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UPDATE REPORT – OCTOBER 2020

Dublin Airport Economic Impact of Operating Restrictions

PREPARED FOR

daa

PREPARED BY

Inter*VISTAS* Consulting

Final Report - October 2020

Executive Summary

In order to meet future demand, daa has commenced construction of the North Runway. The runway's planning permission, granted in 2007, attaches 31 conditions, of which two are particularly problematic due to the significant negative implications they pose for the potential of the airport to operate, grow, and deliver the maximum economic and societal benefit for Fingal, Dublin and Ireland as a whole:

- Condition 3d states that the new North Runway will not be used at night between 23:00-07:00, and;
- Condition 5 limits the number of night time operations at the airport to 65 per night on average when the new runway is complete.

daa commissioned Inter*VISTAS* Consulting (Inter*VISTAS*) to conduct a study of the economic impact of restrictions on permitted operations in the period 23:00-07:00 (the "operating restrictions") at Dublin Airport.

Due to the COVID-19 outbreak in 2020, and the associated air travel restrictions, there has been a large downturn in air traffic globally and at Dublin Airport. This October 2020 update assesses the economic impact of the operating restrictions in the context of a significantly revised traffic outlook for Dublin Airport covering the period 2022-2025.

The operating restrictions incorporated in the grant of permission for the North Runway are forecast to result in a forgone economic impact totalling 3,430 jobs and €262 million in Gross Value Added (broadly equivalent to Gross Domestic Product) by 2025. The majority (83%) of this forgone economic impact is expected to occur outside of the aviation sector (indirect, induced and catalytic impacts) and 26% is projected to occur in Fingal.

All financial figures are in 2020 prices. Numbers may not add up due to rounding.

The operating restrictions incorporated in the grant of permission for North Runway are forecast to reduce traffic at Dublin Airport by 1.1 million passengers by 2025 (-3.5%) with a cumulative loss of 4.3 million passengers between 2022 and 2025 (vs forecast unconstrained passenger traffic levels).

daa commissioned a separate study to assess and quantify the traffic impacts of the operating restrictions during the post-COVID recovery.[1] The unconstrained traffic forecast, with no operating restrictions but with proposed noise mitigation measures,[2] projects passenger traffic in 2020 to decline by over 75% due to the effects of COVID-19 and start to recover in 2021, reaching 32 million annual passengers by 2025 (close to 2019 levels). The constrained forecast captures the impact of the North Runway operating restriction on traffic prior to the airport reaching 32 million passengers again around 2024/25. The constrained forecast shows a loss of 1.1 million passengers by 2025 (-3.5%) relative to the unconstrained forecast and cumulative loss of 4.3 million passengers between 2022 and 2025 (see **Figure ES-2**).

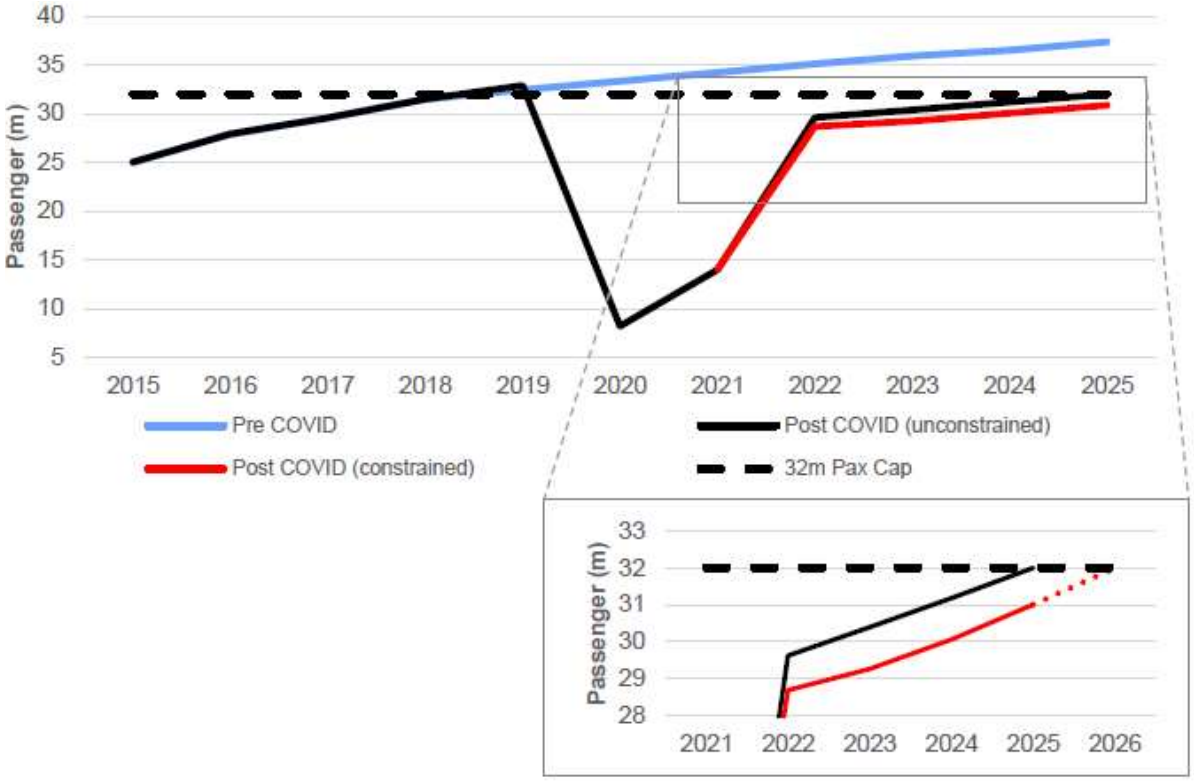
The operating restrictions particularly impact on the recovery and growth of Dublin based Irish carriers Aer Lingus and Ryanair, who are constrained at levels 4.4 % below the unconstrained case by 2025. These carriers require early morning departures and late evening arrivals for their short haul operations, and Aer Lingus requires early morning arrivals for its transatlantic operations. Non-Irish carriers are less affected by the restrictions as they have proportionately fewer operations in the restricted 23:00 07:00 period.

The forecast analysis included the development of unconstrained and constrained busy day schedules for each year from 2022 to 2025. The constrained schedules restricted the operations between 23:00-07:00 to 65 movements with some services being retimed out of this period or being removed entirely as they were no longer viable. The analysis found that overall, only 96.8% of total daily demand could be accommodated in 2025 due to the operating restrictions. This is equivalent to 24 daily aircraft movements.

[1] "Dublin Airport Operating Restrictions - Quantification of Impacts on Future Growth – September 2020 Update – 2022-2025 Period", Version 5.3, September 2020, Mott MacDonald.

[2] The proposed mitigation measures include preferential runway usage (Southern runway preferred for the core night period of 24:00 to 06:00), a noise insulation scheme for dwellings newly affected by night noise and a noise monitoring and trigger framework at the airport.

Figure ES-2: Annual Traffic Impact of the Operating Restrictions



Annual Traffic Impact Summary (millions of passengers)

	2022	2023	2024	2025	2022-2025 Total
Unconstrained	29.6	30.4	31.2	32.0	123.2
Constrained	28.7	29.3	30.1	30.9	118.8
Difference	-0.9	-1.1	-1.1	-1.1	-4.3

Source: Mott Macdonald analysis.

The operating restrictions will have a range of implications for the wider economy and run counter to National Aviation Policy.

The implications of the operating restrictions would extend across the entire economy, due to the lower connectivity that Dublin Airport would be able to offer:

The restrictions will impact on the post-COVID recovery. Like most parts of the world, the COVID-19 outbreak has had a devastating impact on the Irish economy and is expected to result in a severe economic contraction in 2020. The economic recovery will depend on the Irish economy fully re-opening for business, and aviation will play an important role in this regard. Aviation is a major employer in its own right and also facilitates

many other sectors of the economy. Any restrictions on air connectivity at Dublin Airport during this recovery period will have a knock-on effect on these other sectors of the economy: business travel will be more restricted and costly, tourism will be hampered, and the hub benefits of Dublin Airport will be diminished.

Restricted early morning departures to Europe will hamper business connectivity. The operating restrictions will significantly hamper the ability of Dublin-originating passengers to arrive at European destinations in the morning and conduct same-day trips to Europe. With reduced availability of early morning flights, some business travellers would need to depart the day before, incurring significant additional accommodation/subsistence costs for businesses, as well as loss of employee productivity. More travellers may be forced to cancel their trip entirely. This will put Irish businesses at a competitive disadvantage to businesses located in regions with greater access to air services. It will also make the Republic of Ireland a less attractive location to base international businesses, especially those seeking a base for their European operations.

Reduced long haul connectivity will impact business and tourism. Since long haul services are often dependent on connecting traffic, the loss of connecting options associated with the operating restrictions could impact on the viability of long haul services. Any reduction in long-haul services will make Ireland a more difficult destination to visit for some tourists and will reduce its attractiveness for businesses considering locating or investing in Ireland.

The operating restrictions will hamper Dublin's ability to develop as hub airport. Hub airports create economies of scale by pooling both point-to-point traffic (traffic originating or terminating at Dublin) with transferring traffic (passengers connecting between aircraft at Dublin enroute to their final destination). The benefit of attracting transfer traffic is that air services can be supported that could not be sustained on the basis of point-to-point traffic. However, restrictions on night and early morning operations, as described above, will hamper Dublin's ability to act as a hub, by reducing opportunities for convenient transfers. Competition for transfer traffic is strong – transfer traffic can move to any convenient airport in Europe (or elsewhere). The operational restrictions will place Dublin at a considerable competitive disadvantage.

The range of destinations connected to Ireland will be reduced. The operating restrictions will reduce the number of destinations directly connected to Dublin, impacting tourism, trade and business development.

Air fares could increase. The restricted operations will limit the number of hours some aircraft can be operated, potentially reducing aircraft utilisation and, as a result, lead to higher unit costs. These higher costs may be passed onto passengers or result in lower route profitability, with implications for service viability. Furthermore, the limited availability of early morning slots could limit airline competition at these times, resulting in higher fares.

Airlines may base aircraft outside of Ireland. Airlines based at Dublin, currently Aer Lingus and Ryanair, may seek to base some aircraft at airports without operating restrictions in order to improve aircraft utilisation. Ryanair in particular has a wide range of

bases located across Europe. This will reduce the economic activity associated with the aviation sector in Ireland (e.g., aircraft maintenance, air crew employment, etc.).

Air cargo will be impacted. Many air cargo operations occur during the night and these operations are very time-critical in order to connect at sorting hubs and to achieve an overnight package delivery service. A recent study found that 38% of Dublin's air freight was flow at night.[3] The reduction in air cargo services due to the operating restrictions will impact Ireland's trade and supply chain competitiveness.

The operating restrictions run counter to National Aviation Policy. The National Aviation Policy, published by the Department of Transport, Tourism and Sport in 2015, has the following key goals: enhance Ireland's connectivity, foster growth of aviation enterprise, and maximise the economic contribution of the aviation sector.[4]

The operating restrictions imposed by the planning permission for North Runway contradict the aims and commitments of the National Aviation Policy. The negative effects of the operating restrictions on both long haul and short haul flights reduce the connectivity and competitiveness of Dublin Airport. Consequently, the decreased traffic and air services result in a reduced economic contribution to the national economy, as documented below.

Economic impact of the operating restrictions: the forgone economic impact resulting from the operating restrictions is projected to reach 3,430 jobs and €261 million in GVA by 2025.

The estimates of forgone economic impact in 2022, 2023, 2024 and 2025 are presented in **Figure ES-3**. The analysis suggests that as a result of the operating restrictions, the Irish economy could forgo an additional 3,430 jobs and €262 million in GDP by 2025, relative to unrestricted night operations with the proposed noise mitigation measures. The majority of this forgone economic impact is expected to occur outside of the aviation sector – 62% of the total impact is catalytic impacts (tourism, trade, investment, etc.) and another 21% are indirect and induced impacts (supplier and spending in the wider economy). This forgone economic impact is approximately 3% of the total projected economic impact of Dublin Airport in 2025 – in other words, the economic contribution of Dublin Airport will be reduced by 3% due to the operating restrictions.

To put this into context, the number of jobs forgone is higher than the total employment of Google in Ireland.[5]

Based on the current distribution of jobs and economic impact, it is anticipated that a significant proportion of this forgone economic impact will be felt in the Fingal region, with 86% of the forgone direct employment and 26% of the forgone total employment (direct, indirect, induced and catalytic impacts) located in Fingal.

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[3] "The Economic Impact of Cargo Night Flying at Dublin Airport", Freight Transport Association Ireland, March 2020.

[4] Department of Transport, Tourism and Sport, A National Aviation Policy for Ireland, August 2015.

[5] Source: The Irish Time Top 1000: Google – 3,300.

Figure ES-3: Forgone Economic Impact Resulting from Operating Restrictions

Impact	Number of Jobs	Full-Time Equivalents (FTEs)	Wages (€ Millions)	GVA (€ Millions)
2022 Impact				
Direct	440	390	18	36
Indirect	250	220	10	20
Induced	310	270	11	21
Catalytic	1,810	1,600	69	136
Total	**2,810**	**2,480**	**108**	**213**
2023 Impact				
Direct	540	480	22	45
Indirect	300	270	13	24
Induced	380	330	13	26
Catalytic	1,910	1,690	73	143
Total	**3,130**	**2,770**	**121**	**238**
2024 Impact				
Direct	550	490	23	46
Indirect	330	290	14	26
Induced	390	340	13	27
Catalytic	2,030	1,790	77	151
Total	**3,300**	**2,910**	**127**	**250**
2025 Impact				
Direct	580	520	24	49
Indirect	340	300	14	27
Induced	400	360	14	28
Catalytic	2,110	1,860	81	158
Total	**3,430**	**3,040**	**133**	**262**

All financial figures are in 2020 prices.
Numbers may not add up due to rounding.

Glossary of Terms and Abbreviations

Catalytic Impacts	*Catalytic Impacts*, also known as Wider Economic Benefits, captures the way in which specific economic activities facilitates further economic or business impacts in other sectors of the economy. Air transport creates catalytic impacts primarily through increased connectivity and improves national economic performance through the following mechanisms: tourism, trade in goods and services, investment, and increased productivity.
COVID-19	COVID-19 is a disease caused by a new strain of coronavirus which first identified in December 2019 and which spread globally as a pandemic during 2020. In an attempt to control the spread of the outbreak, many governments enacted measures to restrict air travel or quarantine international travellers, which resulted in a massive decline in air travel globally and in Ireland.
CSO	Central Statistics Office, Ireland.
daa	State owned commercial corporation responsible for the operation and management of Dublin and Cork airports.
Direct impacts	*Direct Impacts* arise immediately from the conduct of those entities performing the activity in question. For an airport, the "direct impacts" would include the activities of airlines, the airport itself, forwarders, ground handling agents, and other firms whose principal business involves commercial aviation.
E/D Passengers	Enplaned/deplaned passengers. A measure of passenger volume that counts each passenger who enplanes or deplanes an aircraft.
Economic Impact	Economic impact is a measure of the employment, spending and economic activity associated with a business, a sector of the economy, a specific project (such as the construction of a new facility), or a change in government policy or regulation.
FDI	Foreign Direct Investment. Investment from one country into another (normally by companies rather than governments) that involves establishing operations or acquiring tangible assets, including stakes in other businesses.
FTE	A full-time equivalent (FTE) year of employment is equivalent to the number of hours that an individual would work on a full-time basis for one year (also known as a person year). FTEs are useful because part-time and seasonal workers do not account for one full-time job.
GDP	Gross Domestic Product, a measure of the total output of an economy.

GVA	Gross Value Added (GVA) – the value of the operating surpluses of business linked to Dublin Airport, plus the income/wages of employees and consumption of fixed capital. GVA is broadly equivalent to Gross Domestic Product (GDP), whereby the value-added of each industry sums to the total GDP of an economy.
I-O Model	Input-Output (I-O) model. A representation of the flows of economic activity within a region or country. An I-O model captures what each business or sector must purchase from every other sector in order to produce a dollar's worth of goods or services.
Indirect impacts	*Indirect Impacts* involve the supply chain of the businesses or entities conducting the primary activity (i.e., those included in the direct impact). The airlines at an airport purchase fuel which has been refined at a plant and transported to the airport by pipe or truck. Catering companies at the airport buy food from wholesalers. The items purchased can be used for many purposes besides commercial aviation, and would usually occur off site. The materials support the primary aviation activity, although they could be used for many purposes.
Induced impacts	*Induced impacts* capture the economic activity generated by the employees of firms directly or indirectly connected to the airport spending their income in the national economy. For example, an airline employee might spend his/her income on groceries, restaurants, child care, dental services, home renovations and other items which, in turn, generate employment in a wide range of sectors of the general economy.
Low Cost Carrier (LCC)	Also known as low fares, no-frills or budget carriers. These are airlines that generally have lower fares and fewer amenities than network or legacy carriers. Although there is considerable variation in the business models, low cost carriers typically operate a single aircraft type (to reduce training and maintenance costs), do not offer first or business class travel, do not provide in-flight services such as meals and entertainment (or offer them at additional charge), and focus on point-to-point travel offering limited connecting options. Examples in Europe include EasyJet, Ryanair, Wizz Air, Norwegian Air Shuttle and Vueling.
Multiplier Impacts	Economic multipliers are used to infer indirect and induced effects from a particular sector of the economy. These are typically derived from an Input-Output model.
Wider Economic Benefits	See *Catalytic Impacts*.

Contents

1 Introduction

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Due to the COVID-19 outbreak in 2020, and the associated air travel restrictions, there has been a large downturn in air traffic globally and at Dublin Airport. This October 2020 update assesses the economic impact of the operating restrictions in the context of a significantly revised traffic outlook for Dublin Airport covering the period 2022-2025.[7]

This report documents the methodology and findings of the study, and is structured as follows:

- Chapter 1 – introduction.
- Chapter 2 outlines the methodology used to estimate the economic impact of the operating restrictions attached to the grant of planning.
- Chapter 3 summarises the traffic and demand implications of the operating restrictions at Dublin Airport taken from separate research commissioned by daa which reflects the impact of the COVID-19 outbreak.
- Chapter 4 provides the forgone economic impact resulting from the proposed operating restrictions at Dublin Airport – the lost employment and GDP in Ireland that will result.

Additional details are provided in the appendices. *Key Points* text boxes are provided at the start of the chapters which summarise the key points in each chapter.

[6] daa is a state owned corporation responsible for the operation and management of Dublin and Cork airports.

[7] The impact of the operating restrictions was compared with a scenario where there are no operating restrictions and instead noise mitigation measures are put in place. The proposed noise mitigation measures include preferential runway usage (Southern runway preferred for the core night period of 24:00 to 06:00), a noise insulation scheme for dwellings newly affected by night noise and a noise monitoring and trigger framework at the airport.

1.1 What is Economic Impact?

Economic impact is a measure of the employment, spending and economic activity associated with a business, a sector of the economy, a specific project (such as the construction of a new facility), or a change in government policy or regulation. In this case, economic impact refers to the economic contribution associated with the ongoing activities at Dublin Airport. Economic impact can be measured in a number of ways:

- **Employment –** the number of people employed by businesses involved in activities linked to Dublin Airport.
- **Income/Wages –** the wages and salaries earned by the people employed in activities linked to Dublin Airport.
- **Gross Value Added (GVA) –** the income/wages of employees above *plus* the operating surpluses of business linked to Dublin Airport and the consumption of fixed capital. GVA is broadly equivalent to *Gross Domestic Product* (GDP), whereby the value-added of each industry sums to the total GDP of an economy.[8]

1.2 Categories of Economic Impact

There are four distinct types or categories of economic impact associated with airports, as described below.

1.2.1 Direct Economic Impact

This is the employment, income and GDP associated with the operation and management of activities at Dublin Airport including firms on-site at the airport and airport-related businesses located elsewhere near the airport. This includes activities by the airport operator, the airlines, air traffic control, fixed base operators (General Aviation), ground handlers, airport security, immigration and customs, aircraft maintenance, etc.

While a straight-forward definition of the direct airport economic impact would be the activities and businesses located at the airport, this would not reflect the full extent of the airport's economic base. Other businesses closely connected to airport activities are not based at the airport (or only partially based at the airport), such as aircraft maintenance, logistics operators, aircraft parts suppliers, etc. These businesses would not exist, or would be much smaller, without the activities at the airport. Therefore, off-airport businesses closely linked to airport activities were also included as part of the direct economic impact.

1.2.2 Indirect Economic Impact

The employment, income and GDP generated by upstream industries that supply and support the activities at Dublin Airport. For example, these include: wholesalers providing

[8] GDP is the sum of the GVA of all industries plus taxes less subsidies on production.

food for inflight catering, companies providing accounting and legal services to airlines, travel agents booking flights, etc.

1.2.3 Induced Economic Impact

This captures the economic activity generated by the employees of firms directly or indirectly connected to the airport spending their income in the national economy. For example, an airline employee might spend his/her income on groceries, restaurants, child care, dental services, home renovations and other items which, in turn, generate employment in a wide range of sectors of the general economy.

1.2.4 Catalytic Economic Impacts

While the aforementioned economic impact can be seen as resulting from activities at Dublin Airport, catalytic impacts (also known as Wider Economic Benefits) capture the way in which the airport facilitates the business of other sectors of the economy. As such, air transportation facilitates employment and economic development in the national economy through a number of mechanisms:

- **Tourism**. Air service facilitates the arrival of larger numbers of tourists to a region or country. This includes business as well as leisure tourists. The spending of these tourists can support a wide range of tourism-related businesses: hotels, restaurants, theatres, car rentals, etc. Of course, air service also facilitates outbound tourism, which can be viewed as reducing the amount of money spent in an economy. However, even outbound tourism involves spending in the home economy, on travel agents, taxis, etc. In any case, it is not necessarily the case that money spent by tourists flying abroad would be spent on tourism at home if there were no air service.
- **Trade in Goods and Services**. Whereas air cargo accounts for 1% of Ireland's exports by volume, it accounts for over 35% of exports by value, reflecting generally higher value goods often times perishable or time-critical.[9] Both the trade of goods and the trade of services are facilitated by passenger air services. Face-to-face meetings play a crucial role in making sales and delivering services and support. The ability to be at a client's side rapidly and cost-effectively is important to many industries. Much of the time, these functions cannot be replaced by teleconferencing or other forms of communication. A study in the UK found that a 10% increase in seat capacity increased goods exports by 3.3% and goods imports by 1.7%.[10]

  Air transport connects businesses to a wide range of global markets, providing a significantly larger customer base for their products than would be accessible otherwise. It is particularly important for high-tech and knowledge-based sectors, and suppliers of time-sensitive goods.

[9] Source: Irish Exporters Association.

[10] PWC (2013), "Econometric Analysis to Develop Evidence on the Links Between Aviation and the Economy", Report for the UK Airports Commission, December 2013.

- **Investment**. Air connectivity is important in attracting international business headquarters and foreign investment into a country. A key factor many companies take into account when making decisions about the location of offices, manufacturing plants or warehouses is proximity of an international airport. A study by IATA of 625 businesses in five countries (including China and the United States) found that 25% of the sales of the surveyed businesses were dependent on good air transport links. Further, 30% of Chinese firms reported that they had changed investment decisions because of constraints on air services. [11] Another study found that a 10% increase in supply of intercontinental air service was associated with a 4% increase in the number of large firm headquarters located in the corresponding urban area.[12] Ireland's island status makes air connectivity even more critical.

  Therefore, airports are essential assets for regions wishing to expand industrial activity. Their proximity encourages industrial development. Industries choose to locate close to airports in order to gain easy access to air transport and the associated infrastructure.
- **Productivity**. Air transportation offers access to new markets, which in turn enables businesses to achieve greater economies of scale; inward investment can enhance the productivity of the labour force (e.g., state-of-the-art manufacturing facilities); air access also enables companies to attract and retain high quality employees. All of these factors contribute to enhanced productivity, which in turn increases national income. A study for Airports Council International (ACI) Europe found that a 10% increase in connectivity was associated with an increase in GDP per capita of 0.6%.[13]

Additional research evidence on the link between aviation and economic development is summarised in **Appendix B**.

In effect, the catalytic impact of aviation is to increase the productive potential of the economy (in economist terms, moving the production–possibility frontier). Improvements in aviation connectivity enable economies to attract more tourists, conduct more trade and draw more foreign investment. The overall effect of all these mechanisms is an increase in employment and GDP. Without effective air transportation links, it is much harder for economies to attract tourists, to conduct trade and attract investment from other countries. As a result, the country's economy and employment potential would suffer.

It should be noted that catalytic impacts are not a simple matter of the airport generating employment and economic activity in the same way that direct, indirect and induced impacts arise. National economies are far more complex than that. It clearly takes a wide range of players acting together to generate economic growth – government, business, infrastructure providers, residents, etc. For example, providing air connectivity alone does not guarantee large volumes of tourists. Hotels, restaurants, retail and entertainment etc.

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[11] *Airline Network Benefits*, IATA Economic Briefing No. 3, 2006.

[12] Bel, G. and Fageda, X. (2008), "Getting There Fast: Globalization, Intercontinental Flights and Location of Headquarters", Journal of Economic Geography, Vol. 8, No. 4.

[13] Inter*VISTAS* Consulting, "The Economic Impact of European Airports: A Critical Catalyst to Growth", ACI Europe, January 2015.

are also required. Nevertheless, without convenient air services, a destination will find it more difficult to attract tourists.

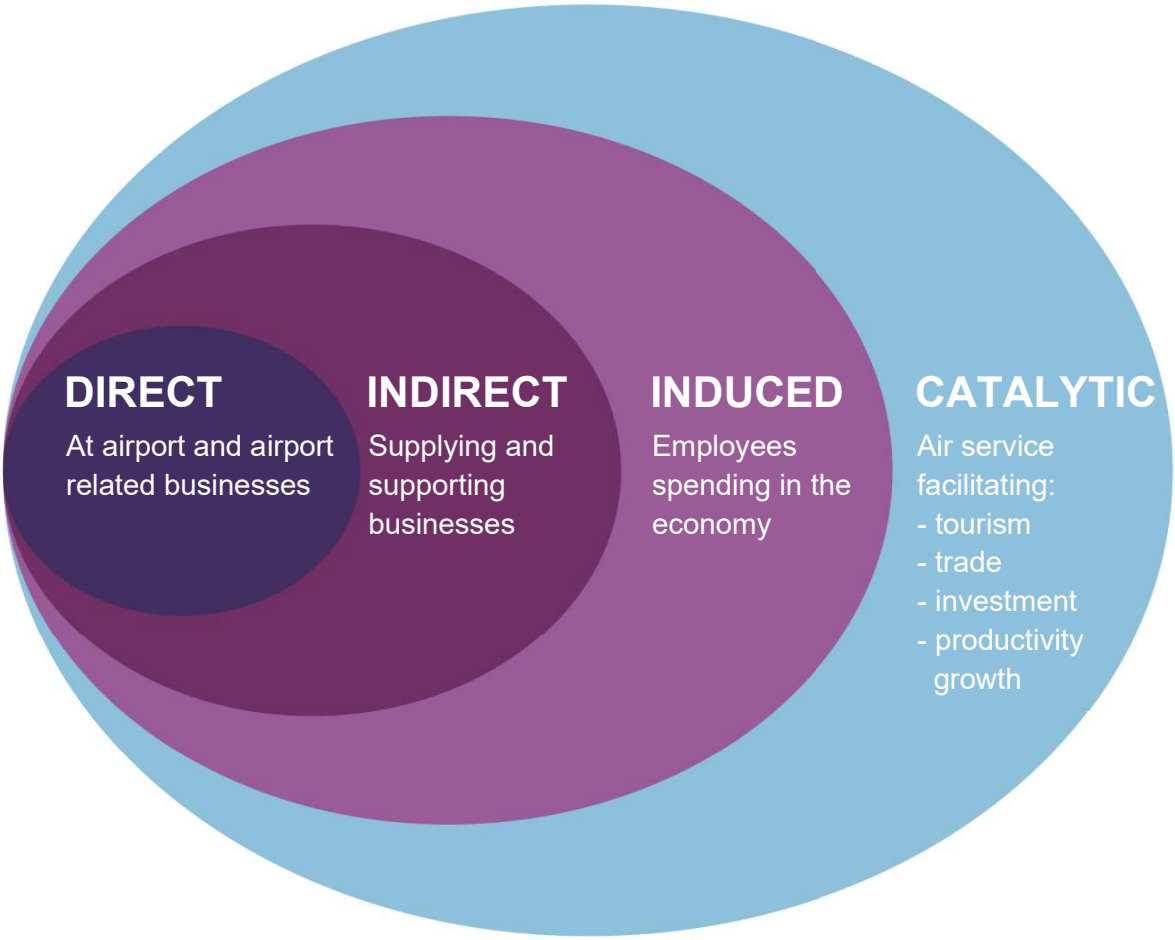
What the catalytic impacts capture is that without efficient airports and associated air services, the economy would be smaller and less affluent. Thus, catalytic impacts are about the economic value and employment that airports facilitate rather than generate. The connectivity enabled by airports is not sufficient on its own to fully support economic activity, but it is a necessary element of economic growth and development.[14]

In discussing catalytic impacts, the issue of causality often arises. For example, while air service can facilitate trade, it is also true that increased trade leads to increased demand for air services. This study recognises that there is a two-way relationship between air connectivity and economic growth. Economic growth stimulates demand for air services while at the same time, these air services open up new opportunities for tourism, trade, business development, etc. This in turn can stimulate further demand for air services, and so on, in a "virtuous cycle". The analysis in this study uses parameters that control for this two-way relationship.

These four categories of impacts are summarised in **Figure 1-1**.

[14] In many parts of the world, airports are also the contributors of some of the other necessary elements for catalytic growth. Various airports have developed their own economic and urban hubs, which can comprise of hotels, offices, entertainment, and other commercial developments, which benefit from the adjacent air connectivity provided by the airport.

Figure 1-1: Categories of Economic Impact Generated or Facilitated by Dublin Airport



2 Methodology for the Economic Impact Study

This chapter describes the methodology and sources that were used to measure the economic impact of operating restrictions at Dublin Airport. The results are provided in **Chapter 4**.

2.1 Previous Economic Impact Study

In 2019, daa commissioned Inter*VISTAS* to conduct an updated economic impact study of Dublin Airport. The study, released August 2019, estimated the direct, indirect, induced and catalytic impacts of the airport measured in terms of employment (jobs and FTEs), incomes and GVA.

The estimated economic impact of Dublin Airport is documented in the report, "*Economic Impact of Dublin Airport*", InterVISTAS Consulting, August 2019, and is available at: https://www.dublinairport.com.

2.2 Estimating the Impact of the Operating Restrictions

The 2019 economic impact evaluation formed the basis for the analysis of the operating restrictions. The estimates of the future economic impact of Dublin Airport were assumed to grow from this baseline as a function of air traffic forecasts for the airport. Air traffic forecasts for Dublin Airport were provided by daa for the period 2022-2025. These included a forecast assuming no operating restrictions (unconstrained forecast) and assuming the application of the operating restrictions specified in the current planning permission (constrained), both reflecting the post-COVID outlook.

While increased air traffic is expected to result in increased employment, the growth in employment is not always in proportion to the growth in traffic. Employment elasticities were applied reflecting the anticipated relationship between forecast traffic growth and employment growth. To account for productivity gains and economies of scale, the direct employment impacts were estimated assuming an economic impact elasticity of 0.67, i.e., each 1% increase in traffic results in a 0.67% increase in airport activity. This elasticity was based on previous research on European airports for ACI Europe, which found evidence of economies of scale in airport employment.[15] The multiplier impacts (indirect and induced) were estimated from the direct impacts, using the multiplier ratios from the 2019 study, calculated from the CSO's latest I-O tables.[16]

[15] "The Economic Impact of European Airports: A Critical Catalyst to Growth", ACI Europe, January 2015. Similar approaches have also been used in the regulatory analysis of airports.

[16] The multiplier analysis has been updated using I-O tables available from the CSO, published in October 2018 and available here: https://www.cso.ie/en/releasesandpublications/ep/p-sauio/supplyanduseandinput-outputtablesforireland2015/.

Similarly, the estimates of catalytic impacts were based on forecasts of future connectivity derived from air traffic forecasts for Dublin Airport. The catalytic impacts of Dublin Airport were calculated using generalised parameters drawn from statistical analysis of historical data. As with the 2019 analysis, the catalytic parameter was taken from a study undertaken by Inter*VISTAS* on behalf of ACI Europe,[17] which was selected because it is the mostly recently completed study of this sort and is based on data from 40 European countries including Ireland. The parameter captures the aggregate net effect of a range of catalytic impacts, including tourism, trade, investment, business location, etc., which manifest themselves as greater per capita GDP.

The COVID-19 related traffic declines in 2020 (and the reduced traffic volumes in subsequent years) are anticipated to result in a lower economic impact from Dublin Airport than would otherwise be the case. Layoffs and redundancies in the aviation sector lower the direct impact of the airport while the indirect impacts are affected by reduced business-to-business spending by companies at the airport. Similarly, the loss of connectivity at the airport reduces the potential catalytic impacts. The projected declines in economic impact were benchmarked against available information from the major airlines and other businesses located at Dublin Airport on current or planned headcount reductions. With traffic forecast to recover from 2021 onwards, the future direct employment impacts were estimated assuming an economic impact elasticity, as described previously.

The methodology above was applied to the forecasts without the operating restrictions (unconstrained) and the forecasts with the restrictions (constrained). The forgone economic impact was then calculated by subtracting the economic impact under the constrained forecast from the economic impact under the unconstrained forecast.

[17] "The Economic Impact of European Airports: A Critical Catalyst to Growth", ACI Europe, January 2015.

3 Traffic Impacts of Operating Restrictions

Key Points

- The post-COVID forecasts project a 75%+ decline in passenger traffic in 2020 followed by a recovery to 32 million (close to 2019 levels) by 2025 in the unconstrained scenario.
- The operating restrictions attached to the grant of permission for North Runway are forecast to constrain traffic at Dublin Airport by 1.1 million passengers (-3.5%) in 2025, and result in a cumulative loss of 4.3 million passengers between 2022 and 2025.
- The operating restrictions particularly impact on the recovery and growth of Aer Lingus and Ryanair, who are constrained at levels 4.4 % below the unconstrained case by 2025.

daa commissioned a separate analysis to assess and quantify the traffic impacts of the proposed operating restrictions during the post-COVID recovery.[18] This chapter provides a summary of that analysis.

3.1 Demand Impacts of the Operating Restrictions

Dublin Airport has been the busiest airport in the Republic of Ireland. In 2019, the airport handled 32.9 million passenger movements and offered scheduled and charter service to over 180 destinations in 40 countries on four continents. The airport has two main carriers: Ryanair and Aer Lingus. Ryanair has a 35% market share and Aer Lingus a 29% share (based on Summer 2019 schedule). The airport serves mostly short haul services (87% of flights) to points in the UK and Europe. The long haul destinations are largely located in North America, with some located in Asia, Middle East and Africa.

In order for airlines to maximise their aircraft utilization on short haul flights, and in turn ensure route viability and profitability, the first departures of the day take place between 06:00-07:00, and the final arrivals take place after 23:00. Furthermore, the one-to-two hour time difference between Ireland and Continental Europe means that flights need to leave early (before 7AM) to ensure a full working day at the destination. The geographical position of Dublin means that there are longer sector distances to European destinations than other competing airports. This requires Dublin Airport to have longer operating days than many other European hubs. Long haul arrivals and a number of cargo flights also take place in the early morning to account for the time differences with long haul international destinations.

The duration of the proposed operating restrictions period, spanning 8 hours from 23:00 to 07:00, is unusually broad compared to other airports with such restrictions. As documented

[18] "Dublin Airport Operating Restrictions - Quantification of Impacts on Future Growth – September 2020 Update – 2022-2025 Period", Version 5.3, September 2020, Mott MacDonald.

in a separate report, the average night restrictions periods are 6h to 6.5h in duration.[19] For example, the London airports night restrictions period is 23:30 to 06:00 local time. The Dublin Airport operating restrictions period is also unusual in that it includes a peak hour of demand at the airport: 06:00-07:00. Therefore, the impact of the restriction on future growth is significant.

The pre-COVID level of demand for operations at Dublin Airport averaged circa 100 per night, with 113 flights associated with regularly scheduled service on a typical busy day in Summer 2019. This is far in excess of the proposed limit of 65 per night. Demand for night flights is forecast to grow in line with the number of based-aircraft at Dublin Airport operating short haul services and with long haul growth to North America in particular.

3.2 Constrained Traffic Impacts

Figure 3-1 shows the post-COVID recovery forecasts alongside the pre-COVID Centreline forecasts for Dublin Airport. The unconstrained traffic forecast, with no operating restrictions but with proposed noise mitigation measures,[20] projects passenger traffic in 2020 to decline by over 75% due to the effects of COVID-19 and start to recover in 2021. Demand is assumed to recover to 90% of 2019 levels by 2022 and to reach 32 million by 2025. The constrained forecast shows a loss of 1.1 million passengers by 2025 (-3.5%) relative to the unconstrained forecast and cumulative loss of 4.3 million passengers between 2022 and 2025.

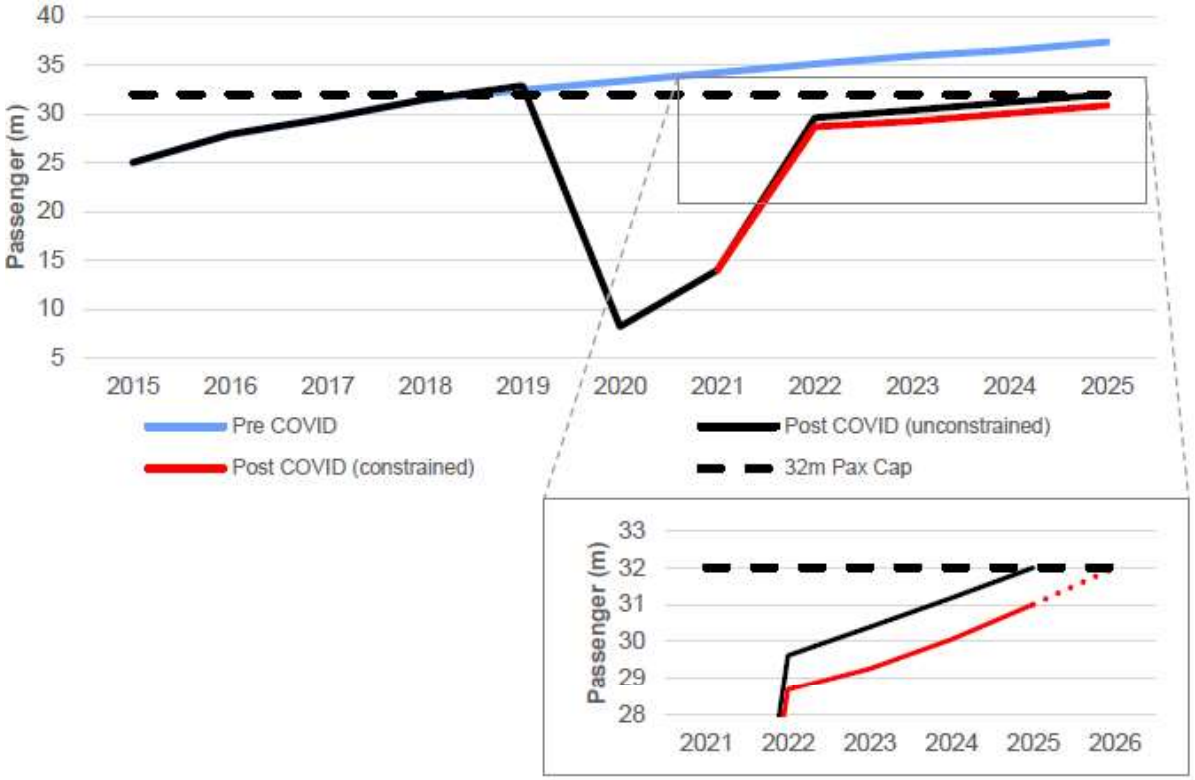
The operating restrictions particularly impact on the recovery and growth of Dublin based Irish carriers Aer Lingus and Ryanair, who are constrained at levels 4.4 % below the unconstrained case by 2025. These carriers require early morning departures and late evening arrivals for their short haul operations, and Aer Lingus requires early morning arrivals for its transatlantic operations. Non-Irish carriers are less affected by the restrictions as they have proportionately fewer operations in the restricted 23:00 to 07:00 period.

The operating restrictions constrain growth in short haul operations throughout the day, as the lack of night slots limits the number of Dublin based aircraft that can be accommodated, with each aircraft performing multiple flights during the operating day.

[19] "Dublin Airport Operating Restrictions - Quantification of Impacts on Future Growth – September 2020 Update – 2022-2025 Period", Version 5.3, September 2020, Mott MacDonald.

[20] The proposed mitigation measures include preferential runway usage (Southern runway preferred for the core night period of 24:00 to 06:00), a noise insulation scheme for dwellings newly affected by night noise and a noise monitoring and trigger framework at the airport.

Figure 3-1: Annual Traffic Impact of the Operating Restrictions



Annual Traffic Impact Summary (millions of passengers)

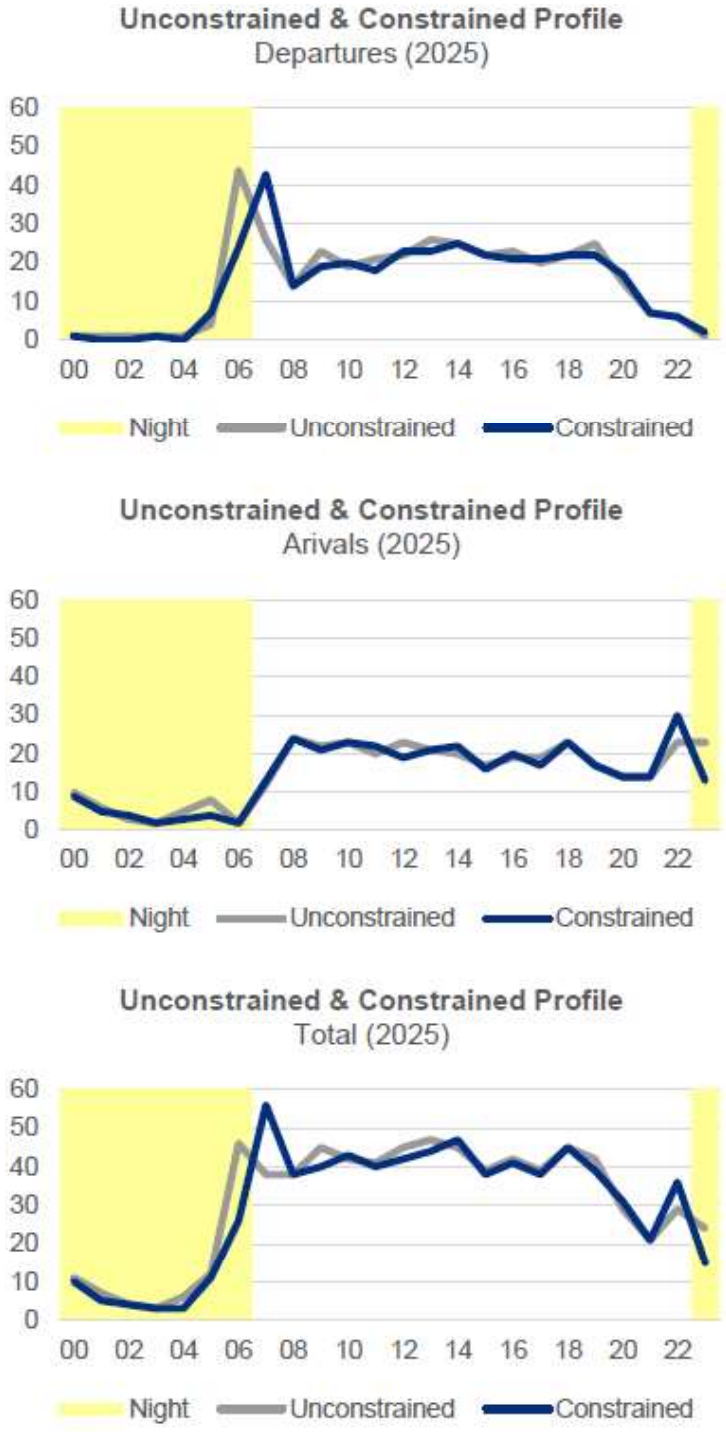
	2022	2023	2024	2025	2022-2025 Total
Unconstrained	29.6	30.4	31.2	32.0	123.2
Constrained	28.7	29.3	30.1	30.9	118.8
Difference	-0.9	-1.1	-1.1	-1.1	-4.3

Source: Mott Macdonald analysis.

The forecast analysis included the development of unconstrained and constrained busy day schedules for each year from 2022 to 2025. The constrained schedules restricted the operations between 23:00-07:00 to 65 movements with some services being retimed out of this period or being removed entirely as they were no longer viable. The analysis found that overall, only 96.8% of total daily demand could be accommodated in 2025 due to the operating restrictions. This is equivalent to 24 daily aircraft movements.

Figure 3-2 summarises the effect of the operating restriction based on the 2025 schedule (similar patterns arise in the schedules for 2022-2024). The morning departures peak is shifted from the 06:00 hour to the 07:00 hour, and is more pronounced, while the evening arrivals peak is shifted from the 23:00 hour to the 22:00 hour due to the constraints of the operating restriction.

Figure 3-2: Unconstrained and Constrained Peak Day Profile



Source: Mott Macdonald analysis.

4 Forgone Economic Impact Resulting from Operating Restrictions

Key Points

- The operating restrictions will have implications for the wider economy of Ireland, impacting trade, tourism, investment and economic growth.
- These restrictions run counter to the stated objectives of the National Aviation Policy, in particular the development of new routes and services, the fostering of competition and to enhance Ireland's global connectivity.
- Furthermore, the operating restrictions could impact on Ireland's post-COVID economic recovery by impeding the rebuilding of air connectivity.
- It is estimated that with the operating restrictions, the Irish economy will forgo 3,430 jobs and €262 million in GDP by 2025.

Chapter 3 documents the forecast loss of traffic due to the operating restrictions that are attached to the grant of permission for North Runway and that would apply at Dublin Airport when that runway becomes operational. This loss of traffic will result in less employment and economic activity at the airport, and in the upstream industries supporting the airport, as there will be fewer flights and passengers to service.

4.1 Implications for the Economy

The economic impacts will extend across the entire economy, due to the lower connectivity that Dublin Airport would be able to offer:

The restrictions will impact on the post-COVID recovery. Like most parts of the world, the COVID-19 outbreak has had a devastating impact on the Irish economy and is expected to result in a severe economic contraction in 2020. The economic recovery will depend on the Irish economy fully re-opening for business, and aviation will play an important role in this regard. Aviation is a major employer in its own right and also facilitates many other sectors of the economy. Any restrictions on air connectivity at Dublin Airport during this recovery period will have a knock-on effect on these other sectors of the economy: business travel will be more restricted and costly, tourism will be hampered, and the hub benefits of Dublin Airport will be diminished.

Restricted early morning departures to Europe will hamper business connectivity. As discussed in Chapter 3, a significant reduction in services and traffic to Europe is expected. The operating restrictions will significantly hamper the ability of Dublin-originating passengers to arrive at European destinations in the morning and conduct same-day trips to Europe. With Europe one to two hours ahead of Ireland, it is necessary to take a very early morning flight from Dublin Airport in order to arrive close to the start of the business day. For example, a 05:55 flight from Dublin will arrive at Frankfurt at 08:55 local time. The need for early morning flights is even more pronounced for Eastern Europe due to the

longer distances involved and the greater time difference. With reduced availability of early morning flights, some business travellers would need to depart the day before, incurring significant additional accommodation/subsistence costs for businesses, as well as loss of employee productivity. Some travellers may be forced to cancel their trip entirely.

This will put Irish businesses at a competitive disadvantage to businesses located in regions with less restricted access to air services. It will also make the Republic of Ireland a less attractive location to base international businesses, especially those seeking a base for their European operations.

In the last ten years there has been a significant change in business travel patterns. People now want to make same day business trips and this necessitates more capacity in the early morning and late evening peaks. As an example, the overall percentage of business passengers at Dublin Airport is 18% (in 2018). However, this starts to increase at 5AM, peaking at 19% between 5AM and 6AM. The percentage of business passengers starts to fall after 9AM.[21] From a business perspective, 70% of business owners in Ireland believe that a flight schedule facilitating arriving in time for the start of the business day is important. Only one in five believe it is not important.[22]

Reduced long haul connectivity will impact business and tourism. Long haul arrivals moved out of the night period will arrive too late to connect with the short haul departures to Europe. Since long haul services are often dependent on connecting traffic to achieve sustainable traffic loads, this could impact on the viability of long haul services. This is compounded by short haul flights departing Dublin Airport later in the morning and so unable to return in time to efficiently connect passengers on the long haul service's return flight.

Any reduction in long haul services will make Ireland a more difficult destination to visit for some tourists and will reduce its attractiveness for businesses considering locating or investing in Ireland.

The operating restrictions will hamper Dublin's ability to develop as a hub airport. Hub airports create economies of scale by pooling both point-to-point traffic (traffic originating or terminating at Dublin) with transferring traffic (passengers connecting between aircraft at Dublin enroute to their final destination). The benefit of attracting transfer traffic is that air services can be supported that could not be sustained on the basis of point-to-point traffic. For example, an air service to a secondary destination in the United States may only be viable through the inclusion of transfer traffic. All major hub airports have a substantial proportion of transfer traffic; some, such as Frankfurt, have more than 50% transfer traffic. However, restrictions on night and early morning operations, as described above, will hamper Dublin's ability to act as a hub, by reducing opportunities for convenient transfers. Competition for transfer traffic is strong – transfer traffic can move to

[21] Source: Dublin Airport Passenger Tracker.

[22] Source: Behaviours & Attitudes Business Barometer Survey. http://banda.ie/techniques/business-to-business-barometer/

any convenient airport in Europe (or elsewhere). The operational restrictions will place Dublin at a considerable competitive disadvantage.

The range of destinations connected to Ireland will be reduced. The analysis described in Chapter 3 also determined that there would be a reduction in the number of destinations served on a non-stop basis. This reduces the number of source markets directly connected to Dublin from which Ireland can attract tourists and the markets that Ireland can easily connect to for trade and business development.[23]

Air fares could increase. The restricted night operations will limit the number of hours some aircraft can be operated, potentially reducing aircraft utilisation and, as a result, lead to higher unit costs. These higher costs may be passed onto passengers or result in lower route profitability, with implications for service viability. Furthermore, the limited availability of early morning slots could limit airline competition at these times, potentially resulting in higher fares.

Airlines may base aircraft outside of Ireland. Airlines based at Dublin, currently Aer Lingus and Ryanair, may seek to base some aircraft at airports without night restrictions in order to improve aircraft utilisation. Ryanair, in particular, has a wide range of bases located across Europe. This will reduce the economic activity associated with the aviation sector in Ireland (e.g., aircraft maintenance, air crew employment, etc.).

Air cargo will be impacted. Many air cargo operations occur during the night, including those by package integrators such as DHL, TNT and FedEx operating to their main sortation hubs. These operations are very time-critical in order to connect at these hubs and to achieve an overnight package delivery service. A recent study found that 38% of Dublin's air freight was flow at night and that 63% of night air cargo is transported by express freight operators primarily shipping time sensitive goods.[24] The loss of air cargo services due to the night restrictions will impact Ireland's trade and supply chain competitiveness.

The operating restrictions will impact trade, tourism, investment and competitiveness. As documented in Chapter 1 and Appendix B, air connectivity facilitates the business of other sectors of the economy. Air service facilitates the arrival of larger numbers of tourists to a region or country, whose spending benefits hotels, restaurants and a wide range of other tourism businesses. Aviation also facilitates trade in both goods and services. For example, a recent study in the UK found that a 10% increase in seat capacity increased goods exports by 3.3% and goods imports by 1.7%.[25]

Air connectivity is important in attracting international business' headquarters and foreign investment into a country. A key factor many companies take into account when making

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[23] These markets can still be accessed through connecting air services, but these are less attractive and more time consuming.

[24] "The Economic Impact of Cargo Night Flying at Dublin Airport", Freight Transport Association Ireland, March 2020.

[25] PWC, "Econometric Analysis to Develop Evidence on the Links Between Aviation and the Economy", Report for the UK Airports Commission, December 2013.

decisions about the location of offices, manufacturing plants or warehouses is proximity of an international airport. A survey by IATA found that 30% of Chinese firms reported that they had changed investment decisions because of constraints on air services.[26]

Therefore, limiting the connectivity of Dublin Airport through the operating restrictions will have implications for the wider economy, as quantified in **Section 4.3**.

4.2 Implications for Irish National Aviation Policy

In August 2015, the Department of Transport, Tourism and Sport published a National Aviation Policy for Ireland.[27] The development of the policy document began in December 2012, with the purpose of providing a policy framework for the country's aviation sector and to enable the industry to remain competitive in the global market. In particular, the National Aviation Policy has the following key goals:

- **Enhance Ireland's connectivity –** respond to the needs of businesses, tourism and consumers through safe, secure and competitive access;
- **Foster growth of aviation enterprise –** support employment in the sector and maintain Ireland's strong tradition and reputation in aviation;
- **Maximise economic contribution of aviation sector –** commit to maximising the benefits of aviation to Ireland's economic growth and development.

In order to achieve these goals, specific policies and actions are provided in the document that aim to encourage increased services to and from Ireland. This includes creating conditions that support the development of new routes and services to new and emerging markets. The National Aviation Policy also commits that airlines operating in the Irish market will have a high level of competition. Furthermore, to enhance connectivity, the national policy seeks to optimise the Irish airport network to benefit air travellers, businesses and tourism. To compete effectively in the global market, the regulatory framework needs to reflect best international practices and facilitate continued investment in aviation infrastructure.

In regard to the second runway at Dublin Airport, the National Aviation Policy specifically states that:

> *"The process to develop the second runway at Dublin Airport will commence, to ensure the infrastructure necessary for the airport's position as a secondary hub and operate to global markets without weight restrictions is available when needed".*
>
> A National Aviation Policy for Ireland, August 2015, Action 4.5.1, page 50.

Based on the impacts of the operating restrictions on passenger traffic and air services described in Chapter 3, it is clear that the operating restrictions at Dublin Airport contradict the aims and commitments of the National Aviation Policy, with both passenger traffic and

[26] "Airline Network Benefits", IATA Economic Briefing No. 3, 2006.

[27] Ireland Department of Transport, Tourism and Sport, A National Aviation Policy for Ireland, August 2015.

air services reduced. The negative effects on both long haul and short haul flights in the constrained schedule also reduce the connectivity and competitiveness of Dublin Airport. Consequently, the decreased traffic and air services due to the operating restrictions result in forgone employment and economic contribution to the national economy, as described in more detail and quantified in the section below.

4.3 Forgone Economic Impact Estimates

The forgone economic impact associated with the operating restrictions was estimated using the methodology described in Section 2.2, the future economic impact was estimated based on forecast traffic, with adjustments to allow for the impact of COVID-19, and of productivity improvements and economies of scale. The methodology was applied to the forecasts without the operating restrictions (unconstrained) and the forecasts with the restrictions (constrained). The forgone economic impact was then calculated by subtracting the economic impact under the constrained forecast from the economic impact under the unconstrained forecast.

The resulting estimates of forgone economic impact in 2022, 2023, 2024 and 2025 are presented in **Figure 4-2**. The analysis suggests that as a result of the operating restrictions, the Irish economy could forgo an additional 3,430 jobs and €262 million in GDP by 2025, relative to unrestricted night operations with the proposed noise mitigation measures. The majority of this forgone economic impact is expected to occur outside of the aviation sector: 62% of the total impact is catalytic impacts (tourism, trade, investment, etc.) and another 21% are indirect and induced impacts (supplier and spending in the wider economy). This forgone economic impact is approximately 3% of the total projected economic impact of Dublin Airport in 2025 – in other words, the economic contribution of Dublin Airport will be reduced by 3% due to the operating restrictions. To put this into context, the number of jobs forgone is higher than the total employment of Google in Ireland.[28]

[28] Source: The Irish Time Top 1000: Google – 3,300.

Figure 4-1: Forgone Economic Impact Resulting from Operating Restrictions

Impact	Number of Jobs	Full-Time Equivalents (FTEs)	Wages (€ Millions)	GVA (€ Millions)
2022 Impact				
Direct	440	390	18	36
Indirect	250	220	10	20
Induced	310	270	11	21
Catalytic	1,810	1,600	69	136
Total	**2,810**	**2,480**	**108**	**213**
2023 Impact				
Direct	540	480	22	45
Indirect	300	270	13	24
Induced	380	330	13	26
Catalytic	1,910	1,690	73	143
Total	**3,130**	**2,770**	**121**	**238**
2024 Impact				
Direct	550	490	23	46
Indirect	330	290	14	26
Induced	390	340	13	27
Catalytic	2,030	1,790	77	151
Total	**3,300**	**2,910**	**127**	**250**
2025 Impact				
Direct	580	520	24	49
Indirect	340	300	14	27
Induced	400	360	14	28
Catalytic	2,110	1,860	81	158
Total	**3,430**	**3,040**	**133**	**262**

All financial figures are in 2020 prices.
Numbers may not add up due to rounding.

Based on the current distribution of jobs and economic impact, the forgone economic impact by region has been estimated and provided in **Figure 4-3**. It is anticipated that a significant proportion of this forgone economic impact will be felt in the Fingal region, with 86% of the forgone direct employment and 26% of the forgone total employment (direct, indirect, induced and catalytic impacts) located in Fingal.

Figure 4-2: Regional Breakdown of the Forgone Economic Impact in 2025

Region	Direct	Indirect	Induced	Catalytic	Total	% Share of Total
Employment (Jobs)						
Dublin Airport / Fingal	500	110	80	200	890	26%
Rest of Dublin	50	130	130	470	780	23%
Rest of Leinster	10	60	90	580	740	22%
Rest of Ireland	20	40	100	860	1,020	30%
Total	**580**	**340**	**400**	**2,110**	**3,430**	**100%**
GVA (€ Millions)						
Dublin Airport / Fingal	43	9	6	18	76	29%
Rest of Dublin	4	11	9	41	65	25%
Rest of Leinster	1	4	6	40	51	19%
Rest of Ireland	1	3	7	59	70	27%
Total	**49**	**27**	**28**	**158**	**262**	**100%**

All financial figures are in 2020 prices.
Numbers may not add up due to rounding.

Appendix A: Further Information on the Input-Output Tables and the Economic Multipliers

As described in Chapter 2, the economic impact multipliers (indirect and induced) impacts were based on an Input-Output (I-O) model of the economy of the Republic of Ireland maintained by the Central Statistics Office Ireland.

The I-O model output was used to estimate the direct, indirect and induced economic effects in this study. This approach has been widely accepted as the most comprehensive approach for the study of economic impact.

The Input-Output Model

The I-O model of an economy links the gross output of an industry to the final demand for that industry and to the intermediate demands made by other sectors for its output. **Figure A-1** illustrates the basic structure of the input-output model.

Figure A-1: A Highly Simplified Input-Output Accounting Framework

	Industries (Purchases)	Final Demand	Total Output
Industries (Sales)	Z	Y	X
Value-added (primary inputs)	V		
Total output	X		

Analytically, we have the following basic identity for sector *i*,

$$X_i = Z_{i1} + Z_{i2} + \cdots + Z_{in} + Y_i, \quad i = 1, \cdots, n. \quad (1)$$

In **Figure A-1**,

- The first row characterizes the "purchasing sectors" (purchasers), while the first column captures the "selling sectors" (sellers);
- Each data column under "Industries" represents the sales from other sectors to sector i; that is, sector i's purchases of the products of various producing sectors in the economy. Hence the column represents the sources and magnitudes of sector i's inputs.
- On the other hand, in engaging in production, a sector also pays for other items – for example, labor and capital – and uses other inputs as well, such as inventoried items.

All of these together are termed the value-added in sector i. In addition, imported goods may be purchased as inputs by sector i. All of these inputs (value added and imports) are lumped together as purchases from what is called the payments sector (Vi in Figure A-1).

In the case of Ireland, the net final demand (Y) is the sum of the following items:

- Final consumption of households;
- Government consumption expenditure;
- Gross capital formation;
- Change in inventory; and
- Exports.

For Ireland, the total value-added (V) is the sum of the following items:

- Imports of goods and services;
- Operating surplus;
- Compensation of employees;
- Consumption of fixed capital;
- Product and other indirect taxes less subsidies.

In other words, referring back to Figure A-1, each row for sector i=1 to n records the sales of that sector's output to other industrial sectors in the economy plus sales to private consumers, government, capital formation, inventory and overseas purchasers. Each column for sector i=1 to n records the purchases of production inputs for that sector in order to produce its total output. This includes purchases from other sectors of the economy, purchases of imports, payment for labour, payment of government taxes, and generation of profits.

Input-Output Coefficients

Input-output table becomes an economic tool when Leontief introduced an assumption of fixed-coefficient linear production functions related to input used by a sector along each column to its output flow, i.e., for one unit of every industry's output, a fixed amount of input of each kind is required.[29] That is, we define the following coefficients:

$$a_{ij} = \frac{Z_{ij}}{X_j}.$$

This ratio is termed a technical coefficient, commonly known as input-output coefficient or direct input coefficient. With this specification of production technology, the model basically assumes that the industry shows constant returns to scale, which is a reasonable approximation in short-run, but nevertheless is also a limitation of the model.

[29] See Leontief, Wassily W. *Input-Output Economics*. 2nd ed., New York: Oxford University Press, 1986.

Once the notion of a set of fixed input-output coefficients is accepted, the system of equations (1) can be represented as follows:

$$X_i = a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{in}X_n + Y_i, \quad i = 1, \cdots, n. \quad (2)$$

This leads to the matrix representation:

$$\boldsymbol{X} = \boldsymbol{A}\,\boldsymbol{X} + \boldsymbol{Y} \quad (3)$$

Hence, with the net final demand vector ***Y***, we can solve for the output vector, via matrix inverse as follows:

$$\boldsymbol{X} = (\mathbf{I} - \boldsymbol{A})^{-1}\,\boldsymbol{Y} \quad (4)$$

where **I** stands for the identity matrix. And the matrix $(\mathbf{I} - \boldsymbol{A})^{-1}$ is the Leontief inverse coefficients. These measure the total amount of output in each sector that is required to be produced in order to satisfy the direct and indirect demands produced by one unit increase in the final demand for a given sector (i.e., the direct + indirect multiplier). The economic interpretation of the Leontief inverse coefficients is consistent with the derivation of the Keynesian multipliers (e.g., expenditure multiplier) that are commonly used in macroeconomics. In other words, it can be interpreted as a result of successive rounds of iterations. An important implication of this connection with the Keynesian multiplier is that the inverse coefficients capture both direct and indirect effects of the final demand from all sectors identified in the I-O table. In practice the multipliers from I-O tables are usually expressed in values so that coefficients measure the requirements in dollars on sector i when sector j increases its final demand by one dollar.

Indirect and Induced Impacts - Open System and Closed System

The economic impact multipliers are expressed as ratios that measure the impact on the total economy as a result of an initial autonomous change in any of the final demand components. The action of the multiplier can be illustrated by the sequence of events that follow after the initial autonomous change. Different kinds of multiplier can be generated depending on the purpose of analysis. The common multipliers used are output, valued-added, employment, and income multipliers. For comparative purposes, multipliers use usually expressed with respect to a unit of autonomous change in final demand.

Open Model: Direct and Indirect Impacts

Each of the multipliers listed above can be generated from two different models: *open* and *closed*. The intrinsic difference between them is the treatment of household income and personal consumption expenditure. In the *open* model, all final demand components are assumed to be exogenous. Hence the *open* model captures the production-induced effects resulting from a change in final demand. The multipliers generated using the open model are also known as simple multipliers or Leontief multipliers. This kind of model is described as *open* because at each round of the multiplier process, there is leakage from the system. The leakage consists of payments for imports and primary inputs and the recipients are assumed to make no use of their receipts. Even if a small part of the receipts were spent on goods and services, there would be further multiplier repercussions. In our analysis,

Leontief multipliers capture the direct and indirect effects of an autonomous change in final demand.

Closed Model: Direct, Indirect and Induced Impacts

Conversely, in the *closed* model, the household sector is treated as endogenous to the system. The household sector receiving income from the work done in the production process would spend some of this income on local products. This increase in consumption would in turn increase the level of output of the products. In other words, the *closed* model accounts for both the production-induced effects as well as the consumption-induced effects. The multipliers generated using the *closed* model are commonly known as the total multipliers or Leontief-Keynes multipliers. In our analysis, Leontief-Keynes multipliers will capture the direct, the indirect AND the induced effects.

The total multiplier from the closed model is by definition larger than the simple multiplier from open model. The difference between the two multipliers is the induced impact.

Appendix B: Overview of Catalytic Impacts

As discussed in Chapter 1, catalytic impacts capture the way in which aviation facilitates the business of other sectors of the economy. This comprises:

- **Tourism –** air service facilitates the arrival of larger numbers of tourists to a country. This includes business as well as leisure tourists. The spending of these tourists can support a wide range of tourism-related businesses: hotels, restaurants, entertainment and recreation, car rentals, and others.
- **Trade –** air transport provides connections to export markets for both goods and services.
- **Investment –** a key factor many companies take into account when making decisions about the location of offices, manufacturing plants or warehouses is the proximity of an international airport.
- **Productivity –** air transportation offers access to new markets which in turn enables businesses to achieve greater economies of scale. Air access also enables companies to attract and retain high quality employees.

A number of studies have demonstrated that air transportation plays an important role in trade, investment and business location decisions, while additional studies have uncovered empirical evidence demonstrating a strong linkage between air service and employment and economic growth. Provided below is a summary of this research examining the catalytic impact of aviation, taken from academic and industry research.

Trade

A number of research papers have produced evidence that aviation positively contributes to the trade of both goods and services

Paper	Methodology	Key Findings
Cech (2004)[30]	Used a cross-section statistical comparison method to investigate how air cargo services affect the economies of 125 U.S. counties.	Higher levels of air cargo services contribute to increased earnings and increased employment.
EUROCONTROL (2005)[31]	The study estimated the net contribution of air transportation to trade (i.e., export minus imports).	Net contribution of air transportation to trade was €55.7 billion in 2003 across the 25 current EU members.

[30] Cech P. (2004), "The Catalytic Effect of the Accessibility to Air Cargo Services", TIACA Graduate Research Paper Competition.

[31] Cooper, A. and Smith, P. (2005), "The Economic Catalytic Effects of Air Transport in Europe," Commissioned by EUROCONTROL. EUROCONTROL is a civil and military organisation established in 1963 to facilitate a safe, seamless pan-European Air Traffic Management (ATM) system.

Paper	Methodology	Key Findings
UK Institute of Directors (2008)[32]	Surveyed 500 UK businesses about their use and the importance of air transportation.	The use of air travel strongly linked to business trade and sales. Almost three quarters of businesses using passenger air services said that their business would be adversely affected if the amount of air travel they could undertake was significantly curtailed.
Poole (2010)[33]	Econometric analysis of U.S. trade and travel data from 1993 to 2013.	A 10% increase in business travel to the U.S. by non-residents led to a 1.2% increase in the volume of exports from the U.S. and 0.3% increase in export margins. The effect was strongest for travel from non-English speaking countries, suggesting that business travel help overcome language barriers in trade relationships.
PWC (2013)[34]	Examined the relationship between the UK's international air seat capacity and international trade, controlling for other factors affecting trade.	A 10% increase in seat capacity increased goods exports by 3.3% and goods imports by 1.7%.

Investment and Business Location

The impact of aviation on investment and business location decisions has been the subject of a number of papers. These papers have found evidence of air connectivity contributing to increased investment and beneficial location decision for the surrounding regions or the country.

[32] UK Institute of Directors (2008), "High Fliers: Business Leaders' View on Air Travel", http://www.iod.com/MainWebSite/Resources/Document/policy_paper_high_fliers.pdf
[33] Poole, J. (2010), "Business Travel as an Input to International Trade", http://www.scu.edu/business/economics/upload/Poole.pdf

[34] PWC (2013), "Econometric Analysis to Develop Evidence on the Links Between Aviation and the Economy", Report for the UK Airports Commission, December 2013.

Paper	Methodology	Key Findings
Hansen and Gerstein (1991)[35]	Used data from 1982 to 1987, the analysis related the amount of Japanese investment in each US state to measures of level of air service operated between Japan and that state (and other background factors).	The amount of Japanese investment in each US state was causally linked to the air service between Japan and that state.
EUROCONTROL (2005)[36]	Analysed the relationship between air transportation and business investment in the EU.	A 10% increase in air transportation usage increases business investment by 1.6% in the long run (the impact takes approximately five years to fully manifest).
IATA (2005)[37]	IATA surveyed 625 businesses in five countries (China, Chile, United States, Czech Republic and France).	25% of surveyed businesses in five countries indicated that 25% of their sales were dependent on good air transport links; 30% of Chinese firms reported that they had changed investment decisions because of constraints on air services.
Bel and Fageda (2008)[38]	Statistically analysed the relationship between international air service and the location of large firm's headquarters across major European urban areas.	A 10% increase in supply of intercontinental air service was associated with a 4% increase in the number of large firm headquarters located in the corresponding urban area.

[35] Hansen, M. and R. Gerstein "Capital in Flight: Japanese Investment and Japanese Air Service in the United States During the 1980s," Logistics and Transportation Review, 1991, Vol. 27, No. 3, pp. 257-276.

[36] Cooper, A. and Smith, P. (2005), "The Economic Catalytic Effects of Air Transport in Europe," Commissioned by EUROCONTROL. EUROCONTROL is a civil and military organisation established in 1963 to facilitate a safe, seamless pan-European Air Traffic Management (ATM) system.

[37] *Airline Network Benefits*, IATA Economic Briefing No. 3, 2006.

[38] Bel, G. and Fageda, X. (2008), "Getting There Fast: Globalization, Intercontinental Flights and Location of Headquarters", Journal of Economic Geography, Vol. 8, No. 4.

Paper	Methodology	Key Findings
Arndt et al. (2009)[39]	Survey of 100 foreign-owned businesses in Germany.	Air connectivity was one of the four most important factors affecting location decisions, and that 57% of businesses would have chosen another location had connectivity been less good.
PWC (2013)[40]	Econometric analysis of the UK's air connectivity, air seat capacity and Foreign Direct Investment (FDI).	A 1% increase in international seat capacity was associated with a 0.47% increase in FDI inflows and a 0.19% increase in FDI outflows.

Impact on Employment, Economic Growth and Productivity

The increased trade, investment, business activity and tourism facilitated by aviation ultimately results in increases in economic productivity (e.g., GDP per worker), in GDP and in employment (e.g., increased trade facilitated by air services results in increased employment in the businesses producing the traded goods and services). A number of research papers have examined the overall impact on the economy and employment as a result of the catalytic effects of aviation.

Paper	Methodology	Key Findings
Button, Lall, Stough and Trice (1999)[41]	Used data from 321 US metropolitan areas in 1994 to regressed high-tech employment against a number of controlling factors including a dummy indicating that the region was served by a hub airport.	The analysis found that the presence of a hub airport increased high-tech employment by an average of 12,000 jobs in a region.

[39] Arndt, A., et al. "Economic catalytic impacts of air transport in Germany–The influence of connectivity by air on regional economic development." ATRS Conference. 2009.

[40] PWC (2013), "Econometric Analysis to Develop Evidence on the Links Between Aviation and the Economy", Report for the UK Airports Commission, December 2013.

[41] Button, K., Lall, S., Stough, R. and Trice, M. (1999), "High-technology employment and hub airports," Journal of Air Transport Management, Vol. 5, Issue 1, January 1999.

Paper	Methodology	Key Findings
Button and Taylor (2000)[42]	Used data for 41 metropolitan areas in the US to regress "new economy" employment against a number of control factors including the number of direct routes to Europe offered by airports in the region.	Increasing the number of routes between the US and Europe from 3 to 4 at an airport generated approximately 2,900 "new economy" jobs in the surrounding region.
Brueckner (2002)[43]	Regressed employment in 94 metropolitan areas in the US against a number of factors including measures of air service.	A 10 percent increase in passenger enplanements in a metropolitan area leads to an approximately 1 percent increase in employment in service-related industries.
Ishutkina and Hansman (2009)[44]	Aggregate and individual country-level data were analysed in terms of the relationship between air transportation passengers and GDP. A data analysis of 139 countries over a time period of 30 years (1975 to 2005).	Found statistical evidence of a (two-way) feedback relationship between air transport and economic activity.
PWC (2013)[45]	Estimated an Error Correction Model of UK GDP and air seat capacity between 1991 and 2010.	A 10% change in the growth rate of seat capacity leads to approximately a 1% change in the growth rate of GDP. The analysis also found evidence of a two-way relationship between the variables – GDP growth causes seat capacity and seat growth causes GDP growth.
ACI Europe/ Inter*VISTAS* (2015)	Analysed the relationship between national air connectivity and GDP per capita using data for 40 European countries between 2000 and 2012.	This recently completed analysis found that a 10% increase in connectivity was associated with an increase in GDP per capita of 0.6%. Additional analysis found evidence that this relationship was two-way.

[42] Button, K. and Taylor, S. (2000), "International air transportation and economic development", *Journal of Air Transport Management*, Vol. 6, Issue 4, October 2000.

[43] Brueckner, J. (2002), "Airline Traffic and Urban Economic Development".

[44] Ishutkina M.A. and Hasnman R.J. (2009), "Analysis of the interaction between air transportation and economic activity: a worldwide perspective", PhD thesis, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology.

[45] PWC (2013), "Econometric Analysis to Develop Evidence on the Links Between Aviation and the Economy", Report for the UK Airports Commission, December 2013.

Paper	Methodology	Key Findings
		That is, as an economy grows, it supports a larger air transport sector, but it appears to also be the case that growth in air transport supports economic growth.
Baker, Merkert and Kamruzzaman (2015)[46]	Analysed 88 regional airports in Australia over a period of 1985–86 to 2010–11 to determine the catalytic impacts of regional air transport on regional economic growth.	A significant bi-directional relationship was established: airports have an impact on regional economic growth and the economy directly impacts regional air transport.

Conclusions

A body of research has developed over the last 15-20 years which has examined and quantified the contribution of air transport to trade, investment and economic growth. Through the use of different empirical methods and data sets, this research has consistently found a significant and positive relationship between aviation and economic growth. Furthermore, much of the research has established that air transport growth has been the *cause* of economic growth, rather than simply economic growth leading to increased air transport levels.

[46] Baker, D., Merkett, R. and Kamruzzaman, M. (2015), "Regional aviation and economic growth: cointegration and causality analysis in Australia", Journal of Transport Georgraphy, Vol. 43, February 2015, pp. 140-150.

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