no reason to maintain an exclusive focus on global policies that have failed and global negotiations that remain stalled.").

177. Dietz, Ostrom & Stern, *supra* note 177, at 1908.

178. Around the time that Ostrom and colleagues were identifying the characteristics of successful private management of common pool resources, research in law and economics scholars were noting the role of social norms in steering the conduct of participants in these types of communities. *See, e.g.*, ROBERT ELLICKSON, ORDER WITHOUT LAW (1991) (examining the role of social norms in interactions between farmers and ranchers in Shasta County, California).

characteristics do not exist,[179] and it has focused in recent years on the private response to climate change.[180]

In theory a government carbon tax, cap and trade program, or regulatory scheme could motivate aviation firms to reduce carbon emissions, and any of these measures could be adopted by the major emitting nations and coordinated through an international agreement. Of course, in practice this process has been difficult at best. The Paris Agreement reflects participation from almost all nations, but it achieved this level of participation by reducing the expectations of the participants. On the domestic level, the prospects for adequate federal, state, and local government action over the next several years are dim at best.[181] Even though polling in the US for much of the last two decades has indicated that most voters support some type of government climate mitigation, support for government action on the issues is not intense, and climate change is among the most polarized issues.[182] As the last two decades have demonstrated, economic and

179. *See* Vandenbergh, *supra* note 4, at 168 ("[A]lthough the global nature of some problems may vastly increase the number of parties at both ends . . . [f]or some goods, a small group of large corporate producers exists, as does a small group of global advocacy groups."). For examples of early research on private ordering regarding environmental protection, see Steven Bernstein & Benjamin Cashore, *Can Non-State Global Governance Be Legitimate?: An Analytical Framework*, 1 REG. & GOVERNANCE 347, 349–50 (2007); David Vogel, *The Private Regulation of Global Corporate Conduct*, 49 BUS. & SOC'Y 68, 68 (2010); Tim Bartley, *Certifying Forests and Factories: States, Social Movements, and the Rise of Private Regulation in the Apparel and Forest Products Fields*, 31 POL. & SOC'Y 433, 433–34 (2003); Marc Allen Eisner, *Private Environmental Governance in Hard Times: Markets for Virtue and the Dynamics of Regulatory Change*, 12 THEORETICAL INQUIRIES IN L. 489 (2011); Abbott & Snidal, *The Governance Triangle*, *supra* note 134; David P. Baron, *Private Politics, Corporate Social Responsibility, and Integrated Strategy*, 10 J. ECON. & MGMT. STRATEGY 7 (2001); Errol E. Meidinger, *Environmental Certification Programs and U.S. Environmental Law: Closer Than You Think*, 31 ENVTL. L. REP. 10162 (2001).

180. *See* Michael P. Vandenbergh, *Climate Change: The China Problem,* 81 SO. CAL. L. REV. 905 (2008); VANDENBERGH AND GILLIGAN, BEYOND POLITICS, *supra* note 5, at 407; Vandenbergh & Gilligan, *Beyond Gridlock*, *supra* note 11, at 228-34; JESSICA GREEN, RETHINKING PRIVATE AUTHORITY: AGENTS AND ENTREPRENEURS IN GLOBAL ENVIRONMENTAL GOVERNANCE (2013); Stewart et al., *supra* note 131, at 274; Cole, *supra* note 177, at 117; Sarah Light, *The Law of the Corporation as Environmental Law*, 71 STANFORD L. REV. (forthcoming 2018).

181. VANDENBERGH & GILLIGAN, *supra* note 5, at ch. 1, 3 & 4.

182. For a discussion, see VANDENBERGH & GILLIGAN, BEYOND POLITICS, ch. 3.

ideologically-motivated interests can block government climate mitigation measures in the United States even when most voters express some level of support for these types of measures.

Although private governance initiatives are an option, it is important to remember that they are not a first-best response: They cannot achieve the large-scale emissions reductions that a carbon price or an effective regulatory scheme can achieve.[183] At the same time, they are an important second-best approach because they can bypass the barriers to government action in the near term by harnessing existing preferences for mitigation, and can do so at low cost.[184] For instance, companies may be motivated to reduce carbon emissions because they respond not just to government regulatory pressure regarding climate change, but also to pressure from retail and corporate customers, lenders, investors, employees, and others.[185] In some cases, companies can respond to this pressure at low or negative cost by identifying energy efficiency and other cost-saving opportunities, as the Virgin Atlantic example suggests. In addition, they can transfer this pressure for emissions reductions to their suppliers and others around the globe through supply chain contracting requirements. Furthermore, research suggests that much of the resistance to climate mitigation is based on worldview or ideological concerns about big government, and by relying on actions by the private sector private initiatives may be able to bypass these concerns, broadening the support for mitigation efforts to include greater numbers of conservatives and libertarians.[186]

Developments in the private sector over the last decade also demonstrate that private governance is not just a theoretical possibility. For instance, Microsoft recently committed to become carbon neutral

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183. *Id.* at ch. 3 & 4.

184. *Id.* at ch. 4.

185. For a brief list of drivers of corporate participation in climate initiatives, see Vandenbergh, *The Drivers of Corporate Climate Mitigation*, *supra* note 12, at 29. In many cases, motivations for increased efficiency exist at both the firm and consumer level. *See, e.g.*, Gerlinde Berger-Walliser & Paul Shrivastava, *Beyond Compliance: Sustainable Development, Business, and Proactive Law*, 46 GEO. J. INT'L L. 417, 420–21 (2015) ("[O]ver the past two decades, corporations have gradually internalized the importance of sustainable development policies.").

186. VANDENBERGH & GILLIGAN, *supra* note 5, at Preface (citing studies).

and achieved that goal within several years.[187] Walmart recently worked with two environmental groups to reduce 28 million metric tons of emissions from its supply chains, an amount equal to roughly half of the annual emissions from the U.S. iron and steel sector, and it has committed to reduce a billion tons by 2030, an amount equal to all of the emissions from Germany or Japan.[188] In other work, one of us has argued that corporate private governance initiatives can contribute half a billion tons per year in emissions reductions each year over the next decade.[189] In addition, private initiatives can target other sectors, including households, religious organizations, civic and cultural organizations, and colleges and universities, and the total reductions from private climate governance can reach more than a billion tons per year. [190]

B. Private Governance Options for Civil Aviation

In Part III.B we match several barriers to government civil aviation efforts with private initiatives that may be able to bypass them. We start with the barriers at the international level and then turn to barriers that arise at the national and subnational levels as well.

1. Overcoming International Coordination Problems

As the ICAO discussion in Part II suggests, efforts to adopt international climate measures for civil aviation are remarkably difficult. On top of the problems that have plagued the UNFCCC process generally, the global presence and emissions of civil aviation make it a particularly challenging area for governments to regulate. The potential for private initiatives at the global level arises because they harness market power and resources rather than governmental authority, allowing them to bypass national boundaries and transfer pressure and resources for emissions reductions around the world. This can happen without the need to coordinate among nations and thus

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187. *See* Sarah E. Light, *The New Insider Trading: Environmental Markets Within the Firm*, 34 STAN. ENVTL. L.J. 3, 41 (2015) (discussing Microsoft's carbon commitment and internal carbon tax).

188. VANDENBERGH & GILLIGAN, *supra* note 5, at ch. 5 (citing Walmart and other examples).

189. *Id.* at ch. 1 & 5.

190. *Id.* at ch. 9.

without the ability of any one uncooperative government to undercut the effort. For instance, a retail airline customer in Denmark or Indonesia can affect the carbon emissions of an airline based in China for a flight that occurs over international waters, all without any government participation. Retail and corporate (e.g., company and group travel) airline markets, air freight markets, and financial markets are global, as are many supply chains for airplanes, equipment, fuel, and other goods and services. As a result, private pressure for emissions reductions can use markets to bypass the barriers posed by sovereign boundaries.

Environmental requirements in the supply chain contracts of civil aviation firms provide many avenues through which firms can impose environmental standards on others without regard to international boundaries.[191] Travel agents, booking services, corporate travel offices, and organizations that host large conventions can make travelers' carbon emissions a criterion in flight selection processes. Airlines can require that new aircraft meet increasingly stringent efficiency standards and can promote alternative fuels.

Pressure from socially responsible lenders and investment funds also can transcend national boundaries.[192] Perhaps the best recent example is the role that CDP has played in creating motivations for climate mitigation by airlines and other corporations around the world. CDP (formerly the Carbon Disclosure Project) uses the influence of investors with over $100 trillion in assets to induce carbon emissions

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191. *See* Larry Catá Backer, *Private Actors and Public Governance Beyond the State: The Multinational Corporation, the Financial Stability Board, and the Global Governance Order*, 18 IND. J. GLOBAL LEGAL STUD. 751, 768 (2011) ("[C]orporations seek to regularize behavior through the application of behavioral norms or standards generated by other groups-particularly nongovernmental organizations that certify products and set standards, or standard-setters concerned with substantive rules for product production and quality."); Li-Wen Lin, *Legal Transplants Through Private Contracting: Codes of Vendor Conduct in Global Supply Chains As an Example*, 57 AM. J. COMP. L. 711, 716 (2009) ("[M]ultinational companies, backed by their strong bargaining power, have transmitted a new legal order to developing countries through contracting with local suppliers . . . ."); Michael P. Vandenbergh, *The New Wal-Mart Effect: The Role of Private Contracting in Global Governance*, 54 UCLA L. REV. 913 (2007) (concluding that more than half of the corporations in eight sectors impose environmental supply chain requirements on their suppliers).

192. VANDENBERGH & GILLIGAN, *supra* note 5, at Preface (citing studies).

disclosure by a large number of firms around the globe.[193] In 2017, Delta, American Airlines, United, Southwest, Boeing, Airbus, disclosed climate data to CDP, along with other firms in the civil aviation sector.[194] This disclosure allows investors to determine which firms are reducing their emissions and motivates the participating firms to reduce emissions. And by voting their shares in favor of efficient practices and other carbon-reducing opportunities, corporate shareholders can exercise a degree of climate-mitigating control over corporate behavior from within the corporation, all of which can transcend national boundaries.

Given the importance of offsets to the CORSIA effort, and the likelihood that offsets will be a part of new private initiatives, private purchaser standards for offsets, which can address quality concerns, can play an important role as well. An example is the Gold Standard, a private standard established by the World Wildlife Fund and other international groups. The Gold Standard originally focused on establishing and monitoring best practices for projects under the UN's Clean Development Mechanism but has broadened its focus in recent years.[195] This is a topic that is already on the agenda of CORSIA for the offsets contemplated in CORSIA's climate program.

As we noted in Part II.A, disagreements between developed and developing nations have posed a barrier to many international governmental initiatives, including as the ICAO civil aviation effort.[196] The UN Framework Convention on Climate Change process assigns developed and developing countries "common but differentiated responsibilities and respective capabilities." Disputes about the meaning of this term, however, have hindered the ability of the ICAO to produce and implement standards that will achieve major emissions reductions from global civil aviation.[197]

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193. *About Us*, CDP, https://www.cdp.net/en/info/about-us [https://perma.cc/8CEW-WANF] (last visited May 5, 2017).

194. *See* CDP, *Companies*, https://www.cdp.net/en/companies [https://perma.cc/929E-5JFV] (last visited July 10, 2018).

195. *Our Purpose*, GOLD STANDARD, http://www.goldstandard.org/our-story/who-we-are [https://perma.cc/XQJ2-Q36L] (last visited July 10, 2018).

196. For a recent overview, see GEHRING & ROBB, *supra* note 132, discussion at n.108-110.

197. *See, e.g.*, *id*. at 11 (concluding that "[a] second major obstacle has been a political debate about differentiation").

Private governance approaches do not provide a silver bullet for this issue, but they provide new options. To the extent disagreements between developed and developing countries arise from underlying concerns about sovereignty, private initiatives may frame issues in ways that can reduce positional bargaining and enable efforts to focus on mitigation measures. For instance, market pressure from retail or other customers that induces an airline to become more efficient may provoke less resistance than pressure from a foreign government. In addition, private climate initiatives can subsidize emissions reductions in developing countries. Carbon offsets can play this role, but a high profile example of another approach has occurred in another sector: Apple's support for the construction of power plants that will generate 2 gigawatts of renewable power in China.[198] This low-carbon power will enable Apple's Chinese manufacturing operations to reduce their carbon footprint while subsidizing the transition to a lower-carbon electric grid in China.[199] These types of private initiatives can be developed for the global civil aviation sector as well. They are unlikely to resolve debates over climate justice, but they can reduce carbon emissions in the near term despite the international gridlock.

2. Closing the Efficiency Gap in Operations

In addition to bypassing barriers that arise at the international level, private initiatives can bypass barriers that confront government efforts at all levels. For instance, although governments often hesitate to become involved in the day-to-day operations of firms,[200] private initiatives are particularly promising regarding civil aviation because large cost savings can be achieved from carbon reduction efforts that target inefficiencies in firm operations. The Virgin Atlantic example suggests that a substantial efficiency gap may exist regarding fuel use, and the ability to root out these types of operating inefficiencies may provide firms in the sector with motivation to seek out carbon reduction opportunities.

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198. VANDENBERGH & GILLIGAN, *supra* note 5, at ch. 8.

199. For a discussion, see VANDENBERGH & GILLIGAN, *supra* note 5, at ch. 8. As Gehring and Robb note "[i]t is within the context of this impasse in negotiations conducted through ICAO to date that the EU acted unilaterally." GEHRNIG & ROBB, *supra* note 132, at 12.

200. An example in the U.S. is the Resource Conservation and Recovery Act, which was designed to avoid direct involvement in industrial production processes.

We might assume that corporate self-interest would have motivated Virgin Atlantic to take cost-effective fuel efficiency steps years ago,[201] yet the pilot fuel efficiency study highlights how private initiatives can accelerate the closing of the gap between the fuel economy steps that are in the firm's interest and the firm's actions.[202] Even under the assumption that the market will eventually incorporate all efficiency gains that are in the firm's interest, the Virgin Atlantic example demonstrates that major, highly profitable efficiency gains are often not achieved promptly. Virgin Atlantic began operating in 1984, yet it was not until 2014 that the airline identified a seemingly obvious, easy way to achieve many fuel cost reductions. A host of reasons could explain why an airline might not have addressed this principal-agent problem in the past (e.g., lack of information regarding fuel use, focus on other issues by management, separation of responsibilities among different units and employees within the firm, lack of expertise about or objections to behavioral interventions that include pilots, and others), but the Virgin Atlantic example demonstrates that pressure for carbon emissions reductions plus technical assistance from a non-governmental organization can overcome the existing barriers.[203]

Moreover, if Virgin Atlantic is in this position, many other airlines and other firms in the civil aviation sector may be as well. Private initiatives that combine pressure with expertise also might yield important emissions reductions from fuel and other inefficiencies in

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201. Gosnell et al., *supra* note 1, at 1 ("fuel use in the industry affects profits—fuel represents an average 33% of [airlines'] operating costs").

202. For a brief overview of the debate between economists and engineers about the size of the efficiency gap, see Michael P. Vandenbergh, *Keynote: Motivating Private Climate Governance: The Role of the Efficiency Gap*, 70 ARKANSAS L. REV. (forthcoming 2018).

203. The efficiency gap in aviation may be driven by several factors, including inefficient operating practices. An example is the inattention to fuel use created by the principle–agent problem highlighted by the Virgin Atlantic study. Although the airline has an incentive to reduce fuel consumption, the actors in the best position to do so are the pilots. If the Virgin Atlantic experience is representative of other airlines, the pilots historically have not been given incentives to reduce fuel use, and until the firm felt pressure to reduce carbon emissions management did not focus on the opportunity to solve the principal-agent problem. Once pilot efficiency information and monitoring were in place, however, and pilot-level incentives were introduced, the research suggests that the pilots acted in ways that were more consistent with their airline principal's preference for reduced fuel consumption, and large emissions reductions occurred. *See generally* Gosnell et al., *supra* note 1.

the civil aviation sector and from similar inefficiencies in other sectors. Studies show that carbon reduction motivations have led to cost savings in industries ranging from potato chip production to electronics to big box retail stores, and other transportation sectors (e.g., trucking) may be particularly promising targets of opportunity.[204]

3. Accelerating the Development and Uptake of Efficient Technologies

In addition to programs that target pilot behavior and other operational aspects of civil aviation firms, private initiatives can promote the development and uptake of more efficient technologies. As we discussed in Part I, new fuel-efficient airplane designs are being developed. A challenge for the civil aviation sector, however, is that the development and implementation of these new technologies is proceeding at a slow pace.

Private initiatives can target both the development and uptake of new technologies through green finance and motivational efforts. Numerous green finance initiatives have emerged in the last decade that are designed to reduce the cost of developing and deploying efficient or low-carbon technologies.[205] Aviation technologies that are not fully developed—like lighter and more efficient batteries that can facilitate electric aircraft, novel wing designs, and more—may be hindered by a lack of necessary investment in the underlying research. The development of more fuel-efficient aircraft may be a natural target for green finance initiatives.

Green finance initiatives also could target the uptake of more efficient aircraft, reducing the cost of capital for airlines that accelerate fleet replacement. Even though new aircraft are already significantly more efficient than older models, the decades-long effective life of an aircraft means that absent additional incentives, fleet replacement will remain gradual. Similarly, a green bond fund could commit to investing in emerging aircraft biofuel technologies, or in the infrastructure needed to use biofuels on a large scale.

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204. VANDENBERGH & GILLIGAN, *supra* note 5, at ch 5.

205. Charles Di Leva, *Financing Climate Mitigation and Adaptation*, 11 CARBON & CLIMATE L. REV. 314, 315-17 (2017) (describing a need to complement government investment with private sector capital).

In addition, private advocacy groups can call attention to airlines' relative carbon emissions. In turn, private investor and lender initiatives can favor airlines that have taken steps to reduce carbon emissions and increase efficiency with aging fleets. In recent years, lending standards have emerged as an important way for banks to impose environmental requirements on borrowers for projects all around the world. For example, the Equator Principles are a collection of disclosure and environmental standards that ninety financial institutions in thirty-seven countries have voluntarily adopted.[206] The effect of these standards is to impose environmental requirements on firms and projects that might otherwise be unaffected by national or international regulation.[207] The Carbon Principles are another example of a private standard designed to address the carbon emissions associated with lending. The Principles foster enhanced climate diligence for new fossil-fuel power plants by requiring prospective borrowers to assess the financial viability of a proposed power plant in light of climate mitigation risks.[208] In addition, the Principles call on banks to "[e]ncourage clients to pursue cost-effective energy efficiency, renewable energy and other low carbon alternatives to conventional generation."[209] The Equator Principles and Carbon Principles do not require that a less carbon intensive option be selected, but they require borrowers to identify carbon implications and to consider lower carbon alternatives. If applied to civil aviation, lending standards like these could increase airlines' motivation to invest in

206. *About the Equator Principles*, EQUATOR PRINCIPLES, http://equator-principles.com/about/ (last visited May. 5, 2017).

207. Vandenbergh, *Private Environmental Governance*, *supra* note 4, at 151–52. The Equator Principles require, for example, that "[f]or all Projects, in all locations, when . . . [e]missions are expected to be more than 100,000 tonnes of CO_2 equivalent annually, an alternatives analysis will be conducted to evaluate less Greenhous Gas (GHG) intensive alternatives." THE EQUATOR PRINCIPLES 6 (2013), http://equator-principles.com/wp-content/uploads/2017/03/equator_principles_III.pdf.

208. *Leading Wall Street Banks Establish the Carbon Principles*, CITIGROUP (Feb. 4, 2008), http://www.citigroup.com/citi/news/2008/080204a.htm. Specifically, adherents to these principles agree to "[a]scertain and evaluate the financial and operational risk to fossil fuel generation financings posed by the prospect of domestic CO_2 emissions controls," and to "[u]se the results of this diligence as a contribution to the determination whether a transaction is eligible for financing and under what terms. THE CARBON PRINCIPLES 2 (2008), http://www.morganstanley.com/globalcitizen/environment/CarbonPrinciplesFinal.pdf

209. THE CARBON PRINCIPLES *supra* note 209, at 2

technologies and infrastructure that will facilitate a more efficient industry and to take other steps to reduce carbon emissions.

4. Increasing Overall Motivation for Climate Mitigation

In addition to providing resources and motivation to achieve greater efficiency, private initiatives can create additional motivations for civil aviation firms to study and reduce their carbon footprints. Firms in the civil aviation sector are exposed to external and internal drivers for private governance, such as pressure from retail and corporate customers, employees, and others. By providing information to retail and corporate customers about the carbon footprint of air travel, private initiatives can allow these private actors to express preferences, even if they are weak preferences, for sustainable travel and can pressure airlines to compete over the carbon footprint of flights. Further, private naming-and-shaming and other reputation campaigns can induce airlines to avoid reputational risks by making efficiency investments and taking other steps to reduce their carbon footprints.[210]

In some cases, information initiatives focus less on naming-and-shaming campaigns than on providing factual information to affect decision-making by retail and corporate customers. For instance, informational initiatives can provide data on the carbon footprint of particular flights. Many large corporations have adopted carbon emissions targets and internal carbon taxes,[211] so employees who are

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210. Reputation campaigns can motivate climate mitigation actions that do not involve efficiency gains. Contrail reduction, for example, will not directly decrease an airline's operating expense. But private reporting schemes that facilitate public awareness of those efforts can enhance the reputation of the firm, the value of which can offset bare cost increases encountered from contrail reduction measures. Although contrail mitigation does not have the same net-zero cost opportunities, the reputational effect on an airline of reducing emissions might be a net positive. Research in several corporate studies has demonstrated that firms often pursue costly climate mitigation steps that are likely to have positive reputational benefits. *See* Markus Kitzmueller & Jay Shimshack, *Economic Perspectives on Corporate Social Responsibility* 50 J. ECON LITERATURE 51 (2012) (reviewing economics literature on corporate sustainability behavior); Vandenbergh, *supra* note 4, at 167 ("Even though consumer demand, as measured by willingness to pay for green goods, is often limited, firms also respond to more generalized concerns about firm or brand reputation.").

211. Light, *supra* note 188, at 41 ("Microsoft's internal carbon fee is a way for the firm to create incentives to reduce emissions, to force emitting business units or

booking corporate travel may have increasing incentives to opt for low-carbon flights.[212] A number of companies are already increasing consumer access to information on the climate effects of individual and corporate travel decisions. Travel search engines Glooby and TripZero allow consumers to compare the carbon intensity of flight options while booking travel.[213] TripZero charges hotels a commission to be searchable through the website, and it uses a portion of those commissions to purchase offsets against consumer travel.[214] In

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divisions to acknowledge the "true cost" of using energy, and to raise money for its emissions-reduction efforts.").

212. Examples of initiatives of this type in other fields include certification and carbon reporting schemes. The Marine Stewardship Council, for example, uses a third party auditing service to prove certifications to fisheries that are deemed sustainable. *See* Will Martin, *Marine Stewardship Council: A Case Study in Private Environmental Standard-Setting*, 44 ENVTL. L. REP. (ENVTL. LAW INST.) 10097, 10097 (2014) ("The story of MSC's development provides a case study of how private environmental standard-setters can make change happen, outside the context of laws and regulation."). Products that come from these fisheries are able to advertise their sustainability with a recognizable label, which allows a consumer to use that sustainability information in making a decision about what to purchase without having to individually research each product. Products that come from these fisheries are able to advertise their sustainability with a recognizable label, which allows a consumer to use that sustainability information in making a decision about what to purchase without having to individually research each product.

213. GLOOBY, https://www.glooby.com/ (last visited June 11, 2018) ("Glooby is a travel search engine that enables users to find and compare prices on airplane tickets and hotels, while indicating the most fuel-efficient flights and eco-labeled hotels. We search among a variety of travel agencies, airlines and booking sites and show you all the information you need to make better travel decisions."); TRIPZERO, https://www.tripzero.com/ (last visited June 11, 2018) ("At TripZero we believe it's our responsibility to protect the planet. So we've created a different kind of travel agency. When you book your hotel with us, we offset the carbon footprint created by your trip—at no charge to you."). Similar initiatives exist for hotel bookings as well. *See, e.g.*, *Easily book a green hotel*, BOOKDIFFERENT, https://web.archive.org/web/20170110015310/https://www.bookdifferent.com/en/page/green-hotels/ [https://perma.cc/6X87-QHK8] (last visited June 11, 2018) ("By offering an easy way to choose a green hotel we hope to increase the number of eco-friendly travelers. Having more travelers that look for sustainable options will also work as an incentive for other hotels to go green too.").

214. Marc Gunther, *TripZero: A lean startup tries to 'green' the travel industry*, THE GUARDIAN (Apr. 15, 2014), https://www.theguardian.com/sustainable-business/tripzero-startup-green-travel-industry [https://perma.cc/T27B-YT6A] ("[H]otels pay commissions to TripZero for attracting customers. A portion of the

calculating the emissions generated by a given flight, Glooby takes into account key efficiency factors such as the type of aircraft operating on a given route, as well as the seating density on that particular flight.[215] Some individual airlines are making carbon emissions information available to retail consumers as well. Air New Zealand, for example, automatically displays the cost of offsetting a flight when a customer books online and gives the customer the option of paying for the offset.[216]

5. Addressing Demand Growth

Government efforts to regulate civil aviation are particularly difficult because the growing demand for civil aviation is putting and will continue to put great pressure on the ability of the sector to meet even modest climate targets. Public and private efforts to lower civil aviation emissions will buy time, but unless civil aviation can adopt carbon neutral practices by the second half of this century, demand growth will continue to undermine emissions reduction efforts. Not only is demand projected to increase sharply, but the principal international governmental body that is charged with reducing civil aviation carbon emissions, the ICAO, arguably has a mandate to promote the growth of the civil aviation industry, a mandate that is in competition with, if not superior to, its mandate to reduce carbon emissions.[217]

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commissions is then deployed to buy carbon offsets, for such projects as the largest native-species reforestation campaign in Chile's history, a forest protection project in Kenya, wind turbines for Indiana schools and a methane capture project on a Pennsylvania dairy farm. The offsets are certified by reputable third parties, including the Verified Carbon Standard . . . .").

215. Michele Herrmann, *How To Book Flights Like An Eco-Traveler*, EPICURE & CULTURE (Mar. 1, 2016), https://epicureandculture.com/green-travel-glooby/ [https://perma.cc/7Q3E-54K5] ("With its search results, Glooby calculates certain factors relating to emission levels for flights, including fuel consumption per aircraft, number of seats, and cabin class.")

216. *Customer carbon offset programme*, Air New Zealand, https://www.airnewzealand.com/sustainability-customer-carbon-offset [https://perma.cc/SS3N-4PTN] ("When booking online, the carbon emissions for your flight(s) and the cost to offset them is automatically calculated and displayed. If you decide to offset, the cost of emission units will be added to the total paid for the flight(s).")

217. *See* GEHRING & ROBB, *supra* note 132, at n.106 (noting that Resolution A36/22 asks Member States to "refrain from environmental measures that would

Private initiatives are not a silver bullet for the challenge posed by increasing demand, but they provide new ways to think about the issue. Private initiatives regarding demand reduction may be perceived as less intrusive and threatening than government initiatives on the topic. Several examples already exist. For instance, corporate carbon commitments that include emissions associated with employee travel are likely to lead companies to reduce travel when possible. Video conferencing can reduce the need for travel. Standardization and other developments in video conferencing equipment and software could reduce the risk of technical glitches that discourage video conferencing. Public information campaigns by NGOs could attach reputational consequences to firms' decisions to hold conferences or meetings that require excessive air travel. Similarly, corporate carbon policies and supply-chain contracts can lessen demand as well by creating incentives not to use forms of expedited shipping that require use of aircraft. Of course, private initiatives also rely on the ability to induce for-profit firms to participate, and it may be hard to tackle demand issues absent the coercion and resources of government.

6. Addressing Actors Beyond the Civil Aviation Sector

In addition to airlines, other actors play important roles in civil aviation carbon emissions but are hard to reach through public governance. For instance, many airports operate without meaningful competition, and consequently lack strong incentives to express consumers' preferences for efficiency and climate mitigation. A recent International Air Transport Association report examined competition among airports and found although internet resources give consumers an unprecedented ability to compare travel options, most still have a strong preference for traveling from their local airport.[218] This highlights the fact that even where a majority of consumers have a preference for an airport with reduced carbon emissions, the strong

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adversely affect the orderly and sustainable development of international civil aviation."). Gehring and Robb observe that "ICAO has been accused of serving 'as much, if not more, as a forum for championing causes to preclude the sector from mandatory measures aimed at reducing [greenhouse gas] emissions as it has for developing such measures.'" *Id.* at n.107.

218. JAMES WILTSHIRE, INTERNATIONAL AIR TRANSPORT ASSOCIATION, AIRPORT COMPETITION: MYTH OR REALITY? 12 (2017), https://www.iata.org/publications/economics/Reports/airport_competition_web_2017.pdf.

competitive position that many airports enjoy may undercut their managers' motivations to reduce carbon emissions.[219] Advocacy groups may need to turn to other sources of motivation, such as bondholders, airlines, and corporate travel to induce airport authorities to place a higher priority on carbon emissions reductions.

An example of an opportunity for private initiatives is that financing for airports can include requirements that facilities be constructed in a way that allows for blended wing body design or strut braced wing aircraft to obtain necessary ground services. Similarly, biofuel use could be increased if lending standards required airports to make alternative fuels available. An example of a recent effort regarding biofuels is the Carbon War Room's work to facilitate long-term investment in sustainable aviation fuels at Seattle-Tacoma International Airport ("Sea-Tac").[220] In a 2017 report, the Carbon War Room investigated long-term funding opportunities that would enable Sea-Tac to increase access to sustainable aviation fuels.[221] Reports of this type provide expertise about the infrastructure needed to support alternative fuels and can increase confidence that a prospective bio fuel project will find a market for its fuel.

Although we have identified a number of potential initiatives and actors, our treatment of the private governance option for civil aviation is not intended to be comprehensive. Many other initiatives and actors could play a role in reducing civil aviation's emissions. In addition, the analytic framework we have used in this paper could be applied to other transportation sectors. Comparable initiatives and actors in the context of shipping, for example, suggest comparable opportunities for prompt, inexpensive climate mitigation even in the absence of

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219. *See id.* at 5 ("Regulators and policy makers need to be careful not to rely on airline competition masking the lack of effective competition between airports and the absence of strong commercial imperatives on airport operators to deliver a good outcome for consumers and other airport users in terms of price and service quality.").

220. ROCKY MOUNTAIN INSTITUTE, *Innovative Funding for Sustainable Aviation Fuel at U.S. Airports: Explored at Seattle-Tacoma International,* https://www.rmi.org/insights/reports/innovative-funding-sea-tac-2017/ [https://perma.cc/433U-N8XX].

221. ROCKY MOUNTAIN INSTITUTE-CARBON WAR ROOM & SKYNRG, INNOVATIVE FUNDING FOR SUSTAINABLE AVIATION AT US. AIRPORTS (2017), https://www.rmi.org/wpcontent/uploads/2017/07/RMI_Sustainable_Aviation_Innovative_Funding_SAF_2017.pdf

traditional governance at the international, national, or subnational levels.

CONCLUSION

Civil aviation is becoming an increasingly large part of the total human influence on the atmosphere. Aviation's effects on the climate are increasingly well understood, as are the methods through which these effects could be mitigated. Much of the industry is international and its effects are widely dispersed both through time and geographically, however, and traditional public governance mechanisms may be inadequate to the challenging task of reducing the carbon emissions from civil aviation. Without intervention of some kind, the industry is not on track to play its part in meeting the Paris Agreement's climate goals.

Private environmental governance initiatives can complement existing government efforts and play a direct role in addressing this problem. Opportunities exist in part because the industry has not incorporated major existing efficiency opportunities, and absent new private efforts civil aviation firms lack the motivation and coordinating ability to take advantage of opportunities on the horizon. A private climate governance agenda for civil aviation could include the types of initiatives described here, plus others developed by experts in the field. The agenda could yield prompt, substantial carbon emissions reductions from the civil aviation sector and could complement more comprehensive government action when it occurs.

APPENDIX A: CARBON EMISSIONS BY COUNTRY[222]

2015 total emissions country rank	**Country**	**2015 total carbon dioxide emissions from fuel combustion (million metric tons)**	**2015 per capita carbon dioxide emissions from fuel combustion (metric tons)**
1	China	9040.74	6.59
2	United States	4997.50	15.53
3	India	2066.01	1.58
4	Russia	1468.99	10.19
5	Japan	1141.58	8.99
6	Germany	729.77	8.93
7	South Korea	585.99	11.58
8	Iran	552.40	6.98
9	Canada	549.23	15.32
10	Saudi Arabia	531.46	16.85
11	Brazil	450.79	2.17
12	Mexico	442.31	3.66
13	Indonesia	441.91	1.72
14	South Africa	427.57	7.77
15	United Kingdom	389.75	5.99
16	Australia	380.93	15.83
17	Italy	330.75	5.45
18	Turkey	317.22	4.10
19	France	290.49	4.37
20	Poland	282.40	7.34

222. *Each Country's Share of CO2 Emissions*, *supra* note 25.