

# Investigating the Impact of COVID-19 Disruption on the Decarbonisation Agenda at Airports: Grounded or Ready for Take-off?

## Supplementary Material S1: Literature Review

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This section is structured as follows: Section 1.1 reviews the current literature and outlines the immediate impacts of COVID-19 on airports and air transport, including economic, environmental, and social impacts. Section 1.2 considers how the sustainability transition of the sector may be affected.

### 1.1. Impact of COVID-19 on Airports: Economic, Environmental and Social Impacts

The economic impact of COVID-19 on the aviation sector has been reported in detail and it is widely acknowledged that this sector is one of the most significantly affected by the pandemic. Compared to a business-as-usual (BAU) scenario, the global impact of COVID-19 in 2020 is estimated to represent a reduction of up to 2.893 billion passengers and a loss of approximately USD 391 billion gross operating revenues for airlines (Air Transport Bureau, 2021). For airports globally, a 64.2% loss in passenger traffic and USD 111.8 billion in airport revenues is estimated for 2020 compared to a BAU scenario (*Ibid.*).

As airport revenues are a function of air traffic and passenger numbers, airports are facing severely contracted revenues against a model that typically operates with high fixed costs. Serrano and Kazda (2020) consider the possible short-, medium- and long-term implications of COVID-19 on airports, with a focus on economic impacts. In the short term, they highlight a likely focus on business continuity, re-evaluation of operations and processes, reduction in Capital Expenditure (CAPEX) and difficulties balancing Operational Expenditure (OPEX) against an uncertain recovery pathway. They add that retail tenants will be under similar financial strain, which is problematic for airports as this typically represents a major component of their non-aeronautical revenues.

As a result of reduced air traffic, many airports have been quick to emphasise COVID-related environmental benefits in the short-term alleviation of greenhouse gas (GHG) emissions. Indeed, the estimated global CO<sub>2</sub> decrease resulting from COVID-19 disruption in the first half of 2020 stands at 1551 Mt CO<sub>2</sub>, with aviation emissions representing a fall of 200.8Mt CO<sub>2</sub> (-43.9%) on 2019 levels (Liu et al., 2020). However, CO<sub>2</sub> should not be considered alone. Forster et al. (2020) estimate an overall negligible impact from the pandemic on global climate (cooling of 0.01 degrees Celsius by 2030), from analysis of changes in ten GHGs in early 2020. Localised improvements in air quality and noise pollution at airports are likely to have been realised but are not in the scope of this study.

GHG emissions aside, the literature calls attention to other potential environmental impacts resulting from COVID-19, for instance, the increase in Single Use Plastics (SUP) and hazardous wastes as a result of virus management and various behavioural changes (Jones and Comfort, 2020). COVID-19 has been described as a potential catalyst for reconsidering how we manage plastic wastes (Klemeš et al., 2020). Patrício Silva et al. (2021) call for the introduction of more suitable dynamic waste management for crises such as COVID-19, where current waste management systems may be unsuitable or inflexible. This may certainly be the case for larger airports where contracts, processes and costs may have been fixed to an assumed steady waste supply and composition.

Evident also is a renewed call for the pursuit of circular economy principles and waste valorisation solutions for the benefit of system resilience to future shocks, including recommendations for the aviation industry (Ibn-Mohammed et al., 2021). With potential to alleviate waste issues, studies have already emerged assessing waste valorisation opportunities for COVID-related PPE, such as syngas production through pyrolysis (Jung et al., 2021).

Beyond economic and environmental impacts, comparatively few studies have considered the social impacts of COVID-19 on airports. Buhusayen, Seet and Coetzer (2020) note that turnaround management strategies (reorganisation, repositioning and retrenchment) in response to crises can, despite the financial benefits, negatively impact workers and organisational culture. Indeed, through semi-structured interviews with frontline staff in airport service providers, the authors found that insufficient human resources and lack of communications resulting from these strategies are serious issues affecting airport workers throughout the COVID-19 crisis. Others have captured insights on behaviour change of airport workers due to COVID-19 and analysed their perception of risk, noting changes in relationships with co-workers and in precautions taken at work (Malagón-Rojas et al., 2020).

#### *Epidemiology and Airports*

The susceptibility of the air transport system to pandemics is not revelatory; previous outbreaks (SARS, 2003) and other environmental shocks have demonstrated this. In response to previous events, researchers have addressed this relationship and noted the need for implementation of pandemic control measures at airports. Chung (2015, p.50) states, *“without effective control measures, economic growth would be fragile as airports’ reputation and confidence could be eroded overnight in times of pandemic crisis”*, this recommendation being largely unheeded. Recognition of aviation’s role in epidemics has been recently elevated, with studies modelling disease spread through the European air transport system and the identification of critical airports (Nikolaou and Dimitriou, 2020).

Ensuring biosecurity for passengers and workers has been a priority for airports since the start of the pandemic and has the potential to undermine existing climate change mitigation measures or wider sustainability gains won over recent years. Studies on transmission mitigation measures at airports include the assessment of novel boarding solutions compared to a standard random boarding scenario, demonstrating the effectiveness of distancing, reducing hand baggage and two-door boarding (Schultz and Fuchte, 2020). Such solutions could also be coupled with the digitisation and optimisation of boarding and other elements of the passenger journey to realise benefits to both environment and passenger health. Responding to social distancing requirements, work has also been undertaken to model terminal subsystems to assess levels of service and suitability of areas to handle distancing should passenger levels return to pre-COVID levels (Di Mascio et al., 2020). Terminal capacity and operation post-COVID may have carbon implications through new infrastructure, retrofit and energy requirements.

Taking the above impacts into account, this study asks if any changes in operation or behaviours at the airport due to COVID-19 have positively or negatively impacted climate change mitigation and the wider environmental sustainability agenda at airports.

#### *Impact on airport climate change mitigation and environmental sustainability initiatives*

It can be hypothesised that the current financial stress on aviation organisations has led to a focus on business survival and a deprioritisation of environmental sustainability initiatives. Barreiro-Gen, Lozano and Zafar (2020), through pre- and mid-COVID surveys to a wide range of organisation types, location and sizes, found that the principal sustainability priority is now social, with environmental sustainability falling in importance irrespective of organisation characteristics, highlighting the

potential risk of losing environmental sustainability gains made over recent years. Amankwah-Amoah (2020,p.2) considers that financial strain, and potential non-market impacts such as changes in environmental regulation with the intention of supporting businesses, may lead to a deprioritisation of environmental sustainability initiatives, stating “*these are often jettisoned as soon as they are confronted by new and difficult to predict challenges*”.

Reflecting on previous global crises, the connection between crises and an organisation’s sustainability or corporate social responsibility (CSR) initiatives has been established (Giannarakis and Theotokas, 2011). There is potential for sustainability initiatives to be reduced in number, delayed or reneged on, as a result of financial crises (Karaibrahimolu, 2010; Njoroge, 2009). On the other hand, the incorporation of such initiatives has been shown to provide organisations with resilience in times of financial crisis (Arevalo and Aravind, 2010). Belén Fernández and Souto (2009,p.44) reflect on the relationship between crises and CSR initiatives: that the lack of initiatives can indeed help *generate* crises; that initiatives can aid organisations in *surviving* crises; yet, in times of crisis, the implementation of such initiatives is difficult as an additional cost. Although CSR initiatives are somewhat removed from more applied and often technology-based climate change mitigation interventions, a similar relationship is evident in the current crisis: aviation in its pre-COVID form has aided the creation of the crisis it faces; implementation of innovative and transformative solutions are required to progress, yet the costs of doing so make this difficult in times of financial crisis.

Whether Airport Operators’ climate change mitigation interventions have been abandoned due to the impacts of COVID-19 is tested in this study. With the climate change and aviation debate arguably reaching a fever pitch pre-COVID in public, government and corporate arenas, it could be hypothesised that aviation organisations will be reluctant to abandon sustainability initiatives. Others have called out this tension: Jones and Comfort (2020) note that organisations will be eager to continue to heed investor and stakeholder demands for sustainable transition, but at the same time, are challenged by capital scarcity and a focus on business continuity.

#### *Post-COVID Airports and Air Travel*

The literature has initiated considerable discussion on how airports may transform in response to the pandemic. On more immediate solutions to financial strain, Serrano and Kazda (2020) consider solutions such as diversification of revenue streams for future resilience, and the outsourcing of services for cost-savings. Although both feasible solutions, the creation of new offerings or out-sourcing contracts must come attached to environmental and sustainability considerations and requirements. Forsyth, Guimard and Niemeier (2020) have discussed how airports, burdened by high fixed costs and low revenue, could react to demand collapse in terms of altering airport charges, based on the various institutional environments of airports (public, private, regulated, etc.). They provide policy options available based on these categories to avoid increases in charges, and thus, passing the burden on to airport users. They note that in some cases, government assistance is justified, giving two arguments: that government is responsible for the decline in demand and that fiscal support for airports would be supporting the wider economic benefits that the sector brings. Others have given consideration to the potential futures of airport investment and privatisation post-COVID (Graham, 2020).

A call for the digital transformation of airports is also evident in the literature. Drljača et al. (2020) argue for the implementation of “Industry 4.0” and Smart Airport Concepts, citing the multiple benefits of operational efficiency, reducing operational costs and improving passenger experience; however, little focus is given to the potential environmental benefits of these initiatives. Additionally, the authors note that experienced human resources are required for maximum impact of these concepts, yet many

airports have seen a reduction in highly experienced management and operational staff with knowledge of the airport subsystems. Further, the rapid investment and implementation of these solutions to avert collapse of airport operations (Serrano and Kazda, 2020) is perhaps unfeasible in the now capital-constrained sector, where the focus is on essential spending only.

Digitalisation has indeed rapidly pervaded everyday life, accelerated in the early months of the pandemic to a rate reportedly equivalent to that of the last 5-year period (Baig et al., 2020). This has triggered calls for embedding sustainable consumption practices going forward, through nudges towards the most sustainable digital offerings (Chiu et al., 2020) and eco-labels for air passengers (Baumeister et al., 2020). Airports will need to consider how they can incorporate such practices into their digital offerings to benefit decarbonisation. Additionally, efforts to digitise airport operations and processes should consider the potential environmental benefits.

On how the air transport system may change in a post-COVID world, Suau-Sanchez, Voltes-Dorta and Cugueró-Escofet (2020) provide valuable insights through interviews with aviation executives during the early stages of the pandemic. In terms of airport operations, the authors capture that domestic markets are faring better than international, with participants predicting a slow recovery of international routes. Regional airports were seen as most likely to be most impacted with hubs having strongest survival potential. Respondents noted the likelihood of COVID-19 measures such as testing and social distancing to impact terminal capacity, CAPEX, human resources and space. With consequences for Scope 3 emissions, the majority of their emissions profile, airports will need to carefully consider the impact of operational changes in their climate change mitigation strategies.

Similarly, uncertainty lies ahead for airport infrastructure with consequences for embodied carbon. Avanzi and Zerjav (2020) contemplate the potential for change in regard to airport expansion and other large capital projects in light of COVID-19, observing that such decisions will need to be re-evaluated given they are influenced by market trends, the regulatory environment, and finance conditions—all of which likely to differ considerably from their post-COVID forms. However, they note that, on comparing three UK and European airport expansion programmes, similar approaches to emission management and consideration of the Net Zero agenda were taken—perhaps a positive of decarbonisation policies or frameworks operating on a supranational level or to similar levels of ambition: Net Zero by 2050 targets; ACI Airport Accreditation Framework.

Research has also focussed on understanding potential change in consumer behaviour both in the short term, with consequences for immediate recovery, and long term, influencing the form of the post-COVID air transport system. Abu-Rayash and Dincer (2020) show public opinion and confidence to return to travel as being non-uniform, differing by country, with some favouring more stringent travel regulations and others more flexible. Song and Choi (2020) survey the Korean public and find that the factors influencing the decision to return to air travel include: self-isolation requirements, destination hygiene, transmission management measures in the aviation sector, and social perception of travel. They note that if the above conditions are met, even without viable vaccines being made available, could lead to a return in demand. Additionally, questions are being asked in regard to whether consumer attitudes and travel behaviours may fundamentally change post-COVID, including whether air travel will remain a social norm (Cocolas et al., 2020). Demand to travel is certainly present for some consumers, with flights laid on to, and from, the same airport, solely for the air travel experience (Wong, 2020).

Eminent Gössling (Gössling, 2020; Gössling and Humpe, 2020) posits that this period allows for reflection on possible fundamental changes to the air transport system to realise a post-COVID system characterised by reduced supply, increased resilience and consequently, reduced risks for society and

environment, with reference to aviation's contribution to pathogen distribution and climate change. Counter to those who attribute impact more toward government restrictions, Gössling (2020,p.2) states that the sector has been responsible for its own vulnerabilities through neglecting to act on known risks: *"Yet, even though these risks are well-documented, the general response has been to either ignore (pathogen/disease) or downplay (climate change) these challenges."* Thus, this implies a conscious decision by the sector to avoid these risks. Others have contemplated the prospect of a smaller future air transportation system as a result of a focus on climate change, aside from other factors such as a potential shift away from the globalisation and neoliberalism of recent decades (Macilree and Duval, 2020).

## **1.2. Impact on the Net-Zero agenda and transition to sustainable aviation**

The goal to achieve "Net Zero", a now frequently adopted commitment to decarbonise industry, can be considered part of the sustainability transition of an industry. Sustainability transitions can be understood as sociotechnical transitions utilising multi-level perspective (MLP) theory (Geels, 2012, 2011). MLP provides a framework to determine what is driving regime stability and change at three, connected analytical "levels", representing different levels of stability (Geels, 2011): niches, sociotechnical regime(s), and the sociotechnical landscape. The sociotechnical regime is the focus of study: this is the set of *"deep-structures"* that agents hold: *"rules"* that are *"both medium and outcome of action"* and drive regime actors, their existing practices and technologies (Geels, 2011,p.27). Niches are the domain of niche-innovations: technologies or practices that are alternative to the regime, aiming to break through into the regime. The sociotechnical landscape has been described as the external *"wider context"* of processes (such as macro-economic change or political ideologies) that pressure both regime and niche in a *stabilising* or *destabilising* fashion (Geels, 2012, 2011).

The typology of transitions has been researched and defined in the literature; of interest here in relation to the sustainable transition of aviation is how a rapid landscape pressure (COVID-19) could be considered to be destabilising the sociotechnical regime (airports) and potentially creating *"windows of opportunity"* for niche-innovations—in this case, the various solutions for carbon reduction and removal (Geels, 2011). This framework is later applied to the study findings to reflect on potential impacts to the "Net-Zero" agenda.

Kanda and Kivimaa (2020) consider the impact of COVID-19 on the sustainable transition of mobility utilising the MLP framework, highlighting both favourable and negative consequences in regard to sustainable transition. For instance: positive in regard to electric vehicle (EV) uptake, yet negative in favouring private vehicle ownership driven by concerns over biosecurity and, for the same reason, the emerging servicisation of mobility (MaaS) and mass transit options has been negatively impacted. Finally, mobility as a whole has been impacted by the aforementioned rapid digitalisation of work, this alone having various positive and negative consequences. Such dualistic impacts from COVID-19 on society, environment and economy have been noted elsewhere; for instance, reduced travel leading to reduced carbon emissions but also a negative impact on clean energy supply chains (Schaltegger, 2020; Sovacool et al., 2020). Both Sovacool, Furszyfer Del Rio and Griffiths (2020) and Kanda and Kivimaa (2020) correctly highlight that these complexities call for careful consideration of the direction in which stimulus, incentives and new practices lead society into a post-COVID world without undesired consequences.

Calls for government intervention tied to sustainability considerations or "green recovery" have been evident throughout 2020. Hepburn et al. (2020) acknowledge that COVID-19 has been detrimental to the momentum on climate change action and that, as previously discussed, any short-term alleviations in GHG emissions will be negligible. The authors posit that the most effective way to impact long-term

climate change efforts will be through fiscal recovery packages and shortlist five policy items to benefit economic and climate change progress: clean physical infrastructure investment; clean R&D investment; building efficiency retrofits; natural capital investment. Just how any government intervention affects airports, and the sustainable transition of airports, remains unknown, with airlines receiving the majority of support within the sector so far.

With the above in mind, this study seeks to identify how COVID-19 has impacted the implementation of climate change mitigation interventions at airports, and stepping back, what impact this may have on the Net Zero agenda. Additionally, it looks to identify any opportunities or unintended benefits from this period that can be maintained to the benefit of the long-term sustainability transition.

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