2026

Aviation Connectivity and Economic Growth: Literature Review

James Laird
Peak Economics
March 2026

Blank.

AVIATION CONNECTIVITY AND ECONOMIC GROWTH LITERATURE REVIEW

Final report to Department for Transport

18th March 2026

James Laird

Blank.

Contents

ABSTRACT

The empirical literature indicates that aviation connectivity positively influences economic growth through multiple channels: enhancing trade, investment, knowledge diffusion, and local economic development. Benefits are concentrated in service sectors, industries reliant on face-to-face communication, and regions with strong complementary infrastructure. However, the magnitude and distribution of impacts vary by region, airport type, and existing economic conditions. There is a notable evidence gap regarding major European hub airports and the UK context, underscoring the need for further causal research to inform policy and modelling of UK airport expansion impacts.

1 INTRODUCTION

1.1 Background and objectives

The Department for Transport (DfT) required a comprehensive review of economic studies assessing the links between aviation connectivity and economic activity. The purpose of the review is to inform further modelling into the economic impacts of airport expansion, and/or as direct evidence of the generalised economic benefit of improving connectivity.

The objectives of the review are:

- To develop a summary of the relevant literature, particularly research produced since 2013;
- To gain understanding of which measures of connectivity (e.g. Air Transport Movements, passenger volumes, destinations served) are most appropriate to use in econometric modelling of the impacts of aviation;
- To highlight possible input assumptions for potential Spatial Computable Equilibrium (SCGE) modelling of airport expansion, alongside the evidence for those assumptions and a critical review of the risks and uncertainties involved; and
- To gain an assessment of the applicability of any studies to the current UK aviation market, particularly in the context of assessing the impacts of an airport expansion.

1.2 Report structure

Following this introductory chapter, Chapter 2 sets out the methodology employed in the literature and summarises the papers identified by category and year. Chapter 3 summarises the evidence within the identified papers, firstly in relation to channels for growth, and then in relation to economic impacts. Chapter 4 summarises the econometric methods employed in the studies to date, and draws out learning points for a future empirical study, whilst Chapter 5 discusses how this evidence base can be used in an S-CGE modelling exercise. Chapter 6 concludes the literature review drawing out the implications of the evidence base for an airport expansion in the UK and identifying future research needs. Appendices A and B contain the abstracts of the empirical studies identified in this literature review.

2 LITERATURE SEARCH METHODOLOGY

2.1 Focus

The focus in the literature review is ex post causal studies. These causal studies have been separated into those that have used causal identification methods and those that have identified causation through statistical association. Causal identification methods would include Difference in Differences (DiD), two stage least squares of instrumented variables (2SLS/IV) and quasi-natural experiments. Statistical association methods would include Granger causality tests. These are weaker than true causal identification methods as they cannot identify if the statistical association is real or driven by dependence on a common 'third' or more unknown drivers.

Further, the focus of the literature review has been on peer reviewed journal articles or book chapters. The review therefore excludes conference papers and industry reports, aside from in providing some introductory context on the role of air transport in the UK economy. A handful of exceptions for recent (2022 or later) working papers, where these are high quality causal studies and very likely to be published in the near future.

2.2 Literature search

2.2.1 Previous literature reviews

The starting point for the literature search was a previous high quality review article by Zhang and Graham (2020). This review was broader than just a review of the role of air connectivity in creating economic growth. In the first instance therefore those papers that were potentially economic growth references were identified. These were then sifted down to those which match the focus of this literature review. That is papers that adopt a causal approach to the identification of economic impacts and are published in journals or books. This resulted in 24 papers of which 10 are pre-2013 and 14 were published in 2013 or later.

Three other literature review papers were also examined: Higgoda and Madurapperuma (2019), Ozmec-Ban and Babić (2023) and Varghese and Pradhan (2025). These were of mixed quality with Varghese and Pradhan (2025) being the most useful. These identified further papers not included in Zhang and Graham.

2.2.2 Snowball search

A seminal piece of work in air connectivity and economic impacts is Brueckner (2003), which is the first high quality causal study. Zhang and Graham (2020) is also a high quality review article. Google Scholar was used to identify papers citing these studies. These were then narrowed down in Google Scholar using search terms such as 'air' plus a term like 'economic growth' or 'economic impact'. Searches were also made using terms like 'air' and 'FDI'. With the interest in more recent studies (2013 or later) date ranges were also used to narrow the search. From these identified studies several contained detailed surveys of the ex post literature, which then provided further references.

2.2.3 Papers identified and categorisation

The result of this literature search is summarised in the tables below. There has been a substantial increase in the quantity of literature on the topic, with an average of about five journal publications per year since 2013.

In total this search has identified 88 papers that meet the focus of this review of which 64 are additional to Zhang and Graham. Looking at publications since 2013, this search identified 72 studies of which 58 are additional to Zhang and Graham.

TABLE 2-1: EMPIRICAL STUDIES BY PUBLICATION YEAR

	Pre-2013	2013 to 2020	2021 or later	Total
Zhang and Graham(2020)	10	14	---	24
Additional papers to Zhang and Graham(2020)	6	26	32	64
This search	**16**	**40**	**32**	**88**

Table 2-2 categorises these studies further. We can see that of the 88 studies identified 47% use a causal identification strategy. The remainder use a predictive approach to causation, such as one based on statistical association (e.g. a Granger test) . We can also see that the majority (16 of 19 studies) that use a causal identification strategy to examine the economic impacts of air connectivity (on GDP, employment, etc.) are concerned with impacts on the richer nations in the world (North America, Europe, Australia and Japan). The USA, as a subject of study, is very dominant in the literature. We can also see that studies with a causal identification strategy are very much associated with the richer nations. The three causal studies associated with the rest of the world are concerned with South East Asia with two on China.

Interest in understanding the channels for growth has grown in recent times. Only one of the 22 studies on the channels for growth occurred before 2013, whilst 12 (55%) have been published in 2021 or later. There has also been a more recent increase in research on the Rest of the World (outside of the richer nations) with 9 of the 30 studies (30%) on these regions being published in 2021 or later.[1]

[1] These data are not shown in Table 2-1 and Table 2-2, but can be supplied if needed.

TABLE 2-2: EMPRICIAL STUDIES BY TOPIC AREA AND GEOGRAPHIC FOCUS

	Causal identification strategy	Predictive causality (e.g. Granger tests)	Total
Channels for growth			
Export and trade	10		10
Investment and FDI	7	3	10
Knowledge creation and diffusion	5		5
Sub-total	**22**	**3**	**25**
Economic impact on GDP, incomes/wages, employment or population			
North America, Europe, Australia and Japan	16	18	35
Rest of the World	3	27	30
Sub-total	**19**	**45**	**65**
Total	**41**	**48**	**89**

Note: (1) Global/international papers have been categorised under North America, Europe, Australia and Japan. (2) Campante and Yanagizawa-Drott (2018) is included twice. Once in investment & FDI and other in economic impact (hence total is 1 higher than Table 2-1)

2.3 Structured summaries

For each of the 88 papers that have been identified as relevant, the abstracts, country studied along with whether a causal identification strategy was used is set out in Appendices A and B. The studies are listed in date order, separating between pre-2013 and 2013 or later, and are also grouped as to whether a causal identification strategy was adopted or not. Appendix A contains the studies that relate to particular channels of growth, and Appendix B whether they concerned with overall economic impacts. The latter studies are further categorised by geographic area.

For the 41 papers that use a causal identification strategy a structured summary was produced identifying:

- Country/region studied
- Econometric method
- Time period studied
- Dependent variable
- Independent variables
- Key findings

Microsoft Copilot was utilised to assist in the production of the structured summaries. These structured summaries were then reviewed against the papers themselves to ensure there have been no errors in summarising and that the key details are set out. The structured summaries form the basis of the tables that have been reported later in this report.

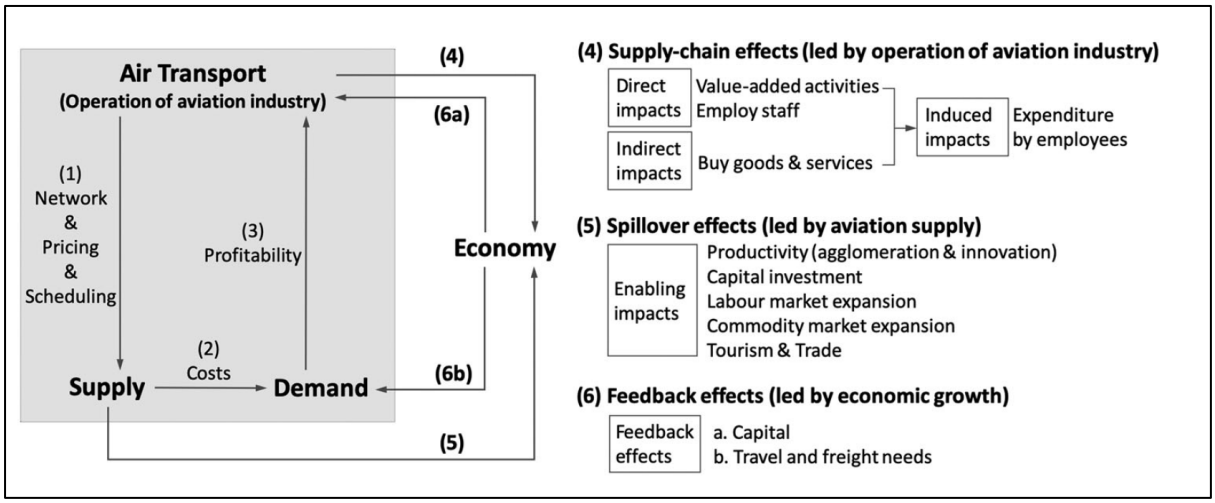
3 SUMMARY OF LITERATURE

3.1 Channels for growth

3.1.1 Conceptual

Figure 3-1 illustrates conceptual linkages between air transport and the economy. There are both demand and supply linkages.

FIGURE 3-1: MAJOR CHANNELS THAT AIR TRANSPORT AND THE ECONOMY INTERACT



Note: excludes a link between air travel demand and the economy (e.g. a change in tourism travel flows creates a demand side shock for the economy)
Source: Zhang and Graham (2020)

On the demand side of the economy, airports are significant employers and locations of activity. Airports and airlines demand goods and services through their supply chain. At Heathrow Airport 83,400 workers are employed across the range of operations and different employers with another 10,800 jobs located locally in the supply chain (Oxford Economics, 2024). This is illustrated by channel 4 in Figure 3-1. Tourism also is also a demand side impact, as they typically demand services from the hospitality, retail and leisure sectors. There is both in-bound tourism and outbound tourism. Thus it is the difference in net tourist flows, and differences in the profiles of such visitors that will create the net demand on the economy for tourist related activities. Arguably this would be best represented in Figure 3-1 with an arrow linking Demand to the Economy (so a 'new' channel 7).

On the supply side air transport lowers journey times for the shipping of freight and business travel. Both improvements to freight and business travel would be seen as improving the productivity of the economy, as it takes less resources (time and money) to transport people and goods between places. This is the same as the underlying concept to the general treatment of changes in travel time and cost in a welfare analysis (Mackie et al., 2001, Mackie et al., 2003).

A final supply side impact is that business air travel facilitates face to face contact (FFC). FFC may be necessary (or helpful) for joint ventures between businesses, collaborations between scientists, the management of subsidiary businesses or business operations in locations far removed from headquarters, etc. These FFCs may lead to increased trade between countries/regions (both of exports and imports), increased investment including Foreign Direct Investment (FDI) and the

creation and diffusion of knowledge. The latter clearly will lead to productivity gains, but Learning By Exporting (LBE) [2] (Crespi et al., 2008, Freixanet and Federo, 2023) and learning from FDI (for a UK example see Liu et al. (2000)) can also lead to further productivity gains. This is a form of knowledge spillover type effect. It is these knowledge spillover effects that lead to the catalytic impacts that are often referred to in the literature on air services and economic growth (see e.g. Zhang and Graham (2020)). These three supply side impacts are encompassed into channel 5 in Figure 3-1.

Extrapolating this conceptual framework to a change in the supply of air transport, such as an airport expansion. Such an airport expansion might increase frequency of air services, the range of destinations served and the price of air services. Such a 'shock' will de-stabilise the equilibrium and lead to a number of adjustments. It will change the demand for leisure/visitor travel which will not only impact on airport operations (via channel 3), but will impact on the tourist/visitor aspect of the economy (not shown in Figure 3-1, but thought of as channel 7) and as well as the demand that increased air operations place on the economy (channel 4). It will change the demand for business travel. New ventures will be set up, new collaborations made, etc. This will create a range of capital investment flows – both inward and outward FDI and within the UK intra-regional capital investments (relating to internal air services).

The economy will re-structure around these demand and supply side impacts leading to changes to employment, population (via migration) and wages/incomes. As airports are located at a particular point in a region, these wider economy outcomes will have a spatial context, with the region around the airport likely gaining more, and displacing activity towards it. The economy would also be expected to re-structure towards industrial sectors that benefit from the improved air accessibility: air operations, tourism, retail and leisure and the industries associated with the business air travellers and air freight users.[3]

As not all sectors of the economy use air services equally, not all industries will gain equally from the supply side impacts from an airport expansion. With regard to freight the nature of air travel (namely high cost and weight constraints) mean that there is a high degree of selectivity of goods that travel by air. By tonnage it is estimated that 1% of goods exported to non-EU countries from the UK go by air, but by value that proportion raises to 40%. The main industries that use air freight in the UK are high value per kilo products such as: gold (reflecting London's globally central financial role), power-generating machinery, complex manufactured goods, transport equipment, scientific equipment and pharmaceuticals (Steer, 2018). With respect to business travellers banking/finance/insurance industries form the largest group of industries that use air travel from the London Airports, and the main purpose for a business trip is to attend an internal meeting or a meeting with an external client (Civil Aviation Authority (CAA), 2011).

[2] Learning By Exporting (LBE) refers to the productivity gain that newly exporting firms have been observed to receive from being exposed to new markets and adapting and learning from them.

[3] An unintended consequence of additional foreign exchange, due to for example increased exports dependent on air travel or inward tourism, is a strengthening of the currency. This can make other exports more expensive and less competitive. Thus some crowding out of existing export driven economic activities can occur. If this crowding out is also associated with a re-structuring to a low value added, low productivity industries (such as those generally associated with tourism) this might be seen as undesirable from a policy perspective. This effect is known colloquially as the Dutch Disease.

3.1.2 Empirical evidence on the channels for growth

SCOPE OF EMPRICIAL STUDIES ON CHANNELS FOR GROWTH

Table 3-1 summarises the findings of studies that have investigated the channels of growth linked to air services. The studies summarised in this table only employ causal identification strategies, studies that have identified causation via statistical association (e.g. Granger type studies), have been excluded. We can therefore be confident that air services have led to changes in these channels for the studies examined.

The first thing to note is that the studies have focused on exports/imports and trade costs, investment and FDI, and knowledge creation and diffusion. These channels do not neatly map on to those identified in the conceptual framework (Figure 3-1), but to an extent focus on the knowledge spillovers within the supply side impacts in channel 5. These are the catalytic impacts that have been referred to earlier. The studies do not specifically refer to the cost reductions in time and cost (e.g. for business travellers or freight) on firm level productivity. Where these are analysed they refer to changes in imports/exports(e.g. Söderlund (2023) on the impact of the jet age) and opportunities for collaboration (Catalini et al. (2020) on the introduction of a Low Cost Carrier (LCC) on scientist collaborations). There are also no explicit investigations into the impact of tourism/visitors and the impact of providing air operations on the local economy. To an extent such aspects are encapsulated into the city level economic impact research, which is discussed in the next section §3.2 and presented in Table 3-2. These are however net impacts across all channels at a city or region level.

INCREASED TRADE OPENNESS. MORE EXPORTS, MORE IMPORTS

Changes in journey time and flight frequency affect trade. A 1% increase in frequency of flights between European regions increased exports in manufacturing for Italian regions by between 0.02% and 0.09% (Alderighi and Gaggero, 2017). A 10% reduction in long haul flight times between Europe and East Asia in the 1980s due to liberalisation of Soviet airspace increased goods trade by 11-13% (Söderlund, 2023). Conversely, increases in flight distances due to closures of Russian airspace, due to conflicts, cut trade by 9-10% (Besedeš et al., 2024). Direct flights between cities reduce trade costs, which is strongest for international city pairs than intra-national city pairs (Yilmazkuday and Yilmazkuday, 2017). This could arise due to competition with land transport, something I return to in section 3.2.

Changes in trade are two way. As exports go up, imports also go up. This is well known in the trade literature. This is explicitly identified in two of the studies. Both relate to China. The first, Wang and Fu (2022), relates to manufacturing and finds that air services increase exports more than they do imports. The second, Oum et al. (2024), focuses on services and finds the converse. That is increased air service connectivity to China increases imports of services more than exports. However, looking deeper it finds that this is driven by transport and tourism services, whilst air services improve commercial service exports more than imports. The interplay between imports and exports will have important implications on the net impact of employment at a city/country level by industry. Conceptually at least we would expect employment in export orientated firms to

increase (along with productivity by the Learning By Exporting channel), but competition effects from imports may decrease employment in firms that serve the domestic market. I look at net employment impacts by industry in section 3.2.

Direct flights seem to be the driver to trade. Five of the nine studies use direct flights as an indicator for increased trade . Drawing an analogy with the rail literature this would suggest that interchange penalties and/or surface access travel time costs are very high for business travellers using air services. This seems reasonable in that for short haul trips travellers may be wishing to complete the trip in a day (thus the time constraint binds very tightly giving a very high value for the marginal value of a travel time change), whilst for long haul trips the burden of interchanging flights or using onward land based transport may be very high when jet lagged and tired. There is some evidence for this hypothesis for short haul flights as low cost carriers (LCCs) in Italy have less of an impact on exports than Full Service carriers (FSC). This is likely due to poor timings for business trips (within a European context) and the use of secondary airports that are not convenient to the final destinations of the business travellers (Alderighi and Gaggero, 2017). In the long haul market there appears a strong discontinuity around the 6,000 miles point, which acts as a regulator limit on the length of direct flights. At this distance a 10% change in 'air connectedness' (a population weighted measure of direct flights) would increase bilateral trade by 2 to 2.2% (Furusawa et al., 2024). Morales-Arilla and Bustos (2025) estimate that country pairs just below the 6,000 mile regulatory limit trade by between 20% and 35% more than country pairs just above the limit. They attribute this difference purely down to the presence of direct flights that permit face to face interactions, where there are no feasible alternatives. With respect to China, Oum et al. (2024) find that trade in services is dependent on direct flights, and not frequency of flights. Route creation matters more than frequency increases.

Business passenger travel drives the increase in trade <u>not</u> freight travel. There are two broad pathways from an increase in trade. The first is via business travel which increases face to face contact between businesses, the second is via driving down the costs of air freight. Four of the studies identify that the air cargo has no or limited impact on trade flows (Wang and Fu, 2022, Furusawa et al., 2024, Morales-Arilla and Bustos, 2025, Wang et al., Forthcoming). The mechanism that drives trade flows is via face to face contact between business travellers.. The other studies on air connectivity and trade do not explicitly seem to examine these two pathways

Not all exporting/importing industries and products gain the same from air travel. It is industries with high FFC communication intensity and higher contract intensity that gain the most from air travel (Wang and Fu, 2022, Söderlund, 2023). Such industries are associated with technologically advanced products, machinery, electronics, fabricated metals and transport equipment. This is based on studies between East Asia and Western Europe or from China. Trade flow changes with changes in air connectivity also seem to be driven by new products (i.e. at the extensive margin) rather than by existing products (i.e. at the intensive margin) (Besedeš et al., 2024, Wang et al., Forthcoming), and for products with lower elasticities of substitution (Furusawa et al., 2024).

INVESTMENT AND FDI

Looking at Table 3-1 we can see some signification impacts on investment and FDI from air services. Giroud (2013) found that new airline routes lead to 8–9% higher plant investment (in existing plants), and plant total factor productivity rises by 1.3–1.4%. Fageda (2017) the availability and frequency of nonstop flights between Barcelona and a destination country significantly increases bilateral FDI flows with a 1% increase in air frequencies leads to between a 0.15–0.46% increase in FDI flows. Campante and Yanagizawa-Drott (2018) find that a 10% increase in network centrality, i.e. the position of the airport in the network, leads to a 10% increase in FDI flows, whilst Tanaka (2019) finds that an increase of one flight a day raises the likelihood of new FDI in high FFC sectors by 0.032 percentage points.

We can also see that when looking at investment and FDI we can see that some of the key messages from trade openness are repeating. Namely:

- **FDI is two way.** Both inward and outward FDI flows are affected by air travel (Fageda, 2017).
- **Direct flights seem to be key indicators for FDI and investment.** For example the location of company headquarter are strongly influenced by intercontinental flights (Bel and Fageda, 2008) and non-stop flights significantly increase FDI flows (Fageda, 2017, Campante and Yanagizawa-Drott, 2018) and intra-company investment (Giroud, 2013).
- It seems **business passenger travel** is the driver to investment and FDI (Bel and Fageda, 2008, Fageda, 2017, Giroud, 2013, Tanaka, 2019); and
- This is in **sectors with high FFC** (Tanaka, 2019)

In addition to the existence of direct flights other air service indicators used in the empirical studies on investment and FDI included the **frequency of flights** (Tanaka, 2019, Fageda, 2017) and a **'network position'** indicator (Campante and Yanagizawa-Drott, 2018).

Net outflow of FDI from high income countries due to air services. At a global level net-FDI flows, due to air services, has flowed from high income to middle income countries. Low income countries are not recipients. This is likely linked to the industries that use air services for business travellers (technologically advanced products), which require threshold levels of human and physical capital which may not be present in low income countries.

Freight flights impact negatively on outward FDI. For Japan Tanaka (2019) finds that outward FDI is significantly reduced by the presence of freight flights between cities.

KNOWELEDGE CREATION AND DIFFUSION

Table 3-1 also shows some significant impacts of air services on knowledge creation and diffusion. Hovhannisyan and Keller (2015) find that a 10% increase in U.S. business travel leads to about a 0.2% increase in patenting in destination country, whilst Catalini et al. (2020) find that after a LCC enters the route collaborations between scientists in different cities increase by 0.3–1.1 times. Bai et al.

(2024) identifying off introductions of new routes find that a 20% reduction in travel time increases patent citation flows by ~0.5% (≈15,000 citations nationally), whilst Chen et al. (2025) find that patent applications between city pairs rise by between 4-11% following the introduction of a new route. Using historic data from the 1950s and 60s Pauly and Stipanicic (2025) find that for Metropolitan Statistical Areas (MSAs) that were greater than 2,000kms apart the 41% reduction in journey times from the introduction of jet passenger planes could explain 30% of the increase in patent citations.

We can also see that once again find that some of the messages are the same as for trade and investment and FDI. Namely.

- **Direct connections** are drivers to knowledge creation and diffusion (Bai et al., 2024, Chen et al., 2025, Pauly and Stipanicic, 2025).
- **Travel time and cost reductions** are also factors that assist in collaborations (Catalini et al., 2020, Bai et al., 2024, Pauly and Stipanicic, 2025)
- Its in industries for **new/complex technologies and where FFC is most relevant** (e.g. lab work, etc.) and hard to substitute for other forms of communication (video/email) that benefit the most (Catalini et al., 2020, Bai et al., 2024, Hering et al., 2025).

These studies also identify that a**ir travel has been an important driver to today's economic geography.** It's argued that jet air travel in the US has helped created the spatial economic structure we see today with clusters in Silicon Valley (30% of observed increase in patents during the 1950s and 60s attributed to air travel) (Pauly and Stipanicic, 2025).

Benefits the weakest. Hovhannisyan and Keller (2015) find that business travellers from the US increase patenting in the destinating country. The effect of inward business travel form the US is equal to 25% of all R&D impact in host country, whilst Pauly and Stipanicic (2025) find the impacts of knowledge transfer are largest in less innovative regions of the US and Catalini et al. (2020) find that scientists with weaker local environments benefit the most. However, and referring back to the FDI discussion, Campante and Yanagizawa-Drott (2018) find that FDI flows benefit weaker countries more than strong countries, but not the weakest countries (poorest). This suggests some threshold effects exist for the benefits of air connectivity to be realised. These are possibly associated with minimum levels of human and physical capital for benefits to be realised (Banister and Berechman, 2001).

Distance and competition with land based transport matter. Air travel is most relevant for collaborations and knowledge transfer where land travel is not feasible. In China this is for distances greater than 750km (due to High Speed Rail (HSR) network) (Chen et al., 2025).

Spatial and firm spillovers. The effect of air services on knowledge creation and diffusion is strongest in the city with the airport, but spillovers can occur within 50-100km (in China)(Chen et al., 2025). These effects also occur across firm boundaries rather than intra-firm and represent joint collaborations (Catalini et al., 2020, Bai et al., 2024). This finding resonates strongly with the concept of agglomeration economies and learning effects (Duranton and Puga, 2004, Duranton and Puga, 2020).

TABLE 3-1: FINDINGS ON CHANNELS FOR GROWTH FROM CAUSAL IDENTIFTICATION STUDIES

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
EXPORTS, IMPORTS AND TRADE			
Yilmazkuday and Yilmazkuday (2017)	**433 cities across 114 countries worldwide** (city-level analysis, both international and intranational city pairs).	**Price data:** 2010–2014 **Direct flight data:** 2013	- **Existence of a direct flight between cities significantly reduces trade costs** (negative and significant coefficient in all specifications). - OLS estimates: direct flights reduce trade costs by about 1.3% (controlling for all variables). - IV estimates (addressing endogeneity): direct flights reduce trade costs by 12–52%, depending on the instrument set. - The effect is **stronger for international city pairs** than for intranational pairs.).
Alderighi & Gaggero (2017)	**Italy** (20 Italian regions exporting to 24 European countries).	**1998–2010** (25 winter/summer semesters).	- **Nonstop flights significantly increase exports** of Italian manufacturers, confirming the importance of face-to-face business travel. - **Full-service carriers (FSCs)** have a stronger positive impact on exports than low cost carriers (LCCs). - LCCs show weaker effects, likely due to secondary airports, lower frequencies, and less appeal for business travel. - 1% increase in flights between euro regions boosts manufacturing exports by between 0.02% and 0.09%.
Wang & Fu (2022)	**China** (58 cities with international direct flights, trading with 54 countries).	**2000–2015**	- **Launching a direct flight route increases a city's exports to the destination country by 11.2% on average** (preferred specification). Imports rise by 8.0%. - **Trade dependence** on partner countries increases by 0.3 percentage points (12% at mean value). - **Firm-level effects:** Number of export firms rises by 2.4%, import firms by 3.6%. Product varieties exported/imported increase by 5.3% and 3.7%, respectively. - **Spatial spillovers:** Cities without direct flights benefit from nearby cities' direct flights (3–4% export boost within 150–600 km). - **Industry heterogeneity:** Industries with higher face-to-face communication intensity and higher contract intensity experience stronger export growth after direct flights are launched (e.g., machinery, electronics, fabricated metals, transportation equipment). - **Channels:** The effect is not due to air cargo (which is less than 0.02% of freight); instead, direct flights facilitate international business travel and face-to-face interactions, especially for contract-intensive and communication-intensive industries..
Söderlund (2023)	- **Western Europe and East Asia** (252 country pairs, e.g., UK–Japan, France–China, etc.)	**1976–1995** (main focus: 1980–1990, bracketing the 1985 liberalization)	- **Shorter flight times (lower business travel cost) led to a substantial increase in trade between Western Europe and East Asia** - A 10% reduction in flight time is associated with an 11–13% increase in goods trade (OLS and PPML estimates) - Business travel time can account for one-third to one-half of the remaining geographical frictions (distance elasticity) in trade, after controlling for standard gravity variables - The effect is stronger for technologically advanced products, suggesting that face-to-face interaction is especially important for complex goods - **Facilitating international business travel can significantly reduce the trade-reducing effect of distance, helping remote countries benefit more from globalization**

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
Besedeš et al. (2024)	- **225 EU–non-EU country pairs** Accounting for roughly 40% of EU–non-EU direct air links and about one-sixth of total extra-EU airborne trade; - routes primarily connect **Europe with the Middle East, Asia, and Africa.**	**- 2009–2017 (annual)** - omitting 2011 and 2014 transition years when restricted airspace changed.	- A 1% increase in flight distance reduces airborne bilateral trade by ~2–2.2%; - the average 4.6% distance increase due to the flight restrictions cut trade ~9–10%. - Effects operate almost entirely via the extensive margin (fewer product varieties), especially for intermittent trading relationships; - maritime trade unaffected.
Furusawa et al. (2024)	- Global bilateral trade among ~100 major trading countries (>95% of world trade), - at the HS-6 product level.	- Main cross-sectional trade data in **2016**; - air traffic data 1989 to 2020	- Focusing on country pairs around 6,000 miles apart direct flights reduce communication costs and increase trade with a 10% increase in air connectedness raises trade ~2.5% for median-elasticity products and ~4.2% at 75th percentile. - trade responses are stronger for products with lower elasticities of substitution - face to face communication is the mechanism, and air cargo is not the driver (as results are robust to exclusion of products shipped by air)
Oum et al. (2024)	- China's bilateral service trade with 45 partner countries. - China treated as a single exporter/importer	**2005–2018 (annual), pre-COVID.**	- Adding direct routes significantly boosts bilateral services trade. - Imports (especially travel and transport) rise more than exports, widening China's overall services deficit; - But commercial services exports respond strongly to new destinations, increasing the commercial services surplus. - Route creation matters more than frequency increases.
Morales-Arilla and Bustos (2025)	- **Global bilateral trade** across all country pairs, - focusing on country pairs around the **6,000-mile threshold**;	- Trade: **1995–2020** (5-year blocks for dynamics). - Flights/business travel/FDI around **mid-2010s**.	- Countries just below 6,000 miles are more likely to have direct flights and trade more (20–35% effect near the threshold). - No evidence that cargo/shipping costs drive results (no cargo effect; no effect due CIF-FOB change) - evidence supports effect driven by business travel with positive impacts on business travel expenditure, little impact on tourism, and significant effects on FDI - specialisation by countries away from products where connected countries hold comparative advantage.

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
Wang et al. (Forthcoming)	- Global bilateral trade: ~18,000 country pairs; - hundreds of industries mapped from six-digit product codes.	**2013–2018**.	- Air connectivity causally increases bilateral trade - A 10% rise in passenger flows raises trade by ~0.31% for average industries and ~0.42% for one-standard deviation more contract-intensive industries. - Effects are stronger for new products and are not driven by air cargo. - Country pairs with stronger online social connectedness show a weaker trade effect (showing some substitution between air travel and digital technology)
INVESTMENT AND FDI			
Bel & Fageda (2008)	**European Union (EU25 + Switzerland and Norway; 87 major urban areas).**	**2003–2005**	- **Availability of direct intercontinental flights strongly influences headquarters location decisions.** - Large firms prefer cities with better international connectivity, skilled labor pools, and specialized services. - Political capitals attract headquarters both for institutional influence and because flag carriers concentrate operations there. - **Policy implication:** improving intercontinental air connectivity enhances a city's attractiveness for global firm headquarters, reinforcing urban economic power.
Giroud (2013)	**United States** (manufacturing plants and headquarters across metropolitan areas).	**1977–2005**	- **New airline routes reducing HQ–plant travel time lead to 8–9% higher plant investment (~$158k–$177k in 1997 dollars).** - Plant **TFP rises by 1.3–1.4%**, with profit gains of ~$275k–$296k. - Effects stronger in earlier years (before widespread IT substitutes) and for **time-constrained headquarters**. - Evidence also at the **extensive margin**: firms more likely to open plants near HQ and less likely to close proximate plants. - **Policy implication:** transport infrastructure facilitates **monitoring and information flows within firms**, boosting investment and productivity, though IT innovations later reduced the importance of physical proximity.
Bannò & Redondi (2014)	**Italy**	*(Not specified)*	- **FDIs increased overall by 33.7% in the two years after opening of the new routes while FDIs in the control group decreased by 16.6%.**
Fageda (2017)	- **Spanish region of Catalonia** (Barcelona) and 81 countries worldwide (bilateral FDI flows).	- **2002–2015** (annual data)	- **Availability and frequency of nonstop flights** between Barcelona and a destination country significantly increases bilateral FDI flows. - Estimated elasticity: 1% increase in air frequencies leads to a 0.15–0.46% increase in FDI flows (depending on method). - **Impact is stronger for inward FDI** (Barcelona as recipient) than outward FDI. - **Policy implications:** Airport capacity expansions and improved international air connectivity can generate positive externalities for regional investment. Electronic communications do not fully substitute for face-to-face contact enabled by air travel.
Campante & Yanagizawa-Drott (2018)	Global sample (819 major international cities with airports).	1992–2010 (night lights data); historical context from late 1980s–2000s.	• Airports with more connections just below 6,000 miles gained more direct air services. • Improving airport network position → ~0.8% annual GDP growth (interpreted from change in night lights). • Direct air links foster business connections, particularly FDI flows from high-income to middle-income countries. 10% increase in network centrality gives ~10% increase in FDI • Low-income countries benefit less, , as they are often excluded from new connections. • Air connectivity boosts development but increases spatial inequality.
Tanaka (2019)	**Japan** (firm-level data on Japanese multinational firms	**1989–2006** (annual data)	**International passenger flight frequency significantly increases the probability of new FDI entry** by Japanese firms. [i.e. outward FDI] **Effect is stronger for sectors with high face-to-face communication intensity** (proxied by expatriate staffing).

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
	investing in 79 foreign markets)		**Marginal effect:** An increase of one flight per day raises the likelihood of new FDI in high FFC sectors by 0.032 percentage points (mean FDI entry is 0.4%). . **Freight flights have a significant negative effect** on new FDI entry, suggesting that freight services may encourage exporting over local production. [i.e. freight flights may promote export over outward FDI] **Electronic communications do not fully substitute for face-to-face contact** in FDI decisions.
KNOWLEDGE CREATION AND DIFFUSION			
Hovhannisyan & Keller (2015)	**34 countries** (both developed and developing) that receive business travellers from the **United States.**	**1993–2003** (11 years)	- **Causal Effect:** There is a significant and robust positive effect of international business travel on innovation (patenting) in the destination country. - **Magnitude:** A 10% increase in U.S. business travel leads to about a 0.2% increase in patenting in destination country. - **Relative Importance:** The effect of inward business travel is about one quarter as large as the effect of domestic R\&D spending on innovation. - **Heterogeneity:** The effect is stronger when travelers originate from highly innovative U.S. states (e.g., California)..
Catalini, Fons-Rosen & Gaulé (2020)	**United States** (scientific collaborations across universities and labs, primarily chemistry; and mathematics)	**1993–2012** (air data); **1991-2013** (scientists data)	**After a LCC enters the route collaborations increase by 0.3–1.1 times**, robustly causal. Benefits strongest for **high-quality scientists in weaker local environments** (i.e. whether they have a strong pool of other scientists locally); women scientists did not benefit equally. Travel cost reductions shift project types: more **novel, higher-quality collaborations**, greater use of complementary expertise and specialized equipment. Effects generalize beyond chemistry, though equipment intensity matters more in lab-based sciences.
Bai, Jin & Zhou (2024)	**United States** (Core Based Statistical Areas, ~923 CBSAs, 110,998 CBSA pairs)	**1977–2010** (patent citations matched with airline route data)	A **20% reduction in travel time increases patent citation flows by ~0.5%** (≈15,000 citations nationally). Effects occur mainly **across firm boundaries** (spillovers), not within firms. Stronger impacts for distant city pairs, complex/new technologies, and regions with higher absorptive capacity. Mechanism: reduced travel time facilitates **tacit knowledge transfer** via inventor mobility and face-to-face interaction. .
Chen et al. (2025)	**China** (334 cities, 53,698 city pairs, 2013–2019)	**2013–2019**	**Main effect**: Introduction of a new non-stop air route increases collaborative invention patent applications between city pairs by about 4% (DID), rising to 9–11% in IV estimates. **Distance matters**: The effect is stronger for city pairs separated by more than 750 km, where air connections outperform high-speed rail in fostering collaboration. **Spillovers**: Neighboring cities (within 50–100 km) of connected cities also experience increased collaboration, indicating spatial spillover effects. **Innovation gap**: Air connections especially boost collaboration between highly innovative cities and between highly and less innovative ones, helping to narrow innovation disparities. **City hierarchy**: The largest gains are for collaborations between mega cities (municipalities, provincial capitals) and non-mega cities. **Applicant type**: Effects are strongest when at least one co-inventor is an enterprise; collaborations across corporate group boundaries benefit more than within-group collaborations. **Mechanisms**: Air connectivity reduces face-to-face communication costs, facilitating knowledge flows and the exchange of

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
			complex, specialized knowledge (effect is most pronounced for patents with greater knowledge depth and breadth)
Pauly & Stipanicic (2025)	**United States** (Metropolitan Statistical Areas, nationwide flight network)	**1951–1966** (flight schedules, patent data 1949–1968)	• Travel time between MSAs >2,000 km apart fell by **41%**, explaining **30% of observed increase in patent citations**. • Elasticity: citations rose **2.4% on average**, **6.8% for long-distance pairs**. • Increased knowledge access led to **3.5% annual growth in new patents**. • Stronger effects in **less innovative regions**, driving convergence. • Innovation activity shifted towards the **South and West**, contributing to the rise of Silicon Valley and other clusters. .
Hering, Poncet & Reshef (2025)	**China** (to rest of word)	**1990-2016**	• introduction of a direct link between a Chinese city and a foreign city increases the number of collaborations between them by half a standard deviation, • Collaborations start 3 to 4 years after the establishment of the connection. • Strongest impact where there is little overlap in business hours and for technology classes where lab experiments are involved, and thus more frequent interactions may be required.

3.2 Evidence on the economic impacts of air connectivity

3.2.1 Scope of the evidence base on economic impacts of air connectivity

Table 3-2 provides a summary of the findings of empirical studies on the economic impacts of air connectivity in North America, Europe and Japan. These studies used causal identification strategies. A further three studies covering China and South East Asia were also identified in the literature search (Gibbons and Wu, 2020, Wong et al., 2022, Nguyen, 2024). The abstracts of all these studies are reproduced in Appendix B.

United States. As can be seen from this table the evidence base is very US orientated, with eleven of the seventeen studies US focused. Of the four studies that relate to Europe, two are from Norway, one from Italy and one from Germany. The other two studies detailed in the table relate to Japan and a global study.

Displacement. The economic impacts identified in the studies are predominantly city or municipality focused. They do not account for displacement, and cannot therefore be viewed as net impacts at a national level. An example of this 'city' focus is that populations are typically found to grow, which would reflect displacement of one form or other (against a counterfactual of no change air services).[4] This can also be seen in the detail of the studies which clearly identify geographic focus on the municipality, city, metropolitan area or alternative area.

Historical. Finally, a number of the studies take an historical perspective looking at impacts over long time periods, e.g. from 1950 to 2010 in the case of McGraw (2020). Only three studies use datasets that span into the 2010s and none in the 2020s. Thus these studies may say more about the historical role of air connectivity in shaping spatial economic patterns, and less about the marginal benefits of expanding an already well developed air network.

3.2.2 US evidence on the economic impacts of air connectivity

Airports lead to sectoral specialisation in services. Six of the eleven papers identify examine differential impacts by industrial sector. The other five papers do not examine the issue. There is a broad consensus that the service sector shows the largest changes in employment at a city level. It is hard to compare elasticities across different studies as they invariably are set against different metrics and variables. For example, Brueckner (2003) identifies a service sector employment

[4] A small growth in population in the airport city due to improved air connectivity, in the context of a growing national population, may in essence result in a lower population growth in a non-airport city, rather than a negative growth. However, against a counterfactual of no change in air services, then air services have reduced the population in the non-airport city, whilst growing it in the airport city.

elasticity of 0.11 to enplanements, whilst Sheard (2014) finds an elasticity of the sectoral share of the service in total employment of 0.22, but this is to total flights (not enplanements).

Some differences also occur between studies regarding what other sectors benefit or what parts of the service sector benefit. There is some evidence that it is only the tradeable service sector that benefits and not the non-tradeable sectors (Sheard, 2019). However, other studies identify that retail also benefits (Sheard, 2014, Blonigen and Cristea, 2015).

Irwin and Kasarda (1991) identify that the manufacturing sector also benefits, but no other study finds this. In fact they find they explicitly find there is no change in manufacturing employment. Irwin and Kasarda's result may be attributable to the historical nature of their work (1950 to 1980) when the manufacturing sector in the US was expanding and air connectivity may have assisted with this. A comparable analogy could be modern day China, where Gibbons and Wu (2020) find the manufacturing sector benefit from air connectivity.

The lack of an obvious impact on the manufacturing and the nontradeable service sectors seems surprising given the findings of air connectivity on increases in trade and investment and FDI. Possibly it arises as a result of the net impact of increases in imports in addition to exports. Whilst an increase in performance by export orientated manufacturing firms will expand manufacturing employment, increased competition from imports may displace manufacturing employment.

No study specifically examines the impact on tourism or the visitor economy, but we can examine employment changes in sectors usually associated with it, which would be non-tradeable services. Here we find limited evidence for a significant impact on the visitor economy. A similar story could be unfolding, in that inward tourism/visitors may increase, but so could outward tourism/visitors. The net impact on the visitor economy in the city is then uncertain. The latter of course is in the context of US metropolitan areas – rather than cities that themselves may form significant international tourist attractions (e.g. Paris, Rome, Vienna, London, Edinburgh, etc.).

City level employment and population. In the main the studies find clear evidence of small to modest increases in total employment and total population at a city level. Of the eleven empirical studies on the economic impacts of air connectivity in the US only one found no impact on city level employment and population. This was Sheard (2014). Possibly this arises due to the econometric strategy employed, which primarily used cross-sectional data. Employment impacts typically slightly exceed population impacts. Thus for example Blonigen and Cristea (2015) find that a 50% increase in city air traffic would increase city population between 0.42-1.14% over 20 years and employment would increase by between 0.6-1.2%, or McGraw (2020) who attributes airports to 3.4% growth in population and a 3.9% growth in employment per decade. The implication here is that there is an increase in the employment rate within a city following an increase in air connectivity.

Wages and incomes. There is mixed evidence on wages and incomes. Bilotkach (2015) finds a positive impact, as does McGraw (2020), but Sheard (2019) finds none. The latter is surprising given the increases in population and employment rates. A lack of increase in real wages/incomes but an increase in population and the employment rate would imply that air services might also be associated with increases in amenity attracting population, or any ancillary investments (e.g. in

surface access infrastructure) lower commuting costs which increase labour market participation. Possibly all these mechanisms are at play but are small or modest and then difficult to detect definitively.

Spatial location in city and airport employment impacts. Whilst there is a substantial literature identifying that airports are very large (and growing) employment areas within the city landscape (Appold and Kasarda, 2013) that can occasionally rival some Central Business Districts (CBDs) (Cidell, 2015), there is also a lot of heterogeneity in the importance of airports as sub-regional (metropolitan) employment centres (Cidell, 2015). Thus where the economic impacts occur within a city occur within a city is of interest. Are they diffused across the city or located in a part of the city. Only one study of the seventeen examines this. This is Sheard (2019). He finds that airport size correlates with employment in all parts of the metropolitan area (i.e. large cities have large airports), but the additional jobs associated with improved connectivity are located on the same side of the city as the airport. This suggests that the benefits of air connectivity are spread between the neighbourhood of the airport and around the CBD, but not over the whole city. From a policy perspective therefore the local labour and housing markets (local to the airport) would need to be able supply additional workers for the full benefits of increased air connectivity to occur.

Spillover impacts between cities and displacement. With the exception of Sheard (2021) these studies consider each city in isolation. Sheard (2021) however finds that air traffic growth in one metropolitan area can rise employment rates in nearby metropolitan areas within approximately 400 miles. Negative impacts occur on metropolitan areas further away, giving direct evidence of displacement effects.

Scope of air networks and frequency are factors in explaining differences in economic performance in addition to enplanements (passenger demand). Sheard in his studies tends to use the number of flights, Bilotkach (2015) found non-stop destinations to be more relevant than frequency, and Irwin and Kasarda (1991) and Cristea (2023) use network centrality indicators.

Passenger air services drive growth. Only Green (2007) specifically examines the contribution of passenger and freight air services to economic growth. He finds that air cargo services have no impact on the metropolitan area, and that growth is driven by passenger transport. Whilst other studies have not specifically examined this question, the metrics used as explanatory variables (e.g. enplanements, number of flights, network centrality, etc.) are passenger focused.

Not all cities benefit equally. The strongest impacts are for airports close to a major research university, a capital city and positive climate factors (McGraw, 2017). Whether the airport is also a hub appears important (Green, 2007). The latter may however reflect the benefits of non-stop destinations, frequency/flights, or network centrality identified above.

3.2.3 European evidence

Similarities with US evidence. Aside from in its quantity (with only four studies employing causal identification strategies), the European evidence differs from the US evidence in that it seems to have a regional airports[5] focus. Three of the four studies specifically focus on regional airports (Tveter, 2017, Breidenbach, 2020, Rattsø and Sheard, 2025). Having said that the evidence from Europe reinforces the US evidence in that:

- **Sectoral differences.** Service sector employment is the main beneficiary (Percoco, 2010)
- **Spatial spillovers.** In Italy, neighbouring regions also gain (Percoco, 2010)
- **Population and employment increases.** Norwegian airports have been associated with population and employment growth within their municipalities (Tveter, 2017, Rattsø and Sheard, 2025)
- **Not all cities gain equally.** Municipalities with universities, colleges or hospitals gained the most from the airports in Norway (Rattsø and Sheard, 2025)

Mixed or limited impacts of airports. A key difference between the US studies and the European studies is that some airports have no or limited impacts. For example Breidenbach (2020) found that the regional airport expansions in the 1990s in Germany have had no economic impacts, and Rattsø and Sheard (2025) conclude that there are likely only marginal gains to be had from further regional airport expansion in Norway. . These mixed or limited impacts can be attributed to a mixture of airport attributes.

- **Links to major cities.** In Norway regional airports that have an air connection to a major city have larger economic impacts (Rattsø and Sheard, 2025). In the context of Norway this means the ability to conduct a day return trip to the major city, so useful for businesses.
- **Surface and air competition.** In Norway regional airports that have a competing rail service have a smaller economic impact, and impacts are larger where a neighbouring airport is further away (Rattsø and Sheard, 2025). Breidenbach (2020)'s findings could in part be attributed to surface and air competition, as Germany and Europe in general, have far more extensive rail networks than the US. Additionally, the regional airports in Germany are sometimes located on old military airfields, which are not proximate to the final city destination (Breidenbach, 2020) increasing surface access costs to the air services and making an end to end rail trip more competitive. The importance of surface competition in determining the economic impact of air connectivity also resonates with the Chinese study showing that air connectivity only increased collaborations between cities more than 750km apart (due to the presence of HSR) (Chen et al., 2025).

[5] Regional airports will usually serve a region, and will predominantly serve a domestic or short haul international market. They can sometimes be defined by thresholds, such as having less than 1 million passengers per annum as in Breidenbach (2020).

- **Negative impacts from a loss of connectivity.** Whilst not European data, the Japanese experience illustrated that regional air service changes can lead to negative impacts if re-organisation of air services leads to a connectivity reduction in peripheral regions (Yamaguchi, 2007).
- **The role of complementary infrastructure and activities.** As mentioned above municipalities with universities, colleges or hospitals gain the most from air connectivity, whilst alternative transport infrastructure (e.g. rail) can diminish the impact of air services.

There is therefore a clear evidence gap in the causal literature on the impact of air services in the European context, particularly in the role of the impact of major hub airports, sectoral impacts on services, manufacturing, and the visitor economy. There is a larger literature that utilises statistical association (e.g. Granger causality tests) to determine whether air connectivity drives growth. This literature also gives mixed results and also contradictory results. The problem with this literature is that we cannot be sure that the studies are fully identifying a causal relationship, and not just a statistical association with a common driver. However, given the paucity of the causal empirical literature in a European context it is worth summarising the literature that identifies causation via statistical association. Briefly, there are broadly three groupings of empirical work. The first is one that finds no or little evidence that air connectivity drives growth, the second that finds it drives growth and the third which gives a more nuanced view.

In the first category, Mukkala and Tervo (2013) find that air traffic drives economic growth only in the peripheral regions of Europe and not in the core parts of Europe. Similarly, Küçükönal and Sedefoğlu (2017) find that for OECD countries that air transport does not (at a country level) drive economic growth.

Contrastingly, in the second grouping of studies, Pot and Koster (2022) find that airports in the core have a larger impact (elasticity) on economic performance than those in the periphery, whilst Brida et al. (2016) find that air connectivity contributes to economic growth in Italy. Çelik et al. (2025) use aggregate country level data for the ten largest users of air services (at a national level) and find in the main that air services drive economic growth. The UK is one of those. For the UK they also find that growth stems from passenger not freight services. The exceptions are Russia and Brazil, where the causation is reversed. Similarly, Akar (2025) finds that air connectivity causes economic growth for developed countries. They also find that for middle income countries[6] a bi-direction causality exists. The latter is relevant to Europe as some Eastern European countries have a similar level of development to these middle income countries. These findings are consistent with Zhang and Graham (2020)'s conclusions, where they viewed a uni-directional relationship from air transport to economic growth existing in the richer more developed countries like the UK and the US, and a bi-directional relationship existing in middle income and lower income countries.

[6] They label countries Argentina, Brazil, etc. as developing countries, but these are middle income in a world sense.

In the final grouping, Van de Vijver et al. (2016) identifies more nuanced results. They find some European regions benefitting from air connectivity and others not. There is no specific pattern to this that they can discern with some core regions benefitting (in Germany and Austria), and other core regions around large hub airports not benefitting (e.g. Amsterdam and Paris), though this result could be due to the manner that they have not captured spatial spillovers between regions. Similarly, some peripheral areas gain and others do not. They also identify that manufacturing in some parts of Europe gain from air connectivity, and that it is not just services. In recent unpublished work Chapman and Pot (2025) identify that only Eastern European countries' economies are currently benefit from air connectivity in Europe. They primarily attribute this to growth in business travel, which is stagnating in other parts of Europe but growing in the east, and growth in leisure travel which leads to an outflow of tourists in some of the richer parts of Europe (e.g. the UK, Germany and Scandinavia). At a country level Kaya and Aydın (2024) identify something similar in that they find that some countries benefit from air connectivity and others do not.

To an extent these statistical association studies complement the four causal identification studies previously discussed. They clearly show that the European situation is more complicated than the US situation, but that given the right conditions air connectivity can create growth. However, we should be careful about reading too much into these statistical association studies as we cannot be sure that they are correctly identifying the economic impacts of air services.

TABLE 3-2: FINDINGS ON ECONOMIC IMPACTS ON GDP, EMPLOYMENT, WAGES/INCOMES AND POPULATION FROM CAUSAL IDENTIFTICATION STUDIES

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
UNITED STATES			
Irwin & Kasarda (1991)	**United States** (104 metropolitan areas)	**1950–1980.**	• Metropolitan areas with higher airline network centrality experienced significantly greater employment growth. • Producer services and manufacturing employment were especially influenced by air network position. • Changes in airline centrality were shown to be a **cause rather than consequence** of employment growth, confirming the causal role of air transport linkages. • The reorganization of the airline network between 1950 and 1980 was a critical factor reshaping the spatial economy of the U.S., with Sunbelt cities gaining centrality and employment advantages.
Brueckner (2003)	**United States** (91 metropolitan statistical areas, including major cities with multiple airports)	**Primarily 1996** (airline traffic and employment measured contemporaneously)	• Passenger airline traffic is a significant predictor of total metropolitan employment, especially in service-related industries. A 10% increase in enplanements leads to about a 1% increase in service employment. • Population grows less than employment. • No significant effect of airline traffic on goods-related (manufacturing) employment. • Hub status and leisure destination status (Las Vegas, Orlando) are strong predictors of higher airline traffic. • Proximity to large airports reduces local enplanements in smaller metros.
Green (2007)	**United States** (83 metropolitan statistical areas with major airports)	**Primarily 1990–2000** (airport activity measured in 1990, growth outcomes over the subsequent decade)	• Passenger activity (boardings and originations per capita) is a strong predictor of both population and employment growth. • Cargo activity does **not** significantly predict growth. • Hub status is positively associated with growth. • Results suggest that airports, particularly passenger traffic capacity, play a meaningful role in metropolitan economic development, beyond simple correlation.
Sheard (2014)	**United States** (metropolitan areas, Core Based Statistical Areas)	Cross-sectional analysis with 2007 employment data, instrumented by 1944 airport plan allocations.	• Airport size has a **positive effect on tradable service employment shares** (elasticity ≈ 0.22). • No measurable effect on manufacturing or most non-tradable sectors. • Retail trade shows some sensitivity to airport size. • Airports lead to **sectoral specialization** (shift toward tradable services) but not overall metropolitan employment growth. • Larger airports facilitate face-to-face interactions crucial for tradable services, but do not expand total job numbers.
Bilotkach (2015)	**United States** (all metropolitan statistical areas with primary commercial passenger airports)	**1993–2009** (17-year panel)	• **Number of non-stop destinations** has the strongest and most robust positive impact on employment, establishments, and wages. • Passenger traffic volume positively affects employment and wages, but not number of establishments. • Adding one new destination at the sample median creates ~98 jobs and ~4 new businesses; at the mean, ~223 jobs and ~15 businesses. • Increasing flight frequency yields smaller effects than adding new destinations. • Airline market competition influences the magnitude of impacts, with concentrated airports sometimes benefiting local economies via loyalty programs.

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
			• Overall, airports stimulate regional development, but mainly through connectivity rather than sheer traffic volume.
Blonigen & Cristea (2015)	**United States** (263 Metropolitan Statistical Areas)	**1969–1991** (pre- and post-deregulation)	• A 50% increase in a city's air traffic growth rate would lead to: 0.42–1.14% increase in city population over 20 years. 0.6–1.2% increase in incomes over 20 years. 0.42–1.14% increase in employment over 20 years. Over 20 years, this translates into ~7.4% of real GDP (≈ $523 million in 1978 dollars). • Effects are strongest in **services and retail sectors**.
McGraw (2017)	**United States** (medium and small cities)	**1950 to 2010.**	•Airports, overall, provided a causal contribution of 0.2– 0.6% per year on population and employment growth over the time period. •City-level factors contributing to airport success include: (I) closer proximity to a major research university, (ii) a capital city location, and (iii) climate factors, particularly higher January mean temperatures and/or hours of sunshine. Also (iv) city size cities in larger metropolitan areas, with larger shares of employment in nontradables in the 1950s, were also better positioned to reap the benefits that airports provided on city growth.
Sheard (2019)	**United States** (181 metropolitan statistical areas with commercial service airports)	**1991–2015.**	•Airport size has a **positive effect on local employment** (elasticity ≈ 0.04). •Effects concentrated in **services and construction sectors**; no measurable impact on manufacturing, wholesale/retail, or utilities. •Airport expansion also increases number of firms, population, employment rate, and GDP. •No significant effect on wages, suggesting elastic labor supply or amenity-driven migration. •Employment gains are concentrated in areas nearer the airport within metropolitan regions. •Overall, airports stimulate local growth by attracting firms and residents, but primarily through sectoral specialization and proximity effects.
McGraw (2020)	**United States** (Core Based Statistical Areas, midsized and smaller cities; thirteen large hubs (cities) excluded)	**1950–2010** (employment, population, wages; with historical aviation data back to 1900 for controls)	•Airports led to **3.9% growth in employment and 3.4% growth in population per decade**. •Nontradable employment grew ~2.9% per decade. Nontradeable = Construction, Retail, finance, insurance and real estate (FIRE) and Services •From 1980–2010, airports increased earnings per worker by 2% and per-capita personal income by 3% (≈1.2% per decade). •Average airport contributed ~916 jobs per decade, mostly in nontradable sectors (660 jobs), and ~$77 million in output growth (2010 dollars). •Findings for mid-size and small cities only (large hubs/cities are excluded)
Sheard (2021)	**United States** (196 airports across 179 metropolitan areas, CBSA-level)	**1991–2018** (panel data for CBSA-level analysis; cross-section for network simulations in 2015)	•Local air traffic increases local population (elasticity ≈ 0.010) and employment (elasticity ≈ 0.036). •Positive spillovers: air traffic growth in one metro raises employment rates in nearby metros (within ~400 miles). Negative impacts on employment in metros further away. •Simulations show that for each job created locally by airport expansion, ~2.5 jobs are created elsewhere in the US due to network effects. •Average airport expansion creates one job per ~$78,000 invested, though returns vary widely across airports (from very high to negative). •The US air network is **less centralized than optimal**, suggesting efficiency gains from reallocation of investment.

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
Cristea (2023)	**United States** (262 metropolitan areas / CBSAs)	**1984–2013.**	•An increase in air connectivity equal to the sample mean **0.1% growth in population**. **0.4% growth in employment**. **0.3% growth in number of local businesses**, especially small and medium firms. •Connectivity expansion matters more than simply increasing seat capacity. •Strong evidence that **aviation networks causally drive urban development**. •Policy implication: cities benefit from expanding the **scope** of their aviation networks (new destinations, hub links), not just traffic volume.
EUROPE			
Percoco (2010)	**Italy** (103 provinces, with focus on 35 major airports)	2000–2005	•Elasticity of service-sector employment to airport passengers ≈ 0.045. •Spatial spillover effects from neighboring airports add ≈ 0.017 elasticity. •Airports significantly stimulate local employment, especially in services, but impacts extend beyond provincial boundaries.
Tveter (2017)	**Norway** (nine municipalities where regional airports constructed	1970–198 (airports constructed 1970-1972)	• Point estimates suggest a ~5% population increase in municipalities near new airports (1970–1980). • Employment also shows positive but statistically insignificant effects. • Overall, results are imprecise, making it impossible to reject the hypothesis of no regional impact. • Highlights the difficulty of isolating productivity or wider economic effects beyond direct transport cost reductions.
Breidenbach (2020)	**Germany** (regional airports with < 1million passengers)	1993–2008 (pre-treatment 1993–96; post-treatment 1997–2008)	•No evidence that regional airport expansions generated positive spillover effects on local economic growth. •Results robust across buffer definitions, alternative specifications, and robustness checks. •Contrasts with findings for large international airports (e.g., U.S. deregulation studies), suggesting limited or negligible growth effects from small regional airports in Germany.
Rattsø & Sheard (2025)	**Norway** (160 labourmarket regions, 50 new airports opened between 1950–2019)	1950–2019.	•Positive overall effects: airport openings increased both population and employment relative to synthetic controls. •Strongest effects for airports opened in the 1950s, in regions far from other airports (>100km), with longer runways, or where air services to major cities occurred, and in regions with universities, colleges, or hospitals. •Employment gains concentrated in transport/communications and services, less so in manufacturing. •Policy implication: early expansion of the network yielded large benefits, but marginal effects of small/peripheral airports today are limited; improving road access to larger airports may be more effective than building new small airports.
JAPAN			
Yamaguchi (2007)	**Japan** (47 prefectures)	1995–2000.	•Air transport accessibility has a significant positive effect on productivity in prefectures. •Coefficient for accessibility increased between 1995 and 2000, reflecting growing importance of air connectivity. •Growth regressions show positive impact of accessibility on GDP growth, stronger when connecting to higher-GDP regions (e.g., Tokyo, Fukuoka). •Core metropolitan areas benefited most; peripheral prefectures (e.g., Hokkaido, Kagoshima) sometimes experienced negative impacts due to increased air generalized costs (with airlines concentrating on trunk routes to/from Tokyo). •Only 9 out of 47 prefectures gained growth from change in air accessibility.

Author (Year)	Country/Region Studied	Time Period Studied	Key Findings
			•Overall, deregulation and infrastructure expansion in the 1990s produced mixed regional outcomes, reinforcing agglomeration in cores while not uniformly aiding peripheries.
GLOBAL			
Campante & Yanagizawa-Drott (2018)	Global sample (819 major international cities with airports)	1992–2010 (night lights data); historical context from late 1980s–2000s with introduction of long-range aircraft.	•Airports with more potential connections just below 6,000 miles gained significantly more direct links. •Improving an airport's position in the global network by one standard deviation increased local GDP growth by ~0.8% annually (interpreted from change in night lights – not estimated directly) •Direct air links foster business connections, particularly FDI flows from high-income to middle-income countries. 10% increase in network centrality gives ~10% increase in FDI •Low-income countries benefit less, as they are often excluded from new connections. •Air connectivity boosts local development but also intensifies spatial inequality, both within countries (airport regions vs. hinterlands) and globally (middle-income vs. low-income countries).

4 ECONOMETRIC ESTIMATION AND CONNECTIVITY METRICS

4.1 Identifying causality

A paper uses a causal identification strategy if It explicitly addresses endogeneity, which in our particular interest is the feedback between air traffic and growth. To do so it would typically methods including: Instrumental Variables (IV) (also known as 2 Stage Least Squares (2SLS); Difference-in-Differences (DiD); or natural experiments / policy shocks. The goal of the method is to isolate exogenous variation in air traffic, so as to estimate its effect on growth.

If instead an empirical strategy uses: Ordinary Least Squares (OLS) regression, Vector Autoregression (VAR) and the Granger causality test, or correlations or descriptive statistics, then it would be viewed as not truly identifying causation. It may just be identifying correlations.

4.2 Methods adopted in selected studies

Table 4-2 contains a description of the econometric methods used in each of the identified studies, the dependent variables used and the independent variables used. The broader literature, some of which is referred to in Appendices A and B, use a mixture of predictive causal methods (statistical association), OLS or similar regressions or descriptive statistics.

4.2.1 Econometric method

By an artefact of the selection strategy used in this literature review only studies employing causal identification strategies have been identified. These contain three broad types of econometric method:

- IV/2SLS methods
- Difference-in-Differences including those using a synthetic control treatment approach
- Quasi-natural experiments (or discontinuities)

In the main the studies utilise a panel dataset. This allows the empirical strategy to control for unobserved heterogeneity for example between cities or regions.

When employing IV/2SLS methods the choice of a good instrument is imperative to identify the exogenous variation of air traffic on economic growth. None of the reviewed papers use the lagged independent variable as an instrument. Such instruments are typically viewed as weak. Instead instruments have been constructed using a historic data (such as McGraw (2020) utilising a historic national airport plan or army air service plan), or Bartik style instruments on national growth in air traffic categories (e.g. Sheard, 2019, Sheard, 2021) or geography, airport or air service characteristics, or destinations (e.g. Brueckner, 2003, Green, 2007, Cristea, 2023).

However, a review of Table 4-2 identifies that Differences-in-Differences or quasi-natural experiments are preferred. Such empirical strategies have often exploited a change in policy. The European regional airports work is linked to a government social policy to connect outlying regions (Norway), whilst in Germany was associated with a liberalisation of the air network. Most often an exogenous policy change regarding air network liberalisation (e.g. open skies agreements) have been exploited.

4.2.2 Independent variables

Within our sample of studies that employ causal identification empirical strategies we can see a range of independent air transport variables being used to explain economic growth:

- Enplanements (number of passengers)
- Frequency/number of flights
- New destinations
- Direct flights
- Generalised cost
- Network centrality

These independent variables are utilised in conjunction with a variety of different control variables.

Only one study (Yamaguchi, 2007) used the generalised cost concept that is ubiquitous in the modelling of travel demand for land based transport (e.g. road and rail). We can however see that key aspects of generalised costs are captured in such things as new destinations or direct flights. Both a new destination or a direct flight, reduce travel time and 'interchange penalties' by removing the need to change flights, or removing long onward surface transport travel times. Other elements of generalised cost (such as price changes) have been captured via entry of a new airline on a route, where that airline is a low cost carrier (LCC) (Catalini et al., 2020).

Enplanements and number of flights can be seen as pure volume metrics. In contrast new destinations and number of flights can be seen as metrics of scope. Volume measures might be seen as measures of the intensive margin, whilst measures of scope might be seen as the extensive margin. The network centrality metrics are also measures of scope. As measures of scope these are closely aligned with the market access literature related to agglomeration economies (Lenaerts et al., 2021). Of course changes in the generalised cost of travel encompasses both aspects of changes in volume (e.g. increased frequency of services) and aspects of scope (increased range of destinations). This is because If there are more direct air services (i.e. an increase in scope) then travel times, and generalised cost, between previously unserved destinations will fall. This is relevant to expected changes in economic growth as reductions in generalised cost create a positive supply side impacts.

Now looking in more detail at the network centrality indices that are seen as encapsulating changes in scope and market access (Lenaerts et al., 2021, Cristea, 2023), aside from an early study by Irwin

and Kasarda (1991) that used a Bonacich centrality measure[7], only three other studies have used network centrality measures: Campante and Yanagizawa-Drott (2018), Sheard (2019) and Cristea (2023). There are several similarities between the different measures used. Quoting from Cristea (2023)

> Sheard (2019) defines the "air access" of a metropolitan area as the number of flights operated to each nonstop destination, weighted by the population size of that destination. This measure is similar to our proposed measure of air connectivity, the main differences being that our weights consist of the shares in total departures accounted by each destination airport (i.e., the "hub-ness" of the destination airport), in addition to factoring in information on the elasticity of substitution between destination routes when evaluating flight frequency. While "air access" is not the preferred airport infrastructure measure used in Sheard (2019), its estimated effect on local employment growth is similar to our estimate. Campante and Yanagizawa-Drott (2018) construct a measure of a location's aviation network centrality, which captures the idea that a direct link to a well-connected destination airport is more economically meaningful than a link to a poorly-connected one. This airport centrality measure is similar to our proposed "air connectivity" measure in that they both use information on the air links of destination airports (i.e., the "hub-ness" of the destination airports) to assess their importance for the origin city. One key difference is that our measure also accounts for the frequency of nonstop flights to those destinations (subject to the elasticity of substitution between them). This may matter since infrequent connections from an origin city to a very large airport hub may hinder access to the services provided by that hub no matter how big that hub might be.
>
> Source: Cristea (2023)

Other measures of network centrality (or air connectivity) also exist in the 'statistical association' literature. These include that developed by Allroggen et al. (2015) which they term the Global Connectivity Index, and that used by Pot and Koster (2022). These metrics also try to reflect the value of frequency, direct connections, hubs, and onward connections to 'attractive' destinations. Allroggen et al. (2015) build their measure up from the core attributes of the air network, though Pot and Koster (2022) develop theirs using passenger throughput at an airport as a measure of its 'attractiveness'. The latter approach likely does not capture the scope/market access element of the metric as well as Allroggen et al. (2015) and Cristea (2023).

[7] Bonacich Centrality is a network analysis measure that defines a node's importance based on its neighbours' importance, using a decay factor to weight distance from neighbouring nodes.

4.3 Identifying channels for growth

In Chapter 3 (section 3.1) four broad channels for growth were identified following a change in air connectivity. These are detailed in the left hand column of Table 2-1. There were the demand impacts of increased airport operations arising from more planes and passengers or freight, and there were the demand impacts associated with changes in visitor numbers. There were supply side impacts from travel generalised cost reductions with quicker journey times, more direct services, less interchanges, cheaper prices, etc. Finally there are the supply side catalytic impacts of air transport are primarily associated with knowledge exchange. These are those that are seen to generate the large productivity impacts by changing imports/exports, FDI/investment, increasing innovation and knowledge diffusion.

The first two demand related channels might be expected to be dependent on volume related metrics such as enplanements or the number of flights arriving/departing. These are shown in the right hand column of Table 4-1. Supply side impacts from a reduction in generalised cost would relate to a mixture of total demand (enplanements) and the sources of the cost reductions such as increased frequency, scope of network and price. Finally the catalytic impacts would be associated with market access (i.e. network centrality) measures.

TABLE 4-1: CHANNELS FOR GROWTH AND POTENTIAL INDEPENDENT VARIABLES

Channels for growth	Possible independent variable
Airport operations:	Enplanements, number of flights
Tourism/Visitors	Enplanements, number of flights
Travel generalised cost reductions: direct benefits to existing travellers/freight	Enplanements, frequency[1], scope[2], price
Catalytic impacts via FFC (increasing innovation, knowledge diffusion, trade, FDI, investment, etc.)	Network centrality or market access measures incorporating destinations served, frequency, timing (arrival/departure time), etc. network centrality

Note: (1) enplanements may need disaggregating in different ways for the different channels. E.g for tourism/visitors there is different economic behaviour between international and domestic visitors/tourists, tourists from different nations, business visitors and tourists. (2) Frequency is a travel cost reduction as waiting time is reduced with increased frequency. Scope is also potentially a travel cost reduction, as surface access may be reduced, or the need to inter-line might be reduced.

The implication of this logic is that there is no single metric to employ. This is because all channels will function simultaneously. It is further likely that the different metrics will be highly correlated. Thus in any estimation it may be necessary to just use one. We see this in the empirical literature. For example Sheard (2019) uses the number of departing flights and then uses three alternative independent variables as robustness checks (passengers, seats, and "air access" measure of number of flights weighted by destination population). The number of flights is itself a volume metric and might be seen as a suitable proxy to pick up the direct benefits from changes in air travel demand on the economy and the knowledge spillovers/catalytic impact benefits.

However, if there is an interest to zero in on the catalytic benefits then a metric most suitable for that should be used. Lenarts et al. (2021) in their paper on the economic impact of aviation and a review on the role of market access argue that volume metrics (e.g. passenger demand or number of departures) are not a good substitute for connectivity metrics which capture market access. Cristea (2023) concludes that scope is important for urban growth, not just traffic volume, and employs a 'novel' air connectivity metric. Thus using a market access measure (i.e. a network centrality metric) would be best to capture the catalytic impacts. However, and this is important, as there is some correlation with the volume metrics (i.e. the other rows in Table 4-1) (see e.g. Lenaerts et al. (2021)) then it will be difficult, if not impossible, to identify a 'pure' estimate of catalytic effects purged of any of the other channels of growth.

4.4 Future empirical analysis

Critical to any future econometric approach is the purpose of the study.

If as, in many of the examples in the literature, the purpose is to understand the economic impact of air connectivity on city performance, then metrics such as number of departing flights (as used by Sheard and other authors) may be adequate to capture the net impact of air services. Such a metric captures elements of both volume and scope effects.

However, if the purpose is to act as a basis for the modelling of a particular channel (e.g. knowledge spillovers) in assessing the impact of a change in air services, then it would be necessary to zero in on that channel, and choose the most appropriate metric. Here a market access type of measure (e.g. network centrality) would seem most appropriate (Lenaerts et al., 2021, Cristea, 2023).

If the purpose is to complement a modelling framework for an economic impact study, then it would be necessary to be mindful of that modelling framework in determining the empirical strategy. I discuss this latter issue further in the context of S-CGE modelling in Chapter 6.

Common to all approaches would be the need to disaggregate the economic data in such a manner so as to identify the industrial sectors that would gain the most from air services. These would be industries that benefit the most from FFC. This is because not all industries gain equally. Similarly, there would be a need to distinguish spatially as not all cities gain equally.

Another commonality to any of the approaches that could be adopted would be the need to control for unobserved heterogeneity and the need to control for endogeneity. Panel data has often been used to control for unobserved heterogeneity, and studies to date have exploited quasi-natural experiments on the liberalisation of air services or other exogenous policy changes to control for endogeneity. Other successful empirical studies that have controlled for endogeneity have employed IV methods using Bartik style instruments or utilised historic national air plans, historic military air field plans and/or instruments based on geography (e.g. distance to the sea).

TABLE 4-2: SUMMARY OF ECONOMETRIC METHODS APPLIED

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
EXPORT AND TRADE			
Yilmazkuday and Yilmazkuday (2017)	- **Main regression:** log(trade cost) on direct flight dummy, log distance, international border, and standard gravity controls (common border, language, colonial ties, regional trade agreement), with city fixed effects. - **Endogeneity addressed using instrumental variables (IV/2SLS),** where direct flights are instrumented with policy-based variables from air services agreements (e.g., Air Liberalization Index, Factor Analysis Index, years since first agreement, incident investigation, security cooperation).	- **Trade costs between city pairs** (measured as the maximum absolute log price difference in traded-input prices across goods, controlling for local wages) - Robustness tests: 2nd maximum, 80th/90th percentile price differences for trade costs	- **Direct flight dummy** (1 if there is a direct flight between cities, 0 otherwise) - **Log of great circle distance** between cities - **International border dummy** - Common border, common language, colonial relationship, regional trade agreement dummies - City fixed effects - Policy-based instruments for direct flights (for IV estimation)
Alderighi and Gaggero (2017)	- **Gravity model of trade** estimated with panel data (1998–2010, half-yearly observations). - **Newey–West two-step GMM estimator** to correct for heteroskedasticity and autocorrelation. - Robustness checks with Poisson pseudo-maximum likelihood (PPML). - Distinction between **full-service carriers (FSCs)** and **low-cost carriers (LCCs)**. - **Classification:** This is a causal-oriented trade study using IV/GMM, though not a natural experiment.	- **Regional exports of Italian manufacturing firms to European destinations.**	- **Air transport connectivity** (number of nonstop flights, disaggregated by FSC vs. LCC). - Standard gravity controls: economic size of origin/destination, distance, trade resistance, fixed effects. - **Instruments:** seasonal flight frequencies
Wang and Fu (2022)	- **Staggered Differences-in-Differences (DID) Approach:** Uses city-country-year panel data from Chinese customs and flight route records (2000–2015). - Incorporates a rich set of fixed effects: city-country pair, year, city/country characteristics, and city-country-specific linear trends. - **Classification:** Causal identification strategy, with careful attention to confounding factors and reverse causality (e.g., cities with growing trade may attract flights). The study excludes cities never having direct flights and uses lagged tourism variables to mitigate endogeneity. Difficult to instrument effectively.	- **City-level exports** (annual value from city to destination country). - **City-level imports** (annual value from source country to city). - **Trade dependence** (city's trade with a country divided by city GDP). - **Number of export/import firms** (city-country-year). - **Product varieties exported/imported** (city-country-year, HS 8-digit code). - **Industry-level exports** (by face-to-face communication and contract intensity).	- **International direct flight dummy** (whether a direct flight route exists between a city and a country in a given year). - **Number of direct flight routes** (treatment intensity). - **City-level controls:** GDP, GDP per capita, manufacturing share, number of tourists, tourism revenue, number of star hotels. - **Country-level controls:** GDP, GDP per capita, trade dependence ratio. - **Industry-level measures:** Face-to-face communication intensity (from Cristea, 2011), contract intensity (from Nunn, 2007). - **Spatial spillover variables:** Number of direct flights in neighboring cities within 150–600 km.

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
Söderlund (2023)	- **Natural experiment:** 1985 liberalization of Soviet airspace, sharply reducing flight times between Europe and East Asia - **Difference-in-Differences (DiD):** Compares trade changes in affected (treated) country pairs to matched controls - Matching via Coarsened Exact Matching (CEM) on pre-treatment observables (GDP per capita, language, border, colonial ties, currency, FTAs) - Estimation: OLS and Poisson Pseudo Maximum Likelihood (PPML) for robustness; extensive fixed effects (exporter-time, importer-time, exporter-importer)	- **Bilateral trade flows** (value of goods traded between country pairs, from UN COMTRADE) - **Trade in goods not typically transported by air** (to isolate business travel effects from air cargo effects)	- **Treatment variable:** Log change in flight time between country pairs, before and after Soviet airspace liberalization - **Control variables:** GDP per capita, shared language, border, colonial ties, currency, FTAs (from CEPII Gravity Dataset) - Other controls: Product-level technological advancement, CPI deflators, etc.
Besedeš et al. (2024)	-Gravity models estimated in panel with country-pair fixed effects and PPML. - Causality identified via a **natural experiment** with time-varying flight distances induced by exogenous FAA NOTAM airspace restrictions (due to conflict zones over Russia). - Country pair fixed effects, and Importer-time and exporter-time fixed effects absorb control for bilateral trade frictions, multilateral resistance and time varying country shocks; - sea-trade flows show no effect supporting a air transport-cost channel.	- Aggregate bilateral exports by air; - (robustness checks) bilateral imports; - extensive margin (number of HS-6 categories); - intensive margin (average value per HS-6).	- Key regressor: log time-varying bilateral flight distance (GIS-constructed least-cost paths reflecting airspace bans). - Fixed effects: country-pair; exporter-time; importer-time.
Furusawa et al (2024)	- Structural gravity model derived from a model with endogenous communication/quality control. - Causality via IV exploiting the discontinuity in direct-flight availability at **~6,000 miles** (crew-duty regulations), using grid-cell shares just below 6,000 miles within a 5,500–6,500-mile window; - fixed effects and distance controls.	- Bilateral exports at HS-6 product level;	- Key regressor: country-pair air-connectedness index (population-weighted grid connectivity to airports with weekly round-trip direct flights). - Interaction with a composite elasticity term. - Controls: population-weighted distance bins; extensive fixed effects; - IVs based on 6,000-mile discontinuity.
Morales-Arilla and Bustos (2025)	- quasi-natural experiment exploiting a sharp discontinuity at 6,000 miles (ULH) to identify exogenous differences in direct passenger flights; - assume all other determinants of trade vary smoothly with distance.	- probability of direct passenger and cargo flights - probability of some trade or high trade - business travel spending, - tourism trips, - FDI, and - specialization (country-product competitiveness).	- Binary indicator if country pair lies above or below **6,000 miles**; - Bilateral distance between country pairs - interaction terms with product characteristics - country and product fixed effects
Oum et al. (2024),	- Reduced-form gravity-type model estimated with 2SLS. - Causality addressed via IV - instrument is average global air connectivity of China and each partner	- Bilateral service trade values for Total services and sub-components: commercial, travel, transport (government	-Key explanatory variables are(1) number of direct routes between China and partner country (network scope), and (2) average passengers per

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
	with other countries (excluding the focal bilateral routes). Measure is number of foreign cities with direct connection to China. (on basis that countries with more developed air networks likely to have a bilateral connection with China), - controls including country pair and year fixed effects	services excluded).	route (route-level density); - controls include GDP per capita, exchange rates, internet penetration, regional trade agreements, maritime shipping connectivity, and geographic and institutional controls.
Wang et al (forthcoming)	- **Industry-level gravity model** - **2SLS IV** with third-country connecting capacity in the global airline network as an instrument. Identification relies on within country-pair variation in the instrument over time - Numerous fixed effects (exporter-industry-year, importer-industry-year, country-pair, tariffs and regional trade agreements).	- Main variable is Log bilateral export value (for each country pair, by industry and year) - robustness checks using imports; margins and new vs. old products.	- Endogenous (instrumented) regressor: log number of passengers from importer to exporter; - instrument: external connecting capacity via third countries (excluding flows from the focal partner) - Interaction with industry contract intensity (Nunn, 2007, measure). - controls
INVESTMENT AND FDI			
Bel and Fageda (2008)	- **Simultaneous equation system** to address **endogeneity** between headquarters location and intercontinental flight supply. - Cross-sectional analysis of European urban areas. - **Two step GMM** to address endogeneity - **Classification:** This is a **causal-oriented study** (structural equations with endogeneity correction), not just correlation.	- **Number of headquarters of Europe's 1,000 largest firms located in each urban area.**	- **Weekly frequency of direct intercontinental flights** (measure of international connectivity). - Wages, fiscal pressure (taxes), industrial employment, services employment, population (congestion), GDP share of region, capital city dummy. - For flight demand: population, international tourists, hub status, capital city dummy.
Giroud (2013)	- **Difference-in-Differences (DiD)** exploiting exogenous variation from the **introduction of new airline routes** that reduce travel time between headquarters and plants. - Controls for local shocks (MSA-year), firm shocks (firm-year), and robustness checks (mergers, hub openings, indirect flights). - **Classification:** This is a **causal identification study** using quasi-experimental airline route entry as the shock.	- **Plant-level investment** (capital expenditures). - **Plant-level productivity** (total factor productivity, profits). - **Plant openings and closures.**	- **Travel time reductions** due to new airline routes between HQ and plants. - Firm and plant characteristics (employment, assets, industry sector). - Controls for local economic conditions and firm-level shocks.
Bannò and Redondi (2014)	- **Treatment and control.** Only weakly causal.	*(Not specified)*	*(Not specified)*

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
Hovhannisyan and Keller (2015)	- **Instrumental Variables (IV) Approach:** Uses "friends & family" travel as an instrument for business travel in a Poisson GMM IV framework (Mullahy, 1997). - Extensive fixed effects (country, year, industry) are included to control for unobserved heterogeneity.	- **Innovation**, measured as: - The number of U.S. patents granted to inventors in each foreign country and industry per year (fractional counts if multiple inventors). -- Also considers patents with U.S. co-inventors as a subset.	- **Main Independent Variable:** Number of U.S. business travellers to each country, by industry and year (weighted by the technological strength of the U.S. state of origin). - **Instrument/Control:** Number of U.S. travellers visiting friends & family (used for control function and as an instrument). - **Controls:** - Population, GDP per capita, R&D expenditures, resident patent applications, U.S. exports/imports, U.S. FDI, FDI to U.S., etc.
Fageda (2017)	- **Gravity equation** for bilateral FDI flows, using panel data (2002–2015). - **Instrumental variables (IV) approach** to address endogeneity between air traffic and FDI flows. - Main instrument: Air frequencies from the destination country to European airports (excluding Spain and hub airports). - **Estimation techniques:** Poisson pseudo-maximum likelihood (PPML), OLS, 2SLS, generalized linear models (gamma and negative binomial distributions).	- **Bilateral FDI flows** (inward and outward) between Barcelona and destination countries (thousands of euros).	- **Main variable:** Number of annual nonstop flights (air frequencies) between Barcelona and destination country. - **Controls:** Population, GDP per capita, GDP growth, distance, openness (trade/GDP), tax burden, time zone difference, exchange rate, broadband penetration, domestic credit, regional dummies.
Campante and Yanagizawa-Drott (2018)	• Regression Discontinuity (RD) design exploiting 6,000-mile threshold for ultra-long-haul flights. • 2SLS for endogeneity. • Satellite night lights as proxy for economic activity. • Firm-level FDI data to trace business linkages. .	• Local economic activity (night lights intensity). • Business linkages (FDI ownership connections).	• Airport connectivity (number and quality of long-haul direct flights). • Share of potential destinations just below vs. above 6,000 miles. • Controls: geography, initial economic conditions, spatial spillovers.
Tanaka (2019)	**Linear probability model** for new FDI entry at the firm level. **Instrumental variables (IV) approach** to address endogeneity (using world heritage sites as an instrument for flight frequency). **Interaction terms** to identify the role of face-to-face communication (FFC) intensity.	**New establishment of foreign affiliates** (FDI entry) by Japanese multinational firms.	**Main variable:** Weekly frequency of international passenger flights between Japan and host country. **Proxy for FFC intensity:** Sector-level measure based on the number of expatriate employees sent from Japan to foreign affiliates. **Interaction term:** Flight frequency × FFC intensity. **Controls:** air freight flight frequency, firm productivity, foreign experience, geography, economic conditions, year fixed effects.

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
KNOWLEDGE CREATION AND DIFFUSION			
Catalini et al. (2020)	**Difference-in-Differences (DiD)** exploiting quasi-experimental variation from **Southwest Airlines' entry on new routes** (lower travel costs). Robust falsification tests and extensions across disciplines. **Classification:** This is a **causal identification study** using exogenous airline route entry as a shock.	**Number of scientific collaborations** (co-publications). **Quality and novelty of projects** (citations, novelty measures, equipment intensity).	**Travel cost reductions** (Southwest route entry). **Scientist characteristics** (age, productivity, gender, departmental R\&D funding). **Field differences** (chemistry vs. mathematics).
Bai et al. (2024)	**Difference-in-Differences (DiD)** with continuous treatment intensity (travel time reductions from new airline routes). Robustness checks with discrete shock variables and hub-opening events. Extensive fixed effects (CBSA-year, CBSA-pair) to address endogeneity. **Classification:** This is a **causal identification study** exploiting exogenous variation in airline route introductions.	**Knowledge flows measured by patent citations** between CBSA pairs.	**Travel time reductions** due to new airline routes. **City-level absorptive capacity**, technology complexity, inventor relocation. **Firm linkages** (joint ventures, block holdings, supply chain ties).
Chen et al. (2025)	**Staggered Difference-in-Differences (DID) Approach**: Compares city pairs that gained new non-stop air routes (treatment) to those that did not (control). Controls for city-pair and year fixed effects, as well as city-level economic, demographic, and innovation variables. **Instrumental Variables (IV) approach:** Predicts air connection propensity using airline and region characteristics, following Chandra and Lederman (2018). **Classification:** Causal identification strategy, with extensive controls for confounding and endogeneity.	**Collaborative innovation**: Number of invention co-patent applications jointly filed by city pairs (log and count). **Knowledge complexity**: Breadth and depth of co-patents (measured by patent classification codes). **Subgroup analyses**: By city innovation level, administrative hierarchy, and applicant type (enterprise vs. institution).	**Air connectivity**: Dummy for new non-stop airline route between city pairs. **HSR connectivity**: Dummy for new high-speed rail connection. **City-level controls**: GDP per capita, population, industry structure, trade, number of universities, non-collaborative patents. **Distance bands**: City-pair straight-line distance (focus on >750 km for long-distance effects). **Instrumental variable**: Predicted air connection propensity based on airline/city characteristics.
Pauly and Stipanicic (2025)	**Quasi-natural experiment**: nationwide rollout of jet aircraft (1951–1966) reducing long-distance travel times. **Gravity model of patent citations** to estimate elasticity of knowledge diffusion to travel time. **Instrumental Variables (IV)** using "fictitious travel time" (holding routes constant, varying only aircraft speed) to isolate exogenous variation. **Classification**: This is a **causal identification study** exploiting exogenous technological shock (Jet Age).	• Patent citations (knowledge diffusion). • New patents filed (knowledge creation). • Geographic distribution of innovation (regional convergence).	• Travel time reductions due to jet aircraft adoption. • Instrumental travel time (speed improvements only). • Controls: highway travel time, telephone connectivity, ticket prices, market access.
Hering et al. (2025)	**Quasi-natural experiment (event study design)**	(not available from abstract)	(not available from abstract)

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
ECONOMIC IMPACTS: GDP, WAGES/INCOME, EMPLOYMENT, POPULATION			
Irwin & Kasarda (1991)	Regression analysis with **non-recursive simultaneous equation models** to test direction of causality. Airline network centrality measured using Bonacich centrality scores. **Classification**: This is a **causal identification strategy**, since the nonrecursive modeling explicitly tests whether employment growth causes airline centrality or vice versa.	• Metropolitan employment growth (overall). • Employment growth in manufacturing. • Employment growth in producer services.	• Airline network centrality (initial level and change in centrality). • Highway centrality. • Exportation index (extent industries serve nonlocal markets). • Occupational specialization of workers Population change, density, age of infrastructure, business phone penetration.
Brueckner (2003)	Panel regressions using **instrumental variables (IV)** to address simultaneity between airline traffic and employment. Instruments include hub status, geographic centrality (distance to US population center), proximity to large airports, slot control status, and leisure destination status. **Classification**: This is a **causal identification strategy**, since IV estimation is explicitly used to isolate exogenous variation in airline traffic.	• Total metropolitan nonfarm employment. • Goods-related employment (manufacturing, construction, mining). • Service-related employment (trade, finance, insurance, real estate, services, government, transport, utilities).	• Airline traffic measures: total passenger enplanements. • Instruments: hub status, centrality, proximity, slot control, leisure destination. • Controls: population (lagged to 1990), age distribution, climate (heating degree days), education (college graduates), union influence (right-to-work law), state tax rates (personal and corporate).
Green (2007)	Panel regressions with **instrumental variables (IV)** to address simultaneity between airport activity and growth. Instruments include geographic distance measures (to Kansas City, to nearest coastline), lagged population growth, and runway capacity. **Classification**: This is a **causal identification strategy**, since IV estimation is explicitly used to isolate exogenous variation in airport activity.	• Metropolitan population growth. • Metropolitan employment growth.	• Airport activity measures: boardings per capita, originations per capita, cargo per capita, hub status. • Instruments: geographic distance variables, lagged population growth, runway counts by length. • Controls: per capita income, industrial structure, proximity to other hubs.
Yamaguchi (2007)	Cross-sectional analysis (1995 and 2000). **Cobb–Douglas production function** including an air transport accessibility index. **Growth regression approach** with simultaneous equations estimated via **3SLS**. **Classification**: A causal approach using instrumental variables (2SLS), not a clean natural experiment.	• Prefectural GDP per capita (adjusted for public investment). • GDP growth rates.	• Air transport accessibility index (based on generalized cost: airfare, travel time, frequency, relative economic levels of origin/destination). • Private capital stock. • Labor input. • Distance, air transport share, agricultural output share (instruments).

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
Percoco (2010)	Extended **Brueckner (2003) framework** with sectoral employment regressions. **2-stage** to correct for **selection bias** (since not all provinces have airports). 1st stage Tobit model and 2nd stage Propensity score **Spatial econometric model** to capture spillover effects across provinces. .	• Local employment, particularly service-sector employment (measure of local development).	• Airline traffic (passenger volumes). • Airport presence/size (continuous treatment variable). • Spatial spillover measures (neighboring airport traffic). • Controls for province characteristics (economic and geographic).
Sheard (2014)	**Instrumental variables (IV)** approach using the **1944 National Airport Plan** as an instrument for airport size in 2007. Two-stage estimation linking planned airport distribution to current airport traffic and sectoral employment. **Classification**: This is a **causal identification strategy**, since the instrument provides plausibly exogenous variation in airport size.	• Employment shares by sector (manufacturing, tradable services, non-tradable services, retail, etc.). • Overall metropolitan employment (employment rate, employment growth).	• Airport size measured by departing flights (traffic). Alternative definitions were departing flights from main airport, direct destinations served daily and passenger numbers. • Controls: population, geography, climate, demographics, aggregate employment.
Bilotkach (2015)	**Dynamic panel data estimation using system GMM (Arellano–Bover/Blundell–Bond)**. Also includes fixed effects two-stage least squares (2SLS) for comparison. **Classification**: This is a **causal identification strategy**, as GMM explicitly addresses endogeneity and dynamic feedback between air traffic and economic development.	• Total employment. • Number of business establishments. • Average weekly wage (inflation-adjusted).	• Air traffic measures: number of flights, passenger volume, number of non-stop destinations. • Controls: population, unemployment rate, airport concentration (HHI), airline market shares, average airfares.
Blonigen & Cristea (2015)	**Difference-in-differences framework** exploiting the **1978 Airline Deregulation Act** as a quasi-natural experiment. OLS and instrumental variables (IV) estimations on differenced growth data. **Classification**: This is a **causal identification strategy**, since deregulation provides an exogenous shock to air traffic patterns.	• Population growth. • Income growth (per capita). • Employment growth (total and by sector).	• Air passenger traffic growth (changes in air service provision following deregulation). • Controls: initial economic conditions, city fixed effects, secular trends, and instruments based on neighboring cities' traffic changes.
Tveter (2017)	**Difference-in-differences (DiD)** design comparing municipalities with reduced distance to airports (treated) against three sets of controls (later airport areas, earlier airport areas, and "just not affected" municipalities). **Classification**: This is a **causal identification strategy**, since it exploits exogenous infrastructure expansion.	• Municipal population growth. • Municipal employment growth.	• Airport accessibility (shorter distance to nearest airport after construction). • Controls: pre-treatment population size, lagged growth, industry structure, travel time to nearest airport.
McGraw (2017)	**Synthetic controls (DiD)** Regression analysis to identify relevant city characteristics	•Population and employment growth over the time period.	(Not specified in abstract)

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
Campante & Yanagizawa-Drott (2018)	**Regression Discontinuity (RD) design** exploiting the 6,000-mile threshold created by regulatory and technological constraints on ultra-long-haul flights. Uses** 2SLS **for endogeneity Satellite night lights used as proxy for local economic activity. Firm-level foreign direct investment (FDI) data to trace business linkages. **Classification**: This is a **causal identification strategy**, since the discontinuity provides plausibly exogenous variation in air connectivity.	• Local economic activity (night lights intensity, proxy for GDP growth). • Business linkages (FDI ownership connections between firms across cities).	• Airport connectivity (number and quality of long-haul direct flights, especially around the 6,000-mile threshold). • Share of potential destinations just below vs. above 6,000 miles. • Controls for geography, initial economic conditions, and spatial spillovers.
Sheard (2019)	Panel data analysis (1991–2015). Novel **instrumental variables (IV)** approach: instruments constructed from national growth in air traffic categories (airlines, aircraft types, distance ranges), applied locally (Bartik-style). **Classification**: This is a **causal identification strategy**, since instruments exploit exogenous variation in national air traffic patterns rather than local demand.	• Local employment (overall and by sector). • Number of firms. • Population size. • Employment rate. • GDP. • Wages.	• Airport size measured by number of departing flights (three alternative measures: passengers, seats, and “air access” measure of number of flights weighted by destination population). • Controls: metropolitan fixed effects, year fixed effects, local employment size, population.
McGraw (2020)	**Pooled synthetic control event-study design** to estimate causal effects of airport presence. Long panel (1900–2010) with staggered adoption of airports. Counterfactuals constructed from nonairport cities with historical aviation potential (Air Mail fields, National Airport Plan sites). **Classification**: This is a **causal identification strategy** (synthetic control with event-study), not just predictive correlation.	• Employment growth (total, tradable vs. non-tradable sectors). • Population growth. • Wages, earnings per worker, per-capita personal income.	• Airport presence (treated vs. control cities). • Historical aviation indicators (Air Mail network, • Army Air Service plan, National Airport Plan). • Controls: geography, climate, human capital (land-grant colleges, political capitals).
Breidenbach (2020)	**Difference-in-differences (DiD)** exploiting the **1997 deregulation of the European aviation market** as a quasi-natural experiment. Treatment = counties within buffer zones (15–30 km) of regional airports that expanded post-deregulation. Control = counties without airports. **Classification**: This is a **causal identification strategy**, since deregulation created exogenous incentives for expansion unrelated to local economic conditions.	• Growth of regional GDP per employed person (GDP/worker). • Employment and prosperity indicators.	• Airport expansion indicator (binary treatment variable). • Controls: population, employment, population density, lagged GDP/worker. Regional and year fixed effects.

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
Sheard (2021)	Two-part analysis: **Instrumental variables (IV)** approach (Bartik-style instruments adapted to air traffic) to identify exogenous changes in local air traffic and their effects on population and employment. **Structural network model** of the US air system (adapted from Allen & Arkolakis highway model) to simulate spillovers across the national network. **Classification**: This is a **causal identification study** (IV-based, with simulation of network effects), not just predictive correlation.	• Local population. • Employment levels and employment rates. • Distribution of labor force across regions.	• Air traffic volumes (departing passengers, flights). • Airport infrastructure measures (runway and terminal values, replacement costs). • Controls: CBSA fixed effects, year fixed effects.
Cristea (2023)	Novel **air connectivity index** (weighted count of nonstop destinations, frequency, and hubness). **Instrumental Variables (IV)** approach using geography and destination airport growth to address endogeneity. Robustness checks with 3-year differences, controls for market access, and fixed effects. **Classification**: This is a **causal identification study** (IV strategy exploiting exogenous variation in aviation network expansion).	• Urban population growth. • Total employment. • Per-capita income. • New firm entry (business establishments).	• Air connectivity index (scope of aviation network, not just traffic volume). • Destination hub characteristics, flight frequency, substitution elasticity. • Controls: wages, market access, geography, etc.
Rattsø & Sheard (2025)	**Synthetic control method (SCM)** with staggered adoption (separate synthetic controls for each airport region). Event-study framework comparing treated regions (airport openings) with counterfactual synthetic regions. Heterogeneity analysis by airport characteristics (size, distance to other airports, network connections, presence of social infrastructure).	• Regional population growth. • Regional employment growth (total and by broad industries).	• Airport opening (treatment indicator). • Airport characteristics: runway length (STOL, regional, primary), distance to nearest airport, connections to major cities. • Local context: presence of hospital, university/college, major roads or railways. Geography and climate controls.
Gibbons & Wu (2020)	Panel fixed-effects regressions using a **closeness centrality index** of air transport access. Focus on "incidentally treated" counties midway between old and new airports to mitigate endogeneity. **Classification**: This is a **causal identification strategy**, since the design isolates exogenous variation in access improvements not driven by policy targeting.	• Industrial productivity (gross output and value-added, conditional on inputs). • County-level GDP.	• Air transport access index (closeness centrality based on journey times to airports and between airports). • Decomposition into **landside access** (distance/time to nearest airports) and **airside access** (potential destination airports). • Controls: geographic and socioeconomic characteristics, industry dummies, firm inputs (employment, assets).

Author (Year)	Econometric Method	Dependent Variables	Independent Variables
Wong, Zhao & Lee (2022)	**Panel data regression** (2005–2017). **Instrumental variable (IV) analysis** to address endogeneity in airport development. Controls for other transport modes (rail, highway, waterway).	•Annual growth rate of real GDP per capita (regional economic growth).	•Air transport indicators: air cargo freight volumes, passenger traffic, airport scale and structure. •Controls: fixed asset investment, labour input, labour quality (education), R\&D expenditure, FDI, exports, freight traffic by rail, highway, and waterways.
Nguyen (2024)	Panel data (1970–2021). Baseline regressions: **OLS, fixed effects (FEM), random effects (REM)**. Robustness checks: **Dynamic OLS (DOLS)** and **IV-GMM** to address endogeneity and autocorrelation. Interaction terms to capture **COVID-19 pandemic effects**.	•Economic growth (GDP per capita).	•**Air transport activity** (passenger and cargo volumes). •**Tourism activity**. •Controls: foreign direct investment (FDI), international trade, renewable energy consumption. •Pandemic dummy and interaction terms (COVID × air transport; COVID × tourism).

5 RELEVANCE TO S-CGE MODELLING

5.1 The evidence base on net economic impact

In the main the econometric evidence on the economic impacts of air connectivity is only indirectly helpful to Spatial Computable General Equilibrium (S-CGE) modelling. This occurs primarily as the empirical studies identify final economic impacts rather than estimating parameters for a modelling exercise. For example, the seminar work by Brueckner (2003) identified that employment in services increases by approximately 1% for a 10% change in air traffic, with no observable change in employment in other sectors. This is clearly the net result of simultaneous multiple channels for growth along with competition effects and local economic conditions.

A model such as an S-CGE model aims to model these channels and forecast the net impacts. Thus outcomes on employment etc. from these empirical studies, as detailed in Table 3-2, are of little direct use in the S-CGE modelling. They are though of value as they indirectly inform the modelling in terms of spatial and sectoral levels of disaggregation.

5.2 S-CGE modelling and channels of growth

I have previously discussed growth from changes in air connectivity occurring through four broad channels. There are two which are demand side related: changes in the demand for air transport related activities and changes in demand for visitor economy activities. There are also two that are supply side related. The first of these relate to improved productivity of air transport for existing trips , which may in turn lead to some induced trips. This would be seen as a generalised cost reduction and is analogous to the business and freight user benefits in appraisals of land based transport modes. The second broad supply side impact are what is sometimes referred to as the catalytic impacts of air services. These encompass the ability to form new partnerships, joint ventures, collaborations leading to changes in trade, FDI and knowledge creation and diffusion.

A suitably disaggregated S-CGE model should in principle be able to capture the first three of these channels: the demand side impacts on air transport services, the demand side impacts on the visitor economy, and the supply side impact on existing users of air services. It would be likely require an exogenous model[8] to capture the fourth channel – the catalytic impacts.

5.2.1 Air transport services

The first broad channel of economic impact is that on the demand for air transport services. Airports can be significant employers in a metropolitan area, and can create employment zones that can rival

[8] Exogenous to the S-CGE model

some CBDs. Supply side constraints in the local/regional economy may therefore bind if there is a significant change in demand for air transport services.

S-CGE models are particularly well suited to modelling the impact of such supply side constraints. However, to do so would likely require appropriate levels of disaggregation, functionality and model closure conditions. Firstly, it would be essential to separate out as a separate industry air transport services. Such a separation would identify not only which industries use air transport services, but which industries are in the supply chain to air transport services. A demand side impact on air transport services then not only changes, for example, the demand for labour in the provision of air transport services, but also the demand for labour in its supply chain.

In terms of modelling supply side constraints in supplying such a change in demand. As local economic impacts in metropolitan areas appear to be confined to the side of the city in which the airport is located Sheard (2019) this would point towards a spatial disaggregation that separates the airport 'zone' from the rest of the metropolitan area/region. Ideally, it would also point towards modelling of the housing market and commuting, as would occur in an urban S-CGE models (Stroombergen and Laird, 2023). Labour supply is often critical in modelling economic impact, and a view on this would often need to be specified as a closure rule (Stroombergen and Laird, 2023).

5.2.2 The visitor economy

Changes in the number of visitors to the UK, and the outflow of UK tourists will create demand changes to the UK visitor economy. An S-CGE model is well suited for modelling how such a demand side change could impact on the economy. This would include both representing how regional supply side constraints may crowd out existing activities (including lower value visitor related activities), and how it may impact on the broader economy via exchange rate adjustments[9].

Taking an idealistic perspective this would require the S-CGE model to model changes in the demand for tourism. Including different expenditure patterns from different types of visitors[10]. Potentially the changes in demand by visitors would be modelled separately as part of the overall modelling of changes in passenger demand, and thus be endogenous to the S-CGE model.

To capture the impacts on the visitor economy, and regional economies in general, it would be necessary to identify as a separate industrial sector those industries associated with the visitor economy. Additionally, which regions of the UK that visitors travel to/from need to be identified. This in itself implies an appropriate level of spatial disaggregation.

If there are uncertainties in the demand modelling of visitors, net inflow/outflow, differences in destinations, expenditure patterns, etc. It would likely be necessary to examine these as sensitivity tests in the modelling.

[9] The Dutch Disease is an example of a negative impact of exchange rate adjustments from increasing exports on the broader economy.

[10] Classically business versus leisure, with leisure possibly disaggregated further

It's worth noting that the evidence base from the US appears to indicate no obvious net impact on the visitor economy in employment terms from changes in air connectivity. This might be a US phenomenon, but it suggests that: either supply side constraints bind very tightly in US regional economies; or that changes in air connectivity predominantly lead to substitution effects between different tourist activities (e.g. destinations). It is therefore important that any modelling of the visitor economy is sensitive to these issues (including via sensitivity testing).

5.2.3 Use benefits of air services

Existing users of air services will get a supply side benefit from any improvements in air connectivity such as reductions in journey time via more non-stop services, increased frequency and price reductions. This will be for both freight and passenger services. With such a supply side impact one would expect that industries that use air services would expand employment and output, with broader impacts on their supply chains.

This points towards the need in the S-CGE to separate out the air service using sectors of the economy from other sectors. This will then capture that the benefits of improved air connectivity will be concentrated in the air using sectors of the economy and their supply chains.

S-CGE models model the impacts of changes in prices (e.g. tariffs) extremely well. Thus if the air connectivity changes lead to significant price changes for passengers and freight, the economic impacts of this on the economy should be well captured.

Whilst it is possibly to capture the 'cognitive' aspects of travel within an S-CGE model (for example journey time) this is only usually implemented in transport specific S-CGE models, particular urban S-CGE models (Stroombergen and Laird, 2023). For regional S-CGE models it would likely be necessary to estimate a productivity benefit to air users based on their value of journey time savings (VTTS). Such an approach has been adopted in previous applications of S-CGEs in a UK context (e.g. to HS2). A difference in an application to a change in air connectivity is the degree of robustness one might attribute to air users' VTTS and associated time metrics including changes interchange (direct vs interchange flights, frequency, etc.). In contrast there is a large evidence base for the VTTS, etc. of rail users. This may also be even more uncertain with respect to overnight long haul travel.

It's important to recognise that business travellers and shippers to the UK will also benefit from air connectivity enhancements. Therefore it would be necessary to separate air users between those who originate in the UK and those who originate elsewhere. The spatial structure of the S-CGE model therefore ideally needs to be set up to capture how the improved competitive position of the rest of the world will impact on imports to the UK, with associated competitive pressures on the domestic economy and exchange rate impacts. In principle S-CGE models are well positioned to model these impacts. It is worth noting at this point that the US evidence suggests that only employment in tradeable services in US cities has been impacted by air connectivity. This would suggest that either competitive pressures from overseas on other air using sectors of the economy (e.g. manufacturing) or local supply side constraints are acting to limit growth. It's therefore important to capture these constraints and competition impacts in the S-CGE model.

5.2.4 Catalytic impacts

Here I use the term catalytic impacts to refer to the additional benefits above use benefits and the demand side impacts of air services. These include for example learning effects from knowledge diffusion both to businesses that export (learning by exporting), spillover productivity benefits from FDI to local firms, and to those that engage in new joint ventures or collaborations. They would also be associated with the ability to improve the supply chain with improved access to product variety. These 'catalytic' impacts are therefore closely related to the external benefits of agglomeration economies.

Whilst changes in trade flows and investment flows (including FDI), could theoretically be modelled in the S-CGE model[11] the spillover benefits from them to the regional economy would be an external input. This is the same as the treatment of agglomeration economies in an S-CGE model.

To capture these external impacts on productivity, etc. we are reliant on the evidence base to offer suitable parameters. Unfortunately, as can be seen from the previous review, this is not available. Specifically, we do not have estimates of changes in either FDI inflows and outflows to the UK following changes in air connectivity, nor any subsequent change in productivity. There is evidence for Catalonia (Fageda, 2017), but such evidence might be best transferred to a regional airport in the UK and not a London airport. There is some evidence of productivity changes following air service led investment with plant total factor productivity increasing by between 1.3-1.4% (Giroud, 2013). this follows the introduction of a new route between headquarters and the region where the plant is located. It relates to US based manufacturing and is pre-2005 (and extensive digital connectivity), therefore might seem more relevant to connectivity to a regional economy (e.g. north of England) than to an increase in connectivity of a capital city where headquarters may already be located. There is also an interaction between FDI flows and shipping costs, with lower freight shipping costs resulting in less FDI (Tanaka, 2019).

There is evidence of significant changes in collaborations following air service changes, but studies do not then translate this into productivity changes or changes in regional GDP. This is a significant evidence gap.

In previous work for DfT PwC made attempts to estimate elasticities of changes in GDP to changes in FDI flows and increased trade openness, as well as elasticities of changes in trade openness and FDI flows to changes in air passenger numbers. Effectively this is aiming to capture these external benefits (PwC, 2013). This econometric work was critiqued by the DfT's peer reviewers as "*to be interpreted with caution and 'literal' interpretation of the magnitude of estimates should be eschewed. Instead, the results should be considered qualitatively as indications from emerging research and as a useful starting point which might be developed further*." (Mackie et al., 2013). To

[11] The endogenous modelling of bi-directional FDI flows in an S-CGE model would likely be very demanding in terms of data, as for each country sufficient data on returns to capital would need to be included in the model.

this I would add the critique that the external benefits are likely related to market access (i.e. related to the scope of the air network) and not to the volume of traffic. Thus the analysis arguably should be pivoting off a change in scope (e.g. a network centrality metric) and not a change in a volume measure, such as passenger numbers as PwC did[12].

Further considerations regarding the modelling of these catalytic impacts relate to whether all destinations are equally attractive or whether some are more attractive than others – attractiveness being some combination of size and quality. This relates to how the market access measure should be derived, and how it should be applied in a policy test. There is also the question as to which industries gain from these 'catalytic' benefits. The empirical literature emphasises that it is industries that require high levels of FFC (Wang and Fu, 2022, Catalini et al., 2020, Chen et al., 2025). This is likely to be a subset of the users of air services, and certainly a subset of the general economy.

Finally, competition effects will determine the net impact of the catalytic effects on a region. Will the benefits be split in some way between the airports at either end of the trip or located at only one of the airports? The New Economic Geography literature emphasises the role of market access and agglomeration economies, as determining how location decisions are determined. The growth in US employment in tradeable services and no or limited impact in manufacturing should be seen in this context. Ideally, the S-CGE modelling should capture these locational choices.

This lack of empirical information on the scale and size of the catalytic impacts following a change in air connectivity clearly creates a number of risks associated with modelling this channel of economic growth. It will therefore be necessary to sensitivity test the model to a range of different elasticities of external productivity growth to changes in market access, and potentially to a range of different industries and regions to which it can be applied to. Benchmarking these elasticities against evidence in the trade literature may also be needed.

5.2.5 Spatial spillovers

The empirical literature typically concentrates on the region in which the airport is located. However, some studies have examined spatial spillovers and found that neighbouring regions also benefit from an airport. We would expect that such regions gain through either 'regional' air services into the hub airport, or from land-transport access to the airport or through supply chain effects. In principle these spatial spillovers should be captured in a suitably specified S-CGE model. Such a model would have an appropriate regional Social Accounting Matrices (for the supply chain effects), and air service 'shock' to firms in neighbouring regions would result in lower costs should they have access to the airport via regional air services or by land-transport.

[12] PwC used total passenger numbers, which included inter-lining trips, which is even less related to market access than a pure volume measure to/from a country or region.

6 DISCUSSION AND FUTURE RESEARCH NEEDS

The empirical evidence leans towards a compelling story where air connectivity has played a significant historic role in not only creating growth at a city and national level, but also in shaping our economic geography. It does this primarily through facilitating face to face contact (FFC). Unsurprisingly the industries that gain the most from it are those in which FFC plays an important role. FFC through air connectivity facilitates trade between countries, and between regions if a country is large enough. It increases inflows and outflows of investment (FDI in an international context). It also facilitates new collaborations that create knowledge and help diffuse knowledge. The locations that benefit the most from air connectivity are those that have sufficient levels of physical infrastructure and human capital for the industries that benefit from air connectivity. This would include universities and hospitals. The poorest regions or countries which may not have such infrastructure or levels of human capital may get little benefit from air services, thus leading to an unequal level of development.

To an extent modern communications (e.g. the internet) and modern high speed land based infrastructure (e.g. motorways and HSR) has lessened the importance of air services (relative to say the 1950s). However, for industries where FFC remains important and difficult to substitute (e.g. laboratory based industries) it remains relevant. Similarly, air connectivity remains relevant when connecting locations beyond where land based transport is competitive (e.g. distances greater than 750km if an HSR network exists). Good land transport access to airports also reduces the need for a large numbers of regional airports. In Norway where the motorway network is limited airports less than 100km apart have limited economic impacts. For regions with good motorway or rail access to airports one would expect this distance to be larger.

Whilst, undoubtedly our understanding of the role of air services in shaping our economies has increased there remain some puzzles. Air connectivity clearly benefits the visitor economy and manufacturing. The latter via increased collaborations and joint ventures leading to increased trade. However, these benefits do not seem to materialise in increased employment in these sectors. The principal industry that expands in employment terms is tradeable services (often called producer services). The finding that freight air services are not vehicles for growth also seems surprising. Potentially both puzzles arise due to competitive effects of a region being able to export more, but also simultaneously being exposed to more imports. Such competitive pressures should also apply to tradeable services, but possibly the US (and Europe) have an added advantage in tradeable services, and with these also being subject to strong agglomeration economies, tradeable services locate in the more developed regions/countries. Thus whilst being exposed to more competition tradeable services activities centralise to US (and potentially European cities) following air service connectivity. To what extent these 'patterns' of growth would continue into the future is an important policy question.

The lack of good causal empirical studies of air connectivity in Europe is a serious evidence gap in extrapolating empirical findings to an airport expansion in the UK. It would seem natural to transfer the seemingly consistent results between the eleven different US studies to Europe, but caution should be exerted as in contrast to the US, Europe is much more diverse. It is diverse in economic performance, with large levels of income inequality between for example its west/north and its

east/south, there exist a large number of 'regional' airports that are quite close together, and there also exists a competitive rail network. It should therefore not be surprising that that what studies that have been undertaken in Europe show that the impact air connectivity is more nuanced in Europe than in the US.

In extrapolating this to the UK a further problem occurs in that the none of the European economic impact studies focus on the UK. The UK does however appear in some of the empirical studies on channels of growth, albeit the UK results are merged into an international dataset. These studies include: Yilmazkuday and Yilmazkuday (2017), Wang and Fu (2022), Söderlund (2023), Bel and Fageda (2008), Campante and Yanagizawa-Drott (2018), Tanaka (2019), and Hovhannisyan and Keller (2015). Thus we can be confident that channels to growth 'are functioning in a UK context, though we cannot be sure of the exact 'size' of that channel in the UK context.

Take FDI for example. Campante and Yanagizawa-Drott (2018) show that net FDI flows go from high income countries (such as the UK) to middle income countries, whilst Hovhannisyan and Keller (2015) show that US outward FDI flows have a significantly positive impact on knowledge creation in the host country (one of which is the UK one would presume). Thus we would expect inflows and outflows of FDI to change in the UK following a change in air connectivity. However, we do not have a firm understanding of the scale of that change in a UK context, nor do we understand whether all connections are equally useful. For example inward FDI may be driven by connections to the Us, Japan and Europe, whilst outward FDI may be driven by connections to South East Asia or South America. Impacts may also differ between different airports. For example, a new international air service may benefit London, which already has good a scope of international air services, less than a regional airport which has a more limited scope of international air services (e.g. Manchester in the north of England and Edinburgh in Scotland).

This discussion also highlights a particular challenge in applying the evidence base to future policy scenarios. A significant part of the evidence base addresses the historic role of air connectivity in economic growth and shaping economic geography. Future UK policies are more associated with changes in large and well established air services. Albeit some of these changes are considered to be step changes in air connectivity at an individual airport level. When considering impacts at the level of an individual city for an airport expansion, it is relevant to consider the counterfactual. For example, the expansion of an airport in London at some point in the future (e.g. mid-2030s) would have a larger impact on the UK if no other airports were permitted to expand in the interim. If for example, airports in the north of England or Scotland were permitted to expand then a raft of displacement effects might occur (between cities and airports), leading to lower net growth at a UK level.

Returning to the evidence base. At this point we have firm results from causal studies that indicate that expansions of European regional airports can have limited impacts. They therefore perform quite differently from US airports. However, we do not have any equivalent results regarding the major hub airports in Europe. This is important as there are good reasons we might expect regional airports in Europe to have limited impacts such as proximity to other airports, usefulness of air services for business and land transport competition. The European hub airports do not suffer these weaknesses, therefore we may expect them to generate economic growth. Unfortunately, the

empirical evidence to test that hypothesis is an evidential gap. This is particularly relevant to an airport expansion at one of Europe's main hub airports (e.g. London Heathrow). Nor do we have firm results from causal studies identifying the role of air connectivity in the very different parts of Europe: in lagging regions (such as the eastern countries in the European Union); or the countries with large visitor economies along the Mediterranean, or some of the major European cities which have large visitor economies (e.g. London, Paris, Vienna, Amsterdam). The latter also has relevance to an expansion of a London airport.

All of this points towards the need for more high quality research to better understand the historic role of air connectivity in shaping the economic geography of Europe, but also the role that expansions to an already well developed European air network can play.

7 REFERENCES

Akar, P. G. 2025. The impact of air transportation on economic growth: Novel findings from the CS-ARDL model. *Transport Policy***,** 103788.

Alderighi, M. & Gaggero, A. A. 2017. Fly and trade: Evidence from the Italian manufacturing industry. *Economics of Transportation,* 9**,** 51-60.

Allroggen, F., Wittman, M. D. & Malina, R. 2015. How air transport connects the world–A new metric of air connectivity and its evolution between 1990 and 2012. *Transportation Research Part E: Logistics and Transportation Review,* 80**,** 184-201.

Appold, S. J. & Kasarda, J. D. 2013. The airport city phenomenon: Evidence from large US airports. *Urban Studies,* 50**,** 1239-1259.

Bai, J., Jin, W. & Zhou, S. 2024. Proximity and knowledge spillovers: Evidence from the introduction of new airline routes. *Management Science,* 70**,** 7464-7485.

Banister, D. & Berechman, Y. 2001. Transport investment and the promotion of economic growth. . *Journal of Transport Geography,* 9(3)**,** 209-218.

Bannò, M. & Redondi, R. 2014. Air connectivity and foreign direct investments: economic effects of the introduction of new routes. *European Transport Research Review,* 6**,** 355-363.

Bel, G. & Fageda, X. 2008. Getting there fast: globalization, intercontinental flights and location of headquarters. *Journal of Economic Geography,* 8**,** 471-495.

Besedeš, T., Chu, J. & Murshid, A. P. 2024. Fly the unfriendly skies: The role of transport costs in gravity models of trade. *Journal of International Economics,* 152**,** 103994.

Bilotkach, V. 2015. Are airports engines of economic development? A dynamic panel data approach. *Urban Studies,* 52**,** 1577-1593.

Blonigen, B. A. & Cristea, A. D. 2015. Air service and urban growth: Evidence from a quasi-natural policy experiment. *Journal of Urban Economics,* 86**,** 128-146.

Breidenbach, P. 2020. Ready for take-off? The economic effects of regional airport expansions in Germany. *Regional Studies,* 54**,** 1084-1097.

Brida, J. G., Bukstein, D. & Zapata-Aguirre, S. 2016. Dynamic relationship between air transport and economic growth in Italy: A time series analysis. *International Journal of Aviation Management,* 3**,** 52-67.

Brueckner, J. K. 2003. Airline traffic and urban economic development. . *Urban Studies,* 40(8)**,** 1455-1469.

Campante, F. & Yanagizawa-Drott, D. 2018. Long-range growth: Economic development in the global network of air links. *The Quarterly Journal of Economics,* 133**,** 1395-1458.

Catalini, C., Fons-Rosen, C. & Gaulé, P. 2020. How do travel costs shape collaboration? *Management Science,* 66**,** 3340-3360.

Çelik, A. K., Yalçınkaya, Ö. & Kutlu, M. 2025. The causal relationship between air transport and economic growth: Evidence from top ten countries with the largest air transport volume. *Transport Policy,* 162**,** 521-532.

Chapman, A. & Pot, F. 2025. *The economics of air transport in Europe: Part one: Air transport and growth*.

Chen, J., Shi, J., Wang, Z., Zeng, S. & Zhou, Z. 2025. The power of wings: How air connections fuel cross-regional collaboration in China? *China Economic Review***,** 102442.

Cidell, J. 2015. The role of major infrastructure in subregional economic development: an empirical study of airports and cities. *Journal of Economic geography,* 15**,** 1125-1144.

Civil Aviation Authority (CAA). 2011. *Flying on Business. A study of the UK buisines air travel market.* November 2011

Crespi, G., Criscuolo, C. & Haskel, J. 2008. Productivity, exporting, and the learning-by-exporting hypothesis: direct evidence from UK firms. *Canadian Journal of Economics/Revue canadienne d'économique,* 41**,** 619-638.

Cristea, A. D. 2023. The role of aviation networks for urban development. *Journal of Regional Science,* 63**,** 947-980.

Duranton, G. & Puga, D. 2004. Chapter 48 Micro-foundations of urban agglomeration economies. *In:* Henderson, J. V. & Jacques-François, T. (eds.) *Handbook of Regional and Urban Economics.* 2063-2117. Elsevier.

Duranton, G. & Puga, D. 2020. The economics of urban density. *Journal of Economic Perspectives,* 34**,** 3-26.

Fageda, X. 2017. International air travel and FDI flows: Evidence from Barcelona. *Journal of Regional Science,* 57**,** 858-883.

Freixanet, J. & Federo, R. 2023. Learning by exporting: A system-based review and research agenda. *International Journal of Management Reviews,* 25**,** 768-792.

Furusawa, T., Sun, C., Tang, H. & Zhang, J. 2024. Communication costs, direct flights and international trade.

Gibbons, S. & Wu, W. 2020. Airports, access and local economic performance: evidence from China. *Journal of Economic Geography,* 20**,** 903-937.

Giroud, X. 2013. Proximity and Investment: Evidence from Plant-Level Data. *Quarterly Journal of Economics,* 128**,** 861-915.

Green, R. K. 2007. Airports and economic development. *Real Estate Economics,* 35**,** 91-112.

Hering, L., Poncet, S. & Reshef, A. 2025. Air Connections and Innovation: Evidence from Cross-Border Patents of Chinese Cities. *Mimeograph, Paris School of Economics*.

Higgoda, R. & Madurapperuma, W. 2019. Dynamic nexus between air-transportation and economic growth: a systematic literature review. *Journal of Transportation Technologies,* 9**,** 156-170.

Hovhannisyan, N. & Keller, W. 2015. International business travel: an engine of innovation? *Journal of Economic Growth,* 20**,** 75-104.

Irwin, M. D. & Kasarda, J. D. 1991. Air passenger linkages and employment growth in US metropolitan areas. *American Sociological Review,* 56**,** 524-537.

Kaya, G. & Aydın, U. 2024. The nexus between air transport and economic growth geographically: An evidence based on heterogeneous panel data models. *Journal of Air Transport Management,* 115**,** 102528.

Küçükönal, H. & Sedefoğlu, G. 2017. The causality analysis of air transport and socio-economics factors: The case of OECD countries. *Transportation Research Procedia,* 28**,** 16-26.

Lenaerts, B., Allroggen, F. & Malina, R. 2021. The economic impact of aviation: A review on the role of market access. *Journal of Air Transport Management,* 91**,** 102000.

Liu, X., Siler, P., Wang, C. & Wei, Y. 2000. Productivity spillovers from foreign direct investment: Evidence from UK industry level panel data. *Journal of International Business Studies,* 31**,** 407-425.

Mackie, P., Starkie, D. & Graham, D. J. 2013. *Econometric Analysis to Develop Evidence on International Business Impacts. Commentary by Peter Mackie, David Starkie and Dan Graham. Report to Airports Commission.* 9th December 2013

Mackie, P. J., Jara-Dıaz, S. & Fowkes, A. 2001. The value of travel time savings in evaluation. *Transportation Research Part E: Logistics and Transportation Review,* 37**,** 91-106.

Mackie, P. J., Wardman, M., Fowkes, A. S., Whelan, G., Nellthorp, J. & Bates, J. 2003. *Values of travel time savings UK*.

McGraw, M. J. 2017. The Heterogeneous Impact of Airports on Population and Employment Growth in Cities. *The economics of airport operations.* 261-312. Emerald Publishing Limited.

McGraw, M. J. 2020. The role of airports in city employment growth, 1950–2010. *Journal of Urban Economics,* 116**,** 103240.

Morales-Arilla, J. & Bustos, S. 2025. *Direct flights, trade and specialization*. Https://Dx.Doi.Org/10.2139/Ssrn.5507340. 18th September 2025

Mukkala, K. & Tervo, H. 2013. Air transportation and regional growth: Which way does the causality run? *Environment and Planning A,* 45**,** 1508-1520.

Nguyen, C. V. 2024. Air transport resilience, tourism and its impact on economic growth. *Economies,* 12**,** 236.

Oum, T. H., Wu, X. & Wang, K. 2024. Impact of air connectivity on bilateral service export and import trade: The case of China. *Transport Policy,* 148**,** 219-233.

Oxford Economics. 2024. *The economic and social impact of Heathrow Airport*. October 2024

Ozmec-Ban, M. & Babić, R. Š. 2023. A literature review of recent causality analyses between air transport demand and socio-economic factors. *Transportation Research Procedia,* 73**,** 85-93.

Pauly, S. & Stipanicic, F. 2025. The Creation and Diffusion of Knowledge: Evidence from the Jet Age. *Working Paper, University of Oslo*.

Percoco, M. 2010. Airport activity and local development: evidence from Italy. *Urban Studies,* 47(11)**,** 2427-2443.

Pot, F. J. & Koster, S. 2022. Small airports: Runways to regional economic growth? *Journal of Transport Geography,* 98**,** 103262.

PwC. 2013. *Econometric analysis to devlop evidence on the links between aviation and the economy. Final report to the Airports Commission.* Pwc. December 2013

Rattsø, J. & Sheard, N. 2025. Airports and regional development: the expansion of the Norwegian air network, 1950–2019. *Journal of Economic Geography,* 25**,** 351-370.

Sheard, N. 2014. Airports and urban sectoral employment. . *Journal of Urban Economics,* 80**,** 133-152.

Sheard, N. 2019. Airport size and urban growth. *Economica,* 86**,** 300-335.

Sheard, N. 2021. The Network of US Airports and Its Effects on Employment. *Journal of Regional Science,* 61**,** 623-648.

Söderlund, B. 2023. The importance of business travel for trade: Evidence from the liberalization of the Soviet airspace. *Journal of International Economics,* 145**,** 103812.

Steer. 2018. *Assessment of the value of air freight services to the UK economy*. October 2018

Stroombergen, A. & Laird, J. 2023. *Spatial general equilibrium models and their application to transport. Report to the Department for Transport.* . 22nd November 2023

Tanaka, K. 2019. Do international flights promote FDI? The role of face-to-face communication. *Review of International Economics,* 27**,** 1609-1632.

Tveter, E. 2017. The effect of airports on regional development: Evidence from the construction of regional airports in Norway. . *Research in Transportation Economics,* 63**,** 50-58.

Van de Vijver, E., Derudder, B. & Witlox, F. 2016. Air passenger transport and regional development: Cause and effect in Europe. *Promet-Traffic&Transportation,* 28**,** 143-154.

Varghese, A. M. & Pradhan, R. P. 2025. Transportation infrastructure and economic growth: Does there exist causality and spillover? A Systematic Review and Research Agenda. *Transportation Research Procedia,* 82**,** 2618-2632.

Wang, L. & Fu, S. 2022. Fly to Trade: Effects of International Direct Flights on Chinese Cities' Trade. *SSRN*.

Wang, Z., Wang, F. & Zhou, Z. Forthcoming. All roads lead to Rome: global air connectivity and bilateral trade. *American Economic Journal: Applied Economics*.

Wong, D. W. H., Zhao, S. X. B. & Lee, H. F. 2022. Air transport, economic growth, and regional inequality across three Chinese macro-regions. *Geographical Research,* 60**,** 446-462.

Yamaguchi, K. 2007. Inter-regional air transport accessibility and macro-economic performance in Japan. *Transportation Research Part E: Logistics and Transportation Review,* 43**,** 247-258.

Yilmazkuday, D. & Yilmazkuday, H. 2017. The role of direct flights in trade costs. *Review of World Economics,* 153**,** 249-270.

Zhang, F. & Graham, D. J. 2020. Air transport and economic growth: a review of the impact mechanism and causal relationships. *Transport Reviews,* 40**,** 506-528.

8 APPENDIX A: JOURNAL PAPER ABSTRACTS ON CHANNELS BETWEEN AIR CONNECTIVITY AND ECONOMIC GROWTH

8.1 EXPORT AND TRADE

CAUSAL METHOD

Cristea, A.D., 2011. Buyer-seller relationships in international trade: Evidence from US States' exports and business-class travel. *Journal of international economics*, *84*(2), pp.207-220.

Geographic scope: USA (and international trade with USA)

International trade has become increasingly dependent on the transmission of complex information, often realized via face-to-face communication. This paper provides novel evidence for the importance of in-person business meetings in international trade. Interactions among trade partners entail a fixed cost of trade, but at the same time they generate relationship capital, which adds bilateral specific value to the traded products. Differences in the face-to-face communication intensity of traded goods, bilateral travel costs and foreign market size determine the optimal amount of interaction between trade partners. Using U.S. state level data on international business-class air travel as a measure of in-person business meetings, I find robust evidence that the demand for business-class air travel is directly related to volume and composition of exports in differentiated products. I also find that trade flows in R&D intensive manufactures and goods facing contractual frictions are most dependent on face-to-face meetings. The econometric identification exploits the cross-state variation in bilateral exports and business-class air travelers by foreign country and time period, circumventing any spurious correlation induced by cross-country differences driving aggregate travel and trade patterns.

Yilmazkuday, D. and Yilmazkuday, H., 2017. The role of direct flights in trade costs. *Review of World Economics*, *153*(2), pp.249-270.

Geographic scope: Global

Effects of direct flights on trade costs are investigated using micro price data at the city level. After controlling for local retail/distribution costs, traded input prices are obtained to be further used in the measurement of trade costs across cities through arbitrage conditions. The existence of a direct flight enters trade costs regressions negatively and significantly. The results are shown to be robust to the consideration of many control variables, nonlinearities in the effects of distance on trade costs, possible endogeneity of having direct flights between cities and alternative definitions of the data. The direct flights that are shown to be determined by bilateral air services agreements are further shown to reduce trade costs through an endogeneity analysis; the main policy implications are twofold: (i) international trade policies through aviation services, such as Open Skies Agreements of the US, are alternative trade policy tools to reduce international trade barriers; (ii) direct flights facilitate the integration of internal markets as in the case of European Union.

Alderighi, M. and Gaggero, A.A., 2017. Fly and trade: Evidence from the Italian manufacturing industry. *Economics of transportation*, *9*, pp.51-60.

Geographic scope: Italy

This paper offers an empirical investigation of the relationship between air transport service and trade, using a panel of 20 Italian regions and 24 European countries observed, half-yearly, over the period 1998–2010. We apply a Newey-West two-step GMM estimator to produce estimates which are robust to the presence of heteroskedasticity and autocorrelation. Our findings suggest that air transport service positively affects the export of Italian manufacturers and that full-service carriers are mainly responsible for this result.

Wang, L. and Fu, S., 2022. Fly to Trade: Effects of International Direct Flights on Chinese Cities' Trade. *Available at SSRN 4185160*.

Geographic scope: China. (International Trade with China)

This paper estimates the causal effect of international direct flights on cities' international trade, using Chinese customs transaction-level trade data and flight route data from 2000 to 2015 and the staggered differences-in-differences approach. On average a Chinese city's exports to a destination country increase by 11.2% after a direct flight route is launched between them. This positive effect is stronger for the industries with higher face-to-face communication intensity and higher contract intensity, suggesting that international direct flights reduce the cost of international trips and promote face-to-face interactions among international business people.

Söderlund, B., 2023. The importance of business travel for trade: Evidence from the liberalization of the Soviet airspace. *Journal of International Economics*, *145*, p.103812.

Geographic scope: Europe and Asia (long distance trade)

The strong negative relationship between geographical distance and trade is not well understood. I use the liberalization of the Soviet airspace to estimate the causal impact of business travel cost on trade. The liberalization radically reduced travel time between Europe and East Asia and was followed by a significant increase in trade. I find that the cost of business travel can account for a large share of the trade frictions that cause trade to sharply decline with distance. A plausible explanation for these results is that face-to-face interaction through business travel is important for trade.

Besedeš, T., Chu, J. and Murshid, A.P., 2024. Fly the unfriendly skies: The role of transport costs in gravity models of trade. Journal of International Economics, 152, p.103994.

Geographic scope: Global

We exploit exogenous shocks to flight distances over time to estimate the distance effect in airborne trade within panel regressions. We find a negative distance effect, which we interpret as evidence of

a link between transportation costs and airborne trade. Notably, this relationship is driven almost entirely by changes at the extensive margin. Specifically, trade in HS 6 product categories with intermittent trading histories becomes dormant when flight distances increase. Conversely, the intensive margin of trade remains largely unaffected.

Oum, T.H., Wu, X. and Wang, K., 2024. Impact of air connectivity on bilateral service export and import trade: The case of China. *Transport Policy*, *148*, pp.219-233.

Geographic scope: China

This paper examines the effect of bilateral air connectivity on bilateral service trade flows. Our service trade data includes 'commercial', 'transport', 'travel', and 'government' services. We developed a reduced-form gravity-type model using the Chinese data. An instrument variable (IV) approach is adopted to address the endogeneity issue between bilateral air connectivity and the service trade variables. Our key results are: (a) increasing the number of direct routes can significantly promote bilateral service export and import trades; (b) the average route-level traffic density has only marginal positive effects; (c) improving air connectivity would enlarge China's overall service trade deficit, because the transport and travel services imports are promoted more than their exports; (d) The 'commercial' service exports can be stimulated more than the imports, making China achieve larger commercial service trade surplus by improving bilateral air connectivity.

Taiji Furusawa & Chang Sun & Heiwai Tang & Jiaxu Zhang, 2024. "Communication Costs, Direct Flights and International Trade," CESifo Working Paper Series 11364, CESifo.

Geographic scope: Global

We build a general equilibrium model of endogenous communication, quality control and trade. We derive a structural gravity equation from the model and show that exogenous communication costs raise the costs of quality control and have a larger impact on products with a lower elasticity of substitution. In our empirical application, we estimate the impact of direct flight connectedness on communication costs using the gravity equation. We overcome the identification challenge using an instrumental variable constructed based on the discontinuity of direct flights at around 6,000-mile distance due to air travel regulations. We find that air connectedness increases trade, especially for products with a low elasticity. We combine the empirical estimates and our equilibrium model to quantify the aggregate impact of air connectedness.

Morales-Arilla, Jose and Bustos, Sebastian, (2025) Direct Flights, Trade and Specialization (September 18, 2025). Available at SSRN: https://ssrn.com/abstract=5507340 or http://dx.doi.org/10.2139/ssrn.5507340

Geographic scope: Global

We leverage geographic discontinuities in international air travel costs to show that regular direct connections between countries enable them to trade, especially in specialized products. Back-of-the-envelope calculations suggest that the effect of direct flights at this margin could account for up to

1.6% of world trade. While direct flights do not affect the shipping cost of goods, they do enable bilateral business travel. Countries with stronger direct air connections tend to specialize away from each other's baseline comparative advantages. These findings suggest that the possibility of conducting business in person remains critical for bilateral trade and influences countries' patterns of specialization.

Wang, Z., Wang, F. and Zhou, Z., (forthcoming). All roads lead to Rome: global air connectivity and bilateral trade. ***American Economic Journal*** [also at: Wang, Zheng and Wang, Feicheng and Zhou, Zhuo, All Roads Lead to Rome: Global Air Connectivity and Bilateral Trade (July 11, 2021). Available at SSRN: https://ssrn.com/abstract=3884374 or http://dx.doi.org/10.2139/ssrn.3884374}

Geographic scope: Global

Using itinerary-level global air traffic data, this paper proposes a novel instrumental variable to estimate the effect of in-person interactions on bilateral trade. By exploiting exogenous variations in air connectivity that are driven by third-country connecting capacities, we show that increased air connections boost trade, especially for complex industries and new products. Online interactions appear to be a limited substitute for in-person contact. These findings confirm the role of in-person communications in reducing information-sharing barriers. Our estimation approach also provides a useful tool for evaluating the social and economic impacts of a complex transport network.

8.2 INVESTMENT AND FDI

CAUSAL METHOD

Bel, G. and Fageda, X., 2008. Getting there fast: globalization, intercontinental flights and location of headquarters. *Journal of Economic Geography*, *8*(4), pp.471-495.

Geographic scope: Europe

This article examines the determinants of the location of large firms' headquarters across a rich sample of European urban areas, focusing on the availability of non-stop intercontinental flights. We also account for the influence of other aspects: the proximity to large markets and specialized providers, congestion and tax costs, the availability of skilled labor, and the role of the urban area in the home country. Controlling for these factors, we find that the availability of direct non-stop flights has a large influence on headquarters' location. This confirms the importance of transport infrastructures and tacit information exchanges between cities for firm location.

Giroud, X. (2013). *Proximity and Investment: Evidence from Plant-Level Data*. Quarterly Journal of Economics, 128(2), 861–915.

Geographic scope: USA

Proximity to plants makes it easier for headquarters to monitor and acquire information about plants. In this article, I estimate the effects of headquarters' proximity to plants on plant-level investment and productivity. Using the introduction of new airline routes as a source of exogenous variation in proximity, I find that new airline routes that reduce the travel time between headquarters and plants lead to an increase in plant-level investment of 8% to 9% and an increase in plants' total factor productivity of 1.3% to 1.4%. The results are robust when I control for local and firm-level shocks that could potentially drive the introduction of new airline routes, when I consider only new airline routes that are the outcome of a merger between two airlines or the opening of a new hub, and when I consider only indirect flights where either the last leg of the flight (involving the plant's home airport) or the first leg of the flight (involving headquarters' home airport) remains unchanged. Moreover, the results are stronger in the earlier years of the sample period and for firms whose headquarters is more time-constrained. In addition, they also hold at the extensive margin, that is, when I consider plant openings and closures.

Bannò, M. and Redondi, R., 2014. Air connectivity and foreign direct investments: economic effects of the introduction of new routes. *European Transport Research Review*, *6*(4), pp.355-363.

Geographic scope: Italy.

Identification strategy features: Treatment and control areas. No control for endogeneity. Weak causal method.

Purpose

The key research question for this study was whether the spatial network structure offered by the global airline system contributes to the development of Italian inward Foreign Direct Investments

(FDIs). We argue that the introduction of a new route, by reducing firm's transport costs and facilitating tacit and complex knowledge flow, should increase the likelihood of FDI exchange between newly connected regions.

Methods

We employed a comparison group design considering both small and medium enterprises and large companies at the municipality level.

Results

The results showed that FDIs increased overall by 33.7% in the two years after opening of the new routes while FDIs in the control group decreased by 16.6%. Similar results were obtained using different measures of FDI (i.e. the number of generated employees) and by weighting the routes by their frequencies.

Conclusions

Given the substantial benefits that urban areas can obtain from attracting multinational firms, our results provide new evidence of the contribution of transport infrastructures to local development. From a policymaker perspective, regional policies aimed at attracting FDIs must contextually promote the development of transport infrastructure and in particular international airports. Investments to improve air transport capacity, strategies to attract both traditional and low-cost airlines, providing legal authorization or financing ground transport are all critical aspects for the success of such policies.

Hovhannisyan, N. and Keller, W., 2015. International business travel: an engine of innovation?. *Journal of Economic Growth*, *20*(1), pp.75-104.

Geographic scope: USA (global trade)

While it is well known that managers prefer in-person meetings for negotiating deals and selling their products, face-to-face communication may be particularly important for the transfer of technology because technology is best explained and demonstrated in person. This paper studies the role of short-term cross-border labor movements for innovation by estimating the recent impact of U.S. business travel to foreign countries on their patenting rates. Business travel is shown to have a significant effect up and beyond technology transfer through international trade and foreign direct investment. On average, a 10 % increase in business travel leads to an increase in patenting by about 0.2 %, and inward business travel is about one fourth as potent for innovation as domestic R&D spending. We show that the technological knowledge of each business traveler matters by estimating a higher impact for travelers that originate in U.S. states with substantial innovation, such as California. This study provides initial evidence that international air travel may be an important channel through which cross-country income differences can be reduced.

Fageda, X., 2017. International air travel and FDI flows: Evidence from Barcelona. *Journal of Regional Science*, *57*(5), pp.858-883.

Geographic scope: Spain (Catalonia)

This paper provides a bridge between the literature examining the economic impact of air services and the literature analyzing the determinants of bilateral FDI flows. I estimate a gravity equation for the determinants of bilateral FDI flows between the Spanish region of Catalonia, home to the airport of Barcelona, and countries of all over the world for the period 2002–2015. I find evidence that the reduction in travel time due to the availability of nonstop flights scheduled with sufficient frequency increases the amount of FDI due to the enhanced transmission of information.

Campante, F., & Yanagizawa-Drott, D. (2018). Long-range growth: Economic development in the global network of air links. *The Quarterly Journal of Economics, 133(3),* 1395–1458.

Geographic scope: Global

We study the impact of international long-distance flights on the global spatial allocation of economic activity. To identify causal effects, we exploit variation due to regulatory and technological constraints, which gives rise to a discontinuity in connectedness between cities at a distance of 6,000 miles. We show that improving an airport's position in the network of air links has a positive effect on local economic activity, as captured by satellite-measured night lights. We find that air links increase business links, showing that the movement of people fosters the movement of capital. In particular, this is driven mostly by capital flowing from high-income to middle-income (but not low-income) countries. Taken together, the results suggest that increasing interconnectedness induces links between businesses and generates economic activity at the local level but also gives rise to increased spatial inequality locally, and potentially globally.

Tanaka, K., 2019. Do international flights promote FDI? The role of face-to-face communication. *Review of International Economics*, *27*(5), pp.1609-1632.

Geographic scope: Japan

International passenger flights facilitate business travel for in-person meetings abroad. However, the significance of face-to-face communication (FFC) is not clear. To identify the FFC channel, this paper examines whether flights promote FDI more strongly for multinational firms that face relatively intensive FFC in foreign production. Expatriate employees are used as a proxy for the FFC intensity. Using firm-level data on Japanese multinational firms for the period 1989 to 2006, I show that more frequent flights increase new FDI entry, with the larger positive effects for multinationals in high FFC sectors. The results support the FFC channel to connect flights and FDI.

GRANGER CAUSALITY OR OTHER NON-CAUSAL METHOD

Strauss-Kahn, V., & Vives, X. (2009). *Why and Where Do Headquarters Move?* Regional Science and Urban Economics, 39(2), 168–186.

Geographic scope: USA.

Identification strategy features: Not causal. Model estimated (nested logit model) relies on economic theory to be correct.

This paper analyzes decisions regarding the location of headquarters in the U.S. for the period 1996–2001. Using a unique firm-level database of about 30,000 U.S. headquarters, we study the firm- and locationspecific characteristics of headquarters that relocated over that period. Headquarters are concentrated, increasingly so in medium-sized service-oriented metropolitan areas, and the rate of relocation is significant (5% a year). Larger (in terms of sales) and younger headquarters tend to relocate more often, as well as larger (in terms of the number of headquarters) and foreign firms, and firms that are the outcome of a merger. Headquarters relocate to metropolitan areas with good airport facilities—with a dramatic impact, low corporate taxes, low average wages, high level of business services, same industry specialization, and agglomeration of headquarters in the same sector of activity—with all agglomeration variables having an important and significant impact.

Kalayci, S. and Yanginlar, G., 2016. The effects of economic growth and foreign direct investment on air transportation: evidence from Turkey. *International Business Research*, *9*(3), pp.154-162.

Geographic scope: Turkey.

Identification strategy features: Possible Granger causality.

The major goal of this research paper is to investigate the relationship among Turkish Economic growth, airway transportation and FDI. Several research results consistent with this papers finding and it has been founded that the economic growth plays a crucial role in air transportation by implementing econometrical models including Multiple Linear Regression (MLR), Johansen co-integration test and VAR model. The variables have been put into the Vector Autoregressive Model (VAR) and Johansen co-integration test. According to the test result of Johansen co-integration test there is a long-term relationship between the variables of GDP, FDI and air transportation. According to the both variance decomposition and Impulse Response analysis, the effect of GDP is found to increase air transportation more than the FDI. Finally, the contribution of Turkish economy to civil aviation seems significant which is consistent with this paper's research results.

Iqbal, A., Tang, X., Jahangir, S. and Hussain, S., 2022. The dynamic nexus between air transport, technological innovation, FDI, and economic growth: evidence from BRICS-MT countries. *Environmental Science and Pollution Research*, *29*(45), pp.68161-68178.

Geographic scope: BRICS countries (Brazil, Russia, India, China, South Africa).

Identification strategy features: Granger causality

This study examines the endogenous growth theory for technological innovation and economic growth with the role of foreign direct investment (FDI) and air transport freight in seven emerging BRICS-MT economies. In the existing literature, there is no significant empirical evidence on the dynamic relationship among technological innovation, air transport freight, FDI, and economic growth in BRICS-MT countries. Thus, the current study contributes to the growing literature regarding the role of technological Innovation, air transport, and FDI on economic growth. To this end, we explore the dynamic nexus between technological innovation, air transport, FDI, and economic growth in 7 selected emerging BRICS-MT countries, including Brazil, Russia, India, China, South Africa, Mexico, and Turkey. This study covers the most recent updated period for panel data from 2000 to 2019. We applied panel cointegration, dynamic ordinary least square (DOLS), fully modified ordinary least square (FMOLS), and Granger causality tests to draw empirical inferences. The Pedroni panel and Kao residual cointegration tests confirm the long-run relationships among the variables. The DOLS results indicate that air transport freight, technological innovation, and FDI significantly positively impact economic growth. This study's findings confirmed the endogenous growth model in BRICS-MT countries. Furthermore, the Granger causality test results show the feedback effect of FDI on economic growth. The outcomes of this study also show the unidirectional causal relationship between air transport freight and economic growth. Moreover, the results provide support to economic policymakers in their decision-making. These results fill the gaps that assist policymakers of BRICS-MT countries in removing barriers to air transport freight, technological innovation, and foreign direct investment, thereby achieving sustainable economic development.

8.3 KNOWLEDGE CREATION AND DIFFUSION

CAUSAL METHOD

Catalini, C., Fons-Rosen, C. and Gaulé, P., 2020. How do travel costs shape collaboration?. *Management Science*, *66*(8), pp.3340-3360.

Geographic scope: USA

We develop a simple theoretical framework for thinking about how geographic frictions, and in particular travel costs, shape scientists' collaboration decisions and the types of projects that are developed locally versus over distance. We then take advantage of a quasi-experiment—the introduction of new routes by a low-cost airline—to test the predictions of the theory. Results show that travel costs constitute an important friction to collaboration: after a low-cost airline enters, the number of collaborations increases between 0.3 and 1.1 times, a result that is robust to multiple falsification tests and causal in nature. The reduction in geographic frictions is particularly beneficial for high-quality scientists that are otherwise embedded in worse local environments. Consistent with the theory, lower travel costs also endogenously change the types of projects scientists engage in at different levels of distance. After the shock, we observe an increase in higher-quality and novel projects, as well as projects that take advantage of complementary knowledge and skills between subfields, and that rely on specialized equipment. We test the generalizability of our findings from chemistry to a broader data set of scientific publications and to a different field where specialized equipment is less likely to be relevant, mathematics. Last, we discuss implications for the formation of collaborative research and development teams over distance.

Bai, J., Jin, W. and Zhou, S., 2024. Proximity and knowledge spillovers: Evidence from the introduction of new airline routes. *Management Science*, *70*(11), pp.7464-7485.

Geographic scope: USA

This paper examines the causal relationship between proximity and knowledge diffusion by estimating the elasticity of core-based statistical area (CBSA) pair-level citations to variations in travel time induced by the introduction of new flight routes. The findings reveal that decreasing travel time between U.S. cities by 20% increases knowledge flow by 0.5%, which corresponds to an increase of over 15,000 citations at the aggregate level. Rather than boosting within-firm knowledge transfer, travel time reduction leads to a rise in knowledge spillovers primarily across firm boundaries, particularly among those that form joint ventures, have block holdings in each other, or form supply chain relationships. These effects are stronger among city pairs located farther away from each other, with higher absorptive capacity, in complex technology classes, and for newly developed technologies. Additional mechanism tests suggest that the most likely channel through which travel time reduction impacts knowledge spillover is by influencing the transfer of tacit knowledge via facilitating cross-CBSA inventor flow and information acquisition

Chen, J., Shi, J., Wang, Z., Zeng, S. and Zhou, Z., 2025. The power of wings: How air connections fuel cross-regional collaboration in China?. *China Economic Review*, p.102442.

Geographic scope: China

How does physical connectedness stimulate knowledge cocreation? This paper sheds new light on this question by focusing on China, one of the largest countries and innovation powerhouses in the world. Exploiting variation in air connectivity across time and space, we find that the introduction of non-stop air connections between cities boosts collaborative innovation, especially for long-distance city pairs. This improvement goes with reducing costs of face-to-face interactions, hence promoting knowledge flows. Further analysis shows that the disparity of within-city-pair innovative capability shrinks following direct air connections. The effects on co-innovation are more pronounced for collaborations: (1) between mega-and small cities, (2) involving at least one cost-sensitive enterprise participant, and (3) across corporate group boundaries among enterprise innovators.

Pauly, S., & Stipanicic, F. (2025). *The Creation and Diffusion of Knowledge: Evidence from the Jet Age*. Working Paper, University of Oslo.

Geographic scope: USA

This paper provides new causal evidence of the impact of face-to-face interactions on the creation and diffusion of knowledge. We construct a novel dataset of the U.S. flight network between 1951 and 1966 and exploit the beginning of the Jet Age as a quasi-natural experiment. Travel time between locations over 2,000 km apart decreased by 41%, explaining 30% of the observed increase in knowledge diffusion as measured by patent citations. This diffusion spurred new knowledge creation, driving innovation convergence across locations and shifting innovation activity towards the South and West of the United States.

Hering, L., S. Poncet, and A. Reshef (2025). Air Connections and Innovation: Evidence from Cross-Border Patents of Chinese Cities. Mimeograph, Paris School of Economics.

Geographic scope: China.

Note: Paper not accessed.

Our paper shows that direct air connectivity promotes and shapes cross-border innovation collaborations. We rely on geocoded data of international co-inventions involving China-based inventors and unique data on new direct air links connecting Chinese cities to the rest of the world between 1990 and 2016. Using an event study design, we find that the introduction of a direct link between a Chinese city and a foreign city increases the number of collaborations between them by half a standard deviation, starting 3 to 4 years after the establishment of the connection. The impact is stronger when there is little overlap in business hours and for technology classes where lab experiments are involved, and thus more frequent interactions may be required. These results confirm that cross-border communication costs constitute an important friction to collaboration between inventors.

9 APPENDIX B: JOURNAL PAPER ABSTRACTS ON AIR CONNECTIVITY AND GDP, WAGES/INCOME, EMPLOYMENT AND POPULATION

9.1 NORTH AMERICA, EUROPE, AUSTRALIA & JAPAN

9.1.1 PRE-2013

CAUSAL METHOD

Irwin, M. D., & Kasarda, J. D. (1991).
Air passenger linkages and employment growth in US metropolitan areas. American Sociological Review, 56(4), 524–537.

Geographic scope: USA

Despite the ubiquity of air travel and the critical role of transportation in spatial processes, no sociological work on the consequences of aviation has been produced in nearly three decades. We analyze the relationship between the structure of the airline network and employment growth in 104 metropolitan areas. Using network methodology, we document the structural changes that accompanied the expansion of the airline system between 1950 and 1980. Using regression analysis and nonrecursive models, we assess the effects of these changes in the airline network on metropolitan employment growth rates, focusing specifically on employment in manufacturing and producer services. Results indicate that position in the airline network has pervasive effects on metropolitan employment growth and that changes in network position are a cause rather than a consequence of this employment growth. We conclude that the reorganization of the airline network has been a critical factor transforming and integrating the spatial economy of the U.S.

Brueckner, J. K. (2003).
Airline traffic and urban economic development. Urban Studies, 40(8), 1455–1469.

Geographic scope: USA

This paper provides new evidence on the link between airline traffic and employment in US metropolitan areas. The evidence confirms the common view that good airline service is an important factor in urban economic development. Frequent service to a variety of destinations, reflected in a high level of passenger enplanements, facilitates easy face-to-face contact with businesses in other cities, attracting new firms to the metro area and stimulating employment at established enterprises. The empirical results show that a 10 per cent increase in passenger enplanements in a metro area leads approximately to a 1 per cent increase in employment in service-related industries. However, airline traffic has no effect on manufacturing and other goods-related employment, suggesting that air travel is less important for such firms than for service-related businesses. These estimates are generated controlling for reverse causality between employment and traffic. The results imply that expansion of Chicago's O'Hare airport would raise service-related employment in the Chicago metro area by 185 000 jobs (this impact assumes that

expansion raises traffic by 50 per cent). Thus, the expansion of O'Hare airport represents a powerful economic development tool, as argued by its proponents.

Green, R. K. (2007).
Airports and economic development. Real Estate Economics, 35(1), 91–112.

Geographic scope: USA

This article tests whether the activity at a metropolitan area's airport helps predict population and employment growth. In regression equations explaining employment and population growth, the article uses various measures of airport activity, including boardings, originations, hub status and cargo volume. Because airports may be a function of, as well as a cause of, growth, the article instruments for airports by using geographical and lagged variables. It finds that, under a variety of specifications, passenger activity is a powerful predictor of growth; cargo activity is not.

Yamaguchi, K., 2007. Inter-regional air transport accessibility and macro-economic performance in Japan. *Transportation Research Part E: Logistics and Transportation Review*, *43*(3), pp.247-258.

Geographic scope: Japan

Although there have been various studies on macro-economic effect of public investment, not much attention has been paid to the impact of actual accessibility realized by transport industry and infrastructure. In this paper, we performed a cross-sectional analysis of 47 prefectures in Japan between 1995 and 2000 by Cobb–Douglas production function and growth regression approach. The results explain why deregulation and infrastructure development in air transport during 1990s manifest mixed results of inter-regional accessibility and per-capita GDP growth for core and peripheral areas in Japan.

Percoco, M. (2010). Airport activity and local development: Evidence from Italy. *Urban Studies, 47(11),* 2427–2443.

Geographic scope: Italy

The role of infrastructure as a factor of growth and development of countries and regions is often considered to be crucial. Among the various types of transport infrastructure, airports are considered as particularly strategic because of the increasing importance of air transport in connecting territories. This paper studies the impact of airports on Italian provinces. To this end, it builds on the framework proposed by Brueckner, where sectoral employment is regressed on a series of controls and on airline traffic. That framework is extended to take account of selection bias due to the location choices of airports and spatial spillover effects. It is found that the elasticity of service-sector employment to airport passengers is 0.045 and that of spillover effects due to neighbouring airports is almost 0.017.

GRANGER CAUSALITY OR EQUIVALENT METHOD

Button, K., Lall, S., Stough, R., & Trice, M. (1999). *High-technology employment and hub airports. Journal of Air Transport Management, 5(1),* 53–59.

Geographic scope: USA.

Identification strategy features: Granger causality.

Deregulation of the US domestic air transport market in 1978 brought significant benefits to air travelers. The scheduled airlines have been given the freedom to improve their efficiency through being able to adopt efficient network strategies and more effective operating practices. This study examines empirically the advantages enjoyed by those passengers having access to a major hub airport. These often include more direct services, more frequent services and a wider range of interconnecting destinations. We seek to examine the benefits that local urban areas enjoy as the result of a major airline selecting the region as the fulcrum point for its hub-and-spoke services.

Cohen, J.P. and Paul, C.J.M., 2003. Airport infrastructure spillovers in a network system. *Journal of Urban Economics*, *54*(3), pp.459-473.

Geographic scope: USA.

Identification strategy features: Not causal. Relies on economic theory for model specification to be correct.

Airports in the US air transport network have become increasingly congested, leading to delays for business travelers and freight shipments. Since disruptions in one part of the network exacerbate problems throughout the system, airport infrastructure expansions to enhance air traffic flows confer travel-time savings and reliability benefits, and thus increased worker productivity and shipping efficiency for manufacturing firms. We evaluate such spillovers, and find that higher own-state airport infrastructure implies lower manufacturing costs from both labor- and materials-savings. Airport expansion in connected states has a comparable effect for states with hub airports, and an even greater impact for other states.

Sellner, R., & Nagl, P. (2010).
Air accessibility and growth – the economic effects of a capacity expansion at Vienna International Airport. Journal of Air Transport Management, 16(6), 325–329.

Geographic scope: Austria.

Identification strategy features: Seemingly Unrelated Regression, which does not address causality (like IV does).

We use an econometric endogenous growth model to estimate the impact of air accessibility on GDP and investment growth. This is done in a dynamic panel system estimation framework for the EU-15 between 1993 and 2006. The results are then used to predict the economic effects of an increase in capacity at the Vienna International Airport using actual forecasts of the required information set.

We find a GDP elasticity of air accessibility of 0.014 and an investment elasticity of 0.05 for our sample. Given the official passenger forecast this would lead to additional GDP growth in Austria of accumulated 0.81% based on the values of the restricted scenario (no third runway). In a more conservative forecast scenario of 3% annual passenger growth, a third runway is projected to increase GDP by 0.2% by 2040.

9.1.2 2013 AND LATER

CAUSAL METHOD

Sheard, N. (2014). Airports and urban sectoral employment. *Journal of Urban Economics, 80,* 133–152.

Geographic scope: USA

This paper estimates the effects of airport infrastructure on relative sectoral employment at the metropolitan-area level, using data from the United States. To address the potential endogeneity in the determination of airport sizes, the 1944 National Airport Plan is used to instrument for the current distribution of airports. Airport size is found to have a positive effect on the employment share of tradable services, controlling for overall local employment, but no measurable effect on manufacturing or most non-tradable sectors. The effect of airport size on overall local employment is practically zero, suggesting that airports lead to specialization but not growth at the metropolitan-area level. The implied elasticity of tradable-service employment with respect to airport size is approximately 0.22. The results are relevant to the evaluation of airport construction or improvement projects that aim to benefit the local economy by making travel to and from the metropolitan area more convenient.

Bilotkach, V. (2015) *Are airports engines of economic development? A dynamic panel data approach. Urban Studies, 52(9),* 1577–1593.

Geographic scope: USA

This paper applies the dynamic panel data generalized method of moments estimator to the data on commercial passenger air traffic at all primary airports in the United States to evaluate the impact of traffic volume and number of destinations served with non-stop flights on the key indicators of regional economic development. We find that number of destinations served with non-stop flights has a much clearer and more robust impact on level of employment, number of business establishments, and average wage in the region. Passenger traffic volume affects employment and average wage, but not number of establishments. At the sample median, connecting a metropolitan statistical area with an extra destination, keeping everything else constant, creates 98 jobs and facilitates the opening of four new business establishments that employ people. The corresponding numbers for the sample mean are 223 jobs and 15 businesses. The impact of air travel on regional economic development is influenced by competition on the respective airline markets.

Blonigen, B. A., & Cristea, A. D. (2015). Air service and urban growth: Evidence from a quasi-natural policy experiment. *Journal of Urban Economics, 86,* 128–146.

Geographic scope: USA

While significant work has been done to examine the determinants of regional development, there is little evidence on the role of air services. This paper exploits the large and swift changes to air traffic induced by the 1978 Airline Deregulation Act to identify the link between air traffic and local

economic growth. Using data for 263 Metropolitan Statistical Areas (MSAs) over a two-decade time period, we estimate the effects of airline traffic on local population, income, and employment growth. Our most conservative estimates suggest that a 50-percent increase in an average city's air traffic growth rate generates an additional stream of income over a 20-year period equal to 7.4 percent of real GDP, the equivalent of $523.3 million in 1978 dollars.

Tveter, E. (2017). The effect of airports on regional development: Evidence from the construction of regional airports in Norway. *Research in Transportation Economics, 63,* 50–58.

Geographic scope: Norway

This paper estimates the effect of airports on regional development using the substantial increase of airports in the 1970s in Norway as the source of variation. The effects are estimated using a difference-in-difference design by comparing municipalities with a shorter distance to the nearest airport (treated) to three sets of control municipalities. As regional impacts, the paper considers population and employment at the municipality level. The results demonstrate a positive but not significant effect on population and employment. The point estimates indicate that the population in municipalities near the constructed airports increased by 5% from 1970 to 1980, but the overall imprecision of the estimates makes it impossible to reject the hypothesis that the airports had no regional impacts.

McGraw, M.J., 2017. The Heterogeneous Impact of Airports on Population and Employment Growth in Cities. In: *The economics of airport operations* (pp. 261-312). Emerald Publishing Limited.

Geographic scope: USA. Small and medium airports.

Identification strategy features: Identifies locational attributes that lead to airports assisting with city growth.

This chapter examines the effects that airports have had on economic development in cities from 1950 to 2010. It uses a novel dataset consisting of previously unexploited data on the origins and history of the aviation system in the United States. Applying the method of synthetic controls to a set of medium and small airports, I examine both the overall impacts and the heterogeneity within the outcomes of various airports. Then, I use regression analysis to determine key factors differentiating successful airports from less successful ones, as it pertains particularly to population and employment growth. I find that, first, on average, cities have benefited from airports over this period. Airports, overall, provided a causal contribution of 0.2– 0.6% per year on population and employment growth over the time period. Second, I show that city-level factors contributing to airport success include: (1) closer proximity to a major research university, (2) a capital city location, and (3) climate factors, particularly higher January mean temperatures and/or hours of sunshine. City size is a consideration as well; cities in larger metropolitan areas, with larger shares of employment in nontradables in the 1950s, were also better positioned to reap the benefits that airports provided on city growth. Significant differences were not found across regions, airport governance structures, or other factors.

Campante, F., & Yanagizawa-Drott, D. (2018). Long-range growth: Economic development in the global network of air links. *The Quarterly Journal of Economics, 133(3),* 1395–1458.

Geographic scope: Global

We study the impact of international long-distance flights on the global spatial allocation of economic activity. To identify causal effects, we exploit variation due to regulatory and technological constraints, which gives rise to a discontinuity in connectedness between cities at a distance of 6,000 miles. We show that improving an airport's position in the network of air links has a positive effect on local economic activity, as captured by satellite-measured night lights. We find that air links increase business links, showing that the movement of people fosters the movement of capital. In particular, this is driven mostly by capital flowing from high-income to middle-income (but not low-income) countries. Taken together, the results suggest that increasing interconnectedness induces links between businesses and generates economic activity at the local level but also gives rise to increased spatial inequality locally, and potentially globally.

Sheard, N. (2019). Airport size and urban growth. *Economica, 86(342),* 300–335.

Geographic scope: USA

This paper studies how airports affect economic growth in US metropolitan areas. The main finding is that airport size has a positive effect on local employment, with an elasticity of 0.04. The effect appears to be mostly due to a positive effect on services employment and to be concentrated in parts of the metropolitan area nearer the airport. To further understand how an airport affects the local economy, the effects on several other variables are estimated. Airport size is found to have positive effects on the number of firms, the population size, the rate of employment, and GDP in the local area. The magnitudes of the effects on population and employment suggest that airport expansion creates jobs for both existing residents and migrants to the area. The estimation uses a novel technique to identify the effects of airport infrastructure. It applies instruments for changes in airport size that are calculated from overall changes in air traffic in a set of categories: the airlines, the types of aircraft, or the distances flown. The technique could be adapted to study the effects of other types of infrastructure.

McGraw, M.J., 2020. The role of airports in city employment growth, 1950–2010. *Journal of Urban Economics*, *116*, p.103240.

This study considers the effects of commercial airports on local economies over the post-World War II period (specifically, 1950–2010). To overcome endogeneity concerns, a pooled synthetic control event study strategy is employed on newly digitized historical aviation data to estimate treatment effects on a variety of employment, population, and wage outcomes. I find that airports have led to, on average, 3.9 percent growth in total employment (and 3.4% growth in population) per decade. Over the 30-year period for which wage and air traffic data are available, earnings per worker increased by 2%, and per-capita personal income increased by 3%, corresponding to growth rates of up to 1.2 percent per decade, respectively.

Sheard, N. (2021). *The Network of US Airports and Its Effects on Employment*. Journal of Regional Science, 61(3), 623–648.

Geographic scope: USA

This paper estimates the effects of airport infrastructure on employment and the distribution of the labor force in US metropolitan areas. The analysis is based on models for the air network and for its effects on employment, which are estimated using US data. Air traffic is found to have a positive effect on the population of the local area, with an elasticity of 0.010, so airport improvements induce a reallocation of workers between regions. Air traffic is also found to have a positive effect on employment in the local area with an elasticity of 0.036 and a weakly positive effect on the employment rate in other places within 400 miles. Simulations suggest that for each job created in the local area by an airport expansion, two and a half jobs are created elsewhere in the United States due to the changes in the air network and the distribution of employment. Expanding the average airport adds one job in the United States for roughly each $78,000 invested. The results further suggest that the US air network is less centralized than would be optimal.

Breidenbach, P., 2020. Ready for take-off? The economic effects of regional airport expansions in Germany. *Regional Studies*, *54*(8), pp.1084-1097.

Geographic scope: Germany

Airports are an important factor of regional connectivity. Following the literature, a sufficiently dense airport network is an important determinant for growth. However, regional airports in Germany exhibit financial losses and depend on subsidies. This paper analyses the potential spillover effects of airports on the surrounding economies that may justify those subsidies by exploiting the deregulation of the European aviation market as a quasi-natural experiment. Subsequent airport expansions are evaluated in a difference-in-differences framework, making use of the exogenous shift in airport demand for regional airports due to the deregulation. Results show no evidence for spillover effects of Germany's regional airports.

Cristea, A.D., 2023. The role of aviation networks for urban development. *Journal of Regional Science*, *63*(4), pp.947-980.

Geographic scope: USA

City officials are continuously working to attract airlines willing to fly to new destinations. The inherent expectation is that a more extensive aviation network stimulates economic growth. This paper investigates empirically the causal implication of this hypothesis. Using data on nonstop flights by origin and destination over the period 1984–2013, we propose a new measure for a metropolitan area's connectivity to the national aviation network. We then use this measure to investigate its contribution to local economic development, as captured by the growth in population, in total employment, in per-capita income, and new firm entry. To ensure causality, we use instrumental variable methods that exploit geography and destination airports growth as a way to capture the exogenous variation in the likelihood to add new travel routes. Our results suggest that a metropolitan area's air connectivity, resulting from an expansive local aviation network, has a

positive effect on population, on employment and on the number of businesses established in that location.

Rattsø, J. and Sheard, N., 2025. Airports and regional development: the expansion of the Norwegian air network, 1950–2019. *Journal of Economic Geography*, *25*(3), pp.351-370.

Geographic scope: Norway

This article studies how airports affect regional growth in population and employment, considering heterogeneity in the circumstances of an airport's opening. We use synthetic controls with staggered adoption and data on the whole airport system in Norway for 1950–2019. We find positive overall effects of airports on population and employment growth. Addressing heterogeneity, we find relatively strong effects of airports opened in the 1950s, more distant from other airports, with longer runways, or with links to major cities. We also find stronger growth if an airport is opened in a region with a university, college, or hospital.

GRANGER CAUSALITY OR EQUIVALENT METHOD

Button, K., & Yuan, J. (2013).
Airfreight transport and economic development: An examination of causality. Urban Studies, 50(2), 329–340.

Geographic scope: US.

Identification strategy features: Granger causality

The paper examines the potential role that airfreight transport in the US can play in stimulating local and regional economic development. The analysis examines trends in employment and income for metropolitan statistical areas that make use of airfreight services. The focus is on causality, and not on simple correlation, and uses econometric analysis rather than simpler economic multiplier approaches. Granger causality testing based on panel data covering 35 airport and 32 metropolitan statistical areas in the US from 1990 to 2009 indicates that airfreight transport was a positive driver for local economic development. The conclusions focus on the strengths but also the weaknesses of the methodology for assessing causality.

Mukkala, K., & Tervo, H. (2013).
Air transportation and regional growth: Which way does the causality run? Environment and Planning A, 45(6), 1508–1520.

Geographic scope: Europe.

Identification strategy features: Granger causality

While there is typically a strong correlation between air traffic and economic growth, the direction of causation between the two is not clear. To address the existence of causality in this paper we

consider the nature of this relationship in different types of regions. The empirical analysis is based on European-level annual data from eighty-six regions and thirteen countries on air traffic and regional economic performance in the period 1991 to 2010. Granger noncausality analysis in a panel framework, which allows possible heterogeneity between regions, was used. The results suggest that the causality processes are homogenous from regional growth to air traffic. There is causality from air traffic to regional growth in peripheral regions, but this causality is less evident in core regions. Thus, air transportation plays a crucial role in boosting development in remote regions. There might, therefore, be a case for subsidizing local airports in these regions.

Baker, D., Merkert, R., & Kamruzzaman, M. (2015).
Regional aviation and economic growth: Cointegration and causality analysis in Australia. Journal of Transport Geography, 43, 140–150.

Geographic scope: Australia.

Identification strategy features: Granger causality

Air transport is a critical link to regional, rural and remote communities in Australia. Air services provide important economic and social benefits but very little research has been done on assessing the value of regional aviation. This research provides the first empirical evidence that there is short and long run causality between regional aviation and economic growth. The authors 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. The analysis was conducted using annual data related to total airport passenger movements – for the level of airport activity, and real aggregate taxable income – to represent 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. The economic significance of regional air transport confirms the importance of the airport as infrastructure for regional councils and the need for them to maintain and develop local airports. Funding should be targeted at airports directly to support regional development.

Florida, R., Mellander, C. and Holgersson, T., 2015. Up in the air: the role of airports for regional economic development. *The annals of regional science*, *54*(1), pp.197-214.

Geographic scope: USA.

Identification strategy features: Quasi-causal elements to the method – uses propensity score matching

Our research examines the role of airports in regional development. Specifically, we examine two things: (1) the factors associated with whether or not a metro will have an airport, and (2) the effect of airport activities on regional economic development. Based on multiple regression analysis for U.S. metros, our research generates four key findings. First, airports are more likely to be located in larger metros with higher shares of cultural workers and warmer winters. Second, airports add significantly to regional development measured as economic output per capita. Third, the effect of airports on regional development occurs through two channels—their capacity to move both people and cargo, with the former being somewhat more important. Fourth, the impact of airports on regional development varies with their size and scale.

Brida, J. G., Bukstein, D., & Zapata-Aguirre, S. (2016a).
Dynamic relationship between air transport and economic growth in Italy: A time series analysis. International Journal of Aviation Management, 3(1), 52–67.

Geographic scope: Italy.

Identification strategy features: Granger causality

Note: Paper not accessed

This paper studies the causal relationship between air transport demand and economic growth in Italy for the period 1971-2012. Johansen cointegration analysis shows the existence of one cointegrated vector between real GDP and air transport (represented by aircrafts movements) where the corresponding elasticities are positive. The Granger Causality test shows that causality goes unidirectionally from air-transport to GDP. The results imply that Italy can improve its economic growth performance by strategically harnessing the contribution of the air transport industry and improving their governance performance. Although air transport industry has grown significantly in Italy, there are no empirical analyses, to our knowledge, regarding European region as an entire case of study, neither the particular case of Italy. Therefore, the value of this work is that it deals with the dynamics between the air transport sector and the Italian economy.

Van de Vijver, E., Derudder, B. and Witlox, F., 2016. Air passenger transport and regional development: Cause and effect in Europe. *Promet-Traffic&Transportation*, *28*(2), pp.143-154.

Geographic scope: Europe.

Identification strategy features: Granger causality.

This article scrutinizes the mutual and complex causal relationship between air passenger transport and regional development in the European NUTS2-regions with heterogeneous Granger causality analysis between 2002 and 2011. Employment is used as a relatively robust and measurable indicator of a region's development and employment in the services sector and in the manufacturing sector is treated separately to discern basic sectoral variances. The proposed methodology allows investigating (i) if air transport in the European regions causally influences employment,(ii) if employment also leads to higher transport levels, and (iii) regional variations in this causal relationship. The results show that both directions of causality occur among the European urban regions, albeit very geographically fragmented. This indicates that air passenger transport is a necessary part of, but not sufficient condition for generating regional development. The more abundant relationships for employment in the services sector confirm the sensitivity of the services industry to air passenger transport.

Küçükönal, H. and Sedefoğlu, G., 2017. The causality analysis of air transport and socio-economics factors: The case of OECD countries. *Transportation Research Procedia*, *28*, pp.16-26.

Geographic scope: OECD.

Identification strategy features: Granger causality

Air transport is one of the most important industries in the world with its rapid growth, and direct and indirect contribution to world economy. In other words, GDP, tourism and employment are the key factors causing that growth in air transport and an increase in those factors boost the demand for air transport. However, uncertainty in economy, rising unemployment and increased terrorist attacks towards tourism would be a big threat to the growth of air transport in the future. To understand the importance of the mentioned factors, we first aim to apply an econometric approach which is panel Granger causality analysis. To achieve that, data from World Bank data set for OECD countries between the year of 2000 and 2013 is used in this study. We apply Pesaran CDLM test and Friedman's test which are preferred when the number of units (N) is higher than the time (T) to test cross-sectional dependence and we then perform Granger causality analysis in order to see whether there is a causal relationship (unidirectional or bidirectional) or not among air transport, tourism, economic growth and employment.

Econometric results indicate that there is a unidirectional short run causal relationship between economic growth, tourism, employment and air transport and that those factors play an important role in the growth of air transport. In this paper, we also aim to discuss the future challenges for air transport within the frame of econometric results and statistical analysis.

Todorova, S. and Haralampiev, K., 2020. Air transport and economic growth of the regions: causality analysis in Bulgaria. In *Air Transport and Regional Development Case Studies* (pp. 145-159). Routledge.

Geographic scope: Bulgaria.

Note: Paper not accessed

This chapter aims to provide an assessment of the issues involved here by isolating bidirectional short- and long-run causality between regional air transport activity and economic growth in their relevant regions. Infrastructure is often considered to be critical as a factor for the growth and development of countries and regions. Air transport is an important structure in the connection of regions. The empirical analysis was conducted using annual data on total airport passenger movements, and growth data (GDP) by regions for the period 1995-2015 for Bulgaria. The chapter aims to establish the first empirical evidence for determining causal relationships between regional aviation/airports and economic growth in Bulgaria. The results clearly demonstrate the long-run causalities between air transport and the local economy only in one direction the growth in GDP causes the growth in the number of the passengers. Economic growth is usually understood as growth of output, growth of output per worker, or growth of output per capita.

Egilmez, F., 2020. The long-run relationship between airline transport, export volume and economic growth: Evidence from USA. *Academic Review of Humanities and Social Sciences*, *3*(2), pp.466-482.

Geographic scope: USA.

Identification strategy features: Cointegration – not a true causal strategy.

The major goal of this manuscript is to determine the overtime changes in series and to examine the long-run stable linkage among air transportation, export volume and economic growth (GPD) for USA from 1980 to 2017 as annual data by using Johansen co-integration test, VAR analysis, variance de-composition and impulse response. Stationary tests of entire variable indicate that air transportation, export volume and economic growth are stationary at the first differences I(1) which are determined through ADF unit root test. According to empirical results of this manuscript, Johansen co-integration test determine the long-term stable relationship among air transportation, export volume and economic growth (GPD). On the other hand, according to the findings of multivariate regression analysis of three variables at Table 5, the impact of export capacity have considerably important on economic growth which is coincide with variance de-composition analysis at Table 4. The findings of this study suggest that appropriate policy should be applied to increase trade volume, air transportation including civil aviation and air freighter would boost considerably the economic growth (GDP) of USA. The government should exercise influence over imports of goods and services in order to provide the maximum benefit from trade in terms of increasing the export volume. In this context, the government should apply import restrictions through legislative regulations.

Balsalobre-Lorente, D., Driha, O.M., Bekun, F.V. and Adedoyin, F.F., 2021. The asymmetric impact of air transport on economic growth in Spain: fresh evidence from the tourism-led growth hypothesis. *Current issues in tourism*, *24*(4), pp.503-519.

Geographic scope: Spain.

Identification strategy features: Non-parametric causality tests. Not a fully causal method.

The tourism sector has emerged as an essential driver for economic growth strategies during the last decades. An asymmetric long-run effect of air transport on economic growth is validated assuming a process of social globalization in Spain between 1970 and 2015. To achieve the study's objective, the recent asymmetric autoregressive distributed lag methodology framework advanced by Shin, Yu, and Greenwood-Nimmo is applied. For determining the causality direction, this methodology is applied in conjunction with the non-parametric causality test proposed by Diks and Panchenko . The current study also accounts for the effects of renewable energy use and urbanization process over economic growth. Empirical results showed that air transport, urbanization process and social globalization exert positive and significant implications over economic growth, while renewable energy use reduces economic growth, as consequence of an energy mix sustained by fossil sources. Based on these outcomes several policy recommendations were offered in the concluding section.

Khanal, A., Rahman, M.M., Khanam, R. and Velayutham, E., 2022. Exploring the impact of Air transport on economic growth: New evidence from Australia. *Sustainability*, *14*(18), p.11351.

Geographic scope: Australia.

Identification strategy features: Granger type analysis

The COVID-19 pandemic has impacted all sectors of the tourism industry, particularly air transportation. However, air transport remains an important contributor to economic growth globally. Thus, this study examines whether air transport (a proxy for tourism) stimulates economic growth to validate the air-transportation-led growth hypothesis (ALGH) in the Australian context. To conduct the study, we analyse the asymmetric long-run and short-run impacts of the air passengers carried (a proxy for tourism) on the gross domestic product (GDP) in Australia. We use the nonlinear autoregressive distributed lag (NARDL) modelling approach on data for Australia from 1971 to 2019. We also examined the effects of selected control variables (i.e., energy consumption, financial development, socialisation, and urbanisation) on economic growth. In both the short and long run, we observed statistically significant asymmetric impacts of air transport on economic growth. The positive shocks in air transport propel the long-term growth of Australia's economy. Additionally, according to the findings, negative shocks of air transport have a stronger detrimental impact on economic development than positive shocks.

Pot, F.J. and Koster, S., 2022. Small airports: Runways to regional economic growth?. *Journal of Transport Geography*, *98*, p.103262.

Geographic scope: Europe.

Identification strategy features: Granger causality

Regions typically take great pride in having an airport within their boundaries. Policymakers go through great lengths in maintaining and sustaining airports, small as some of them may be. This support is often justified by pointing out the potential positive economic spin-off of the airport. This study adds to the body of literature on the role of airports in economic growth by assessing the link between air accessibility – with a focus on smaller airports - and regional economic development across European regions. We take into account spatial and airport heterogeneity as well as overlapping catchment areas. The data set consists of a strongly balanced panel of 274 European NUTS-2 regions spanning the years 2000–2018. For most regions, the contribution of smaller airports in providing accessibility is found to be limited. Nevertheless, in 2018, air accessibility for 19% of the European population covered is provided mainly by medium-sized and small airports, and for 3% mainly by small airports. The long-run elasticity between air accessibility and GDP per capita is estimated at 0.106 and is stronger for large airports (0.179) than for medium-sized (0.033) and small airports (0.022). Causality mainly runs from economic growth to air accessibility, especially considering smaller airports. However, considerable spatial heterogeneity exists in the nature of this causal relationship, with dense regions with lagging per capita GDP levels especially benefiting from air accessibility.

Note: Airport size categories: large (>5m passengers), medium (1–5m), small (<1m).

Kaya, G. and Aydın, U., 2024. The nexus between air transport and economic growth geographically: An evidence based on heterogeneous panel data models. *Journal of Air Transport Management*, *115*, p.102528.

Geographic scope: Global.

Identification strategy features: Granger causality.

Note: Some evidence of causality in some countries (23 of the 91). UK has mixed results. Results per country are not presented.

This study examines the nexus between air transport and economic growth on continents by considering the heterogeneity in panel data with the data of 91 countries for the period 2002–2021. According to the result of the Pedroni's cointegration test, economic growth affects air transport in the long-run. These results are also supported by the results of the error correction model. In the short-run, economic growth is found to affect air transport in a few countries in Europe, while in the long-run, this effect is found to be valid for all countries. On the other hand, Dumitrescu and Hurlin panel Granger causality test shows that air transport causes economic growth in the short-run in at least one panel. This causality is found to be statistically significant in 9 Asian countries, 6 European countries, 4 American countries, 2 Oceanian countries, and 2 African countries in the sample.

Çelik, A.K., Yalçınkaya, Ö. and Kutlu, M., 2025. The causal relationship between air transport and economic growth: Evidence from top ten countries with the largest air transport volume. *Transport Policy*, *162*, pp.521-532.

Geographic scope: UK and 9 other large air countries.

Identification strategy features: Predictive not causal analysis (though not Granger).

Note: Uni-directional from air to economic growth for UK. This comes from passengers, not freight (for UK).

The main objective of this paper is to explore causal relationship between air transport and economic growth for top ten countries with the largest air transport volume worldwide for the sample period 1970–2021 using conventional bootstrap Toda–Yamamoto and bootstrap Fourier Toda–Yamamoto causality tests. For this purpose, a single composite indicator gathered by principal components analysis as a proxy variable of air transport is used to reflect all dimensions of air transport and to better understand potential effects on the relationship between air transport and economic growth. The empirical findings of the present study revealed that there exists an uni-directional causal relationship from air transport to economic growth for all countries except for Russia and Brazil. A bi-directional causal relationship is also found between air freight transport and economic growth for Japan and between air carrier registered departures and economic growth for China. The results indicate that causality tests based on Fourier approach show more consistent results than conventional causality tests. This study also argues that the use of only one dimension of air transport can lead to relatively weak representativeness of air transport.

AKAR, P.G., 2025. The impact of air transportation on economic growth: Novel findings from the CS-ARDL model. *Transport Policy*, p.103788.

Identification strategy features: Granger causality

Note: Includes UK. Uni-directional causality from Air passengers to economic growth in UK. Uni-direction causality from economic growth to freight in UK.

This study examines the effect of air transportation in terms of its two outputs, passenger and cargo transportation, on economic growth in developing and developed economies. For this purpose, the cross-sectional autoregressive distributed lags estimator (CS-ARDL) was used with the number of air passengers, cargo volume, and GDP data from 1980 to 2021 for each country group to investigate the relationship between variables in the long and short run. In addition, the Augmented Mean Group (AMG) and Common Correlated Effects Mean Group Estimators (CCE) were applied for robustness. Also, the causality relationship between air passenger and economic growth and air freight and economic growth was investigated by Emirmahmutoglu and Kose (2011) panel causality methodology. According to the findings of all estimators used, it was determined that air passenger and air cargo volumes positively affected GDP in each group in both the short and long run. Panel causality test (Emirmahmutoglu and Kose, 2011) shows that unidirectional causality runs from air passenger to economic growth in developed and developing countries and unidirectional causality from economic growth to air cargo in developed countries.…

9.2 REST OF WORLD

9.2.1 PRE-2013

GRANGER CAUSALITY OR EQUIVALENT METHOD

Yao, Shujie and Yang, Xiuyun, Airport Development and Regional Economic Growth in China (February 2008). Available at SSRN: https://ssrn.com/abstract=1101574

Geographic scope: China.

Identification strategy features: Tests for cointegration (implies Granger causality)

Air transport has experienced phenomenal growth in China over the last 30 years, but studies on China's airport development are few. This paper aims to fill in this literature gap by focusing on the determinants of airport development in the Chinese regions using the most up-to-day and comprehensive data on China's airports and their related economic and geographical variables. The empirical results based on an augmented production function indicate that airport development is positively related with economic growth, industrial structure, population density, and openness, but negatively related with ground transportation. The growth of airport transportation in the eastern region is slower than in the inland areas, implying a more significant substitution effect of air transport on ground transport in the less densely populated areas, irrespective of economic activities. The results have useful policy implications as any regional transportation development plan has to simultaneously consider the competitive and supplementary effects of both air and land transports in a specific location.

Chang, Y.-H., & Chang, Y.-W. (2009).*Air cargo expansion and economic growth: Finding the empirical link. Journal of Air Transport Management, 15(5),* 264–265.

Geographic scope: Taiwan.

Identification strategy features: Granger causality.

This paper applies Granger causality tests to examine the causal relationship between air cargo expansion and economic growth in Taiwan for the period 1974–2006. The results of cointegration tests show a long-run equilibrium and bi-directional relationship between air cargo expansion and economic growth in the case of Taiwan.

Fernandes, E., & Pacheco, R. R. (2010). *The causal relationship between GDP and domestic air passenger traffic in Brazil. Transportation Planning and Technology, 33(7),* 569–581.

Geographic scope: Brazil.

Identification strategy features: Granger causality.

This paper examines the causal relationship between economic growth and domestic air passenger transport in Brazil, using Granger's causality test. Total domestic passenger-kilometres are used as a proxy for air transport demand and gross domestic product as a proxy for economic growth. The test spans the period from 1966 to 2006. The results lead to the acceptance of the hypothesis that there is a unidirectional Granger causal relationship from economic growth to domestic air transport demand in Brazil, having a high elasticity in the short term.

Marazzo, M., Scherre, R., & Fernandes, E. (2010).
Air transport demand and economic growth in Brazil: A time series analysis. Transportation Research Part E, 46(2), 261–269.

Geographic scope: Brazil.

Identification strategy features: Granger causality

We investigate the relationship between air transport demand (passenger-kilometer: PAX) and economic growth (GDP) between 1966 and 2006 in Brazil. Special attention is paid to stationary features and the existence of a long-run equilibrium between variables to work in a vector autoregressive environment. Our findings suggest that GDP and PAX are co-integrated. Impulse-response analysis indicates a strong positive reaction of PAX due to a positive change in GDP. However, GDP reacts to a change in PAX in a slower and moderated way. We interpret these findings as an empirical evidence of air transport multiplier effects in the economy.

Yao, S. and Yang, X., 2012. Air transport and regional economic growth in China. *Asia-Pacific Journal of Accounting & Economics*, *19*(3), pp.318-329.

Geographic scope: China.

Identification strategy features: Production function, without controls for endogeneity. Relies on correct theoretical specification.

Air transport increased exponentially in China over the last 30 years, but studies on this issue are few. This paper aims to fill in this literature gap. It identifies the key determinants of air transport in the Chinese regions for the period 1995–2006. The empirical results based on an augmented production function indicate that air transport is positively related with economic growth, industrial structure, population density, and openness, but negatively related with ground transportation. The development of air transport, however, varies significantly across regions in terms of growth and competition with ground transport. The competition has become particularly intense in recent years, as high-speed railways have become a formidable challenge to air transport between the short- and mid-range transportation routes.

9.2.2 2013 AND LATER

CAUSAL METHOD

Gibbons, S. and Wu, W., 2020. Airports, access and local economic performance: Evidence from China. *Journal of Economic Geography*, 20(4), pp.903-937..

Geographic scope: China.

In this article, we study the effect of airports on local economic performance that arises from better access to domestic markets in the context of China's recent airport network expansion. We measure access through the changes in network closeness centrality implied by the contraction in potential journey times between counties within China. Our key finding is that better access—primarily due to landside distance reductions to airports—increased manufacturing productivity. The analysis is carried out on a panel of counties built from micro data on industrial firms, administrative records and census data. To mitigate endogeneity issues, we focus on a subsample of 'incidentally' affected counties, whose location midway between existing and new airports implies that they were neither explicitly targeted for development nor directly affected by airport operations.

Wong, D.W.H., Zhao, S.X.B. and Lee, H.F., 2022. Air transport, economic growth, and regional inequality across three Chinese macro-regions. *Geographical Research*, *60*(3), pp.446-462.

Geographic scope: China.

This research considers the effects of air transport on economic growth and asks how airport development affects regional convergence across three Chinese macro-regions. A growing body of research has examined national aviation-growth relationships in developing countries over the last decade. Yet few studies have sought to determine whether air transport boosts regional development, especially in developing and emerging economies. Using a dataset spanning from 2005 to 2017, and drawing on panel data regression and instrumental variable analyses, we provide empirical evidence that air transport drives economic growth in China and its macro-regions. However, we find no major synergy across air, high-speed rail, and waterway transport as drivers of economic growth at national and regional levels. Furthermore, air transport has a significant effect in widening China's per capita income disparity. On that basis, we suggest Chinese local governments should carefully consider equity-efficiency trade-offs and provincial and municipal conditions and regional contexts when planning new airports, increasing airport services, or extending aviation connectivity. Others elsewhere may derive insights from these findings.

Nguyen, C.V., 2024. Air transport resilience, tourism and its impact on economic growth. *Economies*, *12*(9), p.236.

Geographic scope: Thailand, Philippines, Vietnam, Indonesia, Malaysia, and Singapore.

The aims of this study are to evaluate the influence of air transport and tourism on economic growth in selected Southeast Asian countries such as Thailand, Philippines, Vietnam, Indonesia, Malaysia, and Singapore in the period 1970 to 2021. The study applies the ordinary least squares (OLS), fixed

effects (FEM), and random effects (REM), especially to robustness test of the research results by deploying the DOLS, and IV-GMM regression for endogeneity and autocorrelation analysis. The research results confirmed that air transport has a significant and positive impact on economic growth, especially because the positive impact increased in normal economic conditions and decreased during the COVID-19 pandemic. Therefore, if the air transport recovers, it is likely to boost economic development. In addition, there is no impact of tourism on economic growth. The research results also confirmed the positive impact of foreign direct investment and international trade on the economic growth of Southeast Asian countries; however, there is a negative impact of renewable energy consumption on economic growth.

GRANGER CAUSALITY OR EQUIVALENT METHOD

Van De Vijver, E., Derudder, B., & Witlox, F. (2014). Exploring causality in trade and air passenger travel relationships: The case of Asia-Pacific, 1980–2010. *Journal of Transport Geography, 34,* 142–150.

Geographic scope: Asia-Pacific.

Identification strategy features: Granger causality

This paper explores the potential of heterogeneous Granger analysis in transport geography research by applying this method to a specific case of the often complex and potentially reciprocal linkages between the deployment of transport infrastructures and spatial economic development: the linkages between rising intra-regional volumes of trade and air passenger traffic in Asia-Pacific. Although conceptual and empirical linkages between both indicators can be assumed based on previous research, relatively little is known about the actual causality. Using heterogeneous Time Series Cross Section Granger causality analysis for the period 1980–2010, we explore the presence of four 'causality scenarios' amongst different country-pairs: (1) there is no co-evolution, implying that both patterns develop independently (e.g. Japan–Australia); (2) there is 'real' co-evolution in that both patterns influence each other through feedback loops (e.g. South Korea–Philippines); (3) air passenger traffic is facilitated by trade (e.g., South Korea–Philippines); or (4) trade is facilitated by air passenger traffic (e.g. Australia–Malaysia). Some tentative interpretations of this heterogeneity are offered.

Hu, Y., Xiao, J., Deng, Y., Xiao, Y. and Wang, S., 2015. Domestic air passenger traffic and economic growth in China: Evidence from heterogeneous panel models. *Journal of Air Transport Management*, *42*, pp.95-100.

Geographic scope: China.

Identification strategy features: Granger causality but with GMM

This paper applies recent panel methodology to examine the short-run dynamics, the long-run equilibrium relationships and the Granger causal relationship between economic growth and domestic air passenger traffic. It is based on the quarterly panel data of 29 provinces in China from the period of 2006Q1 to 2012Q3. Tests for panel unit roots, cointegration in heterogeneous panels and panel causality are employed in a bi-variate panel vector error correction model (PVECM), which is estimated by the system generalized moment method (SYS-GMM). The results show evidence of a long-run equilibrium relationship between economic growth and domestic air passenger traffic.

Specifically, 1% increase in the air passenger traffic is found to lead to an increase of 0.943% in real gross domestic product (GDP). A long-run and strong bi-directional Granger causal relationship is found between these two series. It is also found that there is a short-run uni-directional Granger causality running from the domestic air passenger traffic to the economic growth.

Saheed, A.A.A. and Iluno, S.Z.C., 2015. Air transportation development and economic growth in Nigeria. *Journal of economics and sustainable development*, *6*(2), pp.1-11.

Geographic scope: Nigeria.

Identification strategy features: Granger causality

This work is an evaluation of the influence of air transport sector development on economic growth in Nigerian. Over the years, various governments of Nigeria have put in place a series of policy instruments for the development of the aviation sector as sinews to bolster the desired growth. But air transport system continues to mirror inefficiency, mismanagement and airline mishap. This study developed a series of econometrics models including dynamic ordinary regression equation, cointegration, error correction model and granger causality techniques to examine the relationship between air transport and economic growth. The analyses suggests a positive influence of air transport on economic growth, a long run equilibrium relationship and a causal unidirectional relations from air transport to economic growth. The diagnostic test for the normality of the model showed that the model functional form is adequate, stable with no serial correlation. From the analysis, this study recommends a proactive and dynamic cohesive transport policy that benefits all the stakeholders. Also, the sector must improve on its managerial expertise guided by adequate transparency and accountability in order to achieve results and develop the sector to an international standard worthy of emulation.

Mehmood, B., Aleem, M. and Shahzad, N., 2015. Air-transport and macroeconomic performance in Asian countries: An analysis. *Pakistan Journal of Applied Economics*, *25*(2), pp.179-192.

Geographic scope: 41 Asian countries.

Note: Paper not accessed.

Identification strategy features: Granger causality (source Kaya and Aydin (2024))

Brida, J. G., Rodríguez-Brindis, M. A., & Zapata-Aguirre, S. (2016b).
Causality between economic growth and air transport expansion: Empirical evidence from Mexico. World Review of Intermodal Transportation Research, 6(1), 1–15.

Geographic scope: Mexico.

Identification strategy features: Granger causality

Note: Paper not accessed

This paper analyses the effects in the long-run between air transport demand and the economic growth in Mexico. Using quarterly data from 1995qIII to 2013qIV, the study investigates possible causal relationships between real GDP and number of air passengers in arriving and departing from Mexican airports. Johansen cointegration analysis shows the existence of one cointegrated vector where the corresponding elasticities are positive. The study shows that the causality relationship is positive and bidirectional. Impulse response analysis shows that an increase in the magnitude of air transport expansion in Mexico produces a positive effect on economic growth in the country.

Hakim, M. M., & Merkert, R. (2016).
The causal relationship between air transport and economic growth: Empirical evidence from South Asia. Journal of Transport Geography, 56, 120–127.

Geographic scope: South Asia.

Identification strategy features: Granger causality

This paper examines the causal relationship between air transport and economic growth in the South Asian context. Using panel data over a period of 42 years (1973–2014), we apply Pedroni/Johansen cointegration test methods, followed by Granger long-run and Wald short-run causality tests. To allow for spatial heterogeneity we then apply Time Series Cross Section (TSCS) Granger causality tests for each of the eight analysed countries separately. Our results confirm a long-run uni-directional Granger causality which runs from GDP to air passenger traffic and also to air freight volumes. Contrary to the existing literature we do not find a long-run bi-directional causality which confirms that spatial dimensions and context matter (i.e. low income and large populations). The absence of short-run causality and the identified time lags of 3–4 years should guide aviation firms and policy makers in the preparation of necessary infrastructure required to support the strong air transport growth potential.

SEÇİLMİŞ, N. and KORAP, L., 2017. A NEW LOOK AT THE RELATIONSHIP BETWEEN AVIATION DEMAND AND ECONOMIC GROWTH: STRUCTURAL MODEL ESTIMATION FOR THE CASE OF TURKEY. *Journal of International Social Research*, *10*(49).

Geographic scope: Turkey.

Identification strategy features: Granger causality

This study aims to consider the relationship between aviation demand and economic growth in an empirical way. For this purpose, the Turkish data are used in light of the advances in time series estimation techniques. The results reveal that cointegration between the variables cannot be rejected. Aviation demand is found like a luxury good and economic growth tend to act as a constraint on demand conditions. Further, a positive real income shock in a structural vector error correction framework leads nearly one-to-one significant response in aviation demand. The forecast error variance decomposition findings give support to these results.

Brida, J.G., Monterubbianesi, P.D. and Zapata-Aguirre, S., 2018. Exploring causality between economic growth and air transport demand for Argentina and Uruguay. *World Review of Intermodal Transportation Research*, *7*(4), pp.310-329.

Geographic scope: Argentina & Uruguay.

Identification strategy features: Granger causality

This paper investigates the effects in the long-term between air transportation and the economic growth in Uruguay and Argentina. Employing annual data from 1970 to 2011, the study uses cointegration analysis to consider the existence of a long-run relation between real GDP and the number of air passengers in each country. Results show that for both considered countries, the series are cointegrated and it is possible to estimate an error correction model (ECM). The Granger causality test shows that causality goes unidirectionally from GDP to air-transport for both countries. The elasticity and impulse-response function analysis shows that the effect of a GDP shock on the number of passengers is higher in Uruguay than in Argentina, which is consistent with the characteristics of the air market and the geographical conditions of each country. The results suggest different policy and planning implications.

Zhong, Z.W. and Raheja, D., 2018. The causal relationship between GDP and air passenger traffic: Evidence from Singapore. *International journal of transport economics: Rivista internazionale di economia dei trasporti: XLV, 1, 2018*, pp.83-95.

Geographic scope: Singapore.

Identification strategy features: Granger causality

The causality relationship between gross domestic product and air passenger traffic is deliberated by many researchers in the field of aviation. While some take aviation as a key driver of Singapore's success, others believe that it is country's value of economic activity that enabled multinational business and people to travel. This paper is an attempt to investigate the causal relationship

between air passenger traffic and GDP in Singapore, using annual data from 1980 to 2015. This paper utilizes Engel-Granger procedure, Johansen-Juselius cointegration methodology and granger causality test to analyze this relationship. Our empirical results show no long run co-integration relationship between both but short run unidirectional causality running from air passenger traffic to GDP. This study also provides reasonable evidence to support aviation-led growth hypothesis for Singapore. The significance of air passenger traffic confirms the importance of airport development and the need to maintain local airport infrastructure. Hence, for Singapore to support regional development, funding should be targeted at the airport directly.

Nasution, A.A., Azmi, Z., Siregar, I. and Erlina, I., 2018. Impact of air transport on the Indonesian economy. In *MATEC Web of Conferences* (Vol. 236, p. 02010). EDP Sciences.

Geographic scope: Indonesia.

Identification strategy features: Granger causality

This study aims to analyze the causal relationship between air transportation and economic growth in Indonesia. The data used are annual time series data from 1990 to 2017 obtained from World Bank. Data analysis method used is method of Vector Error Corection Model (VECM). The results show that there is a relationship between air transport tax and economic growth in Indonesia. Where is the tax of air transport (passenger and goods) and economic growth (GDP). Based on the granger variable or passenger variables test results and the GDP variable indicates that it remains granger-related with significant 1 percent action. Based on these findings it is hoped that further research is suggested to examine the effect of ticket prices or air fares in order to improve economic growth in Indonesia.

Tolcha, T.D., Bråthen, S. and Holmgren, J., 2020. Air transport demand and economic development in sub-Saharan Africa: Direction of causality. *Journal of Transport Geography*, *86*, p.102771.

Geographic scope: South Africa, Nigeria, Kenya, Ehiopia, Senegal & Angola.

Identification strategy features: Granger causality

Air transport may be a key tool to advance economic development. However, it is uncertain whether air transport boosts economic development, or vice versa. Both views have theoretical and empirical support. In some countries and regions, air transport is important for initiating development, for example by attracting foreign direct investment or granting access to lifelines. Elsewhere, economic development drives air transport demand. Establishing the direction of causality for regions/countries segmented by income level may inform pragmatic policy. This study analyzes the causal relationship between air transport demand and economic development for six sub-Saharan African countries for the period 1981–2018. Vector error correction and vector autoregression models are employed to identify long- and short-run causalities. The results reveal heterogeneous, context-specific causal relationships. In the long-run, for South Africa, Nigeria and Kenya, the direction of causality runs from economic development to air transport demand; for Ethiopia, causality runs in the opposite direction, with increased demand for air transport promoting economic development; and for Senegal and Angola, the relationship is too weak to infer causal directions. Possible explanations for this heterogeneity include differences in per capita income, low-

cost carriers' share of national aviation markets, the presence of large home-based airlines, and comparative geographical advantage as a natural hub.

Ananda, R., Jamal, A. and Mahmud, M.S., 2020. Is the economic growth of ASEAN-10 related to air transportation? A panel ARDL approach. *Jurnal Ekonomi dan Studi Pembangunan*, *12*(1), pp.10-17.

Geographic scope: South East Asian countries.

Identification strategy features: Granger type causality/ARDL

Investment in transport infrastructure is one of the important actions to accelerate regional development because it will open access among regions. Thus, it can lead to accelerate economic growth. This study aims to analyze the short-run and long-run relationship between economic growth and air transportation in ASEAN-10 countries. The data used in this study are the number of air transport passengers, air transport carrier, air freights, interactions between passengers and air transport carrier, and gross domestic product growth sourced from World Bank in a year period of 2002-2017. Panel ARDL is used in this analysis. Based on the specification, estimation, and examination of the model, the Panel ARDL is the best choice model. The Panel ARDL model shows that in the short term there is no significant relationship between air transportation and economic growth, but in the long term explains, except air freight, that air transport passengers, air transport airline, and the interaction between passengers have a significant effect on ASEAN-10 economic growth. This study emphasizes that to increase economic growth, increase in air transportation services is an important factor.

Higgoda, R. and Madurapperuma, W., 2020. Air passenger movements and economic growth in Sri Lanka: Co-integration and causality analysis. *Journal of Transport and Supply Chain Management*, *14*(1), pp.1-13.

Geographic scope: Sri Lanka.

Identification strategy features: Granger causality

Background

It is generally recognised that air passenger transport contributes to the economic growth in developed and developing countries. Hence, air transportation is used as a policy instrument for stimulating economic growth. Air transport contributes to the economic welfare of the nation and long-term economic growth throughout trade and tourism. However, relatively little attention has been devoted to this phenomenon.

Objectives

The aim of this research article was to investigate the aviation-centric growth hypothesis for Sri Lanka by testing causation between aviation and economic growth.

Method

Using time series data over a period of 37 years (1983-2019), this study employed Johansen cointegration test methods, followed by Granger's causality tests.

Results

The results of this study confirm that there is no long-run relationship between air transportation and economic growth in Sri Lanka. However, the results show that there is a short-run unidirectional Granger causality, which runs from economic growth to total passenger movements.

Conclusion

It can be concluded from the findings that they disprove the aviation-centric growth hypothesis and instead suggest that air transport does not play a significant role in the promotion of Sri Lanka's economic growth. Furthermore, the existence of unidirectional causality from economic growth to air transport and the recognised time lags of 2-3 years would guide government and policymakers to manage resources properly and allocate resources efficiently for the sectors, which accelerate economic growth in Sri Lanka.

Madurapperuma, W. and Higgoda, R., 2020. Air-transportation, tourism and economic growth interactions in Sri Lanka: Cointegration and causality analysis. *International journal of business & management*, *8*(1), pp.85-107.

Geographic scope: Sri Lanka.

Identification strategy features: Granger causality

Air travel growth is one of the notable responsibilities of a government specifically for an economy which depends heavily on tourism. Air travel strengthens destinations by enhancing connectivity, arrivals and other tourism reactions therefore it is recognized as a medium of revenue generation, work opportunity creation and sustainable business development. The aim of this study is to examine the causal relationship between tourism, air travel and economic growth in Sri Lanka for period of 1983-2019. The study employs the Cointegration and Granger causality approach. The results confirm that there is a stable uni directional relationship running from air transportation to economic growth in the short run bidirectional causality exists between air travel and tourism growth in Sri Lanka. The findings suggested that policymakers do not over-rely on air transportation for economic growth and that they pay more comprehensive attention to integrate the air transportation and tourism growth. It recommends policy makers to develop integrated strategies that connect air travel, tourism and economic growth.

Aprigliano Fernandes, V., Pacheco, R.R., Fernandes, E., Cabo, M., Ventura, R.V. and Caixeta, R., 2021. Air transportation, economy and causality: Remote towns in Brazil's Amazon Region. *Sustainability*, *13*(2), p.627.

Geographic scope: Brazil. Remote small towns.

Identification strategy features: Granger causality

There is a vast amount of literature on relations between air transport activities and economic growth. The recognition that these are important relationships has aroused the interest of researchers, who have studied them with regard to remote towns. The empirical studies have concentrated more on developed areas, such as Europe, North America, and Australia. No empirical studies were found for Brazil, which holds most of the Amazon region. In this study, the Granger causality method was used to investigate for causal relationships between regular domestic air passenger transport links and the gross domestic product of small municipalities in this region. The results indicate short- and long-term, two-way causality in which gross domestic product has a stronger impact on air transport than vice versa.

Alam, K.M., Li, X., Baig, S., Ghanem, O. and Hanif, S., 2021. Causality between transportation infrastructure and economic development in Pakistan: An ARDL analysis. *Research in Transportation Economics*, *88*, p.100974.

Geographic scope: Pakistan.

Identification strategy features: Granger causality

This paper examines the relationship between transport infrastructure and economic development in Pakistan. An autoregressive distributive lag (ARDL) and vector error correction model (VECM) is applied over the period 1971–2017. The results indicate that there is a long-run and causal relationship between transport infrastructure and economic development. Transport infrastructure has long-run positive impact on economic development. Furthermore, Granger causality test shows a unidirectional causality in long-run running from transport infrastructure to economic development. Interestingly, the impact of air infrastructure on economic development is statistically insignificant in long-run and short-run. The new results from this research provides a comprehensive picture of determinants of economic development from transport infrastructure in Pakistan and these new findings not only help policy makers but also can help to advance the current literature. Therefore, it is suggested that the government of Pakistan should concentrate more to increase the transport infrastructure for higher economic development.

Bai, Y. and Wu, C.L., 2022. The causality analysis of airports and regional economy: empirical evidence from Jiangsu Province in China. *Sustainability*, *14*(7), p.4295.

Geographic scope: China.

Identification strategy features: Granger causality

China is the second largest aviation country in the world. The Chinese aviation industry and economy both developed quickly in the last two decades. However, the interaction mechanisms of aviation and the regional economy were different in each province. Jiangsu was the most important province in the Yangtze River delta region. The GDP of Jiangsu ranked second in China, but air transportation didn't have the same leading position in the last decade. Taking Jiangsu province as for analysis, this paper provided empirical evidence of the causality between airport development and regional economic growth. The results showed that: (1) From 2008 to 2018, the overall volume of airport passenger throughput and GDP in Jiangsu had a strong upward trend with strong seasonal fluctuations; (2) There was a bi-directional Granger causality relationship between the airport passenger throughput and GDP in Jiangsu based on the vector autoregression (VAR) model and the Granger causality test; (3) From the impulse response and variance decomposition, the inter-contribution of GDP and airport development was sustainable and increasing over time. However, the impact of economic growth on airports was more significant than the impact of airports on economic growth.

Law, C.C., Zhang, Y., Gow, J. and Vu, X.B., 2022. Dynamic relationship between air transport, economic growth and inbound tourism in Cambodia, Laos, Myanmar and Vietnam. *Journal of Air Transport Management*, *98*, p.102161.

Geographic scope: Cambodia, Laos, Myanmar and Vietnam.

Identification strategy features: Granger causality

Cambodia, Laos, Myanmar and Vietnam (the CLMV countries) in Mainland Southeast Asia share a similar history in their political systems, development of their aviation industries and their economic development in general. This study examines the relationship between air transport development, economic growth and inbound tourism in the CLMV countries. There is bi-directional causality between air passenger traffic and economic growth in the long run. Inbound tourism has a significant impact on air transport demand in the long run but no significant relationship exists between the two in the short run. Air transport deregulation had a positive and significant impact on traffic volumes, particularly for Cambodia. Further reforms are still needed before such an outcome can occur in Myanmar.

Ali, R., Bakhsh, K. and Yasin, M.A., 2023. Causal nexus between air transportation and economic growth in BRICS countries. *Journal of Air Transport Management*, *107*, p.102335.

Geographic scope: BRICS (in 2023) Brazil, Russia, India, China and South Africa.

Identification strategy features: Granger type causality

Air transportation is important factor which helps to vibrate economic activities in any economy. This paper explore causal nexus between air transportation and economic growth in BRICS countries by using balanced panel date for the period 1993–2019. Numbers of air passengers and air freight are used as measures of air transportation. Panel time series econometric techniques coupled with panel Vector Error Correction Model and Dumitrescu and Hurlin tests are applied for causal analysis. Unidirectional long run causalities are found from air passengers and airfreight to economic growth in these countries. Likewise, one way short run causal relation from air transportation to economic growth is found in these countries. Based on the findings of this, there is economic significance of air transportation in these countries, hence, important policy implications are discussed.

Nguyen, Q.H., 2023. The causality between air transport and economic growth: Empirical evidence from regions in Asia. *Research in Transportation Business & Management*, *47*, p.100948.

Geographic scope: Asia.

Identification strategy features: Granger causality

This study examines the causality between air transport (passenger and cargo) and economic growth among regions in Asia. Using panel data from 1975 to 2019, the study applies econometric methods to test the stationarity and cointegration of the data, followed by the Granger causality test, and finally estimates the effect coefficients. The effect coefficients are estimated by the panel autoregressive distributed lag model (ARDL) and robustness tests by comparison with panel least squares (LS) methods. The study results confirm a bi-directional causality relationship in most regions of Asia. However, the study only confirms a unidirectional relationship from economic growth to air passenger transport in South Asia and from economic growth to air freight in Central Asia and West Asia. In addition, specific effect coefficients between air transport and economic growth in the long-run and short-run are also established in regions where they have a causal relationship. These findings serve as a basis for the development of air transport policy in different regions of Asia.

Raihan, A., Voumik, L.C., Akter, S., Ridzuan, A.R., Fahlevi, M., Aljuaid, M. and Saniuk, S., 2024. Taking flight: Exploring the relationship between air transport and Malaysian economic growth. *Journal of Air Transport Management*, *115*, p.102540.

Geographic scope: Malaysia.

Identification strategy features: Granger analysis

All facets of the tourism business, especially air travel, have been affected by the COVID-19 pandemic. The aviation industry continues to contribute to international economic expansion

significantly. The article aims to identify the impact of the development of air transport on the economic development of the Malaysian economy. Therefore, the air-transportation-led growth hypothesis (ALGH) was investigated by examining whether airline travel boosts the Malaysian economy. The effects of air passengers (a stand-in for tourism) on Malaysia's GDP were examined in the long and short term. This study analyzed Data for Malaysia using an autoregressive distributed lag (ARDL) technique. The time covered was from 1970 to 2020. Certain control variables (i.e., energy consumption, financial development, social globalization, and urbanization) were also analyzed to see how they influenced economic expansion. Statistically significant effects of air travel on GDP were found in both the short and long term of this study, suggesting that this mode of transportation contributes to the sustained expansion of Malaysia's economy. Several methods, including Canonical Cointegration Regression (CCR), Dynamic Ordinary Least Squares (DOLS), and Fully Modified Ordinary Least Squares (FMOLS), were used to verify the results independently. The article offers legislative suggestions for improving the aviation industry's productivity, security, and bottom line.

Luque, W.D. and Yu, C., 2025. Evolution of the Airport Industry and Regional Growth in the Pacific Alliance Member Countries. *Journal of Air Transport Management*, *127*, p.102811.

Geographic scope: Chile, Colombia, Mexico, Peru.

Identification strategy features: Granger causality with IV for privatisation and commercialisation.

This study examines the relationship between airports and regional economic growth, and explores the extent to which airport privatization and commercialization have influenced air traffic growth within Pacific Alliance countries. Utilizing a comprehensive dataset comprising 86 airports across Chile, Colombia, Mexico, and Peru from 2006 to 2019, we employed Granger causality tests, Vector Autoregression (VAR), and Instrumental Variables (IV) with Two-Stage Least Squares (2SLS) models. Our findings reveal that privatization and commercialization significantly enhance airport traffic, which, in turn, promotes regional economic growth. Furthermore, we identified a bidirectional causal relationship between airport traffic and economic growth in Colombia, Mexico, and Peru. However, no evidence of such causality was observed in Chile.

Chaitarin, W., Maneejuk, P., Sriboonchitta, S., & Yamaka, W. (2025). *When Does Air Transport Infrastructure and Trade Flows Matter? Threshold Effects on Economic Growth in ASEAN Countries*. Sustainability, 17, 7406. https://doi.org/10.3390/su17167406

Geographic scope: South East Asia.

Identification strategy features: Non-causal approach adopted, but more than just correlation. SE Asian countries only. Minimum thresholds of air travel found before impact on growth.

This study examines how air transport infrastructure and trade flows influence economic growth across ASEAN countries, with a focus on identifying the threshold levels at which these factors begin to enhance growth. Despite increasing investment in regional logistics and connectivity, policymakers often lack evidence-based thresholds to guide infrastructure and trade policy for long-term development. Addressing this gap, this study applies a Dynamic Panel Threshold Model to uncover the tipping points at which improvements in air cargo volume (lnCargo) and air transport

infrastructure quality (lnQAir) translate into stronger economic growth. By employing System-GMM and First-Difference GMM estimations, the analysis captures the threshold effects of air cargo volume (lnCargo) and air transport infrastructure quality (lnQAir) on economic growth over varying regimes. The results reveal significant single-threshold effects for both lnCargo and lnQAir, indicating that their contributions to economic growth become substantial after surpassing specific critical levels. When air cargo volume exceeds approximately 267,067 tons per year (lnCargo > 5.5875), its positive effect on economic growth strengthens, particularly when accompanied by high-quality infrastructure. Similarly, air transport infrastructure quality exhibits a significantly stronger impact on economic growth once it exceeds the critical threshold of lnQAir = 1.5476 (≈4.7001 index points). These findings emphasize the complementarity between trade flows and infrastructure, aligning with endogenous growth theory, which suggests that infrastructure investments yield increasing returns when integrated with trade expansion. Policy implications suggest that ASEAN economies should adopt demand-driven infrastructure development aligned with trade dynamics, prioritizing regional connectivity, logistics efficiency, and investment attraction to sustain long-term economic growth.