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Sustainability and Air Freight Transportation: Lessons from the Global Pandemic

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Abstract: The COVID-19 crisis has transformed the delivery of services and goods by public, private, and non-governmental organizations (NGOs), with one of the largest impacts being in air transport systems. This paper focuses on related opportunities and challenges within air freight transport management, exploring sustainability in light of recent, heavy human and economic costs across the world. There is, in the resulting process of recovery, the potential to create changes in the airline industry and across a number of private and public partnerships that will improve long-term environmental, social, and economic sustainability and stability. This paper also describes the impact of the current environment on air cargo operations to include the role of significantly reduced airline schedules on overall air cargo capacity. It considers the potential role of government in providing the infrastructure for collaboration between sectors, addressing the goals of sustainability, efficiency, effectiveness, and citizen responsiveness. NGOs provide a voice for community groups in ways that governments and corporations may not. Efficient markets link producers at various stages to consumers through global and local supply chains. Integrating key concepts from sustainable development and logistics, this paper explores short-run and long-run planning required by each of the three sectors to tackle the immediate shortfalls in global transportation by air. It then investigates urgent but longer-term environmental issues tied to air transport, such as global climate change, air pollution, and the nonrenewable nature of fossil fuels. Many of the infrastructural changes in the airline industry may offer solutions across public administration. With the tremendous impact of air transport on a number of other goods and services, carefully constructed solutions may have sustainability benefits across industries. As the tragedies of COVID-19 inevitably shake the foundations of organizational systems in all three sectors, this paper offers recommendations for advancing opportunities for a more efficient freight supply industry that minimize negative impacts through sustainable development.

Keywords: sustainability; sustainable development; aviation; air transport; airlines; COVID-19; air cargo



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1. Introduction

The COVID-19 crisis was a major shock to the world economy, disrupting almost every organization—private, public, and nonprofit—in the world. In this piece, we examine the effect of the crisis on the international market for air freight transport. We use the framework of sustainable development to identify the immediate responses, and then use an economic model to speculate on future developments. We look at the trends on the air freight industry, and then discuss the impacts of these changes on public sector organizations (airports and related transportation facilities, and local governments) and nonprofit organizations. The main questions are: will the future air freight industry be more or less sustainable in the long run after the passing of this crisis? How will these

changes affect other businesses, nonprofits, and governments? What are the potential long term sustainability benefits of thoughtful infrastructure changes following the COVID-19 crisis on the airline and on other industries?

2. Sustainability

Drawing from a framework of the UN Economic and Social Commission on Asia and the Pacific [1] and Leuenberger and Bartle [2], there are four dimensions of sustainability:

1. Environmental sustainability: the use of natural capital should be limited to levels that can be replaced by natural regeneration.
2. Economic sustainability: goods and services provided must be cost-effective and achieve the highest social return on physical and natural capital
3. Financial sustainability: long-term balance of funding for capital and operating costs.
4. Social sustainability: consumption should be balanced with social equity, quality of living, and poverty reduction.

These four dimensions should balance each other, with appropriate trade-offs between the four. More formally, the goal should be to maximize the net change in the value of total capital. Total capital includes natural capital, human capital, physical capital and financial capital. Therefore, there can be trade-offs between these four categories as long as net wealth increases. In this context, air cargo transport typically uses natural capital and physical capital (airplanes and related equipment) to produce greater financial capital. Reductions in flights reduces pollution and the negative effect on natural capital but may also reduce financial capital. The question then is, will the net effect on all capital be positive or negative in the long run; that is, is the result more or less sustainable? The location of environmental pollution may also shift as planes are traveling different routes, easing in some areas and worsening in others. Reviewing air travel data before and after COVID-19 may create a natural experiment in which these questions can be better answered. There are few positive impacts of the crisis on human welfare, with a tremendous loss of life and well-being across the world, and these small gains in better understanding the environmental impact of air travel may be one of those.

The relationship between economic activity, the COVID-19 crisis, and sustainability is an important one to explore. The shifting in the location of economic activity resulting from the COVID-19 crisis may threaten all dimensions of sustainability. Social sustainability has been affected by increasing poverty, homelessness and disease. Even in locations where there is economic growth, disruptions caused by higher housing prices and migration may also affect social sustainability. Environmental sustainability may be improved by lower emissions due to reduced flights. Economic sustainability is challenged by shifting wages (increasing in some jobs and decreasing in others) and migration. Financial sustainability is characterized by a balance of costs and revenues. Organizations of all types (public, nonprofit, and private) have seen effects on both sides of their ledgers, requiring them to make changes to rebalance their finances. The airline industry, because it overlaps with the provision of so many goods and services in a global economy, has a powerful impact on all four sustainability dimensions.

The challenge for the future will be to balance these dimensions so the post COVID-19 world will be more sustainable. This may call for easing the transitions of firms and workers to reduce migration and disparate rates of economic growth. Financial changes will undermine the viability of some organizations and stimulate others. Again, managing smooth transitions will be part of the government's role. Social sustainability can be protected by reducing the spread of the disease and strengthening the safety net to protect people from poverty and homelessness. Environmental sustainability can be further enhanced by more efficient routing of flights, packing of cargo and careful logistical planning of freight transport. In the period of recovery, investing in understanding the before and after-effects of COVID-19 on economy and sustainability is critical for long-term social, economic, and environmental sustainability.

3. Economic Model

Our focus is on the impact of the disruptive effects of COVID-19 on the economic relationships in air freight transportation. These disruptions may serve as a point of reevaluation, where there has been a natural experiment and where we have new information about outcomes due to process changes from before and after the crisis. The reduction in business and leisure air travel has had a number of significant economic impacts on the airline industry, with the reduction in the number of flights. Whereas the drop in passenger travel has been costly to airlines, the reduction in air travel can be seen as a positive for environmental sustainability as travel-related carbon emissions are reduced. However, to understand the impact of COVID-19 on the environmental and economic sustainability of the airline industry, it is important to introduce an economic model that examines both the changes in freight and passenger travel. As passenger planes also carry cargo, the relationship is close.

The cost of freight transportation is determined by two major factors: the distance inputs and outputs travel, and the cost per mile of transport [3]. More specifically, the distance factor can be broken down into the distance between (1) the source of input supplies and the assembly location, and (2) the distance from the assembly location to the location of firm's retail locations. The cost per mile of transport will depend on the weight, bulkiness, perishability, fragility and degree of hazard associated with the inputs and outputs. Thus, the firm's assembly location is a key factor affecting the costs of production for firms. As air freight is used for goods for which quick delivery is critical, such as food, medicine, perishable goods and electronics, the firm may be willing to pay more for transport to reduce the time to destination. Firms have the option to transport goods as belly cargo or on cargo-only flights, with COVID-19 reducing the amount of passenger flights and requiring an increase in the number of flights that carry cargo only. Additionally, in a competitive market, firms will seek to minimize costs, and changes in these cost factors will affect the most desirable location for the assembly location. The proximity of raw resources to the assembly site, and of the assembly site to distribution centers and customers is a critical economic input. Also critical is the number of trips raw resources and assembly components must take before reaching the final assembly site.

Changes in the location of assembly sites affects workers at those sites, and can induce migration, which can in turn affect social sustainability. Such migration may reduce or increase inequities, but in either case the change affects workers, their families and their communities. The rapidity of change induced by the COVID-19 crisis creates more stress and also places demands on public and nonprofit organizations to respond to help people affected by these changes.

Firms can be categorized as either "resource-oriented" or "market-oriented." Resource-oriented firms face relatively high costs for transporting their input compared to their output. This may be because the inputs are significantly heavier than the outputs, or more bulky, perishable or fragile. For example, iron ore is significantly heavier than the output of steel, or ears of corn are much heavier than the output, kernels of corn. Flowers are much more perishable than perfume, and strawberries are more perishable and fragile than the jam they can produce. Market-oriented firms are the opposite: the output is heavier than the input, such as canned or bottled drinks, or the output is more fragile or perishable than the inputs, such as baked goods. Resource-oriented firms depend on air transport generally and belly cargo specifically and are highly impacted by increases in transportation costs. As goods such as medicines and food fall into this category due to their fragile and perishable nature, paying attention to their transport can be especially important during times of crisis. Changes in the price of transport could lead to shortages for goods such as medical supplies and personal protection equipment, when they are most needed and when demand is already high.

Over time in a competitive market, firms will select the location that minimizes their costs. Firms may reduce costs by reducing transportation, which also reduces negative environmental impacts. Reducing the number of times a good travels as it moves from being

a raw resource to a finished good has positive economic impacts as well as environmental ones such as less non-renewable energy consumption and less air pollution. However, because transportation is not the only economic variable impacting the cost of production, a number of goods might be produced in regions where the cost of labor is low and/or where the negative externalities of production, such as pollution, may not be built into the price. Unpriced externalities cause inefficiency, and lead to unsustainable practices that become embedded into the economic system.

Low-income communities may disproportionately bear the burden of crisis-related production and transportation because external costs are imposed on these communities. Externalities such as air pollution and environmental damage have long-term cost which are borne not only by the current members of the community, but also by future generations. Increases in transportation costs may increase the price of production materials and raise the price of the good, making it difficult for community members to afford the goods they produce. At the same time, communities who are distant from production sites may face shortages and even higher transportation costs as demand increases. Location of the firm and transportation costs, therefore, have become even more critical factors during the COVID-19 crisis which often exacerbated economic and social sustainability.

Determining the economic and environmental impacts of COVID-19 and related policies in the airline industry is complex. However, these complexities make exploration of air freight transport especially interesting during the COVID-19 pandemic and inform how other systems benefit from and bear costs from the crisis. For instance, subsidies may reduce the cost of fuel or support continued employment of non-essential employees, potentially increasing the amount of air travel in the short run as the airline industry and the firms that use it share the cost burden with taxpayers. However, these fuel price subsidies are likely to aggravate the externality of air pollution and hinder progress towards sustainability. At the same time, the reduction in passenger travel may increase the cost of cargo transport as the number of flights decrease. This paper reviews some of the initial data following the onset of the pandemic to reveal potential economic and environmental patterns and impacts.

3.1. Market Dynamics

When costs change, firms may need to re-think their location and transport decisions. Costs can change because of several factors; of particular interest here is the effect of technological improvements in transportation. For example, if labor costs for assembly vary by location, the firm will have an incentive to locate closer to the lower cost location. Many US firms, for example, have moved their manufacturing facilities to China. Other important cost factors are the cost of motor fuel, energy and water.

COVID-19 caused a major disruption in the cost structure of most markets, including freight markets. The current supply and demand of air freight has resulted in increased transportation costs which will affect long-term location decisions. At the same time, the costs of many inputs changed. Demand and therefore the price of certain output goods increased, such as personal protective equipment (PPE) and toilet paper, causing the price of inputs for these goods to also increase. The demand and price of other goods fell, affecting these markets. The complex relationship between air freight and the delivery of these goods is precisely why a review of the industry is critical post-pandemic.

Disruptions in supply chains have caused a delicately balanced system to break down in some cases. “The sudden shift away from restaurant eating, which in places like the US, used to account for more than half of dining, means farmers have been dumping milk and smashing eggs, with no easy means to redirect their production to either grocery stores, or those in need” [4]. In Belgium, potatoes used to make Belgian frites could not be transported fast enough and the potatoes were diverted to make animal feed and biogas. “By the end of the year 2020, as many as 12,000 people could die a day from hunger linked to COVID-19, potentially more than those perishing from the virus itself” (Ibid).

The efficient, effective, and sustainable transport of goods to citizens is as important as their production.

It is not clear if these changes are permanent or not. Most likely, some but not all of these changes will be permanent. This will affect the location decisions of firms, and in turn their demand for cargo services, and the routes and costs. The disruption has created a tumultuous change in many markets throughout the world. In turn, governments will need to provide physical infrastructure to accommodate these changes, and this will be a burden on their taxpayers. Airports, ports, rail terminals, and highways will all be affected. The capacity demanded for some have increased quickly and significantly, while the demand for others will lapse. As many of these facilities are public, governments in most countries will face new stresses in providing this infrastructure. As populations shift, there will also be changes in the demand for social infrastructure, such as schools and hospitals.

3.2. Economic Sectors

When underlying costs and technology change, firms will experience economic pressure to relocate. Governments then need to provide physical and social infrastructure, among other duties. The nonprofit sector, during the COVID-19 crisis, has attempted to meet gaps in need not met by governments or private for-profit firms. Those commitments have often been in providing public health resources and aid to children and vulnerable adults and there has been some resilience in nonprofit fundraising [5]. However, instability in fundraising opportunities have led to wide differences in the availability of resources through non-profit organizations and have even jeopardized the ability of some of these organizations to keep their doors open [6]. Government and nonprofit organizations, while having some impact on supply chains and resources tied to medical and human services, have largely been unable to provide the full infrastructural support and resources to meet organizational and individual citizen need.

In socialist economies, governments may be more directive about firm location. This may slow the change described above and may increase costs but may also reduce social and economic disruption. Although early reports of interventions from countries such as China were positive, reports six to eight months later ranked China, USA, Mexico, Turkey, Iran and Indonesia among the worst responders to the COVID-19 crisis [7]. Other countries such as Senegal, Denmark, Saudi Arabia, and Iceland are ranked as having stronger government responses [7].

4. The Air Cargo Industry

Air cargo plays a critical role in the transportation of goods and global trade. Air carriers transport USD 6.8 trillion worth of goods each year, representing 35% of global trade by value [8]. As an example of the range of air cargo loads, in a typical 24 h period, international air cargo transports 80,000 flowers, 140,000 tons of cargo, 200 racehorses, and 1.1 million smart phones [9]. Air cargo is generally transported in one of two ways. It may be carried on an aircraft entirely dedicated to the transportation of cargo, sometimes referred to as all cargo carriers or dedicated freighters. Passenger-carrying aircraft may also transport cargo in the lower decks of the aircraft. These are sometimes called combination or combi aircraft, and the cargo is commonly referred to as belly cargo. Major airlines may operate combi aircraft capable of carrying belly cargo, all cargo aircraft, or a combination of both. Emissions by air cargo operators account for 19% of the total commercial aviation global emissions. The breakdown by type of operation reveals 11% of that total comes from belly cargo operations and the remaining balance (8%) is from dedicated freighters. Passenger operations account for the other 81% of global commercial aviation emissions [10].

4.1. Capacity in the COVID-19 World

COVID-19 has devastated the airline industry. The industry has seen unprecedented losses. The International Air Transport Association (IATA) estimates that global airlines

total losses for 2020 were USD 118 billion [11]. In May 2020, US airlines had reduced international flights by 93% and domestic flights by 74% [12]. Across the country airports became ghost towns with the Transportation Security Administration (TSA) processing 95% fewer passengers in April 2020 compared to the year before [12]. In an unprecedented move, airlines parked aircraft anywhere they could find space around the country. By mid-May 2020, US passenger airlines had parked 3188 aircraft, 52% of the fleet [12]. While the numbers have started to uptick, clearly the passenger carrying airlines have a long way to go to a full recovery.

The air cargo industry has also experienced a capacity crunch. In April 2020, global air cargo demand dropped by 27.7% compared to April 2019. To add to the problem, capacity dropped by an even greater rate of 42%. As a result, even with reduced demand, there was not enough capacity to meet that demand primarily because of the loss of belly cargo from the sidelined passenger carrying aircraft [13].

However, air cargo is considered a “bright spot” as compared to passenger carrying airlines [14]. The severe shortage in capacity, primarily due to the loss of belly cargo, resulted in an increase in rates of 30% for the year. “Cargo revenues will reach a near-record USD 110.8 billion in 2020” (up from USD 102.4 billion in 2019) [14].

As Figure 1 shows, the capacity has experienced a sharp decline for both belly cargo operators and all cargo operators with a significant reduction in belly cargo compared to one year earlier. The reduction in belly cargo capacity hit its trough in April 2020 with a 75% drop in capacity. The 75% drop in international belly cargo reduced total global air cargo capacity by 40% [15]. This contributed to the increase in rates. In particular, chartered air cargo rates have skyrocketed, doubling and even tripling in some markets. In March, the increase was referred to as an “absolutely crazy, ultra-competitive” market [16]. By November of 2020, belly cargo capacity had recovered somewhat to a 53% reduction from the previous year and dedicated freighters increased slightly [17]. However, these positive trends were not enough to meet demand, particularly during the peak holiday season. IATA reported that air cargo rates “have continued to rise in November and are now around 70% higher than last year at the global level” [17]. This illustrates the economic disruption referred to earlier and suggests that there will likely be social disruption as well in the affected communities.

To address system cargo capacity, some passenger airlines have utilized their passenger carrying aircraft as all cargo flights. Passenger carrying aircraft are normally restricted to carry cargo only in the designated lower cargo areas. In May of 2020, the Federal Aviation Administration (FAA) granted an exemption to allow passenger carrying aircraft to carry freight in the main cabin when no passengers are being carried [18]. This exemption, originally expiring at the end of 2020, was extended until the end of July 2021. As of June 2020, IATA estimated that passenger airlines had operated approximately 1300 flights as all-cargo [13]. To expand on this option, on 14 July 2020, the FAA issued an exemption that allows airlines conducting Federal Aviation Regulation (FAR) Part 121 operations (includes passenger carrying major airlines), the option to remove some or all seats for the carrying of cargo on the main cabin deck when no passengers are being carried [18]. These unusual exemptions are indicative of the air cargo capacity shortage.

By June 2020, with international passenger flights starting to increase once again, air cargo rates started to decline, in part due to the increased belly cargo capacity. By example, in the first week in June, cargo rates from China to North America were down 30% from the previous week, however they were still 141% higher than the previous year. Rates from China to Europe were down 12% the first week of June but were still 254% higher than the previous year [15]. Overall, cargo revenues are forecast to remain strong in 2021 with estimated record revenues of USD 138 billion, representing 23% of total global airline revenues, double the normal share [14]. Despite this volatility in prices, the air cargo industry seems to have used the flexibility in transport methods and in federal regulations to remain profitable.

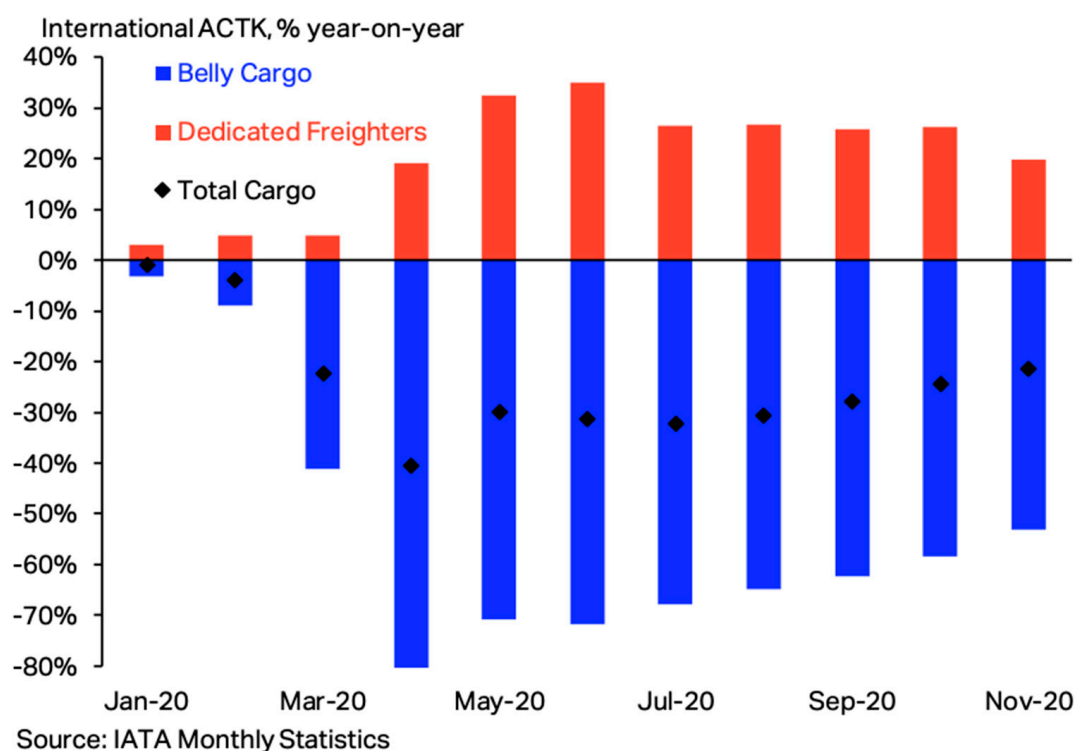


Figure 1. International belly cargo and freighter capacity growth (in available cargo tonne-kilometres [ACTK]) [17].

4.2. CARES Act Effect on Costs

The Coronavirus Aid, Relief, and Economic Security Act (CARES Act) added provisions to help keep air freight moving which also reduced costs for air carriers. Significantly the Act resulted in an excise tax holiday for commercial operators. The holiday, which ran until 31 December 2020, waived the fuel excise tax and the 6.25% tax on amounts paid for the transportation of property [19]. The CARES Act also provided USD 4 billion in payroll protection for cargo carriers. By comparison, the Act provided USD 25 billion in payroll protection for passenger carriers [20]. A total of 287 passenger carriers participated in the payroll protection program including United Airlines, American Airlines, Southwest Airlines, and Delta Air Lines [20]. Since the increased demand in the market has led to increased revenues for cargo carriers, they did not participate at the same rate. Only 28 cargo carriers participated in the payroll protection program and major carriers; for example, UPS and FedEx did not participate [20]. The CARES Act is an example of using governmental resources to save an essential private service. In general, the airlines were fiscally responsible stewards of these resources.

4.3. Jet Fuel Costs

One bright spot regarding cost has been the decline in jet fuel prices. According to the IATA jet fuel analysis, as of mid-July 2020 jet fuel prices were 45% lower than the prior year. IATA estimates that for the year 2020, this will result in global airline industry savings of nearly USD 70 billion [21]. Jet fuel represents a major expense for airlines, about 15 to 20% of total expenses [22]. With the price of jet fuel so low, airlines may have less incentive to invest in biofuels. Biofuels, which use sustainable sources, are believed by some to be “the only real option to achieve significant reductions in aviation emissions by 2050” [23]. Declining jet fuel prices also removes a key incentive for airlines to buy newer, more fuel efficient aircraft, negatively impacting sales for aircraft manufacturers and prolonging the use of less efficient aircraft producing higher levels of emissions [24].

4.4. Role in Supplying Medical Needs

Both FedEx and UPS have participated in addressing the need for medical equipment during this pandemic. UPS collaborated with the Federal Emergency Management Agency (FEMA) to provide supply chain services for essential medical equipment including PPE, respirators, N95 masks, and gloves [25]. FedEx established logistics service lines for the delivery of supplies and test kits.

The next wave in supplying medical needs is supplying vaccines. Described as “a historic supply chain feat,” the challenge will be to distribute millions of doses of vaccines across the globe [26]. The air cargo giant UPS, has prepared for that challenge by building two vaccine storage facilities near major UPS hubs in Kentucky and the Netherlands. This is good example of a rapid market response to a very complex problem. The time and temperature sensitivity of the vaccines are critical and require precision. The UPS facilities include 600 deep freezers, each of which can accommodate 48,000 vials of vaccines at temperatures as low as -112 degrees Fahrenheit [26]. There will also be the need for transportation companies to invest in additional refrigerated trucks for this effort. As discussed above, this is a classic example of a resource-oriented firm which depends on the availability of highly reliable air cargo transit to deliver the vaccines. It will also require the cooperation of governments and local airports.

4.5. Role in COVID-19 Response: Public-Private Partnerships

US airlines have played a key role in providing cargo services to address the shortfall of medical supplies during the COVID-19 pandemic. One example is the public-private partnership, Project Air Bridge, that was established between FEMA and multiple airlines to provide needed supplies to the US. FEMA partnered with all cargo airlines including FedEx, UPS, Atlas Air, and Amazon to charter aircraft for the project. Project Air Bridge began in March 2020 and was phased out at the end of June 2020. During that time, they conducted approximately 249 flights and carried nearly 1.5 million N95 respirators, 937 million gloves, over 2.4 million thermometers, 50 million gowns and additional supplies [27]. The program was not without controversy as Senators Warren, Schumer, and Blumenthal have called for an investigation into Project Air Bridge over concerns such as the effectiveness of getting supplies to the areas of most need, the chain of command within the project, limited amount of supplies provided, and equipment pricing [28].

In another example, air freight companies are contributing to Operation Warp Speed. The program was designed as a public-private partnership for the development and delivery of COVID-19 vaccines. It includes government organizations such as the Centers for Disease Control and Prevention (CDC), Department of Health and Human Services, and the Department of Defense (DoD) [29]. These agencies worked with pharmaceutical firms on the development of the vaccine. Cargo airlines, including FedEx and UPS, are providing cargo capacity for vaccine delivery and play a critical role in distribution.

5. Impact of COVID-19 on Air Cargo Sustainability

5.1. Aviation Medical Supply Impacts

Medical supplies and health services are among the most important resources impacted by the COVID-19 related changes to airline cargo management. An unintended cost of reductions in passenger airline service due to COVID-19 is the disruption to the supply chains in the pharmaceutical industry. Transport in passenger jets was reduced and cost of freight rose from a few US dollars per kilogram to over USD 15 per kilogram [30]. In the wake of supply chain disruptions due to COVID-19, aviation transportation logistics operations have had to become even more nimble and responsive, including in the transport of medical supplies such as masks, protective suits, and gloves across the globe [31]. It may be too early to determine the success of these changes or their impacts on sustainability, but that will be important to consider as new data become available.

One important anticipated change in medical supply management is a move away from a single national center for sourcing medicine and protective equipment. Singular

reliance on China's pharmaceutical industry, for instance is less likely [32]. France has begun to transition its pharmaceutical production away from China and India in light of the supply interruptions of COVID-19, and Japan has invested USD 2.2 billion into shifting international investments from China, focusing on medical supplies and pharmaceuticals [33–35]. These changes will likely be long-term and affect the location of assembly, and so transport of inputs and outputs.

5.2. Sustainability and Aviation after COVID-19

In the long-run, gains in environmental sustainability from reduced air pollution and carbon emissions may not improve as the impacts of COVID-19 on air transport fade. Due to the necessary focus on the financial health of the industry, there may be environmental risks of the return to normal [36]. As an example, a financially devastated airline industry may be less inclined to invest in advancements such as alternative fuels or electric propulsion aircraft which would reduce the environmental impact of air transportation. Technological investments that do not provide relief in the form of cost savings may be lower in priority at a time when airlines are trying to survive. The ICAO efforts to address sustainability in air transportation focus on three key areas: technology, operations, and the development of sustainable aviation fuels. Developments in technology may be impacted by economic stressors. Advancements in sustainability related to operations in some cases are dependent on onboard navigation technology which requires investment from the operator. This may also be impacted by the current devastation of the passenger-carrying air transportation industry. There is a limited window during which the sustainability related changes to air transport can be made post-pandemic. These shifts to sustainability are critical because of the number of industries impacted and because of the long-term economic, social, and environmental outcomes.

Long-standing commitments to reducing carbon dioxide emissions and mitigating global climate change may come in second to the needed economic recovery following the pandemic. For instance, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), developed by the ICAO which has 193 signatory countries and is a market-based emissions reduction program, may not result in agreed upon outcomes. The goal to limit net emissions growth and allow airlines to purchase emissions offset credits beginning in 2021 may be diverted by economic stressors [34]. Absent financial aid or changes in investment decisions by the airlines, progress to more sustainable air transportation is likely to be stalled.

As the industry builds back demand and resultingly increases flight operations, the end result will likely be a return to pre-COVID levels of carbon emissions. In the long-run, “ever-increasing carbon emissions from aviation, and the issues they cause, will ultimately destroy relationships with consumers and regulators, resulting in COVID-like demand destruction, but with no natural recovery on the horizon” [36]. There is a one-time opportunity to invest in a future that is more sustainable. A lost opportunity means that the negative impacts on the environment and on climate change may be impossible to recover from.

5.3. Response of Markets to COVID-19

Early predictions on impacts of COVID-19 on markets and transport are already emerging. According to Bhattacharjee et al. [37], there are four likely patterns. First, there will be a long-term “shift from a freight-heavy to a freight-light economy.” Second, although the recovery may be uneven across sectors and commodities, “trade flows will bounce back and grow at least in line with GDP.” Additionally, there will be an acceleration in the adoption of e-commerce. Finally, there is likely to be ongoing uncertainty about US energy production growth and the strength of that growth. Additionally, in light of production interruptions due to COVID-19, it is predicted that there will be shifts away from Chinese centered production. The most likely scenario is a China plus one model, wherein a second production site outside of China is developed by firms to ensure continuity in future

crises [32,38]. Anticipated production and transportation changes will have a significant impact on environmental sustainability. There are both opportunities and challenges presented by the COVID-19 crisis in improving sustainability related outcomes.

One of these examples is a shift in the source of the emissions. The pandemic has created an unplanned, unintended increase on ground delivery due to the high volume of online ordering. Firms such as FedEx that are used to seeing a four to five week peak during the holidays, are experiencing surges in demand for delivery that exceed the typical holiday peak and have lasted for many weeks [39]. While ground delivery providers are used to preparing for the holiday peak, this unexpected and lengthy surge has resulted in the need to hire more drivers and run extra trucks, increasing emissions from ground delivery sources. This is offset by the overall reduced mobility of people due to the significant reduction in air travel and the reduced movement of people on the roads due to lockdowns or simply staying home to avoid COVID-19 exposure. The end result is lower emissions. Overall, carbon emission levels are expected to drop 7% in 2020, yet the 2020 levels are still 11 times higher than they were in 1990 [40].

6. Conclusions

The COVID-19 crisis has created an opportunity for some sustainability gains in air transport, mostly in the short-run. These gains, such as a reduction in carbon dioxide emissions due to lower fuel consumption from limited passenger travel, are not only temporary, but may be offset by other changes, such as an increase in cargo transport. In order for sustainability gains to stick, it is important to take a planned, long-run approach, building on data gathered before and after the COVID-19 crisis. Implementation based on those data have global economic and environmental impacts. This paper has discussed how location of firm and production sites, the collaboration between governments and the airline industry, and the management and transport of emergency resources are critical areas for review as longer-term approaches are adopted. Building on the implemented changes and on data, it is possible to transition some of the gains into a plan.

The response to the COVID-19 crisis by airlines has already demonstrated three important lessons. First, the airline industry is able to quickly and effectively respond to crises, even with tight financial margins. Examples include the conversion of flights from passenger to cargo freight. Second, there is active collaboration between airlines, governments, and NGOs in managing COVID-19 related resources such as vaccines, PPE, and other medical supplies and equipment. These partnerships have had critical impacts on human welfare and economic outcomes. Third, governmental resources are able to support short-run changes, fostering economic stability and a shared purpose between public and private actors. The quick response under challenging conditions is the free market at its best. It enhanced economic sustainability by moving resources where they were needed. The regulatory flexibility allowed by governments was also critical and likely enhanced the financial sustainability of air freight businesses and airlines. The CARES Act and the Payroll Protection Program enhanced social sustainability by enabling many businesses and nonprofits to stay in business, reducing unemployment and other disruptions. The flexibility and nimbleness in action to save lives and business during the crisis and the ability to introduce system-wide change quickly and effectively should now be directed at the environmental and economic disasters and challenges that are to follow.

For there to be a long-term benefit from the lessons learned following the COVID-19 crisis, it is important to actively pursue sustainability goals into the future. The small, incremental changes must be translated into larger scale infrastructural shifts that protect human welfare and the environment while pursuing economically viable, efficient, and effective airline transport systems. For example, the data available before and after the crisis can be used to reevaluate balance of passenger to cargo flights, types and size of planes, number of flights, and other logistics. Such an evaluation could lead to a different balance of ground versus air transport, which could increase sustainability and lower negative environmental impacts. This is a planned transition from the incremental and

reactionary changes in passenger and cargo transported caused by COVID-19. These types of planned transitions can be applied across industries and at a global scale.

Another example is the reevaluation of fossil fuel use and carbon dioxide emissions in airline transport. In the short run, there have been areas in which fuel use and correlated emissions have declined. These, too, have been a reaction directly to the crisis and are not likely to last into the distant future. Commitment to planning that reduces emissions from air travel, signing on to CORSIA, developing alternative fuel sources, and electric propulsion investments may be possible longer-run solutions that will increase environmental sustainability.

The transporting of medical equipment during the COVID-19 crisis has demonstrated how critical air transport is to human welfare and economic stability. In partnership with public and private firms, there is the possibility of creating secondary locations within and outside of a specific country. This ensures that resources are available through redundant systems but leads to changes in logistics such as more storage, more options for local production, and a possible reduction in longer distance air transport. This redundancy can reduce turmoil caused by disruptions in supply chains and enhance social sustainability. Public-private collaboration in creating effective and efficient systems is critical and is another planning space in which sustainability can be integrated.

The impacts of COVID-19 on the airline industry are likely to be long-term, but are a result of reactionary, short-run response to meet the demands of the active crisis. However, this tragedy has created an opportunity for learning in which new data can lead to new infrastructure and operations that can be more economically sustainable for the airline industry and the communities they serve, while also increasing benefits to human welfare and social sustainability. This type of a planning and action shift, from short-run to long-run and from reactionary to data informed, is possible if there is collaboration between public and private sectors. Further, in the airline industry where government support is long standing, it makes sense for government to assert a more deliberate policy supporting economic and environmental sustainability. By also bringing in NGOs already committed to environmental and social sustainability, it is possible that the crisis can be turned into a catalyst for fostering future gains.

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References

1. United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP); Asian Institute for Transport Development. Sustainable Transport Pricing and Charges: Principles and Issues (ST/ESCAP/139). 2001. Available online: <https://www.unescap.org/resources/sustainable-transport-pricing-and-charges-principles-and-issues-2001> (accessed on 25 March 2021).
2. Leuenberger, D.Z.; Bartle, J.R. *Sustainable Development for Public Administration*; M.E. Sharpe: Armonk, NY, USA, 2009; ISBN 978-07-6562-273-0.
3. O'Sullivan, A. *Urban Economics*, 9th ed.; McGraw Hill Education: New York, NY, USA, 2019.
4. Durisin, M.; Rembert, E.; Freitas, T. A Tenth of the World Could Go Hungry While Crops Rot in Fields. 2020. Available online: <https://www.bloomberg.com/news/features/2020-08-31/hunger-is-threatening-to-kill-more-people-than-covid-this-year> (accessed on 31 August 2020).
5. Hamlin, N. What Data Science Reveals about Nonprofit Needs Amid COVID-19. 2020. Available online: <https://www.globalgiving.org/learn/COVID-nonprofits-data-science> (accessed on 3 September 2020).
6. Levine, M. Nonprofits Struggle to Stay Alive amid COVID-19. Available online: <https://nonprofitquarterly.org/nonprofits-struggle-to-stay-alive-amid-covid-19/> (accessed on 23 June 2020).
7. Meier, L.U.S. COVID-19 Response Ranked among Worse in the World: Report. Available online: <https://www.washingtontimes.com/news/2020/aug/6/us-covid-19-response-ranked-among-worse-world-repo/> (accessed on 6 August 2020).
8. International Air Transport Association [IATA]. Action Cargo: COVID-19. 2021. Available online: <https://www.iata.org/en/programs/cargo/> (accessed on 11 January 2021).

9. IATA. The Value of Air Cargo: Air Cargo Makes It Happen. 2020. Available online: <https://www.iata.org/contentassets/4d3961c878894c8a8725278607d8ad52/air-cargo-brochure.pdf> (accessed on 21 October 2020).
10. Graver, B.; Zhang, K.; Rutherford, D. CO₂ Emissions from Commercial Aviation, 2018. 2019. Available online: <https://theicct.org/publications/co2-emissions-commercial-aviation-2018> (accessed on 21 October 2020).
11. International Air Transport Association. Deep Losses Continue Into 2021. 2020. Available online: <https://www.iata.org/en/pressroom/pr/2020-11-24-01/> (accessed on 21 October 2020).
12. Airlines for America. Tracking the Impacts of Covid-19. Available online: <https://www.airlines.org/dataset/impact-of-covid19-data-updates/#> (accessed on 14 May 2020).
13. IATA. Air Cargo Capacity Crunch: Demand Plummets but Capacity Disappears Even Faster. 2020. Available online: <https://go.updates.iata.org/webmail/123902/1158006775/f9ec1ad9549090c8b11266c01ffb068968c74bffd095aaf1e8eb3523195363fc> (accessed on 27 August 2020).
14. IATA. Industry Losses to Top \$84 Billion in 2020. 2020. Available online: <https://go.updates.iata.org/webmail/123902/1160675010/f9ec1ad9549090c8b11266c01ffb068968c74bffd095aaf1e8eb3523195363fc> (accessed on 27 August 2020).
15. Knowler, G. Air Freight Rates Fall on Easing Capacity-Demand Imbalance. 2020. Available online: https://www.joc.com/air-cargo/air-freight-rates-fall-easing-capacity-demand-imbalance_20200602.html (accessed on 27 August 2020).
16. Curran, E. The “Mad Rush” for Medical Gear Triples Air Cargo Rates. 2020. Available online: <https://www.bloomberg.com/news/articles/2020-04-16/supply-chains-latest-virus-sees-air-freight-costs-soar> (accessed on 21 October 2020).
17. IATA. Air Cargo Market Analysis November 2020. 2020. Available online: <https://www.iata.org/en/iata-repository/publications/economic-reports/air-freight-monthly-analysis---november-2020/> (accessed on 2 December 2020).
18. Federal Aviation Administration. FAA Partial Grant of Exemption. Exemption Number 18584. 2020. Available online: https://www.faa.gov/coronavirus/regulatory_updates/media/18584.pdf (accessed on 27 August 2020).
19. Internal Revenue Service. FAQs: Aviation Excise Tax Holiday under the CARES Act. 2020. Available online: <https://www.irs.gov/newsroom/faqs-aviation-excise-tax-holiday-under-the-cares-act> (accessed on 2 December 2020).
20. U.S. Department of the Treasury. Payroll Support Program Payment. 2020. Available online: <https://home.treasury.gov/policy-issues/cares/preserving-jobs-for-american-industry/payroll-support-program-payments> (accessed on 11 February 2021).
21. IATA. Jet Fuel Price Monitor. 2020. Available online: <https://www.iata.org/en/publications/economics/fuel-monitor/> (accessed on 2 December 2020).
22. U.S. Department of Transportation. What the Cost of Airline Fuel Means to You. 2019. Available online: <https://www.transportation.gov/administrations/assistant-secretary-research-and-technology/what-cost-airline-fuel-means-you> (accessed on 21 October 2020).
23. International Renewable Energy Agency. Biofuels for Aviation: Technology Brief. 2017. Available online: <https://www.irena.org/publications/2017/Feb/Biofuels-for-aviation-Technology-brief> (accessed on 21 October 2020).
24. Josephs, L. The Plunge in Oil Prices is the Last Thing Boeing and Airbus Need Right Now. 2020. Available online: <https://www.cnbc.com/2020/04/20/the-oil-plunge-is-the-last-thing-boeing-and-airbus-needs-on-top-of-the-coronavirus-pandemic.html> (accessed on 2 December 2020).
25. Forde, M. How the CARES Act Will Affect Supply Chains. 2020. Available online: <https://www.supplychaindive.com/news/coronavirus-cares-act-supply-chains/575262/> (accessed on 21 October 2020).
26. Leffert, C. UPS Readies Freezer Farms to Ship Virus Vaccine. 2020. Available online: <https://www.bloomberg.com/news/articles/2020-08-03/ups-readies-freezer-farms-to-ship-virus-vaccine-if-we-get-one> (accessed on 27 August 2020).
27. Federal Emergency Management Agency. FEMA Phasing out Project Airbridge. 2020. Available online: <https://www.fema.gov/news-release/2020/06/18/fema-phasing-out-project-airbridge> (accessed on 21 October 2020).
28. Warren, E. Warren, Schumer, Blumenthal Release New Findings and Documents from Investigation of Trump-Kushner “Project Air Bridge” Coronavirus Response. 2020. Available online: <https://www.warren.senate.gov/oversight/letters/warren-schumer-blumenthal-release-new-findings-and-documents-from-investigation-of-trump-kushner-project-air-bridge-coronavirus-response> (accessed on 11 January 2021).
29. Health and Human Services. From the Factory to the Frontlines: The Operation Warp Speed Strategy for Distributing a COVID-19 Vaccine. Available online: <https://www.hhs.gov/sites/default/files/strategy-for-distributing-covid-19-vaccine.pdf> (accessed on 11 January 2021).
30. Duncan, I. Drug Industry Warns That Cuts to Passenger Airline Service Have Put Medical Supplies at Risk. 2020. Available online: https://www.washingtonpost.com/local/trafficandcommuting/drug-industry-warns-that-cuts-to-passenger-airline-service-has-put-medical-supplies-at-risk/2020/05/02/d34a7c96-83ff-11ea-ae26-989cfce1c7c7_story.html (accessed on 21 October 2020).
31. Wade, S. The Frontlines of COVID-19: Logistics Firms Go All-in to Transport Life-Saving Medical Equipment. 2020. Available online: <https://www.forbes.com/sites/wadeshepard/2020/03/31/the-frontlines-of-covid-19-logistics-firms-go-all-in-to-transport-life-saving-medical-equipment/#5ca0f070b3ad> (accessed on 11 January 2021).
32. Pandey, A. After Coronavirus, Don’t Write off China as World’s Factory. 2020. Available online: <https://www.google.com/amp/s/amp.dw.com/en/after-coronavirus-dont-write-off-china-as-worlds-factory/a-53258107> (accessed on 10 November 2020).
33. Gupta, Y. Shift of Supply Chains from China Accelerates. 2020. Available online: <https://www.google.com/amp/s/www.tribuneindia.com/news/comment/shift-of-supply-chains-from-china-accelerates-81847> (accessed on 2 December 2020).

34. Reynolds, I.; Urabe, E. Japan to Fund Firms to Shift Production out of China. 2020. Available online: <https://www.bloomberg.com/news/articles/2020-04-08/japan-to-fund-firms-to-shift-production-out-of-china> (accessed on 2 December 2020).
35. Laidi, A. Covid-19 Forces France to Look at Relocating Its Pharmaceutical Industry. 2020. Available online: <https://www.france24.com/en/20200514-covid-19-forces-france-to-look-at-relocating-its-pharmaceutical-industry> (accessed on 21 October 2020).
36. Mullaney, D.; Baronett, L. Aviation's Climate Commitments: Clean Skies from COVID-19 and Beyond. 2020. Available online: <https://www.internationalairportreview.com/article/115427/covid-19-sustainability-aviation-opportunities/> (accessed on 11 January 2021).
37. Bhattacharjee, D.; Gould, R.; Greenberg, E.; Kandel, M. US Freight after COVID-19: What's Next? Available online: <https://www.mckinsey.com/industries/travel-logistics-and-transport-infrastructure/our-insights/us-freight-after-covid-19-whats-next#> (accessed on 11 January 2021).
38. Oxford Business Group. Post Covid-19, Can Emerging Markets Capitalise on a Shift in Manufacturing away from China? 2020. Available online: <https://oxfordbusinessgroup.com/news/post-covid-19-can-emerging-markets-capitalise-shift-manufacturing-away-china> (accessed on 27 August 2020).
39. Garland, M. FedEx Ground Contractors Say COVID-19 Is Causing a Volume Spike Surpassing the Holidays. 2020. Available online: <https://www.commercialappeal.com/story/money/industries/logistics/2020/05/21/fedex-ground-shipping-demand-online-shopping-deliveries/5224789002/> (accessed on 2 December 2020).
40. Barone, E.; Tweeten, L.; Wislon, C.; Law, T. The Coronavirus Pandemic Has Caused Carbon Emissions to Drop. But That Likely Won't Last. 2020. Available online: <https://time.com/5864374/coronavirus-carbon-emissions/> (accessed on 2 December 2020).